

1 Volume I

Regional Biosecurity Plan for Micronesia and Hawaii

Volume I

Prepared by:

University of Guam and the Secretariat of the Pacific Community 2014

This plan was prepared in conjunction with representatives from various countries at various levels including federal/national, state/territory/commonwealth, industry, and non-governmental organizations and was generously funded and supported by the Commander, Navy Installations Command (CNIC) and Headquarters, Marine Corps.

Suggested Citation

United States Department of the Navy. 2015. Regional Biosecurity Plan for Micronesia and Hawaii, *{specify volume}*. Eds. University of Guam and the Secretariat of the Pacific Community.

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1. Forward

This document, the Regional Biosecurity Plan for Micronesia and Hawaii or RBP, is the work of many, in fact hundreds of individuals. Various government agencies, organizations, and individuals have contributed either through preparing texts that have become elements of this overall document and/or by supplying detailed comments and suggestions which have been used to build the implementation strategy. The concept of building this plan with such extensive input was felt to be the appropriate mechanism to insure that biosecurity needs for the region were comprehensively documented and it is to be hoped that any errors which do exist in this document are minimal and that any existing errors can over time be identified and corrected for future editions of this living document.

The RBP was originally termed the Micronesia Biosecurity Plan or MBP. Since the inception of the plan the term MBP has been used for a variety of subcomponents as well as to reference the overall project and the term can be found in earlier documents and components including the risk assessments which are part of the RBP. The risk assessment sections of this document are by far the largest components. These assessments contain a vast array of useful information and details and end users are encouraged to explore them in order to benefit fully from these assessments.

Given the extensive size of the risk assessments, an attempt was made to keep the strategic implementation component of the plan as streamlined as feasible to assist end users. The implementation section hinges on the recommendation tables, one table for each jurisdiction, plus additional tables for the U.S. (covering its three jurisdictions within the region) and for the U.S. Department of Defense (DoD). In this regard, the U.S. regional and DoD are treated as jurisdictions, although strictly speaking they are not. The three jurisdictions which fall under U.S. federal oversight and are part of this plan are only a part of the area covered by the U.S. federal jurisdiction. DoD is a department of the U.S. federal government with facilities, personnel, and materials in many areas around the globe. This plan only covers those DoD elements which are within the region or which are either entering or departing the region.

The preparers of the RBP have agreed that the task at hand was not to write a biosecurity plan for the region per se, but rather to serve as compilers, editors, and synthesizers working to produce a regional biosecurity strategy from the input of experts and stakeholders from throughout the region as well as supplementing this core input with additional material from experts from beyond the region as appropriate. Ultimately, what the reader of this document will find is what local, regional, and global experts and stakeholders have suggested should be included in this document. Some jurisdictions provided much more input than others. It is hoped that the information provided in this plan will assist each and every jurisdiction as well as the region in moving forward with improving biosecurity across the board (within jurisdictions, between jurisdictions, and for the region, as well as for linkages outside the region).

This plan was drafted and developed with the intention that it should remain a living document and that once the final product has been delivered to the jurisdictions, the jurisdictions themselves would

determine how best to move forward with recommendations, implementation, and updating their elements of the plan as needed in order to insure that it remains current and ultimately functional. It is hoped that updates both in regards to advancements towards meeting specific recommendations as well as to the plan itself will be shared between jurisdictions and supported by the region, ultimately ensuring that the plan remains a regional concept with a regional focus but driven by the individual jurisdictions via regional agreements and continued planning, development, and implementation.

2. Mission Statement

The concept of the RBP is visionary in its scope. The transfer of invasive species or invasive alien species (IAS) to the region and within the region is real, ongoing, and an increasing problem that must be addressed. The spatial scale for this plan is extremely broad, encompassing most of Micronesia and the archipelago of Hawaii. The plan attempts to cover the broadest possible extent of habitats and taxonomic groups including terrestrial, freshwater, and marine systems. This overall approach is unprecedented due to the broad geographic and taxonomic scope, as well as inclusion of multiple countries and cultures.

The primary entities covered by the RBP are listed below. These entities are often referred to as jurisdictions within the RBP, as most of them are government jurisdictions.

- The U.S. Federal Government, as it relates to its jurisdictions within the region
- The U.S. Territory of Guam, commonly referred to as Guam
- The U.S. Commonwealth of the Northern Mariana Islands or CNMI
- The U.S. state of Hawaii, commonly referred to as Hawaii
- The Federated States of Micronesia or FSM
- The FSM state of Chuuk
- The FSM state of Kosrae
- The FSM state of Pohnpei
- The FSM state of Yap
- The Republic of Palau, commonly referred to as Palau
- The Republic of the Marshall Islands or RMI
- The DoD

The approach used to develop the RBP explicitly considers multiple vectors and environments (marine, freshwater, and terrestrial systems) together, using an appropriate spatial scale at which invasions operate. The implementation of this large-scale, integrative, and cross-cutting strategy should result in improved biosecurity protection, efficiency, and consistency, compared to advancing many individual activities in isolation. By cross-cutting we refer to the fact that invasive species negatively affect most major concerns within the region such as climate change adaptation, human health, green economy development, natural resources conservation, economic stability and growth, food security, etc. and that by addressing invasive species via appropriate biosecurity we are in fact positively affecting all of

these major concerns. The implementation guidance within the RBP supports establishment of a coordinated and consistent strategy internationally, across multiple countries and cultures. Most current understanding and management of invasions come from temperate latitudes and continents, but this plan aims to address invasions on tropical islands ecosystems. Even though Micronesia and Hawaii encompass a large area including multiple countries, current levels of trade and the number of points of entry are few relative to many other global regions. This suggests that understanding transfers of vessels and goods is more feasible here than it is for many other areas and should make developing appropriate and functional biosecurity mechanisms feasible. This underscores the value of Micronesia and Hawaii as a model. It is important to recognize that current capacity and resources limit present day biosecurity activities throughout the region and overcoming these deficiencies needs to be part of the implementation plan for the region. By implementing a cohesive regional plan and developing appropriate mechanisms to address IAS, Micronesia and Hawaii could become world leaders in advancing biosecurity, especially in tropical ecosystems. Coordinated biosecurity within the region could effectively become a global model.

Cooperation among nations in the western Pacific, whereby preventive measures are enacted to reduce the probability of exporting or importing invasive species, will benefit each nation by reducing the probability of such species becoming established (McNeely et al. 2001). A somewhat similar approach has been implemented for northern Australia and is known as the North Australian Quarantine Strategy (NAQS). NAQS has helped address many biosecurity concerns for northern Australia by coordinating efforts between northern ports of entry and Australia's northern neighbors including Indonesia, Papua New Guinea and Timor-Leste (Pheloung 2003). A proactive, precautionary approach is preferred for regional biosecurity development and this will require effective and coordinated efforts together with sufficient resources and networking (Henderson and Bomford 2011). Such cooperation is essential to the development of biosecurity for the western Pacific and it is encouraged between jurisdictions covered by the RBP as well as others.

Advancing a uniform and consistent approach to biosecurity throughout the region is desirable, as it would be the most likely way to reduce overall effort and costs associated with IAS control and management for the entire region and it would serve to increase clarity and possibly compliance. Thus, communication, coordination, and participation among all member countries and jurisdictions in the region are critical elements in regards to reaching the desired outcome of a better protected region.

The RBP, including both the risk assessments and implementation strategy, provides planning and in some cases execution level information. Each jurisdiction within the region will need to review the implementation guidance and in some cases may be required to further tailor the guidance to meet unique needs. Direct details such as timelines, particular costs, and specific personnel and equipment lists are in large part left out unless supplied specifically by the jurisdictions. Each jurisdiction will need to develop specific details for action items they determine are practical, warranted, and feasible to enact. The RBP does not set laws or regulations nor define the responsibilities or obligations of any jurisdictions, agencies, or offices. Again these elements are left for the appropriate authorities to determine. The RBP is a guidance document which is to be utilized to strengthen biosecurity.

3. Executive Summary

The Micronesia Chief Executives (MCEs) and their council on invasive species, known as the Regional Invasive Species Council or RISC, have been in the forefront of regional IAS work for almost a decade. The current effort to develop a regional biosecurity plan originated with the RISC and the MCEs as early as 2005. In 2007, DoD formally announced its intentions to prepare an Environmental Impact Statement (EIS) to address environmental impacts associated with the relocation of military forces from their current location in Okinawa to Guam, as well as the expansion of training in the Mariana Islands (Federal Register Volume 72 No 44, March 7, 2007). The announcement elicited concerns about the unintentional movement of invasive species associated with the relocation effort. In response to regional concerns, the U.S. Department of the Navy (DON) contracted the U.S. Geological Survey (USGS), the Smithsonian Environmental Research Center (SERC), and the U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) to produce three risk assessments, one each for freshwater systems (Volume II), marine systems (Volume III), and terrestrial systems (Volume IV). These risk assessments were to address invasive species whose introduction to, or spread within, the region might compromise human health and safety, animal and plant health, economic viability and/or biodiversity values in the region. These DON funded risk assessments were the first concrete steps in developing this regional biosecurity plan. While DON funded the development of the regional biosecurity plan, the plan itself is not restricted to DON or even only DoD related activities but rather encompasses (or attempts to encompass) biosecurity concerns throughout the region for all levels of society.

Guam is the main transport hub for the rest of Micronesia and Hawaii is a major hub for much of the Pacific Region, including Micronesia. Entry of any pest or disease into either hub could lead to a rapid movement of the same pests into the surrounding region. For this reason, biosecurity within these jurisdictions is of immense regional importance.

Some species' risks are well known but many are unknown and unpredictable. Therefore a comprehensive strategy needs to have both specificity to manage the known high-risk present threats (e.g. brown treesnake (BTS) (*Boiga irregularis*) and coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*)) and generality or precautionary processes for the unknown or infrequent threats.

The means by which the threats arrive or leave a jurisdiction or region can be classified according to their physical vector and/or pathway (ships, aircraft, or people), as diseases brought with incursions of risk species or of non-risk species allowed into each island, and/or in relation to some human derived process (legal, illegal, or accidental introduction). Ultimately how each jurisdiction will handle planning and developing their biosecurity capacity will in part depend on current and future anticipated vectors and pathways and it is essential that a well formed pathways analysis be part of any biosecurity planning efforts.

Mitigation or intervention to manage these high risk species can be done pre-border at a source, along the pathways and/or on the vectors, at the border, or post-border – with generally increasing costs and

potential adverse outcomes as the intervention point is delayed. Identifying the costs of intervention at different points along the risk chain, and also the resulting costs to environment, economy, and health if sub-optimal interventions are used, is essential to managing a biosecurity system and allocating responsibilities.

There is a common belief that intervention all along the risk chain is optimal (e.g. Russell et al. 2008). This is true across the whole biosecurity process, and probably true for high, medium and low risk species when funds are not constrained, but as funds are usually constrained it is not true for each invasive species or class of species generally speaking. Therefore, most biosecurity systems allocate resources to the most effective points in the risk chain. This point varies with the nature of the risk species, the predicted frequency of the event, the cost to detect it, the cost of dealing with an event at the most effective point in the chain, and the consequence and cost of failure to detect and manage the event at that point in the chain. This complexity makes biosecurity planning difficult by requiring a combination of precautionary and reactive management commensurate with the likelihoods of events, and the costs and feasibility of action, and costs of failure. Plans need to focus more on processes than on the specifics of risky species.

A question faced by all agencies developing biosecurity plans is whether to focus activities around particular species or around generic processes designed to cover all eventualities or perhaps more likely, how to determine the optimal mixture of the two. Clear and present hazards (e.g. BTS) tend to focus effort at the species level, but uncertain or rare events need to be managed by more systematic biosecurity approaches. The compromise approach is to ask, "What collateral reduction of risks might be covered by a focus on high-risk species?"

Each of the risk assessments, presented in volumes II, III, and IV, has addressed these considerations in various degrees of detail, especially for those with Guam as an endpoint. However, sources, pathways, and vectors have only been identified and linked to the assessments for some risks. The focus of the assessments on sources and endpoints (the freshwater component), pathways and endpoints (the terrestrial component), pathways alone (the marine component), or vectors (the phytosanitary and disease parts of the terrestrial component) appears to have been determined by the assumed best points of intervention along the risk chains.

Terrestrial, marine and freshwater risk species are all transported from a source (within or outside Micronesia) to an island (or its littoral zone) in Micronesia or Hawaii but, of course, the nature of this transportation differs with the risk species. Terrestrial species can be transported by anything that floats or flies, marine species can float but are transported mostly on ships via biofouling or in ballast or waste water, and freshwater species are mostly deliberately moved in 'fish tanks'. The terrestrial and marine components concentrate on inbound pathways for Guam and have less detail of intra-Micronesia risks. Future updates of the plan will need to refine and enhance the definitions of intra-Micronesia risks for the terrestrial and marine environments.

A focus on pathways is critical (since it is not possible to focus on each and every species), but along with a focus on pathways, it is equally important to also focus on a few key species, as appropriate management of these key species will also reduce the risk of invasion by other species.

The three risk assessments and the implementation strategy are a plan or framework and no matter how well developed and comprehensive they are, until there is effective action taken within the jurisdictions, by the jurisdictions, biosecurity will remain sub-standard for the region. Implementation of this plan by the jurisdictions is the anticipated next step in this process. This is the critical step and it is anticipated that implementation will be a multi-tiered effort, or efforts, undertaken by the leadership and agencies of the individual jurisdictions, in partnership with other jurisdictions as well as external partners. It should be recognized, however, that the RBP does not create any right, obligation, or legal responsibility on the part of any of the jurisdictions discussed herein to fund or execute the recommendations set forth in the plan.

The purpose of this regional biosecurity plan is to act as a tool with which to help enhance the coordination of current management efforts, identify remaining problem areas and gaps, and recommend additional actions that are needed to effectively address IAS issues within jurisdictions as well as regionally. The focus of this plan is the identification of feasible, cost-effective management practices to be implemented by appropriate authorities for the environmentally sound prevention and control of IAS in a coordinated fashion.

The goal of the plan is to provide recommendations that, if appropriately implemented, will minimize the harmful ecological, social, cultural, and economic impacts of IAS through the prevention and management of their introduction, expansion, and dispersal into, within, and from the region and the jurisdictions of the region. Objectives that need to be addressed in order to advance towards the goal include: securing funding, coordination and collaboration, prevention, monitoring, early detection and rapid response, management and eradication (where feasible), education and outreach, research, policy, and restoration.

4. Introduction

4-1. Background

Invasive species pose a constant and costly threat to Pacific islands' native ecosystems, ecosystem functions, biodiversity, watersheds, economies (including tourism, agriculture, aquaculture, importation, exportation, and transportation), public health, cultures, and the quality of life of residents and visitors.

Oceanic islands throughout the world are notoriously vulnerable to biological invasions. Islands experience long periods of evolution in isolation from those forces faced routinely by plants and animals on continents. This isolation also contributes to the vulnerability of islands to biological invasion (Loope and Mueller-Dombois 1989). The relatively small, restricted populations of native species on isolated islands and the intensity of human impacts on the small land areas of islands have clearly made the situation worse by increasing most islands' susceptibility to invasion.

The MCEs and their council on invasive species for years have advocated a regional approach to biosecurity in Micronesia. DON agreed to fund the development of this regional biosecurity plan in part to assist with minimizing the risk of introduction and spread of invasive species to and within the region in response to the proposed U.S. military relocation from Okinawa to Guam and the CNMI (hereafter referred to simply as "the build-up"). This regional plan has been termed the RBP. A critical component of the RBP is its proposed framework for regional biosecurity found within the RBP's implementation strategy (Section 11).

Biosecurity strategies or plans have been formulated for many countries, including island states such as New Zealand (Anon 2003) and the Bahamas

www.best.bs/Documents/Bahamas_Biosecurity_Strategy.pdf, July 2014). There have also been efforts to develop biosecurity strategies that involve multiple countries or regions of countries such as the NAQS. The RBP differs in its scope and ambition in several respects. First, the geographic area being considered is enormous (covering up to 5000 miles east-west and up to 1700 miles north-south), and it includes multiple countries, unique cultures, and diverse activities and institutional structures. Second, the approach adopted here includes all human-mediated mechanisms (vectors) of alien species introductions, attempting to evaluate their operational characteristics and the status of current management practices in the region. Third, the RBP attempts to address biosecurity in a holistic sense considering pre-border, border, and post-border elements for each jurisdiction. Although addressing these dimensions presents obvious challenges, it also represents an important opportunity and step forward in integrating information across vectors at a regional scale. This integration is vital to advance coordinated and effective action for invasion management across countries as well as the military, government, and public and private sectors.

An appropriate definition for biosecurity would be a strategic and integrated approach that encompasses policy and regulatory framework for analyzing and managing relevant risks to human, animal and plant life and health, and associated risks to the environment. Therefore, a regional

biosecurity plan may be considered a set of proposed actions that a group of end users with common goals implement to prevent the incursion and establishment of potential IAS into a region. A strategic implementation plan is a proactive management tool that should be used as a guide that illustrates critical steps in the capacity building process and addresses existing challenges and gaps.

While biosecurity can include post-border responses to new incursions and management of established invasive species, such as eradication, containment, and control, extra emphasis is usually placed on pre-border efforts that aim to prevent invasions from occurring in the first place. Prevention, or minimizing the probability and number of new invasions, is usually viewed as the most cost-effective and desirable strategy to pursue, because it can be extremely difficult to eradicate or control species once they have established (Wittenberg and Cock 2001). Even though prevention may be the best approach to minimizing impacts from potential IAS, other elements should not be neglected, such as early detection and rapid response for post-border situations. No border security can be 100% effective all of the time and, therefore, a good biosecurity plan will incorporate pre-border, border, and post-border elements to insure the best possible protection from potential IAS.

Efforts to prevent the transport or import of potentially harmful species are usually directed at specific vectors and aim to reduce the magnitude (concentration or abundance) and frequency of species transfers to a target area. Such measures may be aimed at entire communities (e.g., ballast water of ships, as discussed in the marine risk assessment) or particular species of concern, and vectors are an explicit focal point for evaluation and management action(s) in most cases. Thus, vector management is a central aspect of most efforts to prevent invasions, whether on land or in water.

4-2. Overview of Invasive Alien Species

In order for an organism to be considered an IAS, it must meet all of the following criteria:

- Non-native
- Able to establish in a new location (start an incipient population or at least seems likely to be able to do this based on life history traits and/or examples of establishment in similar locations)
- Cause harm (to environment and/or directly or indirectly to humans and/or their endeavors or at least seems likely that it would cause harm if permitted to establish based on life history traits and/or examples from other locations)

Non-native species refer to plants, animals, and micro-organisms transported or established outside of their natural range due to the activities of humans, regardless of whether these actions are intentional or not. Non-native species are sometimes referred to as non-indigenous, alien or exotic species. Not all non-native species will become invasive, and not all non-native species cause unacceptable harm. Some intentional introductions are considered beneficial (at least to humans), such as some crops (e.g. rice) and livestock (e.g. cattle and poultry). In fact, many of the species used for agricultural purposes within Micronesia are non-native plants. Introduced species form the basis of the more than \$800-billion food

system in the United States (Pimentel et al. 2000). Some species, either purposely or accidentally introduced, fail to become established or remain restricted in numbers or geographical range, and may be of negligible economic or ecological significance. As an example, many of the bird species currently established on the island of Guam (e.g. blue quail (*Coturnix chinensis*), black francolin (*Francolinus francolinus*)) were introduced during the 1800s and early 1900s as sources of food and while these non-native species have established, they do not currently appear to have extensive negative impacts, although it should be pointed out that their potential impacts to native systems of Guam have not been closely examined and their populations are most likely kept in check by the presence of the BTS. While not all species have the potential to become invasive if introduced to a new location, some do and when they do become established these species have the potential to cause serious harm. There are numerous examples of non-native species having become invasive and causing major disruptions in agriculture, other economic sectors, to people and the natural environment. Examples of such species are numerous and would include organisms such as miconia (*Miconia calvescens*), strawberry guava (*Psidium guajava*), and little fire ant (LFA) (*Wasmannia auropunctata*).

Invasive species are sometimes referred to simply as pest or nuisance species. These terms are misleading as both can also be applied to native species where they cause conflicts with human activities. Therefore it should be clear that not all pest or nuisance species are necessarily non-native and it is better to use the term invasive when discussing IAS.

While the specific biology of invasive species varies enormously, some or all of the following general characteristics apply to many invasive species (both terrestrial and aquatic) worldwide:

- Adaptable to, and capable of thriving in different habitats and a wide range of conditions;
- Have rapid growth rates of individuals, thereby able to displace other plants or animals;
- Are easily dispersible to new localities; and
- Have reproductive characteristics that allow for rapid population growth.

Invasive species often tend to relatively easily surmount geographical and environmental barriers, establish themselves quickly, and then expand their numbers and ranges, often rapidly, in the new habitat (Ehrlich 1986; Mack et al. 2000; Richardson et al. 2000), frequently displacing or extirpating populations of native species in the process (Vitousek et al. 1997). Most of the highly successful invaders have been those introduced into new regions, either inadvertently or deliberately, by human agency (e.g., Baker 1986; Mack et al. 2000; Ruiz et al. 2000; Mack and Lonsdale 2001; Naylor et al. 2001; Reichard and White 2001; Fuller 2003; Kraus 2003).

The establishment and spread of species introduced to regions where they are not native is commonly cited as second only to habitat loss as a cause of global biodiversity decline (Wilson 1992; Wilcove et al. 1998). There is evidence that invasive species are a leading cause of animal extinctions (Clavero and García-Berthou 2005). Reduced diversity and abundance of native species resulting from the widespread

establishment of non-native invasive species has also led to biotic homogenization, a human-mediated phenomenon whereby the species composition of different ecosystems become more similar (McKinney and Lockwood 1999; Lockwood and McKinney 2001; Rahel 2002; Olden and Poff 2004; Olden et al. 2004; Helfman 2007; Rooney et al. 2007). Some scientists have referred to the present as the “Homogocene” era to highlight the unprecedented global redistribution of species and associated alterations to ecosystems (Rosenzweig 2001; Didham et al. 2005). Invasion success depends on the characteristics of introduced organisms and the physical and biological makeup of the environment to which they are introduced. The mechanisms and results of invasions vary widely. Highly invasive species may exploit native species directly, such as through predation or hybridization, may be superior competitors, or may have ecological or economic effects of a more subtle nature.

Although the biological fragility of islands has been debated, evidence suggests that many introduced species are more likely to establish on islands than in mainland areas, and are more likely to have major ecological effects (Simberloff 1995). The vulnerability of islands to invasion has been attributed to a variety of factors. In general, biological communities on islands have evolved and diversified in relative isolation (with limited gene exchange) over many millennia. As a result, islands typically exhibit high species endemism, low numbers of top predators, and species and communities that are highly specialized. These characteristics, combined with other factors, make island floras and faunas especially vulnerable to impacts from the introduction of non-indigenous species (Vermeij 1991; Paulay 1994).

Islands in the Pacific Ocean are among the most biologically diverse in the world, yet also face some of the highest extinction rates and threats to endemic species (CI-MCBC 2007). On Pacific islands the estimated minimum numbers of native species for different biotic groups (percent endemic in parentheses) are: vascular plants 5,330 (57%); birds 242 (68%); reptiles 61 (49%); mammals (all bats) 15 (73%); and amphibians 3 (100%). Data for fish are not as well documented, but at least 100 species, many endemic, occur as adults in freshwater habitats of western and central Pacific islands. The invertebrate fauna is even less well known, but diversity is high; for example, land snails may number over 750 species in Hawaii alone, possibly with as many as 4,000 species throughout the insular tropical Pacific (CI-MCBC 2007).

Although habitat loss may be the primary threat to many insular ecosystems, introduced species on tropical islands of the Pacific play a major role due in part to the vulnerability of a native biota that evolved with less or no exposure to terrestrial predators, grazing herbivores, and pathogens that are typical of larger land masses. For some islands, IAS may currently be the single greatest threat to native wildlife. In Hawaii alone, the large number and diversity of introduced species has resulted in a myriad of impacts to the native flora and fauna. For example, the impacts on the native bird fauna of the Hawaiian Islands by invasive species such as the Indian mongoose (*Herpestes edwardsii*) and mosquitos (and associated pathogens) has been extensive.

There are also cases of widespread harm resulting from the introduction of one or only a few invasive species. One of the most infamous examples in the western Pacific is that of the BTS. The introduction of this snake to Guam has resulted in the extinction or dramatic decline of a variety of native birds, bats

and reptiles (Rodda et al. 1997; Fritts and Rodda 1998). In addition to the ecological threats posed to native species and ecosystems, the economic impact of invasive species can be enormous (NRC 2000; Pimentel et al. 2000; Finnoff et al. 2005; Lovell and Stone 2005; Pimentel et al. 2005; Shogren and Tschirhart 2005). Such impacts can be especially burdensome to island economies.

Biological invasions by non-native species have the potential to cause significant environmental, genetic, economic, social, and cultural impacts as well as effects on human health (Mack et al. 2000; Carlton 2001; Millennium Ecosystem Assessment 2005; Charles and Dukes 2007). Invasions and associated effects are known to occur across diverse global regions and habitats, representing a major force of change. It appears that no area is immune from invasions, which are occurring from the poles to the tropics in terrestrial, freshwater, and marine environments.

Range expansions occur when species establish self-sustaining populations beyond their historical range. While range expansions may result from natural dispersal, in recent times human-aided dispersal has resulted in introductions of harmful non-native species. This includes the unintentional transfer of organisms associated with trade and transportation, as well as intentional introductions for aquaculture and related activities. Human activities have substantively altered invasion dynamics in two major ways. First, the observed rate of new invasions has increased dramatically in recent time, driven primarily by human introductions (Ruiz et al. 2000; Ruiz and Carlton 2003). Second, the geographic scale of invasions has changed, because global commerce moves biota across historical dispersal barriers such as continents and ocean basins, creating connectivity among geographic regions that would not otherwise exist. In addition to the key role of transportation, invasion dynamics are also responding to climate change, which affects the probability of establishment as well as the possible consequences (Stachowicz et al. 2002; Harley et al. 2006; Hellmann et al. 2008). As Hulme (2012) suggests, climate change “may lead to an increase or decrease in susceptibility of ecosystems to invasion such that past patterns of establishment may not hold in the future.”

As a result of the rapid expansion in international travel and trade over recent decades, more people and goods are moving throughout the world than ever before. This increased traffic has been undeniably of great benefit, fostering greater contact and communication and raising living standards. However, the pace and extent of modern global travel also have engendered significant risks, one of the most serious of which is the increased chance of introduction of non-native species that may become invasive (Bright 1998; McNeely 2006).

In their impact on human society, invasive species impose economic, social, cultural and medical costs in a variety of ways. They feed on or infect valued plants (food and fiber crops, ornamentals, timber) or, in the case of weeds, compete with them for nutrients and sunlight, thus reducing yields or causing post-harvest losses; increase crop production costs through increases in mechanical and chemical controls; increase crop protection costs directly or by harboring other pests (arthropods, nematodes, plant pathogens); reduce the quality of farm products (e.g., through contamination of crop seed with weed seed, reduction in the area of useful forage for livestock in pastures and rangelands); damage fisheries and aquaculture; reduce the quality of livestock or game through infection, parasitization, or toxicity,

leading to death or failure to thrive, lowered quality of animal products (milk, fleece, or hides), or reproductive failure; increase processing costs incurred in cleaning contaminated products; interfere with water management in agriculture by infesting irrigation ditches and other waterways; increase utility costs; damage commercial and residential structures; increase costs to maintain rights-of-way for railroads, highways, and power and telephone transmission lines; endanger human health and decrease labor productivity through allergies and poisonings, and the transmission of pathogens; reduce revenues from recreational hunting and fishing, and from tourism; restrict access to foreign markets; and decrease land values (OTA 1993; Westbrooks 1998; Mullin et al. 2000; Huber et al. 2002; Monaco et al. 2002).

Biotic invasions have enormous economic consequences. Worldwide, the annual economic impact of invasive species (losses or damages combined with control costs) is estimated to exceed \$1 trillion, nearly 5% of the global economy (Pimentel et al. 2001). Costs to the U.S. economy alone total approximately \$137 billion annually (Pimentel et al. 2000).

Economic losses due to introduced plants surpass those caused by any other class of invasive species. For example, the annual economic impact of invasive weeds is estimated to be approximately \$39 billion in India, \$34 billion in the United States, \$17 billion in Brazil, \$1.4 billion in the United Kingdom (Pimentel et al. 2001), \$12 billion in South Africa (van Wilgen et al. 2001), \$3 billion in Australia (Sinden et al. 2004), and \$1 billion in New Zealand (Williams and Timmins 2002). Losses to the Canadian economy resulting from invasion by four weeds, Canada thistle (*Cirsium arvense* (L.) Scopoli (Asteraceae)), leafy spurge (*Euphorbia esula* L. (Euphorbiaceae)), diffuse knapweed (*Centaurea diffusa* Lam.), and spotted knapweed (*C. maculosa* Lam. (Asteraceae)), exceed \$250 million annually (Claudi 2002). Rockwell (2003) estimated that the total costs imposed solely by invasive aquatic weeds in the United States ranged from \$900 million to \$14 billion annually. In the United States, invasive plants currently infest an estimated 40 million hectares, and continue to spread into an additional 1.2 million hectares every year (NISC 2001). They have badly degraded more than 15 million hectares of grazing lands and natural ecosystems in Australia (Glanznig 2003). Noxious weeds have invaded an estimated 10 million hectares in South Africa (van Wilgen et al. 2001), where they are appropriating as many as 3.3 billion cubic meters (7%) of mean annual surface water runoff from catchments, riparian zones, and wetlands (Olckers 1999).

Invasive species, in their capacity to modify community structure and ecosystem processes, also impose a heavy toll on natural environments. They impact ecosystems by reducing biodiversity through predation, grazing, competition, or hybridization; simplifying food webs; initiating epizootics or epiphytotics; altering fire regimes and hydrological cycles; changing soil chemistry and biology through, for example, changes in pH and nutrient cycling, salt accumulation, nitrogen fixation, or altering the composition of the soil fauna and flora; affecting normal geomorphologic processes by promoting siltation or erosion; altering the activity of pollinators; and modifying evolutionary trajectories in native species (Mooney and Drake 1989; OTA 1993; Cronk and Fuller 1995; Woods 1997; Mack and D'Antonio 1998; Westbrooks 1998; Mooney and Cleland 2001; Huber et al. 2002; Levine et al. 2003; Zedler and Kercher 2004; Mooney 2005). So large has been the negative impact of some invasive species that they

have been described as “ecosystem engineers” (Crooks 2002). Biotic invasions have been implicated as major actors driving global environmental change (Vitousek et al. 1996; Sala et al. 2000), rivaling habitat loss as a contributor to species extinctions (Vitousek et al. 1997; Wilcove et al. 1998). In turn, the causes and consequences of global change (e.g., increased atmospheric pollution, shifting climatic zones, and habitat disruption) may provide new opportunities for invasions, increasing their frequency and severity (e.g., Huenneke 1997).

4-3. Pathways and Vectors Definitions

Pathways describe the processes or means by which a nonindigenous or alien species is introduced from one location to another (Hulme et al. 2008). According to Ruiz and Carlton (2003), a vector is how a species is transported—the physical means or agent. In this sense, an individual pathway may consist of multiple vectors, with each vector composed of: (1) a carrier (either in the form of a living organism, such as a plant or animal, or a nonliving inorganic or organic item, such as a shipping crate, soil, or volume of water, such as ballast), and; (2) one or more introduced organisms that are transported (or “vectored”) by the carrier. The two authors also identify other terms closely associated with pathways, including “routes” (the geographic path over which a species is transported), and “corridors” (the physical conduit over or through which the vector moves within the route, such as roads and railroad beds) (Ruiz and Carlton 2003).

Non-human mediated colonization of remote oceanic islands by life is a rare event. The modes of long-distance dispersal available to potential colonizers include: 1) direct dispersal, for which flying animals such as birds, bats, and large insects are best equipped for reaching isolated areas under their own power, and are usually well represented in island biotas; 2) windborne dispersal, via which tiny seeds and invertebrates are carried passively on air currents; 3) waterborne dispersal, a mechanism responsible for transporting propagules, such as large seeds capable of floating in seawater for extended periods, or small animals, as well as seeds rafting on trees or mats of vegetation washed into the ocean; and 4) dispersal by birds, who may serve as inadvertent carriers of plant and animal “hitchhikers” adhering to feathers or feet, or, in the case of some seeds, passing through the digestive system to be deposited with feces in a suitable site for germination (Juvik 1998).

5. Limitations to the Scope of the Regional Biosecurity Plan

Though this plan is meant to be comprehensive, there are limitations to its scope that were realized at various stages in its development. Significant aspects that are not fully addressed in the RBP include biosecurity considerations and IAS within the following groups: micro-organisms, terrestrial plants, algae, and arthropods. Micro-organisms (bacteria, viruses, diseases, protists) are certainly part of the invasive species problem, and though they are alluded to in various parts of this plan, the scope of the issues potentially associated with micro-organisms was deemed overly extensive to readily facilitate detailed inclusion within this document. Each of the existing risk assessments does cover some aspects

of the taxon groups mentioned above, but this information should not be considered comprehensive. To properly address each of these taxon groups, an extensive amount of additional work will need to be completed. While the amount of effort needed to complete risk assessments for the region in all taxon groups is extensive, it is hoped that as part of the efforts, which evolve from the recommendations of this plan, work can begin to address these current short comings. All of these taxon groups are known to contribute to biosecurity concerns; in fact, terrestrial plants and arthropods are probably the two IAS taxon groups that currently receive the highest level of funding and management both globally as well as within the region. The lack of detailed coverage of these taxon groups within the RBP was necessitated in part in order to be realistic in where efforts could be initially focused, and in no way is meant to indicate that these groups are not just as important in terms of their threats. Some of the major recommendations coming from this document will be for the region to complete risk assessments and recommendations for each of these groups in order to insure that biosecurity concerns receive full coverage for the region as soon as feasible.

6. Overview of the region

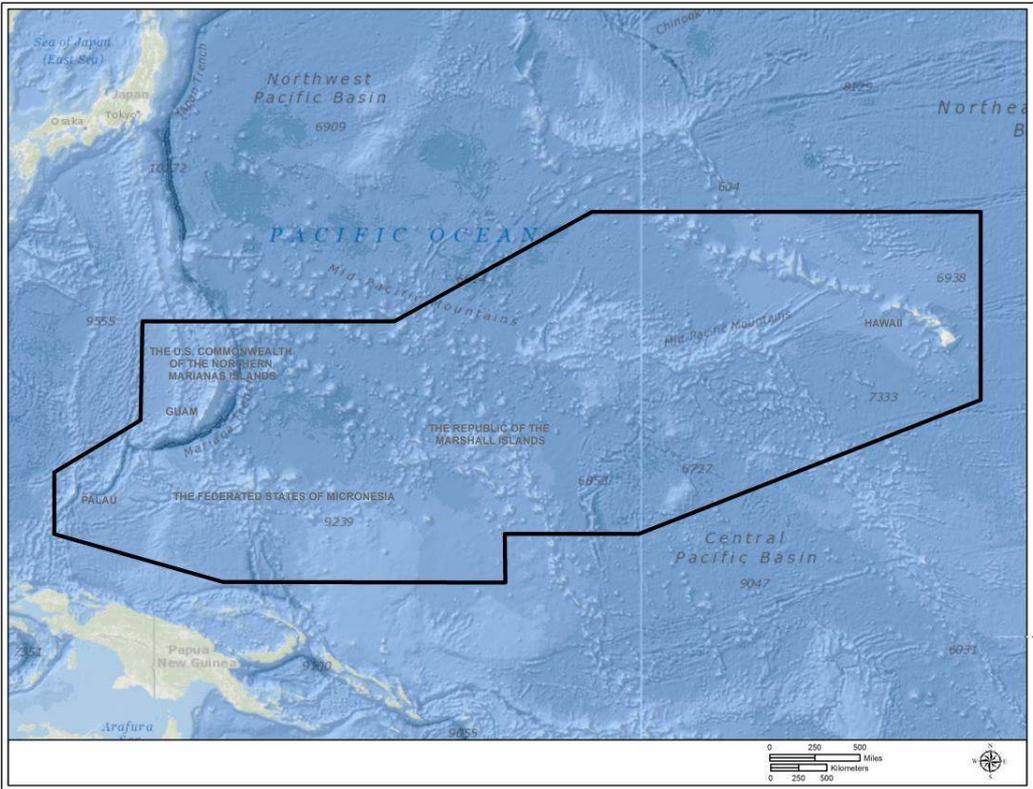
The region of focus for this biosecurity plan includes most of the islands of the global region known as Micronesia and the archipelago of Hawaii (Figure 1). Overviews of the individual jurisdictions can be found in Attachment A of this document. The islands of this region are all located in the tropical or sub-tropical north Pacific.

Micronesia is a sub region of Oceania that is comprised of four main island groups or archipelagos (three of which are covered by this plan: Marianas, Carolines, and Marshalls) as well as numerous outer islands. Overall, Micronesia encompasses thousands of individual islands and is approximately 7,400,000 square kilometers (2,900,000 square mi) in size, with both high islands and atolls. The region has a tropical maritime climate with little annual variation in temperature and a slightly more variable rainfall within parts of the region. Most islands experience wet and dry seasonality, although the dry season may not be very pronounced depending on location.

Guam and the Hawaiian island of Oahu serve as the two main hubs of human activity and shipping for the region, with most goods transshipped through Oahu to Guam with some goods then going from Guam to other islands within the region. Various countries within Southeast Asia are also important trade partners with both the Micronesian jurisdictions and Hawaii.

The Mariana islands are situated about 1,700 km (1,060 mi) south of Japan, 2,100 km (1,300 mi) east of the Philippines, and 1,800 km (1,100 mi) north of New Guinea. There are 15 islands, all of volcanic origin. The archipelago runs more or less north-south. The Mariana archipelago is composed of two jurisdictions, the CNMI and Guam. The CNMI is composed of the 14 northern islands. Guam consists of the single southernmost island.

Figure 1: Republic of the Marshall Islands, Republic of Palau, Federated States of Micronesia, Territory of Guam, Commonwealth of the Northern Mariana Islands, and the State of Hawaii



The Caroline Islands are a widely scattered archipelago north of New Guinea, east of the Philippines, and south of the Mariana archipelago. This archipelago runs more or less east-west. Politically the islands of the archipelago are divided between the Federated States of Micronesia and the Republic of Palau. Palau encompasses the westernmost section of the archipelago and the FSM the central and eastern sections. The archipelago is composed of approximately 500 islands, which include several large high islands and many low atolls.

The Marshall Islands are divided into two island chains, Ratak and Ralik. There are a total of 29 atolls and five isolated islands. The Marshall Islands lie to the east of the Caroline Islands and north of the equator.

7. Pertinent Regulatory Drivers

The regulatory drivers for the region provide requirements and justification for planning, compliance, and development in regards to biosecurity. Regulatory guidance is essential for developing appropriate biosecurity standards for the region. All jurisdictions have existing regulations that support some level of biosecurity. In large part the existing regulations are based on the U.S. system. The U.S. has a quarantine system, which continues to evolve, but which was mainly established to address agricultural concerns on the U.S. mainland. To a large extent these regulations do not adequately address freshwater and marine concerns, nor do they always take the best approach for relatively small tropical islands or island groups. While some regulatory improvements have occurred in most jurisdictions within the past 10 to 20 years, all of the jurisdictions still have gaps in their existing regulations that should be addressed. An overview of the existing regulations for each jurisdiction can be found in Attachment B of this document.

8. Overview of the Proposed U.S. Department of Defense Build-up

The U.S. military has various resources in the Micronesia-Hawaii region and utilizes these and others areas within the region for training purposes. The current DoD facilities and training locations within the region include: Guam Bases (Andersen Air Force Base- AAFB, Naval Base Guam, and the various naval annexes and properties), Tinian training facilities, Palau Civic Action Teams (CAT) Camp Katuu, U.S. Army Kwajalein Atoll (USAKA), Wake Island, and Hawaii based facilities.

The concept of the RBP, or more precisely, the interest in regional biosecurity, existed well before planning for the military build-up in the Marianas was announced, but the actual development of such a framework went unfunded and the concept therefore remained only a concept. Funding to develop the RBP was initiated to assist with planning and environmental impact analysis related to the potential for IAS introduction in the region due in part to the military build-up. Linkages between Micronesia and the State of Hawaii were also added to the overall coverage of the RBP only once the military build-up had been proposed.

The proposed military build-up on Guam has been reduced in size from its original scope. The draft risk assessments relied upon the definition of the build-up as depicted within the 2010 FEIS for the Guam and CNMI Military Relocation (DON 2010). Some of the figures and statistics used in the risk assessments, specifically in regards to the amount of military traffic entering and leaving via military ports may reflect the original larger build-up concept and not reflect build-up planning as of 2014. Similarly, the military build-up statistics considered in the risk assessments date from 2006 and do not reflect current DoD planning.

As of 2014, the number of personnel to be relocated to the region has been reduced from the originally planned 8,600 Marines and 9,000 family members, to a force of approximately 5,000 Marines and 1,300 family members on Guam. Approximately two-thirds of the Marines relocated to Guam will be rotational with the remaining one-third permanent. In addition, the timeline to complete the build-up was extended from 5 to 12 years. As a result of the reduced and more gradual scope of the build-up, peak and steady-state population numbers on Guam will be much less than previously anticipated (see Figure 2.2-1 in Chapter 2 of the Draft Supplemental Environmental Impact Statement (Joint Guam Program Office 2014): <http://guammarines.s3.amazonaws.com/static/draftSEIS/Chapter2.pdf>). Associated with this, the number of off-island workers and amount of commercial port throughput will be substantially less than under the 2010 ROD. More information regarding the proposed military build-up can be found at <http://www.guambuildupeis.us/>.

9. Risk Assessments

9-1. Overview of the risk assessment process

Risk analysis is commonly used for management of IAS because pragmatic decisions can be made that provide a balance between competing environmental and socio-economic interests, despite limited availability of information (e.g., Hayes and Hewitt 1998; Hewitt et al. 2006; Barry et al. 2008; Campbell and Hewitt 2008, 2011).

In a biosecurity context, conventional risk assessment methodology consists of five steps:

1. Identifying endpoints (within biosecurity common endpoints are a breach in quarantine or a subsequent impact)
2. Identifying hazards
3. Determining likelihood
4. Determining consequences; and
5. Calculating risk

This process is similar (following the five step process) to the risk management standard used in Australia and New Zealand and the risk framework agreed on by the U.S. Aquatic Nuisance Species Task Force and U.S. National Invasive Species Council (2007). Biosecurity risk endpoints are typically (a) inoculation (breaking the quarantine barrier), (b) establishment, and (c) spread. Additionally, some would also consider mitigating impacts as an endpoint.

The terms of reference for the development of the RBP risk assessments were set by DoD and are as follows:

The deliverables will cover/discuss three periods; 1) current steady state, 2) during the military build-up, and 3) post military build-up steady state.

1. List of priority species and potential pathways that are not established in the Micronesian region and Hawaii that could pose a high risk to the local economies, environments, and human health.

2. Map of ports of origin for the Micronesian region:

- Rank high/medium/low risk for each port based on priority species previously identified.
- Rank high/medium/low risk for each pathway based on priority species previously identified.

3. Rank high/medium/low risk for the top import and export commodities for each island group based on priority species previously identified.

4. List of priority species established in the region that require pre-departure mitigation measures to reduce the risk of their movement within and outside the Micronesian region:

- Prioritized list of pathways associated with the previously identified locally established species that will be targeted for pre-departure quarantine measures.

5. Ranked list of highest risk regional and trade partner ports based on lists of both locally established priority species and species not yet established within the Micronesian Region:

- Prioritized list of pre-departure mitigation measures for immediate implementation.
- Development of regional monitoring strategy.

9-2. Caveats to the Risk Assessments

1. A major weakness of the risk assessments is that all threat analyses (or attempts at analyses) are measured by intercept data or basically the frequency that organisms are detected at the border. This approach fails to measure slippage (failure to detect an organism during an inspection), and varies in respect of the speed with which actual entry and establishment of new organisms are detected. For example, a dozen or so very serious pests of agriculture and the environment have successfully become established in Hawaii in the past 10 years alone. They include the LFA, varroa mite (*Varroa destructor*), coffee berry borer (*Hypothenemus hampei*), small hive beetle (*Aethina tumida*), coqui frog (*Eleutherodactylus coqui*), ohia rust (*Puccinia psidii*), and several others. These organisms have rarely if ever been recorded in any intercept data prior to their detection as established pests. Another concern with this approach is that not all detections/intercepts are identified.
2. The RBP risk assessments fail to adequately consider the movement of established pests already in the region within jurisdictions and to surrounding jurisdictions. This flaw appears to arise from a notion that once a pest is established it is no longer important to target it for detection

on goods leaving one jurisdiction for another. This assumption of course is not appropriate. The Pacific Region is a complex network of independent nations, nation-states, islands, and island-states. Often the political boundaries do not reflect cultural boundaries and these may overlap considerably. This factor complicates biosecurity activities and needs to be recognized.

3. The RBP marine risk assessment authors did not utilize the term invasive species in their document but rather relied on the term non-native to denote invasive species or potentially invasive species. This is regrettable as not all non-natives should be considered invasive species e.g. many food crops are non-native. The reader should be aware of this anomaly when reading elements of the RBP marine risk assessment.
4. USAKA and the Palau CAT Camp Katuu were not covered in the RBP risk assessments. Wake Island Airfield was mentioned on several occasions in the terrestrial risk assessment but information pertaining to Wake Island was not extensive. Additional information regarding these three facilities and their current biosecurity measures could not be obtained for usage during the strategic implementation development phase, thus these specific locations are not adequately covered by this plan.
5. The RBP terrestrial risk assessment extensively covers Guam, the BTS, and the possible role of USDA-APHIS for U.S. jurisdictions. While much of the information provided is of value, by focusing on these key elements the document minimizes the regional aspect of this effort, other critical IAS or potential IAS, and the roles of other agencies and offices especially in regards to non-U.S. jurisdictions where presumably USDA-APHIS as a U.S. agency cannot provide the same support which they suggest for Guam. While the RBP terrestrial risk assessment addresses BTS issues, it seems to inadequately address the need for surveillance, detection, and rapid response to other potentially invasive species, including ants, aphids, wood-borers, spiders, and microbiological pathogens to name just a few. Invaders from these (and other) taxon groups have enormous capacity to do harm, and little is being done currently to address the imminent threat and their coverage in the RBP terrestrial risk assessment is regrettably insufficient.
6. The RBP terrestrial risk assessment does not adequately cover the concept of stowaway or hitchhiker organisms. Stowaways are a very big concern and should be addressed equally with other invasive species pathways. It was anticipated that the RBP risk assessments would provide information on what each jurisdiction had in terms of established invasive species that others in the region did not. It was also anticipated that there would be some information on potential invasive species found in areas outside of the region (such as southeast Asia) that are linked to the region through shipping and other transportation routes. This information is essential for each jurisdiction in developing adequate and appropriate biosecurity measures. Much of this basic information was regrettably not identified within the RBP risk assessments and, therefore, should be developed in the near future to support and fine tune regional biosecurity efforts.

7. In 2012 the National Oceanic and Atmospheric Administration (NOAA) nominated 66 species of coral for listing under the Endangered Species Act. The proposed action of listing these species as endangered in the U.S. occurred after the RBP risk assessments were drafted and therefore is not covered by the risk assessments. Some coral species are potentially biofoulers. It is unclear if there is evidence of biofouling by any of the 66 nominated species, but presumably the possibility exists. It is unclear what if any impact the potential listing of these marine organisms could have in regards to biosecurity. Would a biofouled vessel arriving at a U.S. port need to be sampled to determine the species composition of the attached biofouling community? Or would it simply fall under recommended regulations which support zero biofouling and immediate remedial action could be taken, potentially including hull cleaning, if biofouling is detected. If sampling of the community would be required prior to treatment, determinations on how and where this would be accomplished are needed. Additionally, if an endangered species or even proposed species were detected, how would treatment of the hull proceed? Regular sampling of biofouling communities to determine species composition is currently not a feasible action within the region covered by this plan. Do any of these 66 nominated species have ranges that overlap with the region? If not, then presumably if they did arrive they could be treated as non-native organism and potentially an invasive species and, therefore, would most likely not be afforded ESA protection. But if the native range of one or more of these species does or is thought might overlap with any portion of the region, then again this situation should be further explored.
8. The original authors of the three sets of risk assessments also proposed recommendations regarding how to improve biosecurity within the region. Many of the recommendations listed within the risk assessments refer directly to Guam but could equally be applied to the other jurisdictions covered by the RBP. Most of the recommendations within the risk assessments are also covered in the implementation strategy recommendation tables, a single section within the implementation strategy that lists all recommendations so that the end user can readily locate them.
9. The assessment of invasive terrestrial plants is limited in scope while invasive plants are a major concern for the region. It would be helpful to have this work completed for the region. Minimally the region should work towards establishing a weeds risk assessment.
10. Arthropods are generally poorly covered in the risk assessments; even though arthropods are one of the largest groups of organisms known to have potential as IAS. This gap should be addressed.
11. The emergency response plans, actions, and capacities listed throughout the terrestrial risk assessment are very USDA-specific. It is doubtful USDA could or should be the lead entity responding in all cases. Additionally, many Micronesian nations may not have capacity or desire to be led under the auspices of USDA. This section of the plan is overly "mono-agency" specific and does not adequately address leadership and capacity beyond USDA programs.

12. No risk assessment was completed for marine algae. This should be addressed for the region.
13. Risk assessments placed disproportionate focus on Guam. For example, air transport is only considered in detail for aircraft arrivals to Guam. The remainder of the region is poorly addressed and follow up work should be conducted including keeping updated details on changes to plane arrivals and locations with direct linkages to the region.
14. Micro-organisms are not adequately covered in the risk assessments. This should be addressed for the region.

To fully explore the risk assessments, refer to Volume II (Executive Summary to the Risk Assessments and the Freshwater Systems Risk Assessment); Volume III (Marine Systems Risk Assessment); and Volume IV (Terrestrial Systems Risk Assessment)

10. Example Species of Concern

Lists of IAS of concern are interesting but can be counterproductive if they are perceived as complete – which in the RBP risk assessments they are not. Within the region it is recognized that one island’s natives or established species might be another island’s invasive species. All islands within the region have at least some species (exotic and native) not found on any other particular island or at least not all islands, and are therefore a proximal source for those species if a pathway or vector exists to move them. Species present on all islands are not necessarily a priority biosecurity issue, unless they pose a disease or health risk that is not present on all islands or if overall impacts from these species are extensively high.

The most devastating invasive ant species to establish to date in both Hawaii and Guam is the LFA. This species is established on the Big Island of Hawaii and several smaller populations are known to exist elsewhere within the state. Surveys for this species have not been completed on Guam but it seems likely that it is wide spread and well established. The LFA if unchecked has the potential to cause significant impacts native ecosystems as well as agricultural production.

The CRB is established in Palau and Guam. Eradication efforts on Guam have not been successful. In December 2013, this same species was detected at on Oahu with numerous individuals being found, including multiple life stages (suggesting it has been there for some time).

The BTS has been established on Guam since at least the early 1950s. To date, no other populations of this species have been confirmed outside of its native range. However, the snake continues to be a major pest on Guam and it threatens the rest of the region.

Dengue virus, zika virus, chikungunya virus, and melioidosis (caused by a bacterium) have all been reported for Yap State in the last few years. These organisms are all non-native to the region and cause or may cause serious human health issues. Some of these organisms are found elsewhere within the region.

Kosrae has been battling a white fly (*Aleurocanthus spiniferus*) outbreak for more than a year now. The larvae of these flies are feeding on the food crops and forestry biomass of the state. In 2013 Kosrae also learned that coconut termites (*Neotermes rainbowi*) have established. These termites have infested coconut trees, which in turn will likely need to be destroyed if there is any hope of containing this pest species.

Attempts to list species of concern have met with limited success, the reason being that there are so many known species of concern. Perhaps, even more important is the understanding that what we don't know is likely or should likely be an even bigger concern. The potential for harmful species to arrive within the region from outside grows every year. Asia is probably the biggest growing influence on the region and regional knowledge of established species within Asian countries that pose a serious risk to Micronesia and/or Hawaii is limited. Some jurisdictions provided a list of species that they currently consider top level concerns and these can be found in the jurisdictional overviews. Trying to determine which IAS pose the biggest threat to a given location given incomplete knowledge is an interesting exercise. When such lists of worst IAS are produced, they should be treated as working lists and not conclusive.

11. Implementation Strategy

11-1. Challenges

For the region, biosecurity risks are high for both marine and terrestrial habitats and are less well defined, but still significant, for freshwater. Many vectors moving within or entering the region transit through the marine environment. Almost all vectors eventually end up on terrestrial habitats or unloaded into terrestrial habitats. Freshwater habitats are generally well protected from IAS due mainly to their limited existence within the region. On the other hand, the limited existence of freshwater habitats also makes them extremely vulnerable, and easily impacted by IAS if and when incursions into these systems do occur. While the likelihood of additional freshwater introductions are relatively low when compared to marine and terrestrial systems, any IAS introductions that do occur within the freshwater systems of the region are likely to have broader impacts on these systems than additional marine or terrestrial introductions would have. In reality, the impacts potentially caused by IAS incursions are in large part dependent on the organism(s) themselves and how these organisms react with the systems they are invading. It is difficult to predetermine exactly what impacts any introduced organism will have, but risk analysis can provide some insight. All systems are at risk and any introduced non-native organisms have the potential to become established, create viable populations, and cause impacts, therefore fitting the definition of an invasive species.

It has been clearly established both globally and within each jurisdiction of the region that some non-native organisms, if permitted to establish, will cause harm. Numerous harmful organisms are already known to be established within parts of the region. Specific examples of non-native organisms that are established within the region, that are causing harm, and that are likely to cause further serious impacts if their current distributions are permitted to expand include some of the same organisms that have

been exemplified time and again throughout the RBP such as the BTS, CRB, and LFA. These are stand out organisms due to the impacts they have already caused, but there are many non-native organisms already established within the region that are less well known and surely others not yet within the region that are relatively unknown but could cause serious damage if they were to become established. Appropriate biosecurity systems once in place can reduce the risk posed by established high risk threats within the region as well as relatively unknown threats from elsewhere.

Within the non-U.S. jurisdictions of the region, inspections are typically carried out by local agricultural quarantine officers. Inspections of cargo are made following reviews of bills of lading and of baggage, based on customs declarations or when there is reason to suspect smuggling (usually based on the inspector's judgment). All inspections are visual, as X-ray machines and other methods (such as trained dogs) are currently not available. As with Guam and CNMI, there is little to no capacity to do random inspections or to carry out investigations beyond entry points.

There are large gaps in the current biosecurity systems in place within the region. In some jurisdictions, these gaps go right to the core of the biosecurity system. One such gap is the almost complete lack of marine system biosecurity regulations and capacity, resulting in a minimal likelihood of intercepting marine risk organisms at ports of entry. This lack of marine system oversight is perhaps one of the most serious gaps identified since the region is composed of relatively small islands separated by large tracts of marine environment. Most materials and commodities arriving in the region arrive via ocean-going vectors. Resolving the current lack of attention to marine system biosecurity across the region should be a high priority for the region and each of the individual jurisdictions. Other gaps are further addressed below.

Another clear example of a major biosecurity gap for some jurisdictions is the lack of biosecurity legislation formulated specifically to address IAS. Where such legislation does exist, it is generally not comprehensive. The inability to collect sufficient revenue and to utilize this revenue to support biosecurity regulations needs to be addressed and in fact should be a high priority for all jurisdictions. Laws are needed to support regulations, regulations need to be improved across the board, and revenue streams to support biosecurity efforts need to be better developed.

Other major gaps that need to be addressed for most if not all jurisdictions include: improved outreach and education improvements enabling citizens and visitors to actively participate in supporting biosecurity efforts; enhanced regulations based on established biosecurity legislation (several of the jurisdictions currently have pending bills); better development, implementation, and enforcement of border quarantine/biosecurity elements; increased pre-border sanitation; and moving beyond the conceptual stages of post-border early detection and response capacity to having solidly developed response capacity including established funding mechanisms that permit truly rapid response to new incursions by appropriately trained responders directed by an incident commander.

11-2. Needs

All jurisdictions within the region have basic infrastructure and staffing needs that should be met in order to address current levels of vector arrivals, on the ground management of established IAS, response to new incursions, and restorative efforts once appropriate management levels (or eradications) have been achieved. Future increases in both vector arrivals and additional IAS becoming established will require more resources than currently exist within the region. With or without the proposed military build-up, the numbers of pathways and vectors both within the region and arriving to the region is likely to continue to increase. Various invasive species are already well established in each and every jurisdiction of the region. Without improved biosecurity, additional invasive species will likely become established and established species will likely expand their current distributions.

11-3. Recommendations

The core of the implementation strategy is the biosecurity recommendations. The recommendations are organized into tables by jurisdiction. The jurisdictional recommendation tables can be found in the following attachments:

- Chuuk State Biosecurity Recommendations, See Attachment C
- Kosrae State Biosecurity Recommendations, See Attachment D
- Pohnpei State Biosecurity Recommendations, See Attachment E
- Yap State Biosecurity Recommendations, See Attachment F
- Federated States of Micronesia National Biosecurity Recommendations, See Attachment G
- Republic of the Marshall Islands Biosecurity Recommendations, See Attachment H
- Republic of Palau Biosecurity Recommendations, See Attachment I
- Commonwealth of the Northern Mariana Islands Biosecurity Recommendations, See Attachment J
- State of Hawaii Biosecurity Recommendations, See Attachment K
- Territory of Guam Biosecurity Recommendations, See Attachment L
- United States Department of Defense Biosecurity Recommendations, See Attachment M
- United States Regional Biosecurity Recommendations, See Attachment N

Recommendations for each jurisdiction include a variety of action items, each with its own time line, lead, resources, and prioritization. Many of the recommendations fall into what could be termed topical areas, which vary from jurisdiction to jurisdiction depending on needs, although many of the same

topical areas or recommendations occur in more than one jurisdiction. Recommendations that are common to all jurisdictions include improvements to pre-border, border, and post-border biosecurity as well as improving the coordinating of outreach efforts.

Recommendations for each jurisdiction have been categorized as one of the following: support, coordination and collaboration, prevention, early detection and rapid response, management and eradication, awareness, research, policy, and restoration. Some recommendations could easily fit into more than one of these categories and where this is the case, an attempt has been made to place the recommendation under the most fitting category with the understanding that categories should not be viewed as exclusive. Not all categories have been used for every jurisdiction.

Action items in the recommendation tables have been ranked into one of three priority levels: high, medium, and low. All listed action items are potentially important, irrespective of prioritization. While the priority ranking should be considered when determining what action items to address and in what order, other considerations should also be taken into account, including what action items, regardless of priority ranking, are readily achievable; or for which items dedicated funding or other resources may be available, or potential could be established relatively quickly.

During the development of the jurisdictional recommendations common themes were identified:

- 1) Current biosecurity measures throughout the region have gaps at all levels including pre-border, border and post-border.
- 2) Pre-border sanitation policies are minimal at best and lacking in many cases.
- 3) Current biosecurity efforts are inadequate largely because of a lack of funding resulting in inadequate staff numbers, inadequate or lacking equipment, and insufficient training (See Attachment P for basic training considerations). There are exceptions; for example, current biosecurity efforts by DoD or funded by DoD within the region are perhaps the most up to date in terms of capacity.
- 4) Other biosecurity gaps include: lack of regulatory support, lack of linkages between trade policy and biosecurity elements, insufficient communication at all levels within jurisdictions and between jurisdictions in regards to biosecurity, and in some cases the inability of offices and agencies at different levels of government to fully support each other due to restrictive policies and operational standards.
- 5) Education and awareness efforts in regards to IAS, while existing throughout the region, have been insufficient in most cases and often focused only on specific species and/or activities. More comprehensive planning and follow through with IAS awareness in regards to educating, changing behavior, and engaging the public are absolutely essential for improving both jurisdictional and regional biosecurity. Again, there are exceptions and various well thought out and functional awareness components do exist, such as the Joint Region Marianas education program for construction workers and military workforce. Hawaii also has a variety of well thought out awareness efforts. Overall coordination of various educational efforts and tools could still be improved, especially at the jurisdictional and regional levels.

6) Early detection and rapid response capacity development has been insufficient, resulting in the lack of capacity or in a few cases the existence of a minimal capacity, which is often focused on specific organisms and not well developed as a true response capacity to IAS in general. This is true at both the jurisdictional and regional levels.

7) The military build-up is going to place an increased strain on some these already inadequate biosecurity measures.

8) Commerce, trade, and visitation are all likely to continue to increase throughout the region (regardless of the military build-up), again resulting in increased strain on existing biosecurity measures.

None of the Micronesia jurisdictions have the capacity to carry out thorough inspections of luggage or cargo in terms of trained personnel and equipment. Many lack equipment such as X-ray machines and computers that could make biosecurity enforcement more efficient and effective. None of the jurisdictions has adequate capacity to carry out investigations or effective enforcement beyond ports of entry. In some cases, this is due to discrepancies between import regulations and other laws, as in the case of Guam, where it is not illegal to possess certain species that are prohibited for import. U.S. domestic mail is not routinely inspected, providing a potentially important (but poorly documented) pathway for trade in non-native species between the continental U.S. and Hawaii, Guam, and CNMI.

Even for declared or permitted live imports, species-level identification; labels and any certification (of disease-free status or absence of associated organisms) are often missing or inadequate, making assessment and pre-screening difficult at best. Little to no screening of outgoing cargo occurs in the region (with the exception of the USDA BTS program on Guam). Anecdotal information, as well as established records from various agencies, indicates that smuggling of live species is occurring throughout the region, including terrestrial, estuarine, and marine organisms. There is currently little capacity to address this situation.

There is clearly a need for additional capacity at most if not all ports in the region in regards to quarantine/biosecurity staff, equipment, and facilities. While numbers of potential organisms and sources that threaten each jurisdiction can never be completely known, it is certain that the amount of goods and personnel moving into and within the region will continue to increase. It appears that the short term anticipated increases will strain the available capacity to inspect and control the flow of these organisms, especially given the current limitations.

There is a regional early detection and rapid response program specifically for BTS incursions, which could be extended to support detection and removal throughout the region of alien reptiles and amphibians and might serve as a model on which to fabricate a truly regional response capacity for IAS. The program is headed by the USGS and since 2002 has provided the region with response training, networking, and limited outreach capacity in regards to alien snakes and on a more limited basis IAS in general (Stanford and Rodda 2007). The program is based around incident command structure principles and utilizes key skilled individuals to lead response actions with a mix of both trained and untrained personnel (Stanford and Rodda 2007). Ultimately, each jurisdiction would need to develop its own early

detection and rapid response capabilities, but a regional office, at least in part based on this existing model, could assist with supporting/supplementing local response capacity as requested.

By and large, the jurisdictional recommendations have been vetted by local stakeholders via extensive consultations conducted both onsite and remotely. A list of jurisdictional consultancy trips is provided in Attachment Q. Draft recommendation tables for each jurisdiction were provided to stakeholders in each jurisdiction during January 2014. In most locations stakeholders held round table workshops to facilitate stakeholder review and comment on the draft recommendations, with these comments being returned to UOG and SPC to support improvement of the draft recommendations. In early May 2014, the draft implementation strategy (including the updated recommendation tables) was provided to registered attendees of a regional workshop scheduled to be held later in the same month. The regional workshop was held on Guam from 18-21 May of 2014 and was facilitated by SPC and UOG with the purpose of reviewing these recommendations. During this workshop the jurisdictions came together to review and comment on the biosecurity implementation strategy. Representatives from all jurisdictions as well as key stakeholder organizations and offices participated in the workshop. A list of workshop participants is provided in Attachment R.

Regional implementation of the biosecurity recommendations will be challenging as the recommendations are extensive and full implementation will require significant increases in funding and other resources to be made available for biosecurity activities. In this regard, it is important to note that the RBP does not create any right, obligation or legal responsibility on the part of any of the jurisdictions discussed herein to fund or execute the recommendations set forth in the plan. In addition, for many of the recommendations to be appropriately developed and implemented, supporting legislation will need to be developed and enacted. What is more, many of the recommendations are linked and can, therefore, best be addressed by first prioritizing recommendations for each jurisdiction and then building on initial successes to achieve additional improvements ultimately resulting in a holistic approach to biosecurity both within jurisdictions but also across the region. Prioritization needs to be carried out at the jurisdictional level by internal stakeholders. Prioritization suggestions are offered for many of the recommendations (where specifics were not previously provided by the jurisdictions). These suggestions as well as suggestions on lead offices, time lines, and resources should be fully reviewed internally and adjustments made as needed.

11-4. Strategies

Finalization of the implementation strategy does not imply a commitment to implement any or all of the recommendations within the plan, but rather it represents that all jurisdictions accept the plan as written and understand it is a tool to be used by each jurisdiction as they move forward with improvement to their respective biosecurity measures. Jurisdictions, if they so choose, may decide to officially endorse the plan and/or their recommendations. It is important to remember that the RBP should remain a living document and that jurisdictions can and should update their elements as needed, checking off completed actions, providing more specific information as possible, and developing recommendations to address new circumstances as they arise.

In regards to the implementation strategy, the overarching goal for the region and each individual jurisdiction is the same, improvement of biosecurity mechanisms leading to better protection from IAS. How this goal is to be achieved within the context of the jurisdictions varies specifically but in large part the needs are similar across the various jurisdictions.

The recommendation tables document specific recommendations for the region and for each jurisdiction. These recommendations and their associated action items are important and extensive. Perhaps a practical way to begin with enhancing regional biosecurity is to outline what could be considered the highest priority recommendations. Given the size and complexity of the region, developing a consensus on what should be the top priorities may be difficult, but it is essential to focus resources and capacity, as spreading efforts over many elements will reduce overall effectiveness. A list of critical elements that need to be addressed in much if not all of the region follows. This list includes items that need to happen, that are likely achievable (at least in part), and that once achieved would greatly enhance the region's biosecurity capacity.

1. All political jurisdictions in the region should have well developed biosecurity legislation. In turn, this legislation should support appropriate and comprehensive biosecurity regulations, policies, and guidelines. Once comprehensive regulations, policies, and guidelines are established, clear standard operating procedures (SOPs) for front line agencies/staffs need to be developed and implemented. All of these items should be clearly and concisely documented and made readily available for interested parties.
2. All jurisdictions should consider developing a cost recovery biosecurity system where users via fees and penalties fund the system, if not completely, then at least in large part (see information regarding cost recovery within the New Zealand biosecurity system model in Attachment O: Models). Jurisdictions need to be realistic in estimating how much revenue such systems can ultimately provide. As an example it has been suggested that for New Zealand, the cost-recovery system which is currently in place probably provides about 30 % of the total funding needs (Pers. Comm. P. Cowan 2014). Ultimately cost-recovery systems will need to be paired with other funding streams in order to insure adequate financial support for comprehensive biosecurity.
3. All jurisdictions need to ensure that biosecurity support and invasive species awareness via outreach and education programs are raised to a level where citizens and visitors are clearly aware of IAS issues, support biosecurity efforts, and willingly contribute to IAS management, control, and prevention activities. Without the support and engagement of the citizenry, biosecurity efforts will remain only partially effective. Once the citizenry is fully engaged and has a deep awareness of invasive species concerns including how invasive species affect them directly, then they and the various governing bodies will effectively support biosecurity. The lack of effective support is currently one of the biggest gaps the region faces in regards to improving biosecurity efforts.

4. Communication and cooperation at all levels needs to be significantly improved. The basic framework for a functional biosecurity effort, including appropriate communication, is established in some jurisdictions but not all. And in no jurisdiction does this framework currently function adequately. Minimally, each jurisdiction should have each of the following:
 - A. An invasive species taskforce (or the equivalent: council, committee, working group, etc.);
 - B. RISC representatives who provide a direct linkage between governance and the various IAS elements within each jurisdiction.
 - C. A jurisdictional invasive species coordinator (or the equivalent) with the capacity and authority to support both coordination of biosecurity and invasive species efforts within the jurisdiction and to facilitate regional (and beyond) two way communication and support of biosecurity and invasive species issues. Ideally this position would work directly with the jurisdictional leadership, play a major role in the invasive species taskforce, and work closely with the RISC.

Each element above should be endorsed and supported by the jurisdictional leadership. The second element above should be retained and reviewed with each change in jurisdictional leadership, to ensure its continued functionality.

In addition to the elements above, the region as a whole should support, develop, create, fund, and utilize a regional invasive species coordination office to support regional and jurisdictional biosecurity and invasive species work. The concept is similar to that of a cooperative invasive species management area or CISMA but on a regional scale and with a central coordinating office. There are various potential ways to establish and support a regional invasive species coordination office, all of which provide specific benefits but each of which also presents specific hurdles. The specifics on how such an office would be established and operate will require consultation throughout the region to ensure that if developed, the office is truly a regional office that all of the jurisdictions support and benefit from.

The Pacific currently has various groups that at least in part are working to address invasive species concerns, including the Secretariat of the Pacific Community (SPC) and the Secretariat of the Pacific Region Environmental Program (SPREP). Both of these groups have a Pacific wide mandate, it may be feasible for one or the other to establish a specific invasive species coordination office, which could support Micronesia and Hawaii. Additionally, there are other organizations working regionally that might also be able to host such an office, including The Nature Conservancy (TNC) and The Micronesia Conservation Trust (MCT). The U.S. via various agencies and offices, both civilian and military, might also be able to support such a regional office. For all of the examples above, another level of consideration would be whether to fund such an office fully as a long term endeavor, fund fully for a few years and then anticipate that the office would begin to function largely on grant support; fund, at least minimally, with support from all of the jurisdictions; or fund and support via some combination of the above

mentioned methods. Such an office could also conceivably be linked with the Micronesia Center for a Sustainable Future and/or one of the land grant institutions within the region.

On a broad scale, the office conceptually should be able to support the region as well as the jurisdictions of the region with biosecurity and IAS issues. The office should be able to work across the region and not be restricted to focusing on U.S. jurisdictions nor non-U.S. jurisdictions, but cover both adequately.

5. All jurisdictions currently have some type of biosecurity mechanism in place for terrestrial risks, although no jurisdiction has a fully comprehensive program. The region as a whole, has little biosecurity in place for aquatic risks. Each jurisdiction needs to determine how best to improve existing biosecurity elements and to ensure that biosecurity activities are adequately covering terrestrial, freshwater, and marine systems. Marine systems are by far the most lacking in regards to current biosecurity efforts regionally. Since the region is encompassed by marine ecosystems most of the region's resources are marine system based and most vectors and pathways are marine system based. Therefore, it seems reasonable that marine systems should have a higher level of biosecurity attention than is currently the case. Each jurisdiction needs to determine how to address this anomaly where the conceivably most important system is receiving the lowest level of protection in regards to biosecurity. Initial steps that should be taken are to insure that legislation adequately covers biosecurity for marine systems, ensure that front line agencies/offices are provided with the training, infrastructure, resources, and capacity to conduct marine biosecurity inspections and management actions, and implement and enforce marine system biosecurity elements such as ballast water discharge, ballast water treatment, and hull cleanliness standards.

For each jurisdiction, it is clear that there are pressing biosecurity system gaps. Addressing these gaps should be a major focus. For example, all jurisdictions have existing regulations that address elements of biosecurity but none are fully adequate. Specific issues include:

1. Guam has a biosecurity law and, therefore, should be considered a model for the other jurisdictions, but it has yet to fully implement this law, as the funding mechanism described in that legislation is still being debated. Guam is currently exploring options regarding how to move forward with the law's implementation.
2. The Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia each have pending biosecurity legislation and each country needs to review, debate, and final determination of these bills a high priority with decisions forthcoming on whether or not the pending bills can be supported or if these countries need to go back and develop new biosecurity bills.
3. Hawaii has reasonably comprehensive biosecurity regulations, but needs to increase support for aquatic biosecurity capacity.

4. The CNMI has no specific biosecurity legislation and should as a first step hold jurisdiction wide consultations to determine if such legislation is needed and if needed, begin the process of bill development with the expectation of having a biosecurity law in place within the next 2-3 years. As part of the consideration on biosecurity legislation, the CNMI should also consider establishing a government endorsed invasive species taskforce. The taskforce could be extremely helpful in the consultation process and, if warranted, with drafting the biosecurity legislation.

Looking at the bigger picture and moving forward with developing mechanisms to address the top recommendations will not only enhance the region's capacity but will also effectively support buy-in from local and regional as well as international partners. This will in turn support funding and regional cohesion, ultimately further advancing biosecurity efforts.

All jurisdictions in the region should develop and implement a mixed model approach to biosecurity, focusing on pre-arrival sanitation with high levels of inspection for all vectors from all pathways on arrival at dedicated entry locations. While the focus should be on these elements, specific policies should also be put in place to address concerns from high priority threats, such as those posed by the potential by BTS and CRB incursions. As part of the planning and development to address high level threats, policies and procedures should be established that while addressing the high level threat also improve overall biosecurity protection from all non-native taxa, i.e., focusing on specific threats should in theory assist with overall protection, not just protection from the specific threats.

Pre-border sanitation, as noted previously, is generally lacking within the region but has the potential to provide the best return per resources engaged. The fact that pre-border sanitation is minimal or lacking for the region, is due in large part to how biosecurity systems have evolved, which typically involved end users trying to reduce the impacts associated with arriving or established pests. While these efforts are worthy of attention, increasing efforts with pre-border sanitation could stop many potential pest species from entering the transportation chain, in effect stopping these species from being transported and potentially establishing. Reductions in pest arrivals and introductions would ultimately be the best way to protect end points from the impacts of invasive species as well as requiring lower levels of resources to intercept pests on arrival and to establish and support management and eradication programs. Greater focus on stopping the transport of unwanted organisms via pre-border sanitation efforts is needed throughout the region.

To improve pre-border sanitation will require expanding the traditional biosecurity role to include working with trade partners (both private and governmental) to develop appropriate sanitation mechanisms such as biosecure staging areas, pre-departure inspection and certification, awareness training for shippers, forwarders, and others working at departure ports and freight consolidation areas, and possibly focusing on specific businesses or practices when required. A developing model of potential effective pre-border sanitation that should be considered is the on-going efforts by DoD on Guam to utilize Hazard Analysis and Critical Control Point (HACCP) planning to reduce the potential of invasive species arriving on Guam with materials, equipment, and personnel. The United States Fish and

Wildlife Service (USFWS) has provided support and training for DoD, civilian agencies, and contractors in regards to utilizing HACCP as a strategic tools to reduce pest arrivals. Jurisdictions and agencies throughout the region should consider utilizing the HACCP process to improve overall biosecurity.

Some recommendations are easily recognizable as high priority items that need to be addressed early on in the biosecurity development process. A clear example of one such recommendation is improved buy-in from citizens as well as other elements of society, including the military, with supporting biosecurity and IAS work. This can best be achieved through a variety of outreach and educational activities, some of which are already either running or being planned but others still need to be developed and implemented (See Attachment O for examples of recent IAS awareness videos). Awareness and buy-in by both local communities and governance is essential to developing appropriate biosecurity for the region. Achieving sufficient levels of awareness should be considered a long term commitment as it will not be achieved overnight or even in a few years. One element that would support long term invasive species and biosecurity awareness is to formalize it as a standardized part of the educational systems throughout the region. Awareness efforts need to be highly coordinated (both within jurisdictions but also throughout the region), broad based, well supported, and improved and expanded over time. By developing such awareness efforts citizens, visitors, businesses, foreign workers, military and all elements of society can be engaged in supporting biosecurity systems through an understanding of IAS, their potential impacts, and the need for biosecurity programs to reduce the risk associated with IAS.

Improving awareness and buy-in will take time and efforts to engage the public and the military should already be underway. Other efforts to improve biosecurity need to move forward concurrently. Outreach to improve buy-in is essential and while efforts for this are being improved and expanded, jurisdictions will also need to determine what other recommendations they can move forward with.

Awareness of IAS and biosecurity within all levels of society, including the military, must be improved. Various groups are currently working within the region to improve environmental awareness. One such program is facilitated by RARE, an NGO which supports localized capacity building in various locations around the globe, including the Pacific Region. The RARE program perhaps should be considered as a model for awareness campaigns. This model utilizes social marketing techniques to change knowledge, attitudes and behaviors in specified target audiences. Building pride for the uniqueness of local natural resources is the foundation and motivation for change, adoption and maintenance of stakeholder support for conservation projects. RARE campaigns are discussed in more detail in the models attachment (Attachment O).

11-5. Costs

Funding and other resources to support biosecurity development, improvements, and maintenance should be supplied from a mixed model approach that relies on cost recovery for services provided, penalty assessment and collection for infractions to established laws, regional collaboration, and the interjection of funds and other resources from external sources. While biosecurity systems should

depend on a variety of funding streams, each jurisdiction should be looking to maximize funding self-sufficiency by engaging full participation by the citizenry and by instituting biosecurity cost-recovery systems.

Primarily all jurisdictions should be operating a cost recovery system where biosecurity fees and penalties are appropriately assessed, instituted, and enforced across the board (and ideally are harmonized as much as is feasible throughout the region to reduce the potential for competition between jurisdictions in regards to user fees). Funds collected via fees and penalties in regards to biosecurity should go directly into government sanctioned revolving funds that are explicitly set up to support biosecurity agencies and activities.

In addition to establishing cost recovery biosecurity systems in all jurisdictions, it is understood that support from external funding sources will continue to be needed and engagement of external donors to support biosecurity must be improved. Funding from external sources should be used to better develop capacities through items such as training and resource development including facilities, fleets, and workspace tools. Each jurisdiction (perhaps working together regionally) should develop long term planning for the acquisition and use of external funds. There are numerous and varied funding and support opportunities available for IAS efforts including donor country aid funds, international programs, NGOs, regional programs, agencies, offices, council, and committees. A short list of possible support sources follows:

- The U.S. Agency for International Development (US AID): <http://www.usaid.gov>
- The Australian Agency for International Development (AusAID): <http://aid.dfat.gov.au/Pages/home.aspx>
- The United Nations Development Programme - Global Environmental Facility (UNDP-GEF): <http://web.undp.org/gef/>
- Birdlife International: <http://www.birdlife.org/>
- Conservation International: <http://www.conservation.org/Pages/default.aspx>
- Island Conservation: <http://www.islandconservation.org/>
- SPC: <http://www.spc.int/>
- SPREP: <http://www.sprep.org/>
- USDA: <http://www.usda.gov/>. The USDA has a helpful website for managers looking for funding to support invasive species work: <http://www.invasivespeciesinfo.gov/toolkit/grants.shtml>
- USFWS: <http://www.fws.gov/>; The USFWS also has webpages to assist with granting opportunities: <http://www.fws.gov/grants/>

- The U.S. Department of Health and Human Services also has a helpful website listing current grants within the U.S. Federal Government: <http://www.grants.gov/web/grants/home.html>

Government buy-in and support will be essential to insuring long term funding. Clearly demonstrating the cost-benefits of improved biosecurity utilizing local, regional, and broader scale examples should be a basic concept that all jurisdictions promote. Improving biosecurity systems is going to require funding. Demonstrating how improved biosecurity can lead to overall cost savings and quality of life improvements utilizing real world examples should become a standard practice. Improved biosecurity versus steady-state or even reductions in current capacity is essential. Support should be sought from governance, local communities and cultural leadership.

11-6. Conclusions

For the RBP to be successfully implemented at its fullest level, each jurisdiction needs to have the capacity to track and manifest passengers and cargo and have an adequate number of professionally trained personnel capable of inspecting cargo, passengers and associated baggage, and vectors at all ports of entry (both internal and external). Legislation and regulations must be in place and enforceable to ensure pre-border, border, and post-border actions biosecurity actions are carried out and enforced. Cost recovery systems must be instituted and managed to help ensure that biosecurity programs are appropriately funding and can expand if the need for services increases. Animal & Plant Health Inspection Service/Plant Protection & Quarantine (APHIS/PPQ) and Customers & Border Protection (CBP) models offer good examples of training and organizational structure. It is highly recommended for all partners in the RBP to receive training using the Hawaii, APHIS/PPQ, CBP programs, or similar programs in New Zealand or Australia.

Suitable inspection facilities must be in place and equipped with the required technical tools and trained staff to identify suspected invasive plants, animals, diseases, and micro-organisms posing threats to terrestrial, freshwater, and marine systems. Access to taxonomic expertise and knowledge of and ability to quickly implement items such as response procedures are also essential. Equipment to look inside cargo containers, to inspect the hulls of watercraft, to identify pests, to implement treatments, etc. are needed and once obtained must be maintained and replaced as needed. Examples include fork lifts, microscopes, sniffing dogs, fumigation equipment, etc. Such facilities should be constructed in a manner that if an invasive pest is found in cargo, the cargo can be quarantined and species appropriate corrective actions implemented (e.g. fumigation) at the shipper's expense. Otherwise, the cargo should be immediately resealed and returned to the ship from which it was off-loaded and the reason for rejection noted electronically along with all pertinent container information. Suspect cargo should be quarantined until it can be properly inspected. Cargo confirmed to contain invasive species should remain quarantined and either be returned to sender or species appropriate corrective actions implemented (e.g. fumigation) with 24 hours of confirmed pest identification.

Biosecurity systems, no matter how advanced, no matter how well funded, no matter how well implemented are never going to stop 100% of all incursions. But a good system that is supported with

ample resources is likely going to prevent most incursions and hence reduce the potential damage that would have been caused if most incursions were not prevented. There are no biosecurity models that function perfectly; they all have troublesome elements, but the system utilized in New Zealand appears to work relatively well. But, what works in one location may or may not be transferrable to another location, and even if transferrable, implementation does not always equate with success. The jurisdictions of Micronesia and Hawaii should review various biosecurity models and through internal consultations determine the best pathway forward in regards to improving their own overall biosecurity strategies.

Whatever initial improvements are made and whatever systems ultimately are developed, detailed monitoring, data collection, and data analysis should become a standard part of all biosecurity systems. These and other elements (such as surveys) should be utilized as feedback mechanisms providing input and details back into the system highlighting what elements of these systems are functional and which continue to need improvement. This information will in turn permit more focused direction and better use of limited resources to address any remaining gaps.

As recommendations are fully implemented, inclusive of feedback follow through, each jurisdiction will have a fully functional biosecurity system, the region will have coordinated biosecurity, and ultimately Micronesia and Hawaii will be better protected from invasive species. The region's commitment towards developing the RBP has made the region a global leader in biosecurity and through its implementation will insure that the region is protected and continues to serve as a model for other areas within the Pacific as well as globally in regards to island biosecurity.

12. Concluding Remarks

For the islands of Micronesia and Hawaii, a stable and sustainable economy is dependent upon a healthy natural resource base. Efforts to enhance food security, develop opportunities for economic prosperity and protect cultures, natural environments and biodiversity are increasingly and fundamentally impacted by a wide range of invasive plants, animals and disease organisms. IAS threaten the way of life for many Pacific islanders. IAS degrade oceans, destroy crops, smother reefs and forests, and kill unique endemic species. IAS impact traditional practices and cultures, as well as, the health of Pacific islanders. Aside from climate change, IAS are the single greatest long-term threat to Pacific Island economies, environments, cultures, people and sustainable livelihoods. IAS undermine ecosystem resilience and the ability to adapt to climate change and develop sustainably.

At the same time, Pacific islands offer some of the greatest opportunities for the successful prevention, eradication, and control of IAS due to their relatively small size, limited number of ports of entry, and isolation from the continental sources of most known IAS. Furthermore, the region is a global leader in IAS expertise and has years of successful collaborative efforts and prevention, eradication and control experience.

It is with this knowledge in mind that the region has enthusiastically joined with partners in the United States Government, the Secretariat of the Pacific Community, Landcare Research and many other Pacific and international biosecurity experts to develop this Regional Biosecurity Plan for Micronesia and Hawaii. This comprehensive plan provides an unprecedented blueprint for effective prevention, management, and control of invasive species within and into the region.

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14. List of Abbreviations*

ABRPI	Aquatic Bioinvasion Research and Policy Institute
ACE	Air Combat Element
ACEM	Amphidromous, catadromous, euryhaline, and marine
ACFW	Amphidromous, catadromous, freshwater
AFB	Air Force Base
AFJI	Air Force Joint Instruction
AFP	Air Force Policy
AHS	African horse sickness
AIC	Akaike's Information Criterion
AIV	Avian Influenza Virus
ALSC	American Lumber Standard Committee
AMDTF	Army Air and Missile Defense Task Force
ANS	Aquatic Nuisance Species
ANSTF	Aquatic Nuisance Species Task Force
AOR	Area of Responsibility
APHIS	Animal and Plant Health Inspection Service (USDA)
AQAS	Agricultural Quarantine Activity System
AQI	Agricultural Quarantine Inspection
AQIM	Agriculture Quarantine Inspection Monitoring
Army	United States Army
ASF	African Swine Fever
AusAID	Australian Agency for International Development
AWA	Animal Welfare Act
AWRAM	Aquatic Weed Risk Assessment Model
BAPHIQ	Bureau of Animal and Plant Health Inspection and Quarantine
BIISC	Big Island Invasive Species Committee
BISH	Bishop Museum Herbarium
BMP	Best management practice
BO	Biological opinion
BOA	Bureau of Agriculture
BOC	Bureau of Customs
BRS	Biotechnology Regulatory Service
BTS	Brown Treesnake
CAPS	Cooperative Agriculture Pest Survey
CAT	Civic Action Teams
CBP	U.S. Customs and Border Protection
C-CAP	NOAA Coastal Change and Analysis Program
CDC	Centers for Disease Control and Prevention
CEM	Contagious Equine Metritis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CGAPS	Coordinating Group on Alien Pest Species
CIKM	Carbonate Island Karst Model
CI-MCBC	Conservation International—Melanesia Center for Biodiversity Conservation

CISMA	Cooperative Invasive Species Management Area
CIST	Chuuk Invasive Species Taskforce
CITES	Convention on International Trade in Endangered Species
CNMI	Commonwealth of the Northern Mariana Islands
CNMI-UWAWG	Commonwealth of the Northern Mariana Islands Unified Watershed Assessment Working Group
CPHST	Center for Plant Health Science and Technology
CQUA-CEM	Central Queensland University, Australia, Centre for Environmental Management
CRB	Coconut Rhinoceros Beetle
CSA	Customer Service Agreements
CSAR	Combat Search and Rescue
CSF	Classical Swine Fever
CSG	Carrier Support Group
CSP	Conservation Society of Pohnpei
CTSA	Center for Tropical and Subtropical Agriculture
CTUS	Customs territories of the United States
CVN	Carrier Vessel Nuclear
DAF	Yap Division of Agriculture and Forestry
DAR	Defense Access Road
DAWR	Division of Aquatic and Wildlife Resources, Guam Department of Agriculture
DFW	Division of Fish and Wildlife
DHS	Department of Homeland Security
DLNR	Department of Land and Natural Resources
DoD	U. S. Department of Defense
DOI	U.S. Department of the Interior
DON	U.S. Department of the Navy
DOGC	Directorate General of Customs
DOT	U.S. Department of Transportation
DTR 5	Defense Transportation Regulation 4500.9-R, Part V
EEE	Eastern Equine Encephalitis
EIA	Equine Infectious Anemia
EIS	Environmental Impact Statement
EIS/OEIS	Environmental Impact Statement/Overseas Environmental Impact Statement
EMRS	Emergency Management Response System
EMUA	Exclusive Military Use Area
END	Exotic Newcastle's Disease
EO	Executive Order
EOCs	Emergency Operations Centers
EP	Equine Piroplasmiasis
EPA	Environmental Protection Agency
EPPO	European and Mediterranean Plant Protection Organization
FAVIR	Fruits and Vegetables Import Requirements
FAVN	Fluorescent Antibody Virus Neutralization
FDA	U.S. Department of Health and Human Services Food and Drug Administration
FedEx	Federal Express
FFDP	Fruit Fly Detection Program
FIA	USFS Forest Inventory and Analysis Program

FMD	foot and mouth disease
FSM	Federated States of Micronesia
FSMC	Code of the Federal States of Micronesia
FSM-DEA	Federated States of Micronesia Department of Economic Affairs
FSM-QS	Federated States of Micronesia Quarantine Services
GADTC	Guam Aquaculture Development Training Center
GARR	Guam Administrative Rules and Regulations
GCA	Guam Code Annotated
GCE	Ground Combat Element
GCQA	Guam Customs and Quarantine Agency
GDAWR	Guam Division of Aquatic and Wildlife Resources
GDOA	Guam Department of Agriculture
GISC	Guam Invasive Species Council
GNA	Guam Nature Alliance, formally known as the Environmental Education Committee
HBOA	Hawaii Board of Agriculture
HDBEDT	Hawaii Department of Business, Economic Development, and Tourism
HDAR	Hawaii Division of Aquatic Resources
HDOA	Hawaiian Department of Agriculture
HASLA	Hawaii Chapter American Society of Landscape Architects
HBS	Hawaii Biological Survey
HEAR	Hawaiian Ecosystems at Risk
HEPEP	Hawaii Exotic Plant Evaluation Protocol
HFRS	Hemorrhagic Fever and Renal Syndrome
HISC	Hawaii Invasive Species Council
HMU	Habitat Management Unit
HNL	Honolulu International Airport
HPAI	Highly pathogenic avian influenza
HPAIV	Highly Pathogenic Avian Influenza Viruses
HPWRA	Hawaii/Pacific Weed Risk Assessment protocol
HRS	Hawaii Revised Statutes
HS	Harmonized Schedule
HSC	Helicopter Sea Combat Squadron
HSV	High-Speed Vessels
HQ	Headquarters
IAPS	Invasive alien plant species
IAS	Invasive alien species (also commonly referred to as invasive species)
IC	Incident Commander
ICS	Incident Command System
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
ISC	Invasive Species Committee
ISR	Intelligence, Surveillance, and Reconnaissance
iSTOP	Invasive Species Taskforce of Pohnpei
JE	Japanese encephalitis
JEV	Japanese encephalitis virus
JGPO	Joint Guam Program Office
JHSV	Joint High Speed Vessels

KISC	Kauai Invasive Species Committee
KIST	Kosrae Invasive Species Taskforce
LBA	Leaseback Area
LCAC	Landing Craft Air Cushion
LCE	Logistics Combat Element
LCS	Littoral Combat Ships
LEMIS	Law Enforcement Management Information System
LFA	Little Fire Ant
LICH	Landscape Industry Council of Hawaii
LPAIV	Low Pathogenic Avian Influenza Viruses
MAC	Manual for Agricultural Clearance
MAGTF	Marine Air-Ground Task Force
Marine Corps	U.S. Marine Corps
MARFORPAC	Marine Forces Pacific
MBP	Micronesia Biosecurity Plan
MCBH	Marine Corps Base Hawaii
MCEs	Micronesia Chief Executives
MCES	Micronesia Chief Executives' Summit
MCI	Military Customs Inspection
MEF	Marine Expeditionary Force
MIA	Miami International Airport
MIIST	Marshall Island Invasive Species Taskforce
MIRC	Mariana Islands Range Complex
MIU	Maritime Intelligence Unit
MLA	Military Lease Area
MLG	Marine Logistic Group
MMDC	Micronesia Mariculture Demonstration Center
MOU	Memorandum of Understanding
MPSA	Military Postal Service Agency
NAQS	Northern Australia Quarantine Strategy
NAVFAC	Naval Facilities Engineering Command
NAVFACPAC	Naval Facilities Engineering Command Pacific
NBS	National Biosecurity Strategy
NCAHEM	National Center for Animal Health Emergency Management
NDAA	National Defense Authorization Act
NDV	Newcastle disease virus
NECC	Navy Expeditionary Combat Command
NEPA	National Environmental Policy Act
NEPC	Palau National Environmental Protection Council
NGO	Nongovernmental Organization
NIMS	National Incident Management System
NIS	National Identification Services
NISC	U.S. National Invasive Species Council
NMC	Northern Marianas College
NMC-CREES	Northern Marianas College Cooperative Research Extension and Education Service
NOAA	National Oceanic and Atmospheric Administration
NPDN	National Plant Diagnostic Network

NRC	National Research Council
NRCS	Natural Resources Conservation Service (USDA)
NVS	National Veterinary Stockpile
NWDP	National Wildlife Disease Program
NWI	National Wetlands Inventory
OED	OISC's Oahu Early Detection Project
OIE	World Organization for Animal Health
OISC	Oahu Invasive Species Committee
OTA	Office of Technology Assessment
PACAF	Air Force Pacific
PAG	Port Authority of Guam
PBOA	Palau Bureau of Agriculture
PCS	Permanent Change of Station
PEQPB	Palau Environmental Quality Protection Board
PIER	Pacific Islands Ecosystems at Risk
PII	Pacific Invasives Initiative
PILN	Pacific Invasives Learning Network
PIP	Pacific Invasives Partnership
PIST	Pohnpei Invasive Species Taskforce. This group is now known as iSTOP.
PMDC	Palau Mariculture Demonstration Center
PNISC	Palau National Invasive Species Committee
PNRC	Palau Natural Resource Council
POV	Privately Owned Vehicle
PPA	Plant Protection Act
PPPO	Pacific Plant Protection Organization
PPQ	Plant Protection and Quarantine, APHIS
PPS	Plant Protection Station
PQ	Plant Quarantine Branch of HDOA
PRA	Pest Risk Assessment
PRI	Primary Training Area
PSI	Pacific Safeguarding Initiative
PSU-ABRPI	Portland State University, Aquatic Bioinvasion Research and Policy Institute
PWS	Public Water System
QM	Quarantine Plant and Animal Materials
QRAF	Quarantine Regulations of the Armed Forces
RAM-ANSTF	Risk Assessment and Management Committee—Aquatic Nuisance Species Task Force
RBP	Regional Biosecurity Plan
RCS	Ramsar Convention Secretariat
RIFA	Red Imported Fire Ants
RISC	Micronesia Regional Invasive Species Council
RMI	Republic of the Marshall Islands
Roadmap	United States- Japan Roadmap for Realignment Implementation
ROD	Record of Decision
SEC	Secondary Training Area
SERS	Surveillance and Emergency Response System
SERC	Smithsonian Environmental Research Center
SITC	Smuggling Interdiction and Trade Compliance

SLAMRAAM	Surface-Launched Advanced Medium-Range Air-to-Air Missile
SOP	Standard Operating Procedures
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SSN	Nuclear Submarine
SUA	Special Use Airspace
SVD	Swine Vesicular Disease
T-AE	Auxiliary Ammunition Ships
T-AFS	Auxiliary Combat Stores Ships
T-AKE	Auxiliary Dry Cargo/Ammunition Ships
THAAD	Terminal High-Altitude Area Defense
TSA	Transportation Security Administration
TSV	Theater Support Vessels
TT&E	Test, Training, and Exercise
TBEV	Tick-borne encephalitis virus
UNDP-GEF	United Nations Development Programme – Global Environmental Facility
UOG	University of Guam
UPS	United Parcel Service
U.S.	United States
USACE	U.S. Army Corps of Engineers
US AID	U.S. Agency for International Development
USAKA	U.S. Army Kwajalein Atoll
USARPAC	U.S. Army Pacific Command
USCBP	U.S. Customs and Border Patrol
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USDA-FS	U.S. Department of Agriculture, Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Service
USPS	U.S. Postal Service
U.S.C.	United States Code
USCS	U.S. Customs Service
USPACOM	U.S. Pacific Command
USTRANSCOM	United States Transportation Command
VEE	Venezuelan Equine Encephalitis Virus
VS	Veterinary Services
WBCA	Wild Bird Conservation Act
WEE	Western Equine Encephalitis
WERI	Water and Environmental Research Institute of the Western Pacific
WHO	World Health Organization
WNV	West Nile virus
WPM	Wood Packaging Material
WRA	Weed Risk Assessment
WS	USDA-Wildlife Services

***This list encompasses most, but possibly not all, acronyms used throughout the four volumes of the Regional Biosecurity Plan.**

15. Key Terms*

Animal Contamination: Something that comes in contact or association with animal secretion.

Antifouling paint: Any coating (generally applied as a paint) specifically designed to prevent or deter the settlement and growth of biofouling organisms on a submerged surface (e.g., vessel hull) including biocidal coatings and fouling-release coatings.

APHIS Compliance Agreement: Written agreement that demonstrates understanding between or among parties agreeing to follow APHIS procedures.

Ballast water: Any water (including associated sediments) taken on board a vessel for the express purpose of managing the trim and stability during a voyage.

Ballast water exchange: Emptying and refilling a ballast water tanks typically conducted in order to reduce the potential number of coastal organisms within the holding tank.

Benthic: Pertaining to the flora and fauna found on (or associated with) the bottom of the ocean.

Biofouling: Marine organisms attached to any submerged artificial structure, including wharves, jetties and any part of a vessel hull (including the hulls, rudders, propellers and other hull appendages) or internal seawater systems (including sea-chests and pipe work), or to any equipment or equipment spaces attached to or onboard the vessel (including mooring devices, anchor wells, cable lockers, cargo spaces, bilges, etc).

Bioinvasion or biological invasion: The movement of a living organism to an area outside its natural range, potentially resulting in the establishment or spread of the organism.

Bioregion: An area constituting a natural ecological community with characteristic flora, fauna, and environmental conditions, and bounded by natural rather than artificial borders.

Biosecurity: The management of the risks to animal, plant, human, and environmental health posed by pests and diseases. Managing the risks associated with pests, diseases, genetically modified organisms (GMOs), and other live organisms entering, emerging, establishing or spreading which would potentially cause harm to: human, animal or plant health, the environment or the economy.

Biotic resistance: The hypothesized intrinsic resistance to new species entering a community by the existing members. Elton (1957) suggested that well-connected, species rich communities would naturally resist new species entering by predation, parasitism, and direct and indirect competition.

Build-up:The United States Department of Defense proposed relocation of US Marine Corps forces from Okinawa to Guam and the CNMI.

Bulk Cargo: Cargo not enclosed in a container

Colonize: Refers to larvae or propagules that successfully settle and establish on a submerged substrata.

Dry and semi-dry ballast: The largely historic (though some vessels still use dry ballast) use of rocks, cobble, sand and other dry substances to help maintain the trim and stability of a vessel, semi-dry refers to the wet nature of the bilge, providing a humid environment.

Dunnage: Wood packaging material used to secure or support a commodity during transport, but which does not remain associated with the commodity.

Epibenthic species: Species found living on the surface of the benthic substrata on the bottom of the ocean or estuary.

Endemic species: A species unique to a defined geographic area, such as an island or group of islands.

Exotic: Not native to the specified region or country.

Fomite: An inanimate object or substance, such as a tool, clothing, packing or bedding materials, capable of carrying infectious organisms and thus transmitting from animal to animal (or human to human).

Fumigation: Treatment with a chemical agent that reaches the commodity wholly or primarily in a gaseous state.

Garbage: All waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse of any character whatsoever that has been associated with any such material aboard any means of conveyance and includes food scraps, table refuse, galley refuse, food wrappers or packaging materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters, dining rooms, or any other areas on vessels, aircraft, or other means of conveyances.

Hitchhiker: Species unintentionally moved to a different location in cargo, packing material, a shipping container used for transport, or on/in the conveyance of transport.

Inoculate/inoculation: Refers to the release of a non-indigenous species into the surrounding environment. This includes the release of offspring, fragments and/or direct transfer of individuals, but does not infer successful establishment.

Indigenous or native: Species that are naturally occurring in a region, having evolved or migrated into a region without human intervention.

Infestation: The occurrence of one or more pest species in an area or location where their numbers and impact are currently or potentially at unacceptable levels. A sudden increase in destructiveness or population numbers of a pest species in a given area.

Introduced species: Species that have been transported by human activities – intentionally or unintentionally – into a region in which they did not occur in historical time. See also ‘invasive’, ‘non-indigenous’, and ‘non-native species’.

Invasive species (or invasive alien species): Exotic species, including animal and plant disease agents, microbes, and pests, whose introduction does or is likely to cause economic, environmental, social, and/or cultural harm and/or harm to human health.

LLOYDS MIU: Lloyds compiles and provides data on the global fleet of commercial vessel, including vessel characteristics and traffic patterns (www.lloydslistintelligence.com).

Meroplankton: The category of organisms that spend a part of their life cycle in the water column as plankton. For invertebrates and many fishes, the planktonic stage is usually the larval stage.

Micronesian Region: Guam, the Republic of Palau, the Federated States of Micronesia, the Commonwealth of the Northern Mariana Islands, and the Republic of the Marshall Islands.

Niche area or vessel niche area: The wetted (submerged) surfaces of a vessel that are distinct from the contiguous hull, usually sheltered from laminar flow, including propulsion and steering gear, internal cooling circuits, sea strainers, sea chests, bow and stern thrusters, transducers, log probes, anchors, anchor chains, anchor lockers and bilge.

Non-indigenous or non-native species: see exotic species definition

Pest: Any species, strain or biotype of plant, animal or pathogenic agent considered injurious.

Phytosanitary Certificate: Official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations.

Propagative plant material: Plant material which may include nursery stock, plants, and other propagative parts such as bulbs, seeds, roots, rhizomes, tubers, corms, etc.

Recruitment: The post-settlement survival of an individual or species within a defined time period.

Reproductive phenology: The timing and period (duration) of reproductive activity for an individual species.

Sea-chests: Recesses built into a vessel’s hull below the waterline that house the seawater intake pipes used for ballast uptake, engine cooling, firefighting and other onboard functions.

Sessile: Species that are firmly attached to the hard substratum (e.g., sponges, corals, barnacles).

Transport pressure: Refers to the numbers of vessels that arrive from a particular bioregion and multiplied by a port duration weighting.

Species richness: The number of species represented in an ecological community.

Wood Packaging Material (WPM): Wood or wood products used in supporting, a commodity to protect it during transport (includes dunnage).

Vector: The physical means, agent or mechanism which facilitates the transfer of organisms or their propagules from one place to another.

Zoonoses: Any disease or infection that is naturally transmissible from animals to humans.

***This list encompasses key terms used throughout the four volumes of the Regional Biosecurity Plan.**

16. Acknowledgments

The plan was created by a truly collaborative effort, as over 150 individuals had direct input into its development. This includes resource managers, policy makers, researchers, educators, representatives from the shipping, aquaculture, aquarium, and tourism industries, active ocean and inland water users, as well as other stakeholders throughout the region and from further afield.

The concept of the plan came originally from the RISC and the Micronesia Chief Executives. Personnel from NISC and the DOI were instrumental in further developing the concept and bringing the concept to the attention of the DoD. The DoD funded both the development of the risk assessments and the final RBP product and in addition has been extremely supportive throughout the developmental process.

The risk assessments were drafted by U.S. federal agencies including the Smithsonian Institute, USGS, and USDA. The risk assessments were reviewed by LandCare New Zealand as well as dozens of independent and agency level reviewers.

The University of Guam, SPC, and LandCare updated the risk assessments in regards to review of comments and worked synergistically on developing the other components of the RBP including the implementation strategy.

Development of the implementation strategy involved numerous consultations with thematic experts and government officials throughout the region with various feedback mechanisms incorporated into the process with the outlook of insuring the most effective and efficient end product possible for each of the jurisdictions.

Large components of the original risk assessments completed for this project by USDA, USGS, and the Smithsonian Institute, element of the peer review completed by LandCare, and hundreds of comments and remarks from stakeholders throughout the region have been incorporated into this body of work.

As in many collaborative projects, the list of names to be thanked is long and it is not possible to list everyone who has contributed to this plan. The contributions and participation of all involved is much appreciated and played a large part in the success of development of this plan.

Attachment A: Overview of the Island Jurisdictions Included in the Regional Biosecurity Plan

Territory of Guam

Guam is the largest and southernmost island in the Mariana archipelago as well as being the largest island within Micronesia (Figure A-1). The surface geology of the southern half of the island is primarily volcanic rock and the northern half is limestone (Gingerich 2003). Guam has extensive coastal reefs, eroded volcanic hills in the south and a raised limestone plateau in the north. Elevations range from sea level to the summit of Mount Lamlam at 406 meters (1,332 feet). The climate is warm tropical maritime, generally warm and humid; temperature varies little during the year, averaging 26°C (Western Regional Climate Center: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?pigum>). Mean annual precipitation ranges from 216 to 292 cm (85 to 115 inches) (Gingerich 2003). A dry season occurs from January to June with a rainy season from July to December. The exact timing and extent of the dry season varies annually. About 40 watersheds are present on Guam, mostly on the southern half of the island. Artificial freshwater habitats on Guam consist primarily of small to large impoundments, the largest being Fena Reservoir. Since precolonial times, the island of Guam has been a center of trade and travel. Guam laid on the colonial trade route between the Philippines and Mexico and more recently was of strategic importance during World War II (WWII) and the Cold War and continues to play a major role in U.S. military strategy. Guam has been a U.S. territory since 1898, and about a third of the island is currently devoted to military installations. Guam has 544 square kilometers of land with a 125.5-km (78-mile) coastline and a population of approximately 154,805 in 2010. Located about three-quarters of the way from Hawaii to the Philippines, Guam occupies a strategic location for the U.S. military in the western North Pacific, and it is the primary focus of the proposed military relocation of U.S. forces currently located in Okinawa, Japan.

According to data from the Guam Bureau of Statistics and Plans for 2009, the major suppliers for imported commodities were the United States (50%), Japan (14%), Western Europe (13%), and Asia (China, Korea, Taiwan, Hong Kong, Singapore, Thailand, and the Philippines) (16%). Food commodities and non-alcoholic beverages represented the largest commodity group, making up more than 30% of all imports in 2009 (Guam BSP 2009).

Guam's economy depends largely on U.S. military spending and tourism. Over the past 30 years, the tourism business has grown to become the largest income source following national defense. The Guam economy continues to expand in both tourism and military sectors. As military expansion continues, environmental protection and aesthetics should continue to be a primary focus for the protection and development of Guam's tourist industry. Most visitors to Guam arrive by air from Japan (78%) and Korea (10%).

Natural resources include the marine environment, agricultural products, and the terrestrial environment. Aquatic wildlife from the marine environment supports tourism and some recreational

and subsistence fishing. Guam's agricultural production is extremely limited and what does exist are mainly fruits and vegetables produced for local consumption. The terrestrial environment of Guam has been fairly heavily impacted by various elements including major battles during WWII, extensive and long term human habitation, and various established and highly detrimental invasive species.

Guam has a history of invasive species problems, including the establishment of the Brown Treesnake, Coconut Rhinoceros Beetle, and Little Fire Ant (*Wasmannia auropunctata*). Guam is a major transportation hub for the Micronesia region and could also be a hub for dispersal of IAS within the region. DoD, GDOA, GCQA, Guam Port Authority, UOG, USDA, USFWS, Guam Invasive Species Council (GISC) and Guam Invasive Species Advisory Committee (GISAC) are all involved in IAS control and management on Guam.

Figure A-1: The Territory of Guam



Summary details of the Territory of Guam:

1. Location: latitude 13°28'N and longitude 144°45'E
2. Number of islands: 1
3. Size: 544 km²
4. Population: 154,805
5. Examples of native species that are imperiled: Guam Rail (*Gallirallus owstoni*), Mariana Fruit Bat (*Pteropus mariannus*), Guam subspecies of the Micronesian Kingfisher (*Todiramphus cinnamomina cinnamomina*), Mariana Crow (*Corvus kubaryi*), Mariana Common Moorhen (*Gallinula chloropus guami*), Mariana Swiftlet (*Aerodramus bartschi*), Green Sea Turtle (*Chelonia mydas*), Hawksbill Sea Turtle (*Eretmochelys imbricata*), *Serianthes nelsonii* (organisms listed are only those considered at the federal level, local experts may want to expand this to include species of local concern)
6. Examples of established IAS of significant concern: Brown Treesnake, Coconut Rhinoceros Beetle, Little Fire Ant, various rat species (*Rattus* spp.), numerous plant species and arthropods
7. Example of an IAS with significant threat of establishing: Coqui Frog (*Eleutherodactylus coqui*)
8. Main economic drivers: Tourism, DoD, and local businesses
9. Main trade partners: U.S. mainland
10. Import examples
 - a. Food stuffs and beverages
 - b. White leg shrimp also known as Pacific white shrimp (*Litopenaeus vannamei*) post larvae and broodstock (Arthur et al. 2012). Adults were imported in 2007 from Hawaii and Kentucky.
 - c. Mangrove Crab (*Scylla serrata*) annually imported from the FSM and the Philippines (Arthur et al. 2012)
 - d. Mozambique Tilapia (*Oreochromis mossambicus*) fry annually imported from the Philippines and Taiwan POC (Arthur et al. 2012)
 - e. Freshwater and Marine aquarium fish imported from Malaysia, Singapore, Taiwan POC, and US (Arthur et al. 2012). Pet shops import aquatic organisms on a monthly basis
11. Export example: Guam has a live export trade of the aquatic species *Litopenaeus vannamei* which is exported to China and the United Arab Emirates as brood stock (Arthur et al. 2012).
12. Ports and post offices points of entry
 - a. Air
 1. Won Pat International Airport: Guam's Antonio B. Won Pat International Airport (A.B. Won Pat Airport), also known as Guam International Airport, serves as the hub for regional air travel, international cargo, and passenger transport. Fiscal Year (FY) 2006-2007 had an average of 756 aircraft operations/week and numbers of aircraft operating averaged 1,610/month (approximately 400/week). Several international airlines operate from Guam: United, Northwest, Japan, Korean Air, Philippine Airlines, China Airlines, and Asia Pacific. The airport has 21 aircraft parking positions with 18 common-use terminal gates. U.S. Customs and Border Protection (CBP) personnel provide immigration services, and Guam Customs and Quarantine Agency (GCQA) personnel conduct

customs and agriculture clearance during scheduled aircraft operations and on prior arrangements with field supervisors.

2. AAFB
- b. Sea
 1. Guam commercial port
 2. Naval Base Guam
- c. Post offices
 1. Barrigada
 2. DoD

Commonwealth of the Northern Mariana Islands

The 14 northern islands of the Mariana Archipelago make up the CNMI (Figure A-2). The three largest of these islands are currently the only ones with permanent human settlements. The three inhabited islands are Saipan, Tinian, and Rota. Saipan is the seat of the commonwealth government and also the island where most of the population resides. On Saipan, tourism is a main economic activity, while manufacturing which was an important economic resource has all but closed down in recent years. Rota and Tinian are primarily dependent on agricultural activities. Visitation to the CNMI is mainly from Southeast Asian countries with most visitors arriving and staying on Saipan and only a few visiting Tinian or Rota.

Several international airlines fly to the CNMI, mainly Saipan, while Tinian and Rota are generally accessed by Mariana Islands based commuter planes. Delta flies 21 times a week into Saipan with three flights daily from Nagoya and Narita, Japan. Asiana has 11 flights a week from Incheon, South Korea, four flights a week from Pusan, South Korea, and four flights a week from Osaka, Japan. Charters include China Southern, Air China, and Shanghai Airlines; China Southern and Shanghai Airlines bring two charter flights twice weekly from Guangzhou. Air China only occasionally operates (holidays, special occasions) from Beijing (Deposa 2010).

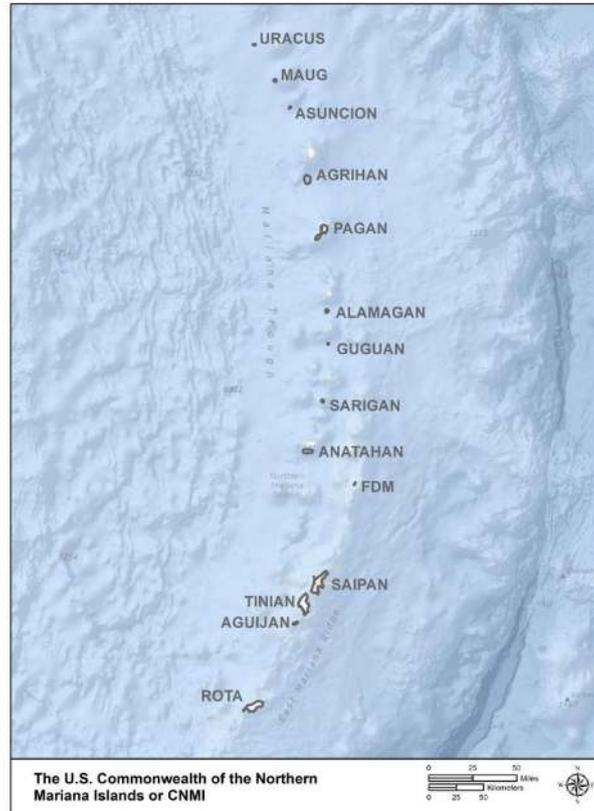
The climate of the CNMI is similar to that of Guam, with pronounced wet and dry seasons.

Saipan: Saipan is located between latitude 15°5'30" to 15°17'30" N and longitude 145°41'30" to 145°50'00"E. The island is about 21 km (13 mi) long and about 6.4 km (4 mi) wide, with a surface area of about 124 km² (48 mi²), making it the largest island in the CNMI. Saipan also has the largest human population among all of the CNMI islands. A ridge extends centrally through the island and there is a wide coastal area to the west. The highest point is Mount Tapochau, with a maximum elevation of 466 m (1,530 ft.). Annual rainfall averages about 203 cm (80 inches) (van der Brug 1985).

Tinian: Tinian is located at 15°N and 145°E. With a surface area of about 101 km² (39 mi²) it is the second largest island in the CNMI, and measures about 19 km (12 mi) long and 9.7 km (6 mi) wide. The surface topography is divided into five physiographic areas, with the southern part of the island having the greatest elevation; the highest point is Mt. Kastiyu (Lasso Hill), at 187 m (614 ft.) (Gingerich 2002).

Rota: Rota is located between latitude 14°06' to 14°12'N and longitude 145°07' to 145°17'E. It is the southernmost island of the CNMI and lies about 72 km (45 mi) north-northeast of Guam. The island is oriented east-west and is about 18.5 km (11.5 mi) long and 4.8 km (3 mi) wide. Including two small islands along its west shore, the surface area of Rota is approximately 85.5 km² (33 mi²).

Figure A-2: The Commonwealth of the Northern Mariana Islands



Summary details of the Commonwealth of the Northern Mariana Islands:

1. Location: the western Pacific between latitudes 14°08 and 20°33'N and between longitude 144°54' and 146°04'E
2. Number of islands: 14 islands, including 3 which are inhabited (Saipan, Tinian, and Rota)
3. Size: 475 km²
4. Population: 53,883 (2010 census); 90% of population lives on the island of Saipan
5. Examples of native species that are imperiled: Mariana Fruit Bat, Micronesian Megapode (*Megapodius laperouse*), Mariana Crow, Mariana Common Moorhen, Mariana Swiftlet, Nightingale Reed Warbler (*Acrocephalus luscinius*), Rota Bridled White-eye (*Zosterops rotensis*), Green Sea Turtle, Hawksbill Sea Turtle, *Serianthes nelsonii*, *Nesogenes rotensis*, *Osmoxylon mariannense*

6. Examples of established IAS of concern: Giant African Snail (*Achatina fulica*) and Melon Fruit fly (*Bactrocera cucurbitae*)
7. Examples of IAS of significant concern of establishing: Coconut Rhinoceros Beetle, Brown Treesnake, Coconut Termite (*Neotermes rainbowi*)
8. Main economic drivers: Tourism, Services
9. Main trade partners: USA and Japan
10. Import examples: food, construction material and equipment, and petroleum products
11. Export examples: Garment production was a major revenue earner for the island of Saipan prior to 2010. Garments were exported to USA mainland. The industry has closed. At present exports are mainly sweet potato, yam and taro. These agricultural products are exported to Guam.
12. Ports
 - a. Air
 1. Saipan International Airport: A Port of Entry responsible for enforcing the Immigration and Nationality Act (INA) for arriving aliens and establishing departure control for certain flights as part of the “Northern Mariana Islands Immigration, Security, and Labor Act.” Officers perform admission of aliens; travel control of citizens and aliens; inspections; apprehensions; examinations; exclusions and removals. It is the gateway to the CNMI, serving Saipan, Rota and Tinian. It can accommodate wide-bodied aircraft, i.e. DC 10's and 747's. The runway is 8,700 feet long with a parallel taxiway and connecting taxiways. The main terminal accommodates international passengers with six jet ways and houses the Immigration and Customs processing areas. Major airlines operating include: United Airlines, All Nippon Airlines, Delta Airlines, Asiana Airlines, Shanghai Airlines, Sichuan Airlines, China Eastern and Fly Guam. Flights arrive direct from cities in Japan, Korea, Hong Kong, Philippines, China and Guam. Saipan International Airport operates mainly inter-island flights. In FY 2006–2007, the number of plane operations per week equaled those at Guam over roughly the same FY period with the majority (71%) from commuter traffic compared to 18% for commercial traffic. The commuter terminal serves as feeder for a Tinian and Rota. The airport operates 24 hours 7 days a week with 24-hour availability of aircraft rescue personnel and equipment (CPA 2007b). Ground handling is by POI Aviation Services affiliated with Tan Holdings Company (POI 2010). Immigration and customs are available during scheduled operations, otherwise by prior arrangements with the chief of Immigration in Saipan (CPA 2007b). DoD also utilizes this airport.
 2. Tinian International Airport: Tinian International Airport hosted approximately 252 plane operations in FY 2008–2009 with 99% commuter and fewer than 1% commercial (CPA 2007c). Tinian has multiple daily commuter flights from Saipan and is also utilized by privately chartered Star Marianas Airlines which provides services for the Tinian Dynasty Hotel & Casino customers originating primarily from China. Passenger traffic is mainly inter-island from Saipan, Rota, and Guam. The airport has accommodations for aircraft with capacities of up to 36 passengers. The current runway is 8,600 feet in length with a parallel taxiway and two connecting taxiways at each end. Construction of a high-speed taxiway has been advertised for bid and the runway expansion is expected to increase traffic. The airport is equipped for night operation with night flights from Saipan

and Guam transporting passengers destined mainly for the hotel and casino. DoD also utilizes this airport.

3. Rota International Airport: Rota International Airport hosts primarily inter-island traffic from Saipan and Guam. An average of 18 aircraft operations/day occurred in FY 2007-2008, 72% commuter and 27% commercial. In FY 2005-2006, a total of 6,550 aircraft operations averaging 17/day ranged from 94% air taxi to 4% general aviation. The airport can accommodate aircraft with capacities of up to 39 passengers. The airport is equipped for nighttime operations. U.S. Immigration (conducted by CBP) and CNMI Customs and Quarantine services are available during scheduled aircraft operations and on prior arrangements with field supervisors. Airlines operating include Freedom Air, Cape Air, and Arctic Circle Air Company. DoD also utilizes this airport.

b. Sea

1. Port of Saipan: The commercial seaport has 2,600 linear feet of berthing space and a 22-acre container yard. The channel, turning basin, and berthing areas have been widened and deepened to a uniform -40 feet in order to accommodate medium to deep draft vessels into port. The port has two fuel storage facilities and shares space with a bulk cement company, three freight forwarding companies and three shipping agents. Sunset Cruises, a private concession, also utilizes the port. The U.S. Coast Guard recently assisted with improved navigational aids and repositioned harbor buoys to mark the safest route into port. There is a quarantine zone established at the Saipan seaport which is enclosed in a snake proof barrier where suspect materials including multiple sea containers can be placed until appropriately investigated.
2. Port of Rota: One stevedoring company is available and two storage companies. Quarantine, Customs, and Immigration services are also available at the seaport. The port has sixteen 22-foot Boat Slips.
3. Port of Tinian: There are two stevedoring companies available at the Tinian harbor and a bulk fuel plant operated by Mobil Oil. Three finger piers are available for berthing including a small boat ramp. The port has a quarantine area enclosed with a snake repellent barrier.

State of Hawaii

Elevations range from sea level to over 4,000 m (Loope and Mueller-Dombois 1989). The climate is tropical at sea level, although freezing conditions occasionally occur at high elevations (Juvik and Juvik 1998). Mean monthly temperatures in Honolulu range from 23° C (73° F) in January to 28° C (82° F) in August, and mean annual precipitation in Hawaii ranges from 38 to 1,016 cm (15 to 400 inches) (Juvik and Juvik 1998). The major islands of Hawaii have a wide diversity of inland and coastal aquatic habitats, including about 400 reservoirs and other artificial impoundments, 360 perennial streams, and 30 stream-mouth estuaries, as well as many irrigation ditches, a few natural lakes, and numerous fresh and saline wetlands (Maciolek 1984; Yamamoto and Tagawa 2000). Parham et al. (2008) provided detailed information about all of Hawaii's watersheds, including distributions of nonindigenous species. Streams in Hawaii tend to be steep with widely-varying flow rates.

1. Location: The Hawaiian archipelago is a series of volcanic islands in the central Pacific Ocean between latitudes 18°55' and 28°27'N and longitudes 154°48' and 178°22'W. The island group is over 3,000 km (1,864 mi) from the nearest continent.
2. Number of islands: There are eight major high islands
3. Size: The eight major high islands have a total land area of 16,500 km²

The Hawaiian archipelago comprises eight main, or high, islands and a series of leeward atolls, banks, reefs, and shoals, extending southeast to northwest for about 2,400 kilometers (km) (1,491 miles) in the north Pacific Ocean, from approximately 19° to 28° north latitude (Loope 1998) (Figure A-3).

Figure A-3: The Hawaiian Archipelago



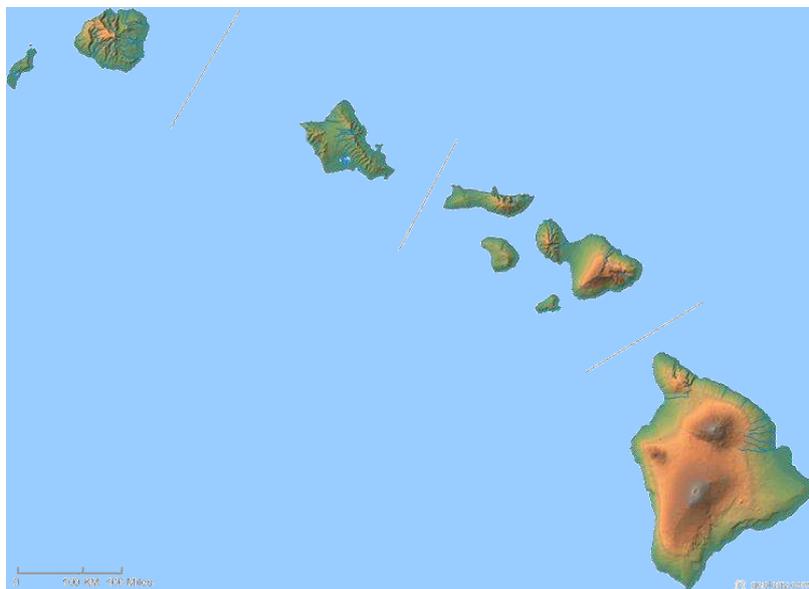
Source: Loope 1998

Hawaii's agreeable climate derives from its location mainly within the tropics (Giambelluca and Schroeder 1998). The annual variation in mean monthly temperatures is only about 5°C, and the length of the daylight period between the shortest and longest days of the year varies only by about 2.5 hours. Only two seasons generally are recognized in the state, the warm season (summer), extending from

about May through September, and a cooler and wetter season (winter), from October to April. Average annual rainfall ranges from 250 millimeters (mm) to 11,300 mm; the summit of Mt. Waialeale on the island of Kauai is one of the wettest places on Earth. Although generally equable, climate exhibits substantial spatial variability due to the influence of the islands' mountainous topography. Rainfall, solar radiation, temperature, humidity, and wind all may show spectacular differences over short distances (Giambelluca and Schroeder 1998). Changes in climate are particularly evident along elevation gradients where temperatures may dip below freezing on the highest mountain peaks. The varied topography and climate have been major influences on the high rates of speciation and resulting diversity within the Hawaiian biota (Peck et al. 1999; Price 2004).

As of 2006, the State of Hawaii (16,635 km² in land area; [USCB 2006]) had a population of 1,285,498 (HDBEDT 2007). This equates to an average density of 77 persons per km². Figure A-4 shows the State of Hawaii with counties demarcated, from upper left to lower right: Kauai County (comprising the islands of Kauai and Niihau), City and County of Honolulu (Oahu and the northwestern Hawaiian Islands excluding Midway), Maui County (Maui, Molokai, Lanai, and Kahoolawe), and Hawaii County (Hawaii Island) (HDBEDT 2007). The majority of residents (75% or more) lives on the island of Oahu (Schmitt 1998), at an average density of about 585 persons per km². In general, Hawaii residents exhibit educational levels, family incomes, and employment rates above the national average, while experiencing exceptionally high costs of living (Schmitt 1998).

Figure A-4: The Eight Main Islands of the State of Hawaii



Source: Modified from: <http://geology.com/state-map/hawaii.shtml>

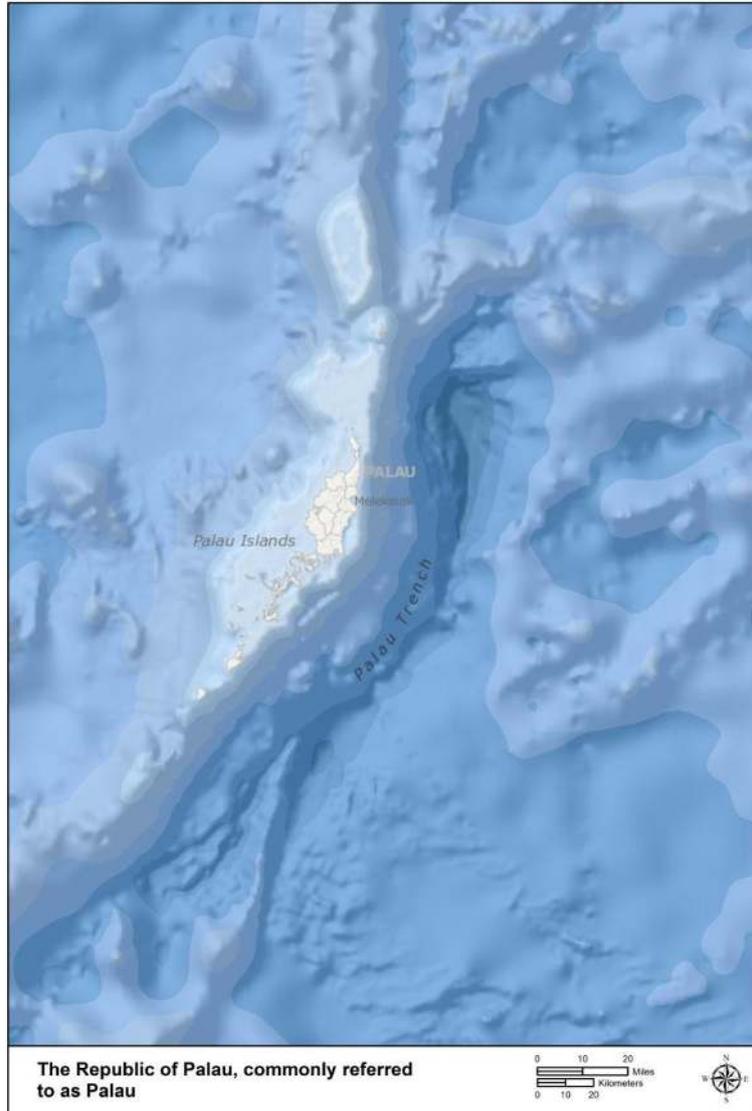
Gross state product in 2005 was \$53.7 billion (HDBEDT 2007). The top three contributors are federal government expenditures (\$12.2 billion in 2004, of which defense spending contributed \$4.8 billion), tourism (\$11.9 billion in 2005), and agriculture (\$516.1 million in 2004).

During the first half of the twentieth century, agriculture dominated the economy in Hawaii, and was itself dominated by sugarcane and pineapple production; however, with the closing of several plantations in recent years, diversified agriculture has gained in importance (Kelly 1998a). The state's agriculture can be divided into three sectors: traditional plantation crops (pineapple and sugarcane) produced for export; commodities, such as vegetables, eggs, and milk, produced for local consumption; and newer export crops, such as macadamia nuts, flowers, and nursery stock. Although more than two-thirds of the food supply is imported, Hawaii is self- or near-self-sufficient in the production of certain commodities (Kelly 1998a). All of the papaya and most of the pineapple consumed in the state is grown locally, as are most of the head cabbage, Chinese cabbage, green onions, and watermelons. Fewer than half of the bananas, tomatoes, pork and other meats, onions, lettuce, and carrots consumed are produced in Hawaii.

Republic of Palau

The islands of Palau are within the western portion of the Caroline Islands (Figure A-5). Much of the information summarized below is taken from van der Brug (1984c), Scott (1993), Crombie and Pregill (1999), and Hein et al. (2005). The islands of Palau range in size from very small islets to quite large islands, with a total land area of only about 494 km² (Scott 1993; Crombie and Pregill 1999). Of the islands in the chain, only 12 are greater than 1 km² in land area (Steadman 2006). Babeldaob, with an area of about 396 km², approximately 80% of Palau's total land area, is the largest island in Palau and one of the largest in the entire western Pacific. A few of the other larger islands of Palau, all dwarfed by Babeldaob, include Koror (9.3 km²), Arakabesang (2.3 km²), and Malakal (0.8 km²). The island of Koror and its major town (also known as Koror) contains the largest proportion of inhabitants and is the commercial center of the republic. The highest point is Mount Ngerchelchuus on the northern part of Babeldaob Island, cited as ranging anywhere from about 242 m to 287 m (794 ft. to 941 ft.) in elevation (Crombie and Pregill 1999; Hein et al. 2005). The Palau Islands are physiographically diverse, with various areas categorized as volcanic, high limestone, low platform, reef, or atoll. Some islands (e.g., Koror, Peleliu, and Angaur) contain multiple physiographic areas. The northern group of larger islands form a dissected volcanic plateau characterized by rolling uplands, sharp ridges and cliffs, flat alluvial areas, and extensive coastal mangroves. Most of the Palau Islands are coralline limestone ridges covered by dense tropical vegetation. The climate within the archipelago is warm and humid; mean annual temperature is about 27.6°C (81.7°F) and average annual rainfall is about 376 cm (148 inches) per year (van der Brug 1984c). The wettest months are from July to October and the driest months are from December to April when northeast trade winds prevail. Although Palau lies outside the main paths of severe typhoons, the islands occasionally receive strong tropical storms. Most visitors to Palau are from Southeast Asia.

Figure A-5: The Republic of Palau



Summary details of the Republic of Palau:

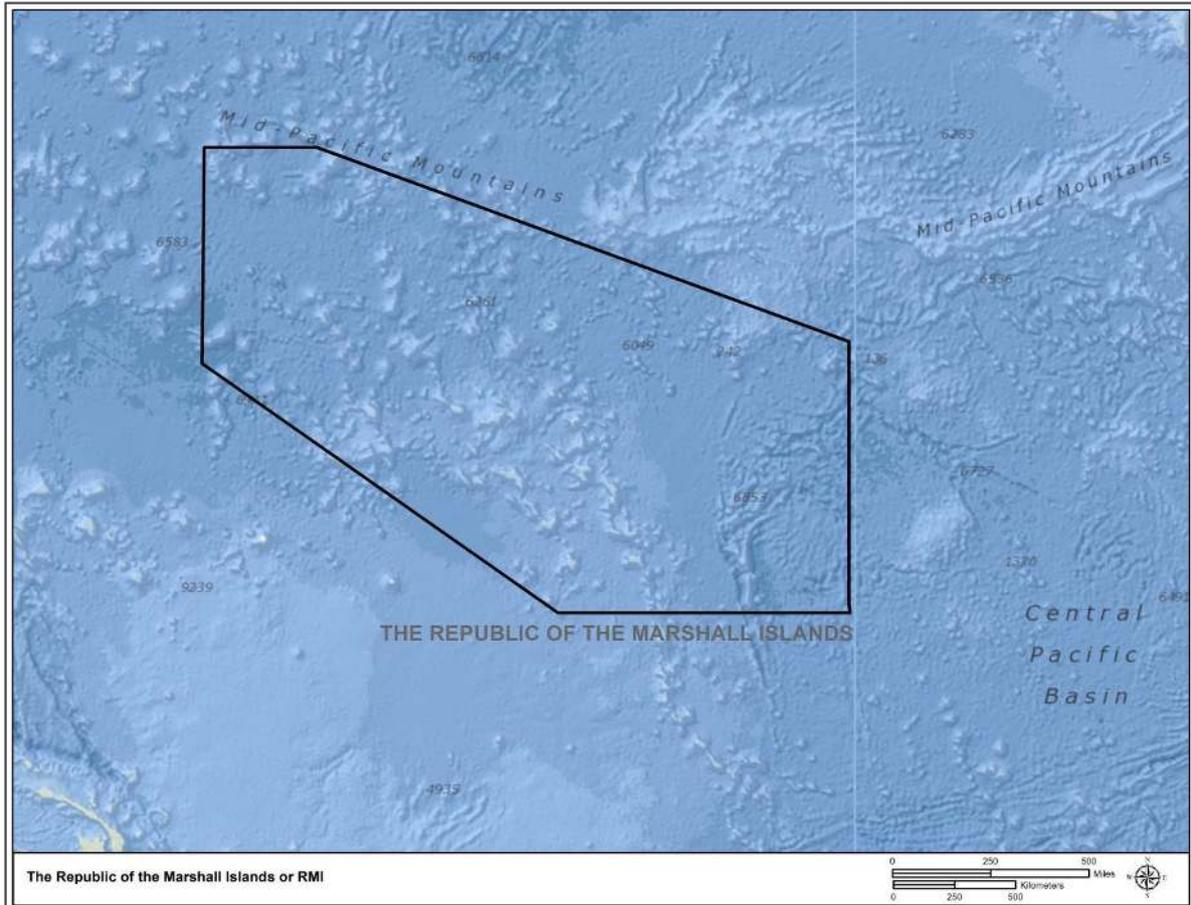
1. Location: The Republic of Palau extends across nearly 240 km (150 mi) in western Micronesia between latitude 6°53' to 8°12'N and longitude 134°07' to 134°44'E. It is located about 770 km (480 mi) north of New Guinea, 800 km (500 mi) east of the Philippines, and 1,135 km (700 mi) southwest of Guam.
2. Number of islands: 250+ (approximately 200 of these are the uninhabited rock islands)

- a. Koror
 - b. Barbeldaob
 - c. Angaur
 - d. Peleliu
 - e. Kayangel
 - f. Rock Islands
 - g. Southwest Islands
3. Size: 458 km²
 4. Population: approximately 21,000 spread across 16 states with more than half of the population living in the state of Koror
 5. Main economic drivers: Tourism, agriculture, and fisheries
 6. Examples of native species that are imperiled: Hawksbill Sea Turtle, Dugong (*Dugong dugon*), Micronesian Megapode, Saltwater Crocodile (*Crocodylus porosus*), Rock Island Palm (*Gulubia palauensis*), Palau Palm (*Ponapea palauensis*) (IUCN listed species)
 7. Examples of established IAS of concern: Long-tailed macaque monkey (*Macaca fascicularis*), Tilapia (*Oreochromis mossambicus*), Mikania (*Mikania micrantha*), Cogon grass (*Imperata cylindrica*), Philippine Fruit Fly (*Bactrocera philippinensis*), Praxelis (*Praxelis clematidea*), Water Hyacinth (*Eichornia crassipes*), Singapore ant (*Monomorium destructor*), Giant reed (*Arundo donax*), Cycad scale (*Aulacaspis yasumatsui*), Rats – (*Rattus spp.* 3 species) (PNISC 2013)
 8. Examples of IAS of significant concern of establishing: Brown Treesnake, Little Fire Ant, Coqui Frog (*Eleutherodactylus coqui*), Red Imported Fire Ant (*Solenopsis invicta*), Other tilapia species, and hybrids, Other frogs, Ivy Gourd (*Coccinia grandis*) (PNISC 2013)
 9. Import examples: electronic parts, cars and beverages (Japan, Philippines, China, South Korea, Australia) and Milkfish (*Chanos chanos*) fry (Arthur et al. 2012) imported from Taiwan POC
 10. Export examples: Marine products (93%) to Japan (94%)
 11. Ports
 - a. Air
 1. Palau International Airport on the island of Barbeldaob has international flights to and from various counties including: Guam (USA), Yap (FSM), Manila (Philippines), Seoul (South Korea), Taipei, and Narita (Japan). DoD also utilizes this airport.
 - b. Sea
 1. Malakal Harbor, Malakal Islands is the main seaport

Republic of the Marshall Islands

The Republic of the Marshall Islands is composed of a large number of islands on the western side of Micronesia (Figure A-6). The Marshall Islands are bordered to the east by the Federated States of Micronesia, to the north by Wake Island, and to the south Kiribati and Nauru.

Figure A-6: The Republic of the Marshall Islands



Summary details of the Republic of the Marshall Islands:

1. Number of islands: 1156 islands spread out within 29 coral atolls and 5 isolated islands
 - a. Majuro
 - b. Ebeye
 - c. Arno
 - d. Kwajalein

- e. Other islands
- 2. Size: 181 km²
- 3. Population: 68,000 (2009 UN estimate)
- 4. Main economic drivers: Service, fisheries, and agriculture
- 5. Examples of native species that are imperiled: Hawksbill Sea Turtle, Leatherback Sea Turtle, Green Sea Turtle, Loggerhead Sea Turtle, Pacific Ridley Sea Turtle (*Lepidochelys olivacea*), Ratak Micronesian Pigeon (*Ducula oceanica ratakensis*), various cetaceans (IUCN listed species, CITES and/or RMI listed species)
- 6. Examples of established IAS of concern: Siam Weed (*Chromolaena odorata*), Merremia (*Merremia peltata*), Mile-a-minute Vine (*Mikania micrantha*), Ivy Gourd (*Coccinia grandis*), Rats (*Rattus* spp.), Feral Pigeon (*Columba livia*), Red-vented Bulbul (*Pycnonotus cafer*)
- 7. Examples of IAS of significant concern of establishing: Coconut Rhinoceros Beetle, Brown Treesnake
- 8. Import examples
 - a. Giant Clam (for export to the US) imported from the FSM (Arthur et al. 2012)
 - b. Coral (for export to the US) imported from the FSM (Arthur et al. 2012)
- 9. Export examples: Copra oil, Copra, Frozen fish
 - 1. Aquarium fish (US, Taiwan POC, China, Japan, Korea) (Arthur et al. 2012)
 - 2. Coral (US)
 - 3. Giant clams (US)
- 10. Ports
 - a. Air (official ports of entry are listed, other minor airstrips exist)
 - 1. Amata Kabua International Airport, Majuro: The airport is capable of handling all propeller driven aircrafts, turbo props, business jets and small to medium size jet aircraft (e.g. Boeing 737, Boeing 727) and Boeing 767s. In 2003 the Republic of the Marshall Islands port authority took over the management of the airport from the Marshall Islands Airport Authority. Three airlines utilize this airport: United Airlines, Air Marshall Islands, and Our Airline. Japan Airlines also occasionally runs charter flights to Majuro direct from Tokyo. Air Marshall Islands provides links to the following islands: Airok, Aur, South Tarawa, Ebon, Enejit, Jaluit, Jen, Kaben, Kili, Kwajalein, Majkin, Maloelap, Mejit, Mili, Namdrik, Utirik, and Wotje. It is not clear how often flights take place nor what types of materials may be moving around the Marshall Islands via these linkages, but there is definite potential that IAS could be transported and internal mechanisms should be considered to reduce this potential. With the opening of Our Airline, Micronesia now (again) has direct air linkages with several South Pacific locations via flights from Majuro. Destinations with Our Airline from Majuro include: Fiji, Brisbane, Nauru, and Tarawa. Both passengers and air cargo are moved between Majuro and these destinations via multiple flights per week. United Airlines connects Majuro directly to both Hawaii and Kwajalein and indirectly to other destinations beyond these 2 locations. There are daily United Airline flights which transport both passengers and air cargo.
 - 2. The Bucholz Army Airfield: This U.S. Army airfield is located on Kwajalein Island. The airport is available to civilians through Air Marshall Islands and United Airlines. All civilian and military flights into Kwajalein require prior 24 hour approval. Kwajalein Island is the southernmost and largest island in Kwajalein Atoll. The Kwajalein airfield is 267 miles (430 kilometers) west of Majuro. The atoll lies in the

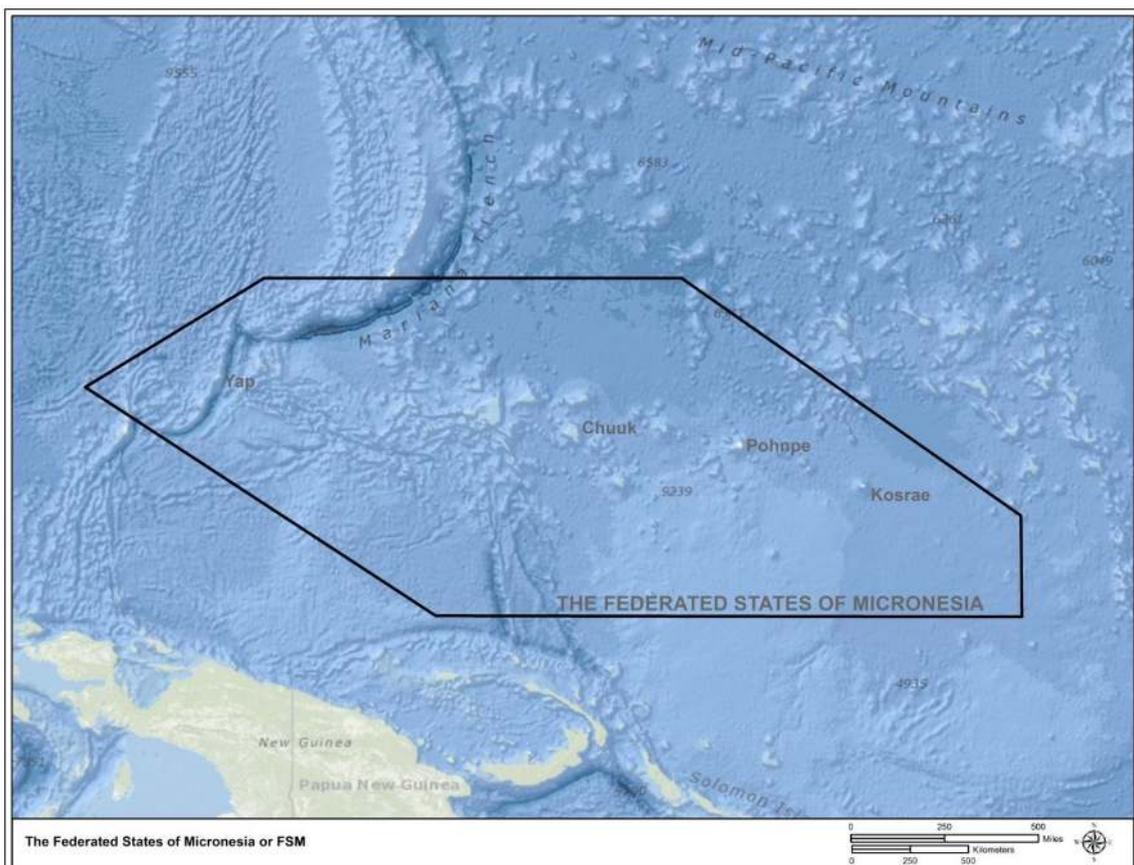
Ralik Chain and is 2,100 nautical miles (3900 kilometers) south west of Honolulu, Hawaii.

- b. Sea (official ports of entry are listed, other anchorages also exist)
 - 1. Port of Majuro
 - 2. Port of Kwajalein

Federated States of Micronesia

The FSM comprises a vast region of over 600 islands spanning a distance of about 2,700 km (1,678 mi). It is located within that part of Micronesia and the western Pacific known as the Caroline Islands, just north of the equator and north-northwest of New Guinea (Figure A-7). The FSM is an independent island nation that includes four states, three located in the eastern part of the Caroline Islands (Chuuk, Pohnpei and Kosrae) and one (Yap) in the western part of the Caroline Islands. Most visitors to FSM are from the United States (43%), Japan (16%), and Europe (13%). IAS of concern already established in the FSM include: Mile-a-Minute (*Mikania micrantha*), Cane Toad (*Rhinella marina*), various rat species (*Ratus* spp.), feral pigs (*Sus scrofa*) and feral cats (*Felis catus*) (FSM NBSAP 2002). Main imports are: food and beverages (topping the list were rice, poultry meat, canned fish and beer) (30% of total imports in 2005). Main exports are: offshore fish (91% total exports in 2005), reef fish, and betelnut. Japan and Guam are the two main recipients of exports. On a smaller scale, the FSM also exports coral, aquarium fish, *Tridacna* spp. (to Europe), and sponges (to New Zealand) (Arthur et al. 2012). Imports include: *Tridacna* spp. from Palau and the RMI.

Figure A-7: The Federated States of Micronesia



Summary details of the four states of the FSM:

a. Chuuk State (Figure A-8)

Mean annual air temperature in Chuuk State is about 27°C (81°F) and varies little throughout the year. Annual rainfall averages about 356 cm (140 inches) per year, ranging from about 254-457 cm (100-180 inches) per year for the Chuuk Island group. Droughts are common; rainfall from January through March is about half that of the remainder of the year (Hamlin and Takasaki 1996).

1. Location: The islands of Chuuk State are located between latitude 4° to 10°N and longitude 148° to 154°E.
2. Number of islands: 19 high volcanic islands and about 65 smaller coralline islands divided into five major island groups: Chuuk, Western, Namonweito, Hall, and Mortlock (Hamlin and Takasaki 1996).
3. Size: 91 km² (van der Brug 1983a). The volcanic islands comprise about 97% of the total land area (van der Brug 1983a).
4. Population: 48,651
5. Ports
 - a. Air (official ports of entry are listed, other minor airstrips may also exist)
 1. Chuuk International Airport
 2. Satowan Airstrip
 3. Ta Airstrip
 - b. Sea (official ports of entry are listed, other anchorages also exist)
 1. Weno Anchorage: This is the main seaport for the state of Chuuk.
 2. Satowan Anchorage
 - c. Post office
 1. Weno

b. Kosrae State (Figure A-9)

The summit of Mount Finkol (Mt. Crozer), elevation 629 m (2,065 ft.), is the highest point of the Kosrae island, and one of the highest peaks in the western Pacific (van der Brug 1984a). Mean annual air temperature near the coast is about 27°C (81°F) and fluctuates relatively little throughout the year. Annual rainfall is about 508 cm (200 inches) per year near the coast and as high as 571 cm (225 inches) inland, although the latter value was an estimate based on drainage runoff calculations rather than actual rainfall stations (van der Brug 1984a).

1. Location: Kosrae is the easternmost of the Caroline Islands, situated near the equator between latitude 5°16' to 5°23'N and longitude 162°55' to 163°03'E
2. Number of islands: 1
3. Size: 110 km²
4. Population: 6616 (2010)
5. Main trade partners: USA, Japan
6. Main imports: food, building material and equipment, fuel
7. Main exports: marine products, Kosrae lime
8. Ports
 - a. Air
 1. Kosrae International Airport
 - b. Sea
 1. Lelu harbor

- 2. Okat harbor
- c. Post office
 - 1. Tofol
- c. Pohnpei State (Figure A-10)

Pohnpei Island is the third largest island in Micronesia and contains the highest peaks which include Mt. Nahna Laud, at about 782 m (2,565 ft.) in elevation and Nghnjeni Peak, at about 768 m (2,519 ft.) in elevation (van der Brug 1984b). Pohnpei Island is circular in shape, and the deeply dissected mountainous interior is dome shaped, with valleys and steep ridges extending radially to the coasts. Monthly air temperatures on Pohnpei Island are similar to those on Kosrae and also vary relatively little throughout the year. Pohnpei receives extensive rainfall that varies considerably with topography; mean annual rainfall in coastal areas and at the town of Kolonia is about 305-482 cm (120-190 inches). The greatest mean annual rainfall occurs in the interior highland rainforest with about 762-864 cm (300-340 inches) (van der Brug 1984b; Landers and Khosrowpanah 2004).

 - 1. Location: between latitude 6°47' to 7°01'N and longitude 158°06' to 158°22'E.
 - 2. Number of islands: Pohnpei State consists of the volcanic, high island of Pohnpei and six smaller atolls.
 - 3. Size: 344 km² (Pohnpei island makes up most of the state's territory at 334 km²)
 - 4. Population: 35,981 (2010 census)
 - 5. Ports
 - a. Air (official ports of entry are listed, other minor airstrips may also exist)
 - 1. Pohnpei International Airport
 - 2. Kapingamarangi airstrip
 - 3. Sapwuahfik airstrip
 - b. Sea (official ports of entry are listed, other anchorages also exist)
 - 1. Mesenieng Harbor
 - 2. Temwem Harbor
 - 3. Kapingamarangi anchorage
 - c. Post offices
 - 1. Kolonia
 - 2. Palikir
- d. Yap State (Figure A-11)

Maximum elevation is about 183 m (600 ft.) on Yap Island and about 76 m (250 ft.) on the other islands. Mean annual air temperatures are about 27°C (81°F), with a maximum difference between monthly extremes of about 2.6°C (7.1°F) (van der Brug 1983b). Annual rainfall totals about 310 cm (122 inches) per year and on the islands of Yap and Tomil-Gagil about half of the yearly rainfall drains directly to the ocean.

 - 1. Location: between latitude 9°27' to 9°38'N and longitude 138°03' to 138°12'E.
 - 2. Number of islands: Yap proper is composed of four major islands which include Yap, Tomil-Gagil, Map, and Rumung. In addition there are 14 outer atolls reaching to the east and south for about 800 km.
 - 3. Size: 100 km² (Yap proper encompasses approximately 98 km²)
 - 4. Population: 6300 (2003)
 - 5. Ports
 - a. Air (official ports of entry are listed, other minor airstrips also exist)
 - 1. Yap International Airport

- 2. Ulithi airstrip
- 3. Woleai airstrip
- b. Sea (official ports of entry are listed, other anchorages also exist)
 - 1. Tomil Harbor
 - 2. Ulithi anchorage
 - 3. Woleai anchorage
- c. Post office
 - 1. Colonia

Figure A-8: Chuuk State



Figure A-9: Kosrae State



Figure A-10: Pohnpei State

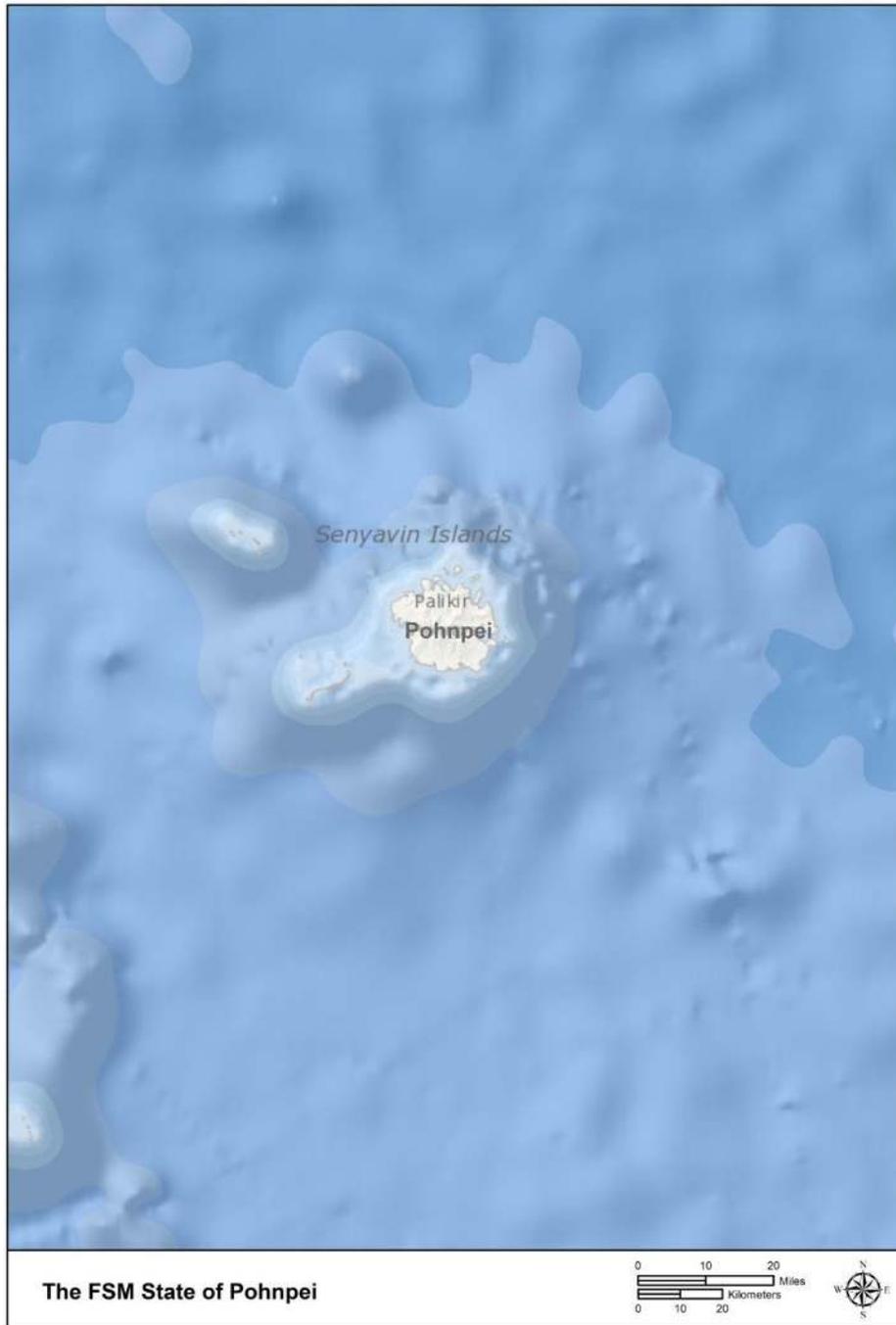
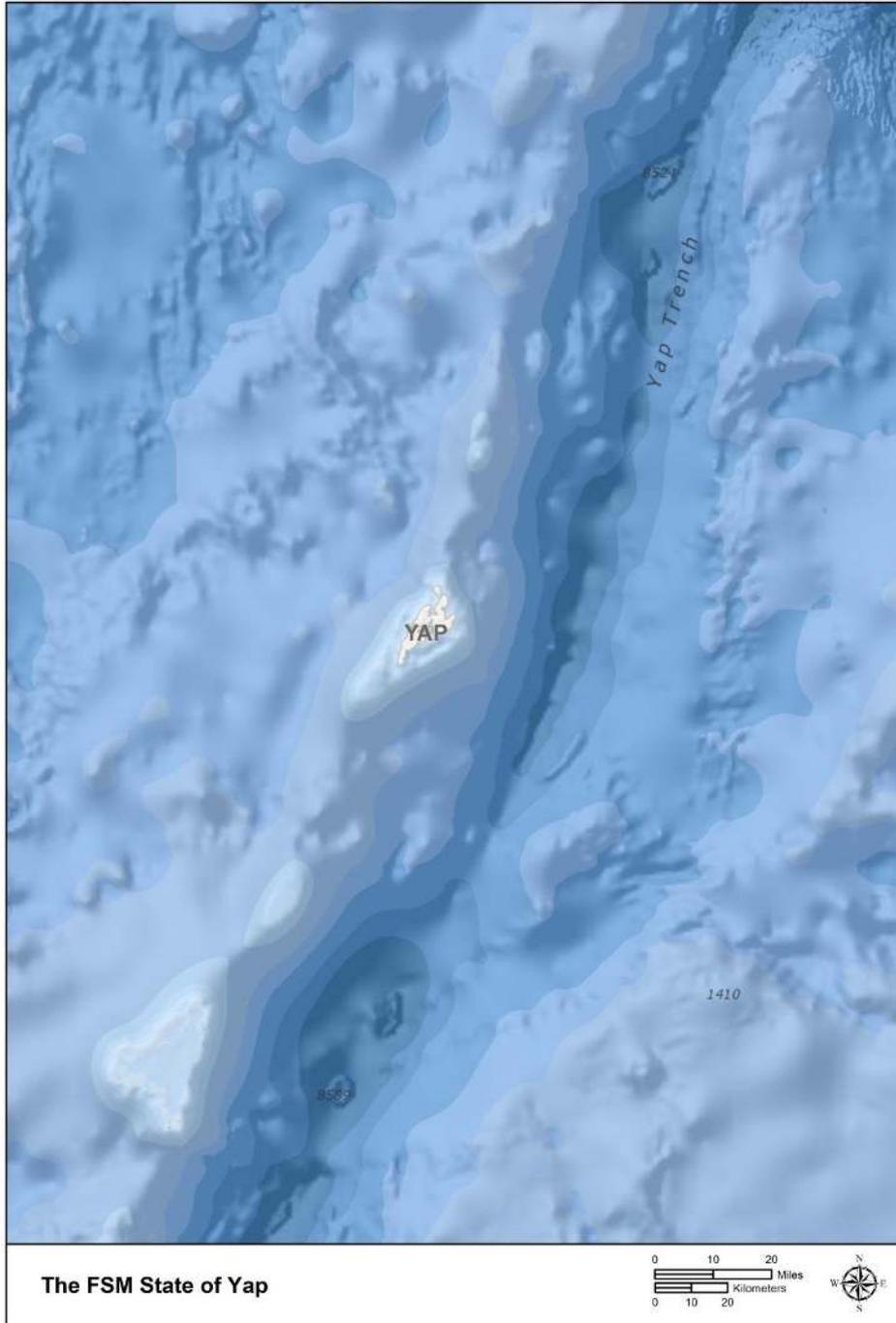


Figure A-11: Yap State



Attachment B: Existing Pertinent Rules and Regulations

The independent nations of the FSM, RMI and Palau have each entered a compact of Free Association with the United States. They are therefore not bound by the U.S. Constitution, but are subject to the National Environmental Policy Act, which was enacted prior to declarations of independence. National invasive species action plans have been formed by each of these countries (Pacific Invasives Initiative 2010).

A. Global Biosecurity Directives, Statutes and Regulations

The global concern about biological invasions is reflected by a diverse number of international agreements and strategies to minimize risks associated with invasions. These global agreements and strategies include, but are likely not limited to the following:

- The International Plant Protection Convention (1951, revision 1987; 1997 FAO Conference)
- The United Nations Convention of the Law of the Sea (1982, Article 196(1))
- The European Inland Fisheries Advisory Commission (EIFAC) Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms (1988)
- The Convention on Biological Diversity (1992, Article 8; see also Global Biodiversity Outlook 3 2010, www.cbd.int/GBO3)
- The World Trade Organization (Agreement on the Application of Sanitary and Phytosanitary Measures, 1995)
- The International Maritime Organization (IMO) (International Convention for the Control and Management of Ships' Ballast Water and Sediment, 2004)
- The International Council for the Exploration of the Sea (ICES) Code of Practice on the Introductions and Transfers of Marine Organisms (2004)
- The Convention on Biological Diversity's "Consideration for implementing international standards and codes of conduct in national invasive species strategies and plans" (2011): <http://www.cbd.int/invasive/doc/cbd-invasive-species-strategies-en.pdf>
- The International World Organization for Animal Health (Fifth Strategic Plan, 2011-2015)
- The United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries
- The FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents

- The FAO/Network of Aquaculture Centers in Asia-Pacific (NACA) Asia Regional Guidelines on Fish Health
- The Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES)
- The Global Convention on Migratory Species
- The Ramsar Convention on Wetlands, resolution VII.14: Invasive Species and Wetlands.
http://www.ramsar.org/cda/en/ramsar-documents-resol-resolution-vii-14/main/ramsar/1-31-107%5E20830_4000_0

As an example of how these international agreements work, trade in certain live organisms is regulated at the international level by CITES, to which the US and Palau are signatories, and whose conventions are followed in the FSM and the RMI. With the goal of protecting endangered or threatened species, CITES restricts the trade of organisms appearing in its three appendices. Of relevance to the region, giant clams (those in the Family Tridacnidae) and many coral species are CITES species, and are thus subject to specific restrictions. By working to protect CITES listed species, it is possible to address numerous invasive species concerns.

It is important to note that currently there are no international conventions specifically prohibiting trade of organisms considered to be non-native, invasive, or potentially invasive species. Trade in live marine organisms and plants/plant products are both known major vectors for the transfer of non-native species around the globe. Trade in other organisms such as reptiles is also likely an important contributor of both direct and indirect movement of non-native species.

B. United States Biosecurity Directives, Statutes, Regulations, and Guidance

A patchwork of U.S. Federal laws and regulations address invasive species. There is no one agency or office with sole leadership on, or authority for, invasive species within the United States. While many invasive plant issues fall under the purview of the U.S. Department of Agriculture, IAPS are also covered by agencies with additional oversight of aquatic invasive species. U.S. federal and local government mandates and regulations include guidance promulgated by USDA-APHIS, EPA, USFWS, and DoD. The U.S. does not have a specific biosecurity department or agency.

- Lacey Act of 1900: the Lacey act combats trafficking in “illegal” wildlife, fish, and plants.
- Animal Damage and Control Act: 7 U.S.C. §§ 426-426c, 2 March 1931, as amended in 1987 and 1991. This Act gives the Secretary of Agriculture broad authority to investigate and control certain predatory or wild animals and nuisance mammal and bird species.
- National Environmental Policy Act (NEPA) of 1969 [as amended 42 U.S.C. 4321 et seq.]:
<http://www.nepa.gov/jm/>

- Endangered Species Act (ESA) of 1973 [as amended 16 U.S.C. 1531 et. seq.] requires U.S. federal agencies to not jeopardize the continued existence of any listed threatened or endangered species or adversely affect critical habitat for such species. The purpose of the ESA is to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by USFWS and the National Marine Fisheries Service.
- Federal Noxious Weed Act of 1974 (7 U.S.C. 2814) although the Plant Protection Act (PPA) superseded and repealed most of the Federal Noxious Weed Act of 1974 (FNWA), it left intact section 15, "management of undesirable plants on federal lands" (7 U.S.C. 2814). Section 15 of the FNWA requires U.S. federal land management agencies to develop and establish a management program for control of undesirable plants that are classified under state or federal law as undesirable, noxious, harmful, injurious, or poisonous, on federal lands under the agency's jurisdiction (7 U.S.C. 2814(a)). Based on authorities established in the PPA, USDA-APHIS is the primary agency responsible for preventing introductions of invasive species into the U.S. and its territories. The APHIS plant protection and quarantine (PPQ) program is responsible for safeguarding agricultural and natural resources by implementing plant importation regulations and permitting, and operating the pest detection and the federal noxious weed programs.
- Executive Order (EO) 12114 – Environmental effects abroad of major Federal actions (January 4, 1979): the purpose of this EO is to enable responsible officials of federal agencies having ultimate responsibility for authorizing and approving actions encompassed by this EO to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions.
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, revised and renamed the National Invasive Species Act in 1996 (as amended, p.l. 106–580, 29 December 2000) addresses unintentional introductions of aquatic invasive species. The act established the aquatic nuisance species task force under the leadership of the USFWS and NOAA. The act also promoted the development and implementation of state plans for managing aquatic species as well as regional panels (Guam and Hawaii are part of the western regional panel).
- Alien Species Prevention Enforcement Act of 1992: section 631 of the Treasury, Postal Service and General Government appropriations for fiscal year 1993, Public Law 102-393, 6 October 1992, requires the Secretary of Agriculture to operate a program to protect the state of Hawaii from the introduction of prohibited plants, plant pests, and injurious animals that may be contained in the mail.
- Wild Bird Conservation Act (WBCA) of 1992: importation of exotic birds into the U.S. must comply with APHIS and USFWS requirements. Certain exotic birds are protected by CITES and the WBCA.

- Executive Order 13112 (3 February 1999) created the National Invasive Species Council (NISC) and directed U.S. federal agencies to: prevent the introduction of invasive species; detect and respond rapidly to and control invasive species in a cost-effective and environmentally sound manner; restore native species and habitat conditions in ecosystems that have been invaded; promote public education on invasive species and the means to address them; and to not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to prescribed guidelines, the benefits of such actions clearly outweigh the potential harm caused by invasive species and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.
- Plant Protection Act (PPA) of 2000 consolidates the authorities formerly based within the Plant Quarantine Act, Federal Plant Pest Act (7 U.S.C. 150a et seq.), Federal Noxious Weed Act of 1974 (7 U.S.C. 2801 et seq.), and others (7 U.S.C. §7701 et seq.). The PPA allows the U.S. Secretary of Agriculture to restrict or prohibit the importation, entry, exportation or movement in interstate commerce, including Hawaii, Guam and the CNMI, of any plant, plant product, or noxious weeds. Plant products include all flowers, fruits, vegetables, roots, bulbs, seeds, or other plant parts. Noxious weeds are defined broadly to include any plant that may cause harm to “crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the U.S., the public health, or the environment” (7 U.S.C. 7702). Civil and criminal penalties for violations of the PPA serve as a deterrent to individuals and businesses interested in cultivating or transporting invasive plant species and other invasive organisms.
- Animal Health Protection Act (AHPA) of 2002: the AHPA is purposed to prevent, detect, control, and eradicate diseases and pests of animals in efforts to protect animal health, the health and welfare of the people of the United States, the economic interest of the livestock and related industries of the U.S., the environment of the U.S., and the interstate and foreign commerce of the U.S. in animals and other articles (7 U.S.C. § 8301 et seq.).
- Animal Welfare Act (AWA): a modification to AWA, the Animal Fighting Enforcement Act of 2007, made interstate commerce of a bird for the purpose of participation in a fighting venture illegal, regardless of the law in the destination state, including Guam.
- Implementing recommendations of the 9/11 commission act of 2007: the implementing recommendations of the 9/11 commission act of 2007 (public law 110-53) implements some of the recommendations of the 9/11 commission including mandating 100% inspection of all air and sea cargo entering the U.S., and a new method of redistributing antiterrorism funding.
- National Defense Authorization Act of 2008, public law 110-181, section 314: requires prohibiting the transport and spread of Brown Treesnake via aircraft.

- USCG Regulations 33 CFR Part 151 and 46 CFR Part 162 will enter into force on 21 June 2012 and apply to all new ships constructed on or after December 2013 as well as to existing ships from 2014 onwards at certain time intervals. The USCG is amending its ballast water management regulations by establishing a standard for the allowable concentration of living organisms in ships' ballast water discharged in U.S. waters. The USCG is also amending its engineering equipment regulations by establishing an approval process for ballast water management systems. Ships calling at U.S. ports and intending to discharge ballast water must either carry out exchange or treatment, in addition to fouling and sediment management (there are some exceptions to this). The exchange of ballast water will only be allowed until the implementation deadlines for treatment systems. A third option is to use potable water (from the U.S. public water system) and in such case the ballast tanks need to be cleaned and sediments removed beforehand.
- USDA-APHIS plant health regulations (title 7 code of federal regulations): 7 cfr §§ 318.13-9; 318.60; 319; 330.111; 330.400-403.
- USDA-APHIS animal health regulations (title 9 code of federal regulations): 9 cfr §§ 71-89, 92, 93, 93.201, 209, 94.5, 94.6, 95, 166.
- USDA animal product manual: guidelines for regulating the importation of specific animal products and by-products. The manual can be downloaded at: http://www.aphis.usda.gov/import_export/plants/manuals/ports/apm.shtml
- USDA combined animal and plant health risk ratings for countries: USDA-APHIS analysis of relative risks presented from other countries as a result of animal and plant diseases found inside their borders (CPHST, VS-center for epidemiology and animal health, October 2010).
- USDA fruits and vegetables import requirements (FAVIR) online reference: www.aphis.usda.gov/favir/
- USDA-APHIS manual for agricultural clearance: the APHIS manual of agricultural clearance (MAC) provides comprehensive guidance for practices required for safeguarding imported products and articles. Safeguarding is a preventive action for handling, maintaining, or disposing of prohibited or restricted products and articles to maintain cargo control and eliminate the risk of plant and animal pest and disease dissemination. The manual can be downloaded at: http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/mac.pdf
- USDA-APHIS PPQ manuals: guidelines for regulating the importation of specific plants, plant products, and international regulated garbage.

In the U.S., some non-native species are specifically listed and prohibited from importation by the Lacey Act 1900 (for animals) and the Plant Protection Act 2000 (for plants and plant pests). Organisms listed as "injurious wildlife" are prohibited for importation or interstate movement of live

organisms without a federal permit. Organisms listed as “noxious weeds” under the Plant Protection Act are also prohibited for importation into the U.S. or transportation across state boundaries without federal permit. The importation of live organisms into the U.S. for any purpose, including food, pets, bait, and aquaculture is regulated through the USFWS and the USDA for animals and plants (and plant pests), respectively. Importers and exporters are required to have a license to do business, to file a declaration at an official port of entry, and to receive clearance from Customs before these goods can be released. In most cases, they also need to present health certifications from the importing country. In addition to U.S. federal regulations, many states and territories, including Hawaii, Guam and CNMI, have their own regulations regarding live organism imports. In general Hawaii, Guam and the CNMI, as U.S. jurisdictions, must abide by U.S. Federal regulations and requirements.

Enforcement of U.S. live import regulations is carried out by state and federal quarantine inspectors at airports and seaports. On Guam and CNMI, imports of wildlife arriving by air or sea cargo are monitored by USFWS (Guam), U.S. Customs and Border Patrol, Department of Fish and Wildlife (CNMI) and DAWR, with some assistance from NOAA (Guam) when illegal imports of marine life are suspected. Under federal law, U.S. mail cannot be inspected unless there is a reason to suspect that it contains an illegal substance or import, so routine inspections are not carried out on mail arriving into Hawaii, Guam, or CNMI.

All commercial airline baggage is screened by Transportation Security Administration (TSA) agents/airline employees upon departure using X-ray machines on Guam, Saipan, and Hawaii. Inspectors are looking for weapons and other prohibited items, but could potentially find and confiscate live organisms.

Regulatory drivers are in place to prevent the transport of vertebrate species within the U.S., but these regulations are only realized under well-funded, comprehensive enforcement.

Two pertinent regulatory drivers are the National Defense Authorization Act (NDAA), Public Law 110-181, Section 314 that requires prohibiting the transport and spread of Brown Treesnake via aircraft, and the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 that authorizes a cooperative program to control Brown Treesnake outside its historic range. These two regulations if fully implemented could result in the mandatory 100% inspection of vessels and cargo departing Guam.

Enforcement of existing biosecurity regulations may differ across sectors. For example, the military is exempt from biosecurity inspections if such inspections jeopardize national security (e.g., when craft is actively engaged in warfare, cargo is classified, or mission is an emergency situation). Also, within the United States, regulatory drivers have the tendency to differ in level of enforcement by state. This is seen in the implementation of biocontrol where policies can differ vastly in stringency by state, leading to disjointed implementation of the regulation (Messing and Wright 2006). Therefore, monitoring and surveillance of enforcement such as detailed reports, summaries of prosecution of regulation breaches, and corresponding trends of introduction incidences are all

necessary checks and balances to evaluate the efficacy of the upholding of regulations regarding invasive species through enforcement.

Biological Opinions (BOs), resulting from Endangered Species Act consultations, are critical regulatory drivers for the management of species including some IAS such as Brown Treesnake.

C. United States Department of Defense Biosecurity Guidance and Instructions

- Air Force Instruction (AFI) 32-1053 integrated pest management program
- AFI 32-7064 integrated natural resources management
- Air Force Joint Instruction (AFJI) 48-104, quarantine regulations of the armed forces: incorporates regulations to mitigate the risk for introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other transport of the armed forces arriving at or leaving U.S. and foreign ports, installations, or other facilities. The quarantine regulations of the armed forces (QRAF), AFJI 48-104, states that cargo is subject to inspection by a representative of the USDA to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is considered part of the U.S. DoD maintains customs and border clearance policies and procedures for wildlife, agricultural and animal products, pets, plants and plant products.
- Air Force Policy Directive (AFPD) 32-10 installations and facilities
- Armed Forces Pest Management Board (AFPMB) Technical Guide No. 31 (2004): delineation of responsibilities for the military with meeting USDA APHIS requirements for internal and external inspections for terrestrial vertebrate species, insects, and plant species. This guide covers retrograde wash-downs—cleaning and inspection procedures.
- Andersen Air Force Base Integrated Pest Management Plan
- Army Regulation 40-12 quarantine regulation of the armed forces
- COMNAVMAR Instruction 5090.10a: Brown Treesnake control and interdiction plan. This instruction outlines specific responsibilities and establishes policy for coordination and procedures governing the control and interdiction of Brown Treesnake on Navy installations on Guam and during military training within the Commander, U.S. Naval Forces Marianas (COMNAVMAR) Area of Responsibility (AOR).
- DoD Instruction 4150.07 DoD pest management program
- DoD Foreign Clearance Manual 25 January 2012 issued under authority of DoD Directive 4500.54e

- DoD Instruction 4500.9-r defense transportation regulations: (<http://www.transcom.mil/dtr/part-i>)
- DoD Instruction 4715.03 natural resource conservation program
- DoD Directive 5158.04 U.S. Transportation Command (USATRANSCOM)
- DoD memorandum: DoD memorandum outlines Navy personnel with authority to inspect and issue ship sanitation certificates (ship sanitation control exemption certificate and ship sanitation control certificate) for Navy, Army, military sealift command, Coast Guard, and National Oceanic and Atmospheric Administration vessels to provide standard procedures and policy-IAW article 39 of the WHO 2005–certificate (good for 6 months) with section for observed rodent infestations.
- Defense electronic foreign clearance guide (<https://www.fcg.pentagon.mil/fcg/fcg.cfm>)
- DoD SDDC PPCIG 2010 personal property consignment: the DoD personal property consignment instruction guide online system, which provides guidance to military and DoD civilian personnel being assigned to foreign duty stations, states that there are “no restrictions identified” for plant movement into Guam.
- Guam and the CNMI military relocation EIS/OEIS: the Guam and the CNMI military relocation EIS/OEIS provides a description of military relocation plans, schedules, impacts and mitigations.
- MIL-STD-904b: provides guidance on the detection, identification, and prevention of pest infestations.
- Naval supplemental publication number 486, volume 1: Naval policy parallels APHIS requirements for foreign garbage.
- NAVFAC Pacific 2010: master planning process, Navy sustainability summary report
- NAVMED P-5010-8, the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) outlines preventive measures for rodent control on ships, including proper sanitation, pier side inspections, rat guards, illumination and movement restrictions, glue boards, snap traps, and limitations on vessel access points.
- NAVMED p-5052-26: U.S. Navy shipboard pest control manual provides guidance on inspection and de-ratting procedures for ships.
- Naval Base Guam Integrated Pest Management Plan
- OPNAVINST 5090.1D Environmental Readiness Program

- OPNAVINST 6210.2: quarantine regulations of the Navy. This instruction is intended to prevent the introduction and dissemination, domestically or internationally originated, of diseases affecting humans, plants, and animals; prohibited or illegally taken wildlife; arthropod vectors; and pests of health and agricultural importance. USDA APHIS PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases.
- OPNAVINST 6250.4b pest management program
- SECNAVINST 6210.2a afr 161-4, DoD, 1992, section 9: rat guards are used at ports with known rodent infestations
- Senior officer present afloat Pearl Harbor instruction 5000.1g
- Subsistence manual COMDTINST m4061.3c: waste disposal requirements
- USAF 36 WG INSTRUCTION 32-7004 (2006) Brown Tree Snake Management
- USAF 611 CES Wake Island biosecurity plan

D. Territory of Guam Biosecurity Directives, Statutes, and Regulations

- Guam Administrative Rules and Regulations (GARR) Titles 8, 9, and 10: Title 8, division 2-plant industry, chapter 10 provides regulations for food and agriculture and importation of plants and plant products. Title 9, division 1, chapter 1 of the GARR provides regulations regarding the importation of live animals. Section 2 of § 1103 (GARR) states that under no circumstances shall any animal be turned loose at the port, and that hogs and sheep may be confined in temporary pens or crates, cattle and horses may be tied, and dogs and cats shall be confined in crates. GDOA: Title 8 GARR chapter 10; Title 9 GARR 1 §§ 1100-1113, 2101 and 2102, division 1, chapter 1. Title 9 GARR, division 1, chapter 1, § 1109 requires that all cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawaii and New Zealand) must have a certificate from the national chief livestock sanitary officer stating that the animals originated in a state, country, or other political subdivision officially declared free of Surra, animal African Trypanosomiasis, and Leishmaniasis. Title 9 GARR 1 § 1110 of Guam territorial regulations require all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian. Subchapters §§ 2101 and 2102 provide regulations for the importation of pet birds (all birds except poultry).
- Title 5 Guam Code Annotated (GCA) §60108: the importation of pets to Guam is regulated by the Guam Department of Agriculture (GDOA). Title 10 GCA chapter 34 article 3 states that animals imported are to complete a maximum of 120-day confinement in a commercial quarantine facility.

- Guam public law 31-43 establishes the Guam invasive species council (GISC) and states that GISC will develop a Guam invasive species management plan (GISMP). This law also authorizes the Guam Department of Agriculture to establish a Guam Invasive Species Inspection fee. This fee is to support an invasive species coordinator position for Guam and to fund a biosecurity division within the Guam Department of Agriculture. This law and the GISC are to support and update the Guam interagency biosecurity task force work plan originally established 10 November 2009. The Guam invasive species council (GISC) was established in 2005 by executive order no. 2005-13 and enacted into law in 2011 by bill no. 111-31 (COR). The purpose of the GISC is for “providing policy direction, coordination, and planning among government of Guam departments and federal government agencies; to provide local initiatives for the control and eradication of harmful invasive species throughout the island of Guam; and to assist in preventing the introduction of other invasive species that may be potentially harmful to Guam”. The GISC is co-chaired by the director of the GDOA, and the president of UOG. Other members include the directors of GCQA, Department of Administration, Bureau of Statistics and Plans; the Homeland Security advisor; the administrator of the Guam EPA; the executive manager of the Guam International Airport Authority, the general manager of the Port Authority of Guam, and the Guam Visitors Bureau. The GISC will develop an invasive species management plan which shall “detail and recommend performance-oriented goals and objectives and specific measures of success for Government of Guam agency efforts concerning invasive species”. The plan will be updated biennially. Bill no. 111-31 also establishes the Guam invasive species inspection fee and fund which imposes a one dollar per ton fee on all freight brought into Guam. The fees collected will be used to “support efforts to provide inspection, quarantine, and eradication of invasive species contained in freight brought to Guam; support efforts to eradicate invasive species present on Guam by means of a rapid response team; and develop the Guam invasive species management plan and its updates.” Finally, the bill authorizes the Department of Agriculture to “create a biosecurity division to function as its first responders in efforts to address invasive species coming to, and present on, Guam.” **Bill No. 111-31 (Cor) "An Act to Add a New Chapter 70 to Division 6 of Title 5, Guam Code Annotated, Relative to Establishing the Guam Invasive Species Council; to Establishing the Guam Invasive Species Inspection Fee and Fund; and to Authorizing the Department Of Agriculture To Establish A Biosecurity Division"**
- Agricultural inspections and quarantine of cargo in Guam are performed by APHIS PPQ as well as GDOA. The authority to “inspect cargo, stores, quarters, baggage and any other thing” is granted to GDOA according to Title 5 GCA § 61103. Regulations exist for the importation of nursery stock, herbs, rhizomes, seed, leaf, root, fruit, or any other plant-growth or plant-product to Guam (Title 9 GARR 1-§4201). Importation and sale of aquatic plants is limited to a white list, however, this list is not codified in rule or statute. Commercial shipments of aquatic plants are held by GCQA until DAWR can inspect the contents and confirm plants are on the white list. Guam’s Department of Aquatic and Wildlife Resources (DAWR) maintains an informal “white list” of marine and aquatic organisms that can be imported live, including aquarium species and

food species, such as New England lobster (*Homarus americanus*) and Pacific oysters (*Crassostrea gigas*). The white list mainly includes species already present on Guam (native or already established non-natives) and those that have a long history of importation into Guam with no known negative impacts. A few organisms are allowed for import only for Underwater World, Guam's main public aquarium, as the biosecurity and sanitation procedures at the aquarium presumably meet high standards. Permits must be obtained to bring in species on the white list, even small numbers of individuals for personal use. Importers can submit requests for permits to import organisms not on the list; these are reviewed and approved on a case-by-case basis, with the onus on the importer to prove an organism is not harmful. Importers must have a certificate of health from the point of origin for organisms being brought to Guam.

- As a territory of the United States, Guam is subject to Federal regulations that restrict the importation of certain live aquatic animals intended for aquaculture food production. For example, under the injurious wildlife provisions of the Lacey Act (P.L. 97-79 as amended), the USFWS prohibits the importation and interstate transport of certain injurious terrestrial and aquatic animals, including various species of mammals, birds, fish, amphibians, reptiles, mollusks, and crustaceans.
- Any animal found clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites must be returned to the point of origin or destroyed (GARR 2004).

E. State of Hawaii Biosecurity Directives, Statutes, and Regulations

Hawaii has the most extensive and active IAS policies in the Region. Large amounts of cargo move through Hawaii before passing on to other locations including Guam. Materials from foreign countries or U.S. territories are inspected by U.S. Customs, USDA PPQ, or U.S. Fish and Wildlife Service Law Enforcement Division (USFWS - LE). USDA APHIS and PPQ conduct pre-departure agricultural inspections of baggage and cargo leaving Hawaii and heading to the U.S. Mainland or Guam. No agricultural/quarantine inspections are made on cargo leaving the region except in Hawaii.

- Hawaii Department of Agriculture (HDOA) is the sole state agency with responsibility to prevent introductions from the U.S. to ports in Hawaii. The HDOA plant quarantine program is responsible for inspecting domestic cargo and passengers incoming to Hawaii air and sea ports (HRS 150a) (Ikuma et al. 2002). Imported plants are either regulated (require permits, treatments and /or require quarantine, or may be prohibited), restricted (noxious weed list), or allowed entry subject to inspection and clearance (Shluker 2003).
- Hawaii's Department of Agriculture maintains a list of organisms that cannot be brought into the state, including many marine fishes and some species of crabs, octopus, and jellyfish (scyphozoans), as well as a list of conditionally approved and restricted organisms, both of which contain numbers of marine species. An importer must have a permit to import anything on the

list of conditionally approved organisms. Businesses wishing to import organisms on the restricted list must, as a condition of obtaining a permit, undergo a site inspection. Although terrestrial plants, microorganisms, and pathogens appear on the various lists, we could find no lists for macroalgae. The state's rules and lists are available on the state Department of Agriculture's website: <http://hdoa.hawaii.gov/>.

- The Hawaii Division of Aquatic Resources (HDAR) in the Hawaii Department of Land and Natural Resources (HDLNR) is responsible for management of Hawaii's aquatic resources (HRS 187a-2.1). Release of non-native fish or other aquatic life into state waters is prohibited (except for permitted fish stocking) and HDLNR staff may seize, confiscate, or destroy any prohibited or restricted organisms (HRS 187a-6.5). Violation of this statute may result in a petty misdemeanor charge and a fine from \$250 to \$1000 (HRS 187a-13).
- The Hawaii Invasive Species Council (HISC), established in 2003 by HRS 194-2, is co-chaired by the HDLNR and the HDOA. The HISC has five working groups that make recommendations to the council; the prevention working group is chaired by the HDOA and recognizes the need to understand and minimize all pathways for both terrestrial and aquatic species into Hawaii and between Hawaiian islands. Designation of noxious weeds follows criteria set by the HDOA (HRS 152-2). The list of invasive species recognized by the HISC (HAR 4-68) is nearly 20 years old and includes just three freshwater aquatic plants: Buddha Pea (*Aeschynomene indica*), Giant Sensitive Tree (*Mimosa pigra*), and Torpedo Grass (*Panicum repens*) (HAR 4-68). The import or sale of Giant Salvinia (*Salvinia molesta*), Common Salvinia (*Salvinia minima*) and Water Cabbage (*Pistia stratiotes*) plants and propagative material is prohibited by statute (HRS §150a-6.1). The authority to control recognized invasive species, including noxious weeds, on private property is granted through HRS 194-5 to any department that is a member of the HISC.
- The HISC provides policy recommendations, coordination and planning between agencies and initiatives for the control or eradication of potentially harmful invasive species (HRS 194-2). HISC developed the Hawaii invasive species strategy 2008-2013. County-level invasive species committees (ISCs) exist on the Big Island (Hawaii), Kauai, Maui, Molokai and Oahu. County ISCs focus on localized needs for early detection, rapid response and outreach to the general public.
- The Hawaiian Ecosystems at Risk (HEAR) project (<http://www.hear.org/>) provides "technology, methods, and information to; and to facilitate communication among: decision-makers, resource managers, and the general public to help support effective science-based management of harmful non-native species in Hawaii and the Pacific". HEAR provides general information regarding the threat of invasive species, as well as a species-specific bibliography and other information. Information on weed risk assessments (WRA) are available on the HEAR website, including the Hawaii/Pacific weed risk assessment protocol (HPWRA). HPWRA was developed based on the Australian and New Zealand WRA (Daehler and Carino 2000; Daehler et al. 2004). The HPWRA is designed to identify species with high and low risk for invasion. Working in

tandem with HPWRA, the Hawaii exotic plant evaluation protocol (HEPEP) gathers field observations of plants in order to evaluate ecosystem impacts.

F. Commonwealth of the Northern Mariana Islands Biosecurity Directives, Statutes, and Regulations

Offices in the CNMI that play a role in biosecurity include: CNMI Department of Lands and Natural Resources including the Division of Fish and Wildlife and the Division of Agriculture and the CNMI Department of Finance, Division of Customs. The CNMI Division of Agriculture in the Department of Land and Natural Resources (DLNR) is responsible for inspection of imported and exported commercial and passenger cargo and implements quarantine programs in order to protect natural resources from invasive species. DLNR agricultural inspectors are, similar to operations by GCQA in Guam, guided by Federal regulations and work under the guidance of APHIS PPQ (D. Berringer, APHIS-PPQ, pers. comm.).

Imports to CNMI are regulated by USFWS and the Commonwealth's Department of Fish and Wildlife (DFW) and the Department of Agriculture. The DFW website (<http://www.dfw.gov.mp/Enforcement/Fishing%20Regulations.html>) lists species that are allowed for importation; these include several species of birds and mammals. No amphibians or reptiles are permitted. For invertebrates, including marine invertebrates, only those that can be demonstrated to be "not harmful" are permitted. Marine invertebrate importations tend not to be closely regulated. Giant clam spat (young clams) have been provided to the CNMI from Palau on several occasions over the past 25 years. The only requirements were health certificates from Palau that stated that the clams were not harmful for human consumption. No fish or algae are listed on the DFW website, although enforcement officers are using an unofficial "white list" of freshwater fish species from Australia to make determinations for import permits to CNMI. These rules apply regardless of the number of individuals or purpose of the importation.

Aircraft from foreign countries arriving in the CNMI are cleared by CNMI Quarantine. Fourteen quarantine officers are assigned to the Saipan Airport. Intensive blooms/blossoms and cut flowers examinations are undertaken to check for import violations, and orchid shipments are limited to a total of 12 individuals per shipment. Plants imported into CNMI arrive via Guam from California or Hawaii. Propagative plant shipments and cut flowers are inspected for plant pests and diseases and for import permit violations. Every large bag or box brought into CNMI by a foreign passenger is inspected visually. The CNMI is part of the alien snake rapid response team and has federal and commonwealth staff on the ground to inspect incoming cargo and planes from Guam for Brown Treesnakes. Current Brown Treesnake inspection capacity includes visual searches, detector dogs, and sentinel traps as well as specific quarantine facilities at the sea ports in Saipan and Tinian.

- Council on environmental quality (CEQ): environmental impact statement; 40 CFR §§ 1502.09 and 1502.20

- CNMI regulations part 5 sections 10 and 20 cover importation and introduction of animals to the CNMI. Section 10 includes a list of permitted species (and also indicates some prohibited species or groups of species). These regulations are enforced by the CNMI DLNR.

G. Republic of the Marshall Islands Biosecurity Directives, Statutes and Regulations

Offices in the RMI which play a role with biosecurity include: the Ministry of Resources and Development, Department of Quarantine and the Environmental Protection Authority; Ministry of Finance, Division of Customs, Treasury, Revenue, and Taxation. Within the RMI, inspections of aircraft and vessel cargo, baggage and ships stores are permitted by agricultural quarantine inspectors who have authority to seize and destroy any materials subject to plant and animal quarantines and regulations (MIRC Title 8 §102 et seq.). The Division of Agriculture in the RMI Ministry of Resources and Development processes plant quarantine permits for all plants, plant parts, and seeds, but it is unclear what specific plants are currently prohibited from import, export, or transit within RMI. The Marshall Islands Invasive Species Taskforce (MIIST) has drafted the Marshall Islands Invasive Species Taskforce Strategic Action Plan 2007-2010 that addresses threats to marine habitats, including ballast water introductions, and four targeted organisms (fire ants and three terrestrial species) (Pacific Invasives Initiative 2010). The Ministry of Resources and Development enacted its Animal and Plant Inspection Act in 2004. The act is responsible for the protection of endangered areas and the designation, maintenance, and surveillance of pest-free areas and areas of low pest prevalence. It is also responsible for the inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of other regulated articles, particularly with the object of preventing the introduction and/or spread of pests. The RMI has trained inspectors who are part of the regional alien snake rapid response team and they have an ERP for alien snakes.

The RMI does not maintain a list of either prohibited or allowed marine species. Requests for importation permits are decided on a case-by-case basis by Marine Resources and Agricultural Quarantine. For a permit to be approved, an importer must make the case that a proposed species does not pose an environmental threat. A health certificate from an independent veterinarian must accompany live imports. The RMI is in the process of reviewing its quarantine regulations. A draft biosecurity bill is also now being reviewed and if enacted may revise import and export regulations and practices. In this bill, discharge of ballast or bilge water is prohibited “at sea” in the Marshall Islands rather than specifically in port and the maximum fine for such discharge is \$100,000 (no specific fine is listed in the Palauan bill). This is the only specific reference to marine species and their vectors.

Aquatic organisms imported into the RMI (and not for direct export to other countries) require the following: quarantine for 1-2 weeks, sterilization of quarantine media using UV light before release from the holding tanks, and visual inspection for signs of stress/disease (Arthur et al. 2012).

Evaluation of the risk associated with the import of live aquatic organisms is conducted by an interagency committee (including members from the Coastal Management Advisory Council & the Marshall Islands Invasive Species Taskforce). At the moment, this is done in an ad-hoc style, because the Biosecurity Bill is still pending with the legislature (Arthur et al. 2012).

- RMI Code Title 7 Public Health, Safety and Welfare.
- RMI Code Title 8 Agriculture and Animals, especially Chapter 3: Quarantine Restrictions and Chapter 4: Export meat inspections
- RMI Code Title 9 Public Lands and Resources
- RMI Code Title 10 Planning and Economic Development
- RMI Code Title 11 Taxation and Finance, especially Chapter 5: Import duty.
- RMI Code Title 12 Aeronautics
- RMI Code Title 33 Marine Resources
- RMI Code Title 34 Admiralty and Maritime Affairs
- RMI Code Title 35 Environment
- RMI Code Title 38 Postal Service
- RMI Revised Code Title 51 Management of Marine Resources: Marshall Islands Marine Resources Act (MIMRA) 1997

H. Federated States of Micronesia Biosecurity Directives, Statutes and Regulations

- FSM Code Title 18 Territory, Economic Zones and Ports of Entry, especially chapter 2: Ports of Entry.
- FSM Code Title 19 Admiralty and Maritime
- FSM Code Title 20 Aeronautics
- FSM Code Title 22 Agriculture and Livestock, especially Chapters 4: Quarantines and Chapter 5: Export meat inspection, and Section 42: Aquatic animal health
- FSM Code Title 23 Resource Conservation
- FSM Code Title 24 Marine Resources
- FSM Code Title 25 Environmental Protection

- FSM Code Title 38 International Trade
- FSM Code Title 39 Postal System
- FSM Code Title 41 Public Health, Safety and Welfare
- FSM Plant & Animal Quarantine Regulations (2000)

Agencies and/or departments responsible for aquatic animal health at the national level: FSM Quarantine Office and FSM R&D Office

Agencies and/or departments responsible for aquatic animal health for Pohnpei State: Pohnpei State Office of Fisheries and Aquaculture (OFA), Environmental Protection Agency Office, Pohnpei State and Conservation Society of Pohnpei (CSP) Office

Offices in the FSM which play a role in biosecurity include: Resources and Development Agriculture Unit, Yap Department of Resources and Development; Kosrae Department of Economic Affairs; Department of Finance, FSM Division of Customs, departments of Agriculture for each of the 4 states. Within the FSM (Chuuk, Kosrae, Pohnpei, and Yap) quarantine inspectors may inspect all aircraft and vessels, or their cargoes, for animals and plants or their parts and refuse their entry (FSMC Title 22 §410). Customs inspections, agricultural inspections and quarantines may be performed on all vessels or aircraft entering or departing from any ports of entry (FSMC Title 18 §206). Noxious weeds have not been designated by FSM, but the Plant and Animal Quarantine Regulations (2000) includes two lists that specify plants prohibited for import from outside FSM (Schedule 1), and plants prohibited from transport between states of FSM (Schedule 2); neither schedule includes aquatic plants. Plants or plant material produced within the FSM may be issued a phytosanitary certificate by inspectors following pre-export inspections according to the FSM Plant and Animal Quarantine Regulations of 2000.

FSM Resources & Development, Agriculture Unit, enacted the FSM Plant and Animal Quarantine Regulations in 1991, revised them in 2000, and began to enforce the FSM Biotechnology and Biosafety Act in 2007. The FSM Resources & Development, Agriculture Unit, is responsible for the protection of endangered areas and the designation, maintenance, and surveillance of pest-free areas and areas of low pest prevalence as well as for the inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of other regulated articles, particularly with the object of preventing the introduction and/or spread of pests.

The FSM national government and/or the individual states have a variety of draft plans for responding to invasive organisms. These include a national government draft contingency plan for Avian Influenza, draft Coconut Rhinoceros Beetle ERP, and draft Alien Snake ERPs for each of the states. Several FSM quarantine staff members have received advanced training in alien snake early detection and rapid response.

The FSM National Biodiversity Strategy and Action Plan (FSM-NBSAP 2002) recognizes the top ten invasive weed species (all are terrestrial) within FSM. The plan acknowledges that a comprehensive lists of aquatic invasive organisms (e.g. African land snail and cane toad) is not available (FSM-NBSAP 2002).

By federal law, Federated States of Micronesia prohibits the importation of exotic plants or animals, except under permit by the Director of Resources and Development (FSM Code, Title 23, Resource Conservation, Section 315). The code also states that no CITES species can be imported (FSM Code, Title 23, Section 8). All import permits must be approved by federal quarantine and undergo a pest risk analysis before a permit is approved. Under Kosrae State Code, if a plant or animal is not already found in the state, an importer must apply to the Department of Agriculture, Land and Fisheries for permission (KSC Title 14 Section 14.204), but it appears that review of permit applications happens at the federal level. Importers must have a certificate of health from the point of origin. Elsewhere in FSM, there do not appear to be any additional regulations at the state level regarding the importation of live marine species. A biosecurity bill is being considered for the FSM, which if enacted, may change some of the existing biosecurity regulations.

The Invasive Species Taskforce of Pohnpei (ISTOP) surveys and manages invasive species for the state. The ISTOP Strategic Action Plan 2010-2013 targets ten invasive plant and animal species; outlines goals, objectives, and activities; and identifies partners and funding sources.

Chuuk State's Invasive Species Taskforce has developed a draft strategic action plan (Chuuk Invasive Species Task Force Strategic Action Plan, draft version November 2010). The plan focuses on programmatic development, including finding funding and resources, building capacity, increasing coordination between agencies, and generating public awareness. However, it also (a) includes eradication/control measures for two terrestrial plants on the island of Weno, (b) identifies one marine species – the crown-of-thorns sea star (*Acanthaster planci*), a native species which can severely impact coral reefs -- for control measures in Chuuk Lagoon as well as some of the outer islands and (c) calls for 10 surveys in the Chuuk Lagoon and six on outer islands to identify other invasive marine species. No measures for preventing non-native species transfers are addressed.

Kosrae's Invasive Species Action Plan is modeled on the SPREP plan, based on that plan's three major theme areas and nine sub-themes (Section 6.1.3). The Kosrae plan lists specific objectives to achieve the more general objectives suggested by SPREP, however the proposed activities do not appear to meet objectives in many instances. For example, the general Objective 2 in Table B1.2 is "Monitoring invasive species movement on island, and between countries and territories." The matching proposed specific objective is to "review existing port and border surveillance and rapid response arrangements" and the proposed activity is "quarterly visits to Quarantine for bio-security updates." It is not evident how this would result in species-level monitoring information. Although marine species are mentioned in the Kosrae plan, no specific vectors are addressed nor are any actions proposed to deal with marine species.

I. Republic of Palau Biosecurity Directives, Statutes and Regulations

The Palau Ministry of Natural Resources, Environment, and Tourism houses several bureaus involved with national biosecurity, including the Bureau of Marine Resources, the Bureau of Agriculture, and the Bureau of Protected Areas Network. The Republic of Palau Bureau of Agriculture established its Plant and Animal Quarantine regulations in 1999 and revised them in 2008 and is responsible for the inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of other regulated articles, particularly with the object of preventing the introduction and/or spread of pests. Palau's Plant and Animal Quarantines and Regulations (1999) contain schedules of prohibited plants and animals. These schedules were updated in 2002 to include any species or hybrid of tilapia (*Oreochromis* spp.), which is currently the only listed marine or aquatic species; however, the government is currently considering removing tilapia from the prohibited list to promote its use in agriculture. In 2006, the regulations were again amended, giving the Palau National Invasive Species Council (Palau NISC) the responsibility of reviewing applications for the importation of any species not already present within Palau. The Palau NISC has 30 days to carry out its review, but may request longer if further study (at the importer's expense) is required. This amendment also gives the Palau NISC the responsibility of advising the Palau Department of Agriculture on species that should be added or removed from the prohibited species schedules.

At ports of entry, including the post office, inspectors from the Palau Bureau of Agriculture are charged with carrying out inspections of cargo, mail, baggage, passengers, ships and airplanes. All live imports must have a permit issued by the Palau Bureau of Agriculture and live organisms must have received a certificate of health from their country of origin. Imported organisms can be placed in quarantine for further observation and treatment at the importer's cost if necessary.

In Palau, species intended for aquaculture must be approved by the Bureau of Aquaculture, and are to be held in quarantine for seven days for observation by the Bureau of Marine Resources. Nonetheless, there appears to be little capacity to do more than qualitative, visual screening to make a judgment about whether organisms "look healthy" and to sort out obvious non-target species accidentally included in shipments before release. Quarantine officials have the legal authority to inspect an importer's facilities after organisms have passed through quarantine and can order organisms back into quarantine and/or destroy them after release, but it is not clear how frequently, if ever, this has been done.

The national government of Palau is tasked by the National Environmental Protection Council (NEPC) to "provide and enforce an appropriate legislative framework, including quarantine and environmental legislation, necessary to prevent the introduction or reduce the impact of invasive species and prevent them from spreading" according to the Palau National Invasive Species Strategy originally developed in 2004.

The Bureau of Agriculture has the authority to inspect plants and animals intended for export, but it is unclear how frequently this occurs.

- Bureau of Agriculture: in Palau, quarantine laws are enforced by the Bureau of Agriculture (Title 25 PNC § 2003). Quarantine inspectors may inspect “all aircraft and vessels or their cargoes, including baggage, ship's stores, and ballast, entering or moving” within Palau for “all animals and plants or parts thereof, including seeds, fruits, vegetables and cuttings” (Title 25 PNC § 2005). Plants and plant material require a permit to enter Palau and, if in transit through the country, material requires a permit to transit and must follow certain safeguarding measures.
- Executive Order 219, issued in November 2003 by the President of the Republic of Palau, instructed the National Environmental Protection Council (NEPC) to create the Palau National Invasive Species Committee (PNISC).
- Palau National Invasive Species Strategy drafted by PNISC lays out the roles and responsibilities of landowners, land users, communities, industry, traditional leaders, and the state and national governments. According to the Palau National Invasive Species Strategy, the national government of Palau is tasked to “provide and enforce an appropriate legislative framework, including quarantine and environmental legislation, necessary to prevent the introduction or reduce the impact of invasive species and prevent them from spreading”.
- The invasive weeds committee (also known as weedbusters) of the Palau Natural Resource Council (PNRC) has worked on invasive plant issues, but according to Space et al. 2009, this group has been inactive recently.

Palau’s National Invasive Species Strategy (2004) includes consideration of marine species and outlines a number of action items:

- 1) Periodic review of the country’s legal and regulatory framework with regards to invasive species, and the revision and adoption of updates to these as needed;
- 2) Preparation of a National Invasive Species Strategy (below), which was drafted nearly simultaneously with the National Invasive Species Policy;
- 3) Surveys in terrestrial and marine environments to identify and quantify invasive species;
- 4) Identification of priority species for management actions, and the identification of areas at greatest risk for entry and establishment of invasive species;
- 5) Prevention of new invasions, detection through regular monitoring, and management/eradication of established species;
- 6) Restoration and re-establishment of native species to be included as part of management activities; and
- 7) Cooperation between various local, regional and international agencies working on invasive species.

Many of these items have since moved forward.

Palau's National Invasive Species Strategy (2004), or NISS, acknowledges explicitly the potential importance of marine invasions in a country that depends heavily on a healthy marine environment. The NISS was written by the country's National Invasive Species Committee, after a review of relevant documents from Australia, SPREP, the Global Invasive Species Programme, the Convention on Biological Diversity, and the Bahamas National Invasive Species Strategy. The NISS lays out a series of objectives to meet four major goals:

- 1) The provision of a national framework for dealing with invasive species;
- 2) The prevention of new invasions;
- 3) Management of invasive species already in Palau; and
- 4) Coordination with other regional and international organizations dealing with invasive species.

Additionally, the document details the roles and responsibilities for dealing with invasive species for the national and state governments, traditional leaders and community members.

The NISS was formed after a SPREP-led workshop in 2003, and recommendations from this workshop appear as an appendix to the strategy document. Two specific recommendations for dealing with aquatic/marine species in Palau came out of this workshop: 1) immediate action to eradicate tilapia and 2) working with dive operators to involve recreational divers in hull inspections of yachts and commercial vessels. In addition, the appendices include voluntary codes of conduct for many sectors (vectors), including aquaculture. It was agreed that use of non-native species for aquaculture ought to be discouraged generally, and, wherever used, the species should be contained in secure facilities.

In 2006, the PNISC reviewed the NISS. The committee modified language for clarity and to make several of the major goals and objectives more comprehensive. The NISS added a fifth major goal, that of increasing public awareness and support for invasive species prevention and management.

Following its review of the NISS, PNISC developed an Action Plan (Palau National Invasive Species Committee 2007). The PNISC Action Plan follows the structure of the NISS closely, laying out specific actions to be taken to achieve the goals and objectives of the NISS as well as time frames for these.

Palau has taken initial steps to gather baseline data on invasive marine species within its borders. With help from Australian scientists, the PNISC and other agencies carried out a training workshop and a baseline survey of its major port in 2007. Several new non-native species were found as a result of this survey and a manual removal of some of these was attempted. In addition, a public

awareness campaign was carried out by Koror state on an invasive anemone in Jellyfish Lake (Palau National Invasive Species Committee 2007).

Palau also launched major campaigns to eradicate tilapia that involved the assistance and support of many agencies and community members. Tilapia was also added to the list of species prohibited for import into Palau, although the government is now reconsidering this.

Palau is considering the adoption of a biosecurity bill. The bill would create a Division of Biosecurity, increasing the ability of biosecurity agents to inspect incoming vessels and goods and to act to control or eradicate pest or disease outbreaks. The bill would specifically prohibit the release of bilge or ballast water in Palauan ports (draft version February 2010), but otherwise would not address ship-mediated invasions. Many of its provisions, such as requiring an incoming vessel to submit voyage records prior to arrival, and granting biosecurity agents the power to sample vessels or parts of vessels, would create an initial framework to reduce ship-mediated invasions associated with ballast water and hull biofouling.

Palau has trained alien snake rapid response team members and Palau has developed an ERP for alien snakes. Palau also has ERPs for fruit flies and tramp ants. There is also an established emergency response standard operating procedure for Avian Influenza.

Palau Code Title 25 Chapter 20 Plant and Animal Control: This Chapter regulates certain aspects of the international trade in plants and animals in order to protect Palau against the introduction and further dissemination of injurious insects, pests, and diseases into and within the Republic. With the prior approval of the President, the Chief of the Division of Agriculture shall issue plant and animal quarantines and regulations relating to the administration and enforcement of the controls established by this Chapter. Letters and memoranda may be issued from time to time by the Chief of the Division of Agriculture and the President relating to the administration and enforcement of such quarantines and regulations. The Chief of the Division of Agriculture shall administer the provisions of the plant and animal quarantines and regulations. Agricultural quarantine inspectors may be appointed by the President, and shall, under the direction of the Chief of the Division of Agriculture, enforce the provisions of the plant and animal quarantines and Regulations.

Live aquatic organisms for import require 3-7 days holding quarantine to examine the stock for any contamination by alien species and the presence of diseased or sick fry as well as a health certificate issued by a veterinarian certifying that the stock being imported is free from Finfish disease, Mollusk disease, Crustacean disease, and the bacterium *Vibrio anguillarum*.

Requests to introduce new species must be reviewed by the National Invasive Species Committee before the Director of Agriculture may issue an import permit.

Attachment C: Chuuk State Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Chuuk section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	Chuuk Invasive Species Taskforce	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	FSM RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Chuuk RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including distributing a written report to the region and beyond.	continuous, yearly	State RISC Representatives and ISC	Biosecurity cost recovery system	High
Establish a jurisdictional invasive species coordination office that is tasked with supporting statewide IAS efforts across agencies and offices as well as working nationally and regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the invasive species coordination position.	2015	CIST and Governor's office	Biosecurity cost recovery system	High
	Once established this office should support and assist in coordinating efforts with invasive species within the state. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that state governance is regularly updated regarding both state and regional invasive species developments.	2015	CIST	Biosecurity cost recovery system	High
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of R&D	Biosecurity cost recovery system	High
	Add GMO and LMO coverage to the draft bill.	Complete by August 2014	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	2014	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	2014	CIST	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	Chuuk RISC representatives and the Governor's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support state efforts with engaging external resources to support state invasive species efforts.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support capacity building, training, and advice.	As soon as the office can be established	Chuuk RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Assistance with protocol and methods development.	As soon as the office can be established	Chuuk RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Support with establishing ER &RR capacity.	As soon as the office can be established	Chuuk RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Support the development of guidelines and regulations.	As soon as the office can be established	Chuuk RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Seek and coordinate regional funding.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Support management, response, and eradication efforts.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts within the state.	As soon as the office can be established	Chuuk RISC representatives and the Chuuk ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve state level communication and coordination	Develop a state invasive species task force (CIST) or council and includes NGOs, state and national government stakeholders.	2015	Governor's Office	Biosecurity cost recovery system	High
	Ensure the task force meets regularly (quarterly).	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Develop a state invasive species action plan and update regularly (every 3-5 years).	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Report annually on the status of elements of the state invasive species action plan.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Develop State biosecurity act.	2016	Chuuk ISC or Task force	Biosecurity cost recovery system	High
Improve capacity to identify biosecurity intercepts and organisms detected post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity such as SPC) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	Chuuk Invasive Species Coordinator	Biosecurity cost recovery system	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Chuuk Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	College of Micronesia	external donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of Micronesia	external donor	Low
	Support the development of an algal risk assessment for the region.	2016	College of Micronesia	external donor	Medium
	Support the development of an arthropod risk assessment for the region.	2016	College of Micronesia	external donor	Medium
	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	Office of the Governor	SPC	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.)	2015 and on-going	Chuuk ISC	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Chuuk ISC	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region.	2016	College of Micronesia	external donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Chuuk RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Chuuk RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	Chuuk RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Chuuk RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Chuuk RISC representatives	NA	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Chuuk RISC representatives	external donor	Medium
Prevention					
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 support national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	Biosecurity cost recovery system	High
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve border biosecurity	Support national government efforts to acquire X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Support national government efforts to ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Support national government efforts to ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority	
Improve border biosecurity (continued)	Support 100% x-ray of all arriving passenger baggage.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High	
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High	
	Support the development of a canine pest detection program for items such as snakes, fruits, and vegetables. Consider the potential to combine this program with similar programs for detection of illicit materials such as drugs.	2016 hold national consultation on the need for a biosecurity canine program; 2017 establish program if deemed appropriate		Ministry of Resources and Development	Initial support might have to be sought in the form of external donor funding; once the program is established, it should be supportable under an appropriately managed cost recovery system for biosecurity	Low
	Develop specific regulations and enforcement SOPs for imported seeds. All imported and viable seeds should require completed risk assessments and permitting.	2015		Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support biosecurity cross training of staffs from agencies which are involved in border inspection processes.	implement in 2015		Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Develop appropriate inspection facilities including a biosecure inspection facility at the seaport large enough for sea containers and wash-down areas with appropriate retention and treatment facilities for waste water produced.	2015 Develop planning; 2016 fund and move forward with developing infrastructure; 2017 operational		Ministry of Resources and Development	External donor support may be needed for infrastructure; once completed, cost recovery funds should be able to support up keep	Medium
	Establish a centralized facility for quarantine offices, including quarantine areas (plant and animal and aquatic organisms), treatment areas, laboratory space, offices, and equipment storage.	2017		Ministry of Resources and Development	External donor support may be needed for infrastructure; once completed, cost recovery funds should be able to support up keep	Medium
	Ensure that quarantine freezer facilities are restricted used (only quarantine should have access to these) and that they are functional back up power supplies.	2015		Ministry of Resources and Development		Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border biosecurity (continued)	Ensure that inspectors have access to freezers and incinerators at both air and sea ports for destroying pests and other materials as needed.	2015	Ministry of Resources and Development	Equipment may best come from external donors; Space and maintenance of equipment will need to be under agreements with local port authorities	High
	Support improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection. Mail should be inspected via x-ray and visual inspections (as well as by canine teams if possible) and should be standardized, not only by request from Customs (which is the current procedure).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, etc.).	on-going	Ministry of Resources and Development	SPC	Medium
	Support development of quarantine exchange programs with New Zealand, Australia, and/or U.S. biosecurity agencies as a mechanism for improving inspector capacity and further development of the nation's biosecurity program.	2016	Ministry of Resources and Development	External donor	High
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Support efforts to ensure that FSM quarantine is appropriate funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts in all 4 states).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border biosecurity (continued)	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Address IAS concerns as they relate to smuggled goods by developing appropriate SOPs, enhancing inspections, instituting fines and other actions such as confiscation and destruction of smuggled goods. Efforts should be both border and pre-border and will need the support of both national and state offices to ensure the best level of protection possible.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should include materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support development of legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	SPC, Regional ISC Office	Medium
	Support national efforts to address the lack of marine biosecurity oversight by FSM quarantine. Need to build legislation to support FSM quarantine having marine biosecurity capacity.	should be added to current draft legislation 2014	Ministry of Resources and Development	External donor	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2016	Ministry of Resources and Development	SPC, Regional ISC Office	Low
	support the establishment of national standards for the importation and use of GMO and LMO.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High	
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	CIST	external donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of WPM (continued)	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering Chuuk should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve ability to better enforce pre-departure sanitation	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	SPC	Medium
	Develop and institute standards which would increase pre-departure inspections. Visual inspections are conducted pre-departure which focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture. All jurisdictions should add quarantine inspections to the SOP of departing materials.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
Improve overall post border biosecurity	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2017	Chuuk ISC	External donor	Low
	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	2016 develop strategy; 2017 begin implementation	Chuuk ISC	External donor	Low
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	Chuuk ISC	External donor	Medium
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the state.	2015	Chuuk ISC	Biosecurity cost recovery system	Medium
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct onsite capacity training in ant id and inspection in the near future.	2015	Chuuk Agriculture	SPC and/or UH	Medium
	Establish watch list of high risk non-native species that can or may pose significant ecological, economic, social or cultural impacts.	2015	Chuuk ISC	Biosecurity cost recovery system	Medium
	Develop surveillance programs for high risk species not yet established such as fruit flies, coconut rhinoceros beetle, tramp ants, and alien snakes.	2015	Chuuk ISC	Biosecurity cost recovery system	Medium
Improve biosecurity for intra-state and inter-state away from the main air and seaports	Develop biosecurity standards for ports throughout the state.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve biosecurity for intra-state and inter-state away from the main air and seaports (continued)	Coordinate National Government field trip ship and Quarantine inspections at each port.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement and enforce biosecurity standards at ports throughout the state.	2017	lead will be determined during consultation and planning phases	Biosecurity cost recovery system	Medium
	Conduct an state wide consultation regarding intrastate biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	Chuuk Agriculture and Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct risk assessments for outer islands for terrestrial and aquatic concerns.	commence planning in 2015; risk assessments should be completed by 2018	Chuuk Agriculture and Marine Resources	External donor	Low
	Helicopters and private planes (or small scale commercial ventures) can be used to move passengers and cargo and where they exist or where there are plans for their use, they should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Establish internal biosecurity to prevent spread of established non-natives from one island to another e.g. tramp ants.	2017	Chuuk Agriculture and Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Implement and follow up recommendation to improvement of internal biosecurity.	2017	Chuuk Agriculture and Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Use Pohnpei (Nukuoro Island) as model for quarantine protocols and biosecurity standards.	2016	Chuuk Agriculture and Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve biosecurity for intra-state and inter-state away from the main air and seaports (continued)	Develop state biosecurity regulations to support intra-state efforts.	2017	Chuuk Agriculture and Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns	Develop a state endorsed white list of species permitted for import.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update white list.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop a state endorsed black list of prohibited species.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	update black list.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national level efforts to ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts to the state. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list. The state does this now for plant species proposed for import.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Support national government with developing and updating public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via existing FSM government website and linked to state websites.	Implement in 2015; update annually once implemented	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade.	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery biosecurity system	High
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	FSM Office of the Attorney General	Biosecurity cost recovery system	High
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	Office of Environmental Planning and Policy Coordination	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Department of Agriculture	Biosecurity cost recovery system	Medium
	Improve capacity and infrastructure regarding animal health. There should be a national veterinarian with support staff (para-vets?) in each state.	2016	Department of Agriculture	Animal health cost recovery system	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop biosecurity standards for small scale, private citizen aquaculture set-ups and enforce these standards.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support national government efforts to establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct an national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Develop plan for containment and control measures in regards to exotic farmed and traded species.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Improve screening and reporting system for lawful export of live organisms.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	Chuuk Invasive Species Coordinator	external donor	Low
Increase export potential	Support national efforts to establish produce export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national efforts to establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Improve capacity to export crops, which will involve finding/establishing markets with trade partners.	2016	Chuuk Agriculture	Biosecurity cost recovery system	High
	train and certify state agricultural staff to support local farmers with enhancing the potential for export crops.	2016	Chuuk Agriculture	SPC	Medium
	Support local farms with capacity development to increase potential to export crops.	2016	Chuuk Agriculture	SPC	Medium
	Ensure that fumigation for export crops is available and appropriate used.	2016	Chuuk Agriculture	SPC	Medium
	State officials should work with proposed external trade partners to ensure that export crops of interest are permitted for importation.	2015	Chuuk Agriculture	SPC	High
	Improve ability to meet import standards imposed by trade partners in regards to agricultural produces and processed foods.	2015	Chuuk Agriculture	SPC/USDA	High
	Increase protection of export crops from invasive pests by better management of established species and improved border security to reduce the introduction of new pests to the state.	on-going	Chuuk Agriculture	SPC	High
	Ensure that all proposed agricultural exports go through an establish protocol to ensure cleanliness before entering the shipping lines to reduce the potential for transport of unwanted pests.	2016	Chuuk Agriculture	SPC	High
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	USCG	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	USCG	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Develop capacity to deal with grounded and/or abandoned vessels (continued)	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
Support the national government with establishing and enforcing biofouling standards	Support establishment of standards and regulations regarding biofouling, including inspection and certification for all vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support establishment of additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support establishment of additional regulations for impounded vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support development of capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	Ministry of Resources and Development	External donor	High
	Support establishment of regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support the establishment of criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government with establishing and enforcing biofouling standards (continued)	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support establishment of the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	External donor	High
	Review and revise (as needed) legal authority to implement a biofouling management program.	2014: this should be included in the current draft biosecurity legislation; May need to update and expand in 2016-17 as elements come on line	FSM Office of the Attorney General	Biosecurity cost recovery system	High
	Support ensuring that regulations include the ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Support the national government with establishing and enforcing ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national level participation and enforcement of globally ballast water requirements including discharge 200nm from shore and inspection of ship logs for compliance.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support of establishment of ballast water management and reporting requirements for all vessels utilizing ballast water.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government with establishing and enforcing ballast water standards (continued)	Support development of capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support national level adoption of proposed USCG regulations to move to in hull sanitation of ballast water.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Increase marine system protection from invasive species	Support the establishment of biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for fishing vessels that operate in jurisdictional waters to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	external donor	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015	Ministry of Health	external donor	Low
Address climate change linkages to invasive pests		Framework should be in place by 2016	Chuuk ISC	US AID	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address food security for the state in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of Micronesia	FAO	Low
Early detection and rapid response					
Improve early detection and rapid response capacity	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	Chuuk ISC or Task force	Regional ISC office	High
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	Chuuk ISC or Task force	External donor	Medium
	Develop taxa specific ERPs as needed.	On-going	Chuuk ISC or Task force	Regional ISC office	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	Chuuk ISC or Task force	External donor	Medium
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2016	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2016	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2016	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Develop protocols for responding to non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Hold consultations to determine what agency(s), office(s) and/or groups will be responsible for surveillance programs.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Increase support for BTS Early Detection/Rapid Response.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	Medium
	Develop and institute surveillance programs for non-established species consider high risk of arrival such as CRB, alien snakes, fruit flies, tramp ants, etc.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	High
	Work with police to develop MOU to assist with enforcing internal quarantine if needed during a response action.	2015	Chuuk ISC or Task force	Biosecurity cost recovery system	Low
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	start in 2015	Chuuk ISC or Task force	Biosecurity cost recovery system	Low
Management and eradication					
Increase management and control of established invasive species	Determine which established invasive species are actionable and proceed with developing management strategies.	conduct consultations 2015; develop strategies 2016	Chuuk ISC	External donor	Medium
	Create GIS layers regarding the distribution of established IAS and use to support biosecurity and IAS management efforts.	2015	College of Micronesia	External donor	Low
	Key staff need to receive GIS training both in regards to field data collection and the utilization of GIS databases and computer systems.	2015	College of Micronesia	SPC	Low
	Key offices need resources to support electronic mapping efforts (GIS), including computers, software, and GPS units.	2015	CIST	External donor	Low
	Train natural resource staffs at the local level in regards to IAS management support.	2015	Chuuk ISC	Regional ISC office	Low
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	2015	Chuuk ISC	Regional ISC office	Low
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2015	Chuuk Agriculture	External donor	Low
	Develop standardized SOPs for IAS monitoring and surveys.	2015	Chuuk ISC	External donor	Low
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distribution is current.	2015	Chuuk Agriculture	External donor	Low
	Identify frog found on Satowan Island.	2014	CIST	External donor	High
	Investigate spiders encountered on Polowat.	2014	CIST	External donor	High
Coordinate management of monitor lizards on Houk Island.	2015	Chuuk Agriculture	External donor	Low	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase management and control of established invasive species (continued)	Survey islands within the state to determine baseline information regarding both native species and established non-natives such as tramp ants.	Develop strategy 2015; start survey work in 2016	Chuuk Agriculture	External donor	Low
	Train natural resource staffs at the local level in regards to IAS management support.	2015 this should be implemented	Chuuk ISC	SPC, Regional ISC Office	Low
	Document the differences between established non-native species such as ant faunas amongst various islands.	2015 develop strategy; 2016 begin implementation	Chuuk Agriculture	External donor	Low
Increase efforts to eradicate targeted species	Conduct surveys and hold stakeholder consultations to determine what established species are viable candidates for eradication efforts.	2015 consultations; 2016 develop strategy; 2017 implement	Chuuk ISC	External donor	Low
	Develop strategies to conduct eradication campaigns including securing funding streams to support these efforts.	2016	Chuuk ISC	External donor	Low
	Develop resources to respond to new pest incursions beyond ED & RR, including conducting delimiting surveys and potential eradication efforts.	2016	Chuuk ISC	Biosecurity cost recovery system	Medium
	Eradicate small and feasible invasive species incursions promptly, while it is most feasible, least expensive, and before extensive damage has occurred.	Develop capacity by 2017; process should be on-going from that point	Chuuk ISC	External donor	Medium
	Determine feasibility of fruit fly eradication on Chuuk in relation to current biosecurity levels.	2016	Chuuk Agriculture	USDA	Low
	Consider ant species with limited distribution for eradication.	2016	Chuuk Agriculture	SPC	Low
Awareness					
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and state wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	CIST	External donor	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the state from unwanted pests.	2015	CIST	External donor	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	CIST	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	CIST	External donor	High
	Coordinate existing outreach efforts.	2015	CIST	External donor	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2015	Chuuk ISC	Regional ISC office	Medium
	Support adding invasive species education as a standard part of school curriculums region wide.	2017	CIST/Ministry of Education	External donor	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2016	CIST/Ministry of Education	External donor	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	on-going	CIST	External donor	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	On-going	CIST	External donor	Medium
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	CIST	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	C ISC	Regional ISC office	Medium
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop a wildlife reference collection (i.e., taxidermy mounts, computer photo files, etc.) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.	2016	Chuuk Agriculture	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	Chuuk RISC representatives	External donor	Medium
	Provide reports and newsletters to educators, journalists, lawmakers, and business and community leaders.	2016	CIST	External donor	Medium
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials in Chuuk , including the potential loss of business if invasive species are permitted to establish.	2015	CIST	Biosecurity cost recovery system	High
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of Micronesia	External donor	Low
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2016	College of Micronesia	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment D: Kosrae State Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Kosrae section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	KIST	Biosecurity Cost Recovery System	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	Kosrae RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Kosrae RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including distributing a written report to the region and beyond.	continuous, yearly	State RISC Representatives and ISC	Biosecurity Cost Recovery System	High
Establish a jurisdictional invasive species coordination office that is tasked with supporting statewide IAS efforts across agencies and offices as well as working nationally and regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Conduct a state wide consultation to determine the most appropriate way forward with establishing a single office which can support state wide IAS efforts.	2015	Governor's Office	External donor	High
	Following consultations, develop planning and implement strategy, including staffing the office.	2015	Governor's Office	External donor	High
	Once established this office should support and assist in coordinating efforts with invasive species within the state. Part of this effort will	on-going	Governor's Office	Biosecurity Cost Recovery System	High
	Once established this office should serve as the main linkage between the state and the region on invasive species issues, communicating state activities to the region as well as engaging the region and beyond when feasible to support and assist with invasive species efforts within the state.	On-going	Governor's Office	Biosecurity Cost Recovery System	High
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward (continued)	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	2014	KIST	Biosecurity Cost Recovery System	High
Update and regularly maintain the state invasive species action plan and annually report on progress	Update current plan.	2014	KIST	External donor	High
	Establish protocol to revisit and update every 3 to 5 years.	On-going	KIST	External donor	High
	Include annual reporting on progress of the state ISAP at the MCES and development a short annual 1-2 pagers to share progress regionally and beyond (combine with similar activities for the RBP).	On-going annually	State RISC Representatives and State ISC	External donor	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office	ideally this office would be up and running before the end of 2015	Kosrae RISC representatives and the Governor's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information	As soon as the office can be established	Kosrae RISC representatives and the Kosrae ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support state efforts with engaging external resources to support state invasive species efforts	As soon as the office can be established	Kosrae RISC representatives and the Kosrae ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued)</p>	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Assistance with protocol and methods development</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support with establishing ER &RR capacity</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Kosrae ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued)</p>	<p>Support the development of guidelines and regulations</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Seek and coordinate regional funding</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Kosrae ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support management, response, and eradication efforts</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Kosrae ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information</p>	<p>As soon as the office can be established</p>	<p>Kosrae RISC representatives and the Kosrae ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued)	Engage the regional invasive species coordination office to support outreach and education efforts within the state	As soon as the office can be established	Kosrae RISC representatives and the Kosrae ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve capacity to identify biosecurity intercepts and organisms detected post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	Kosrae Invasive Species Coordinator	Biosecurity Cost Recovery System	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Kosrae Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	College of Micronesia	External donor	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of Micronesia	External donor	Low
	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	Office of the Governor	SPC	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	Kosrae ISC	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Kosrae ISC	Regional ISC office	Low
	Support the development of a algal risk assessment for the region.	2016	College of Micronesia	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of a arthropod risk assessment for the region.	2016	College of Micronesia	External donor	Medium
	Support the development of a weeds risk assessment for the region.	2016	College of Micronesia	External donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Kosrae RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Kosrae RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	Kosrae RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Kosrae RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Kosrae RISC representatives	NA	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Kosrae RISC representatives	External donor	Medium
Ensure that the Kosrae Invasive Species Taskforce (KIST) is functional and meeting regularly	KIST should ensure that it is endorsed and supported by the governance and state agencies and has appropriate bi-laws in place	2014	Governor's Office	Biosecurity Cost Recovery System	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Ensure that the Kosrae Invasive Species Taskforce (KIST) is functional and meeting regularly (continued)	KIST should elect officers (minimally a chairperson, treasurer and secretary)	annually	Governor's Office	Biosecurity Cost Recovery System	High
Prevention					
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations.	2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Improve communication and information sharing in regards to IAS and biosecurity	SOPs should be developed at the state level to facilitate communication and information sharing between offices and agencies within the state in regards to invasive species.	2015	Kosrae ISC	External donor	High
	Support the development of SOPs at the national level to facilitate communication and information sharing between offices and agencies in regards to invasive species and biosecurity.	2015	Kosrae ISC and FSM ISC	External donor	High
	Support the improvement of communication, information sharing, and active support between agencies and offices at the national and state levels.	2015	Kosrae ISC and FSM ISC	External donor	High
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 support national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	Biosecurity Cost Recovery System	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve pre-border sanitation efforts (continued)	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA, APHIS materials	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Improve border security	Support national government efforts to acquire X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Establish a quarantine buoy, develop standards for its use, and enforce these standards.	2016	Ministry of Resources and Development	External donor	High
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support national government efforts to ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support national government efforts to ensure appropriate long term maintenance for X-ray machines used for biosecurity	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, etc.).	on-going	Ministry of Resources and Development	SPC	Medium
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	Biosecurity Cost Recovery System	Low
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Support development of legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2016	Ministry of Resources and Development	SPC, Regional ISC Office	Low
	Support efforts to ensure that FSM quarantine is appropriate funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts in all 4 states).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	SPC, Regional ISC Office	Medium
	Support national efforts to address the lack of marine biosecurity oversight by FSM quarantine. Need to build legislation to support FSM quarantine having marine biosecurity capacity.	should be added to current draft legislation 2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	support the establishment of national standards for the importation and use of GMOs and LMOs.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Improve overall post border biosecurity	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2016	KIST	External donor	Low
	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	2016 develop strategy; 2017 implement	KIST	External donor	Low
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the state.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	Ministry of Resources and Development	External donor	Medium
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species.	2015	KIST	Biosecurity Cost Recovery System	Medium
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	Ministry of Resources and Development	External donor	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering Kosrae should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of WPM (continued)	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
Improve ability to better enforce pre-departure sanitation	Develop a secure departure area for both personnel and baggage which reduces the potential for invasive species to hitchhike on air passengers and cargo. Currently this area is open air and therefore there is little potential in stopping the movement of potential pest species from Kosrae to other locations such as Pohnpei, Kwajalein, and Majuro.	2016	Port Authority and Ministry of Resources and Development	External donor	Medium
	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	SPC	Medium
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	External donor	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015	Ministry of Health	External donor	Low
Increase export potential	Support national efforts to establish produce export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Support national efforts to establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Develop capacity to export citrus and other produce. For citrus, there is currently a experimental effort to reduce citrus canker which should be supported and if found viable, instituted state wide.	2016	Kosrae Agriculture	External donor	Medium
	Ensure that fumigation for export crops is available and appropriate used.	2016	Kosrae Agriculture	Biosecurity Cost Recovery System	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase export potential (continued)	Improve ability to meet import standards imposed by trade partners in regards to agricultural produces and processed foods.	2015	Kosrae Agriculture	SPC/USDA	High
	Ensure that all proposed agricultural exports go through an establish protocol to ensure cleanliness before entering the shipping lines to reduce the potential for transport of unwanted pests.	2016	Kosrae Agriculture	SPC	High
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery/biosecurity	High
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or traded in Kosrae.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms within Kosrae.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Improve capacity and infrastructure regarding animal health. There should be a national veterinarian with support staff (para-vets?) in each state.	2016	Kosrae Department of Agriculture	Animal health cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Establish explicit aquaculture biosecurity practices for Kosrae (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Support national government efforts to establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct a national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Develop biosecurity standards for small scale, private citizen aquaculture set-ups and enforce these standards.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	Low
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	Kosrae Invasive Species Coordinator	External donor	Low
	Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns	Develop a state endorsed white list of species permitted for import.	2014	Ministry of Resources and Development	Biosecurity Cost Recovery System
Update white list.		annually	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
Develop a state endorsed black list of prohibited species.		2014	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Update black list.		annually	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
Support national government with developing and updating public dissemination of white and black lists as well as details on the risk assessment process for proposed species imports. This could likely be done via existing FSM government website and linked to state websites.		Implement in 2015; update annually once implemented	Ministry of Resources and Development	Biosecurity Cost Recovery System	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns (continued)	Support national level efforts to ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts to the state. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
Better develop infrastructure to support port biosecurity efforts	Support national government efforts to provide adequate offices, inspection space, laboratory for pest identification, quarantine areas, treatment areas, etc. proximal to the ports for quarantine staff and activities.	2017	Ministry of Resources and Development	External donor	Medium
	Support national government efforts to ensure that quarantine staff has appropriate day to day resources such as computers, phones, internet access, vehicles, fuel, microscopes, etc. and that equipment can be both utilized and maintained.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Support the national government with establishing and enforcing biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government with establishing and enforcing ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Support national level participation and enforcement of globally ballast water requirements including discharge 200nm from shore and inspection of ship logs for compliance.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Support national level adoption of proposed USCG regulations to move to in hull sanitation of ballast water.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	USCG	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
Increase marine system protection from invasive species	Support the establishment of biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
	Establish biosecurity practices and requirements for fishing vessels that operate in jurisdictional waters to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase marine system protection from invasive species (continued)	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity Cost Recovery System	Medium
Address climate change linkages to invasive pests		Framework should be in place by 2016	Kosrae ISC	US AID	Medium
Address food security for the state in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of Micronesia	FAO	Low
Early detection and rapid response					
Improve early detection and rapid response capacity	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	KIST	Regional ISC office	High
	Establish a watch list of high-risk non-native species that are known or thought to pose significant ecological, economic, social, or cultural impacts to Kosrae.	2015	KIST	External donor	Medium
	Develop a detection program and response plan for new incursions by a few focal non-native species on the watch list of high-risk non-native species for Kosrae, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	KIST	Biosecurity Cost Recovery System	Medium
	Develop taxa specific ERPs as needed.	On-going	KIST	Regional ISC office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	KIST	External donor	Medium
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2016	KIST	Biosecurity Cost Recovery System	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2016	KIST	Biosecurity Cost Recovery System	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2016	KIST	Biosecurity Cost Recovery System	High
	Develop protocols for responding to non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response.	2015	KIST	Biosecurity Cost Recovery System	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	KIST	Regional ISC Office	High
	Work with police to develop MOU to assist with enforcing internal quarantine if needed during a response action.	2015	KIST	Biosecurity Cost Recovery System	Low
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	KIST	Regional ISC Office	Low
Management and eradication					
Increase management and control of established invasive species	Determine which established invasive species are actionable and proceed with developing management strategies (this should be part of the state ISAP).	2015	KIST	External donor	Medium
	Create GIS layers that delineate management zones, land tenure, and current distribution of established IAS and use to support biosecurity and IAS management efforts.	2015	KIST	External donor	Low
	Advance efforts to address the Giant African Snail infestation.	on-going	KIST	External donor	High
	Train natural resource staffs at the local level in regards to IAS management support.	2015	KIST	Regional ISC office	Medium
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	2015	KIST	Regional ISC office	Low
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2015	Kosrae Agriculture	Biosecurity Cost Recovery System	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase management and control of established invasive species (continued)	Advance efforts to address the white fly outbreak. There is work already being done in regards to the white fly, it is not clear if sufficient resources are available or have been brought to bear to ensure appropriate levels of management. Stakeholders and experts should convene to discuss the topic and agree on a plan of action which should include appropriate identification of the pest, surveys to determine extent of the spread and surveys outside of Kosrae to determine if it has been transported to other locations outside of the state. Effectiveness of released biocontrol agents needs to be determined as well as if more biocontrol need to be raised and released and if so how many and by whom should this be done. Field crews and funding will also need to be established to deal with the management of this pest.	on-going	KIST	External donor	High
	Advance efforts to address the coconut termite infestation. A response plan should be developed with clear, concise actions and who or what agencies/groups will be response for these actions. Extent of the spread of this pest on the island, when it arrived, where it came from and if it has spread from Kosrae to other locations all need to be determined (if feasible). Ground crews and funding to support the response and/or management plan for this pest need to be established.	on-going	KIST	External donor	High
	Develop standardized SOPs for IAS monitoring and surveys.	2015	KIST	External donor	Medium
	Develop a management plan for the established non-native oyster.	2016	KIST	External donor	Medium
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distribution is current.	2016	KIST	External donor	Low
Increase efforts to eradicate targeted species	Conduct surveys and hold stakeholder consultations to determine what established species are viable candidates for eradication efforts.	2015	KIST	External donor	Medium
	Develop strategies to conduct eradication campaigns including securing funding streams to support these efforts.	2015	KIST	External donor	Medium
	Develop resources to respond to new pest incursions beyond ED & RR, including conducting delimiting surveys and potential eradication efforts.	2015	KIST	External donor	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase efforts to eradicate targeted species (continued)	Eradicate small and feasible invasive species incursions promptly, while it is most feasible, least expensive, and before extensive damage has occurred.	on-going	KIST	External donor	High
Improve usage and better regulation of pesticides used for both agricultural purposes and to treat specific pest infestations (termites, etc.)	Pesticide training courses should be held to provide farmers and others with basic skills in pesticide use. Use of restricted pesticides should be done by licensed applicators only.	2015	KIRMA	External donor	Low
	Educational materials regarding pesticides are needed for distribution to assist farmers and others with appropriate use of chemicals, but also to better inform the public regarding pesticide use. UH extension has already developed posters for chemical education which could be used once verbiage in local language(s) is add to these posters.	2015	KIRMA	University of Hawaii	Low
Awareness					
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and state wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	KIST	External donor	High
	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the state from unwanted pests.	2015	KIST	External donor	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	KIST	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	KIST	External donor	High
	Coordinate existing outreach efforts.	2015	KIST	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Support adding invasive species education as a standard part of school curriculums region wide.	2017	KIST/Ministry of Education	External donor	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2016	KIST/Ministry of Education	External donor	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	on-going	KIST	External donor	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	On-going	KIST	External donor	Medium
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	KIST	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	Kosrae ISC	Regional ISC office	Medium
	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	Kosrae RISC representatives	RISC	Medium
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2015	Kosrae ISC	Regional ISC office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials in Kosrae, including the potential loss of business if invasive species are permitted to establish.	2015	Ministry of Resources and Development	Biosecurity Cost Recovery System	High
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of Micronesia	External donor	Low
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2015	College of Micronesia	External donor	Low
Restoration					
Increase restoration efforts of native systems where IAS management and/or eradication efforts are underway or have been successful.		on-going	KIST	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment E: Pohnpei State Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Pohnpei section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	iSTOP	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	Pohnpei RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Pohnpei RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report distributed to the region and beyond.	continuous, yearly	State RISC Representatives and ISC	Biosecurity cost recovery system	High
Establish a jurisdictional invasive species coordination office that is tasked with supporting statewide IAS efforts across agencies and offices as well as working nationally and regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the invasive species coordination position. The concept of this position is established in the state ISAP but until funding can be ensure the position remains unfilled.	2015	Governor's Office	Biosecurity cost recovery system	High
	Once established this office should support and assist in coordinating efforts with invasive species within the state. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that state governance is regularly updated regarding both state and regional invasive species developments.	2015	Governor's Office	Biosecurity cost recovery system	High
	Once established this office should serve as the main linkage between the state and the region on invasive species issues, communicating state activities to the region as well as engaging the region and beyond when feasible to support and assist with invasive species efforts within the state.	2015	Governor's Office	Biosecurity cost recovery system	High
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of R&D	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward (continued)	Add GMO and LMO coverage to the draft bill.	Complete by August 2014	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	2014	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	2014	iSTOP	Biosecurity cost recovery system	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	Pohnpei RISC representatives and the Governor's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	Pohnpei RISC representatives and iSTOP	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support state efforts with engaging external resources to support state invasive species efforts.	As soon as the office can be established	Pohnpei RISC representatives and iSTOP	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Assistance with protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support with establishing ER &RR capacity.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and ISTOP</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Support the development of guidelines and regulations.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Seek and coordinate regional funding.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and ISTOP</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support management, response, and eradication efforts.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and ISTOP</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.</p>	<p>As soon as the office can be established</p>	<p>Pohnpei RISC representatives and ISTOP</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to support outreach and education efforts within the state.	As soon as the office can be established	Pohnpei RISC representatives and iSTOP	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve capacity to identify biosecurity intercepts and organisms detected post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity such as SPC) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	Pohnpei Invasive Species Coordinator	Biosecurity cost recovery system	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Pohnpei Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	College of Micronesia	External donor	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of Micronesia	External donor	Low
	Support the development of an algal risk assessment for the region.	2016	College of Micronesia	External donor	Medium
	Support the development of an arthropod risk assessment for the region.	2016	College of Micronesia	External donor	Medium
	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	Office of the Governor	SPC	High
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Pohnpei Invasive Species Coordinator	Regional ISC office	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	Pohnpei Invasive Species Coordinator	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region.	2016	College of Micronesia	External donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Pohnpei RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Pohnpei RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	Pohnpei RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Pohnpei RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Pohnpei RISC representatives	NA	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Pohnpei RISC representatives	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Prevention</i>					
Improve pre-border sanitation efforts	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 support national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve border security	Support national government efforts to acquire X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and	External donor	High
	Establish a quarantine buoy, develop standards for it use, and enforce these standards.	2016	EPA/Port Authority	External donor	Medium
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support national government efforts to ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Support national government efforts to ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, etc.).	on-going	Ministry of Resources and Development	SPC	Medium
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	External donor	Low
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support efforts to ensure that FSM quarantine is appropriate funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts in all 4 states).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Review and update ship clearance procedures.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support development of legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2016	Ministry of Resources and Development	SPC, Regional ISC Office	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	SPC, Regional ISC Office	Medium
	Support national efforts to address the lack of marine biosecurity oversight by FSM quarantine. Need to build legislation to support FSM quarantine having marine biosecurity capacity.	should be added to current draft legislation 2014	Ministry of Resources and Development	External donor	High
	Support the establishment of national standards for the importation and use of GMO and LMO. GMOs and LMOs should be labelled as such.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Support review of the draft FSM biosafety act in regards to its coverage of GMOs and LMOs.	June 2014	Pohnpei Economic Affairs	Biosecurity cost recovery system	Low
	Support national review of GMOs and LMOs and if and how they may be covered by intellectual property rights.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Develop MOU's between FSM Quarantine and other agencies involved in border inspections so that these offices/agencies can support FSM Quarantine with biosecurity aspects.	2015	Ministry of Resources and Development	NA	Low
	Support review of official ports of entry for the nation to better determine if and how FSM Quarantine's biosecurity role needs to be expanded to include additional ports.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support review of field ship ports of call and development of biosecurity standards for field ships and other intra and inter state conveyances.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Support development of regulations regarding biosecurity and visiting cruise ships. These ships, if visiting multiple jurisdictions should fund having a biosecurity office on board during their time within the FSM, provide for inspection services at all ports of call, cover all travel expenses for the biosecurity office, and coordinate with FSM Quarantine to ensure that the inspector's home port does not experience a drop in quarantine services during their absence (this may including paying for overtime).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Develop SOPs regarding specifics of how other agencies and offices can support the role of FSM Quarantine during border inspection process.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Support biosecurity cross training of staffs from agencies which are involved in border inspection processes such as the office of health and social affairs, Pohnpei EPA, Port Authority, and Customs.	implement in 2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	NA	High
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	Ministry of Resources and Development	External donor	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering Palau should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	SPC	Medium
	Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
Improve overall post border biosecurity	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2016	iSTOP	External donor	Low
	Develop a local depository for pest information.	Implement in 2015	College of Micronesia	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve overall post border biosecurity (continued)	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	2016 develop strategy; 2017 begin implementation	iSTOP	External donor	Low
	Develop best management practices for public utilities and contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	iSTOP	External donor	High
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the state.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support development of a regional depository for pest information.	2015	Pohnpei Invasive Species Coordinator	Regional ISC office	Low
	Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of locally sourced plants, preferably native plants. If non-natives are going to be used for landscaping, ensure that they are non-invasive species. If plants will be brought into an area from outside for landscaping, ensure that they are pest free. This code of conduct should encourage businesses: to make their staff knowledgeable about invasive plants, to inform their customers about invasive plants, to report immediately any likely exotic pest organisms found on their premises, and to use native or non-invasive plants locally sourced.	2015	iSTOP	External donor	Low
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species.	2015	iSTOP	Biosecurity cost recovery system	Medium
Improve capacity for intra-state biosecurity	Develop MOUs between the State Economic Affairs Office, iSTOP, and FSM Quarantine. Pohnpei State Control Plan Indicates that the State Department of Economic Affairs is responsible for all IAS issues within the state but iSTOP and the national quarantine office would have the best capacity.	2015	Economic Affairs	NA	High
	As the agency responsible for IAS within the state, the Office of Economic Affairs should be updated on a regular basis regarding IAS issues and a primary partner in any ERP documents.	2015	iSTOP	NA	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve capacity for intra-state biosecurity (continued)	Develop biosecurity standards for all ports.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement and enforce biosecurity at all ports.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct an state wide consultation regarding intrastate biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	iSTOP	External donor	Medium
	Conduct risk assessments for outer islands for terrestrial and aquatic concerns.	commence planning in 2015; risk assessments should be completed by 2018	iSTOP	External donor	Low
	Consider example of Nukuoro Island (which does have its own biosecurity standards which FSM Quarantine supports) when considering how to develop intra-state biosecurity.	2016	iSTOP and Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Helicopters, private planes and small boats (or other small scale commercial ventures) can be used to move passengers and cargo and where they exist or where there are plans for their use, they should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns	Develop a state endorsed white list of species permitted for import.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update white list, working with and informing local partners.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop a state endorsed black list of prohibited species.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	update black list, working with and informing local partners.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns (continued)	Support national level efforts to ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts to the state. Organisms which are deemed potentially harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Support national government with developing and updating public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via existing FSM government website and linked to state websites.	Implement in 2015; update annually once implemented	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Better develop infrastructure to support port biosecurity efforts	Support national government efforts to provide adequate offices, inspection space, laboratory for pest identification (have lab but lacking equipment), quarantine areas, treatment areas, etc. proximal to the ports for quarantine staff and activities.	2016	Ministry of Resources and Development	External donor	Medium
	Support national government efforts to ensure that quarantine staff has appropriate day to day resources such as computers, phones, internet access, vehicles, fuel, microscopes, etc. and that equipment can be both utilized and maintained.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Seaport inspection site needs to be developed and should include an indoor biosecure inspection site large enough to enclose an entire container.	2016	Ministry of Resources and Development	External donor	High
	Develop an appropriate wash down area at the seaport (USDA has guidelines which should be considered).	2016	Ministry of Resources and Development	External donor	High
	Airport inspection area should be enclosed.	2016	Ministry of Resources and Development	External donor	High
	Develop partnership with health care facilities in regards to sharing incinerator facilities at the land fill (proximal to Kolonia air and sea ports).	2015	FSM Quarantine	Biosecurity cost recovery system	Medium
Increase export potential	Support national efforts to establish produce export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase export potential (continued)	Support national efforts to establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Improve ability to sanitize produce prior to shipping. Consider forced hot air and/or fumigation treatments.	2016	Pohnpei Agriculture	SPC	Medium
	Improve ability to meet import standards imposed by trade partners in regards to agricultural produces and processed foods.	2015	Pohnpei Agriculture	SPC/USDA	Medium
	Ensure that all proposed exports go through an establish protocol to ensure cleanliness before entering the shipping lines to reduce the potential for transport of unwanted pests. Should be clean and free of pest and disease.	2016	Pohnpei Agriculture	SPC	Medium
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	External donor	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015	Ministry of Health	External donor	Low
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a state/national biosecurity advisory committee to review proposals for the importation of exotic species. There is currently a national risk assessment process but no specific protocol in place.	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery biosecurity system	High
Reduce risk associated with live traded species (continued)	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	Pohnpei office of Economic Affairs	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Improve capacity and infrastructure regarding animal health. There should be a national veterinarian with support staff (paravets?) in each state.	2016	Pohnpei Department of Agriculture	Animal health cost recovery system	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Support national government efforts to establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct a national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop biosecurity standards for small scale, private citizen aquaculture set-ups and enforce these standards.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Finalize state draft plan for containment and control measures in regards to exotic farmed and traded species.	2014	iSTOP	NA	Medium	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	Pohnpei Invasive Species Coordinator	External donor	Low
Support the national government with establishing and enforcing ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national level participation and enforcement of globally ballast water requirements including discharge 200nm from shore and inspection of ship logs for compliance.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national level adoption of proposed USCG regulations to move to in hull sanitation of ballast water.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Support the national government with establishing and enforcing biofouling standards	Support the establishment of criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	External donor	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	USCG

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Develop capacity to deal with grounded and/or abandoned vessels (continued)	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel	2017	Ministry of Resources and Development	USCG	Medium
Increase marine system protection from invasive species	Support the establishment of biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for fishing vessels that operate in jurisdictional waters to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Address climate change linkages to invasive pests		Framework should be in place by 2016	iSTOP	US AID	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address food security for the state in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of Micronesia	FAO	Low
Early detection and rapid response					
Improve early detection and rapid response capacity	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and the government. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	iSTOP	Development of a generic ERP is mentioned in the 2013 state ISAP	High
	Consider linking invasive species ED & RR capacity with the State disaster management office.	2014	iSTOP	NA	Medium
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species on the watch list (established in the 2013 state ISAP) of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	iSTOP	External donor	Medium
	Develop taxa specific ERPs as needed.	On-going	iSTOP	ERPs exist for fruit flies, alien snakes; Ministry of RAD is currently developing a tampa nt ERP, and planning is underway to develop a CRB ERP	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	iSTOP	Bisoecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable). Currently have 8 advertised office numbers plus port numbers which are available 24/7. But no dedicated pest hotline and no protocols in place for reacting to calls coming in on currently advertised lines.	2015	iSTOP	Biosecurity cost recovery system	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2015	iSTOP	Biosecurity cost recovery system	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2015	iSTOP	Biosecurity cost recovery system	High
	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	iSTOP	Biosecurity cost recovery system	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	iSTOP	Regional ISC Office	High
	Work with police to develop MOU to assist with enforcing internal quarantine if needed during a response action.	2015	iSTOP	Biosecurity cost recovery system	Low
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	iSTOP	Regional ISC Office	Low
Management and eradication					
Improve post border invasive species control and management capacity	Develop a coordinated mosquito monitoring program	2015	State offices of EPA, Health, and Agriculture	External donor	Medium
	Develop a coordinated mosquito control program	2015	State offices of EPA, Health, and Agriculture	External donor	Medium
Improve usage and better regulation of pesticides used for both agricultural purposes and to treat specific pest infestations (termites, etc.)	Pesticide training courses should be held to provide farmers and others with basis skills in pesticide use. Use of restricted pesticides should be done by licensed applicators only.	2015	Pohnpei EPA	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve usage and better regulation of pesticides used for both agricultural purposes and to treat specific pest infestations (termites, etc.) (continued)	Support development of a regional standard in pesticide labelling (US pesticides are already labelled, but those coming from Asia typically are not). US Mainland standards may not be appropriate for the region and therefore while they should be consider, they should not necessarily be the final determination.	2015	Pohnpei EPA	FAO may in fact be developing something similar and they should be consulted and worked with in this regard	Medium
	Educational materials regarding pesticides are needed for distribution to assist farmers and others with appropriate use of chemicals, but also to better inform the public regarding pesticide use. UH extension has already developed posters for chemical education which could be used once verbiage in local language(s) is add to these posters.	2015	Pohnpei EPA	University of Hawaii	Medium
Improve the management of established invasive species	Conduct surveys to determine the extent of the Tilapia and catfish invasions.	2015	iSTOP	External donor	Medium
	Determine what species/hybrids of Tilapia and catfish are present and extent of the range of each if more than one.	2015	iSTOP	External donor	Medium
	Develop and implement a Tilapia management/eradication plan.	2016	iSTOP	External donor	Medium
	Develop and implement a catfish management/eradication plan.	2016	iSTOP	External donor	Medium
	Train natural resource staffs at the local level in regards to IAS management support.	2015	iSTOP	External donor	Low
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distribution is current. SPC did some of this 2012. Existing survey information needs to be compiled, made available to managers, and updated as needed.	2016	iSTOP	See state ISAP	Low
Awareness					
Increase outreach and education on biosecurity and invasive species	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	iSTOP	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	iSTOP	External donor	High
	Coordinate existing outreach efforts.	2015	iSTOP	External donor	Medium
	Support adding invasive species education as a standard part of school curriculums region wide.	2017	iSTOP/Ministry of Education	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and analysis to assess the role of citizens and visitors in regards to protecting the state from unwanted pests.	2015	iSTOP	External donor	High
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2016	iSTOP/Ministry of Education	External donor	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	on-going	iSTOP	External donor	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	On-going	iSTOP	External donor	Medium
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	iSTOP	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	Pohnpei Invasive Species Coordinator	Regional ISC office	Medium
	Support the development of a regional video to be shown on air flights prior to arrival and at baggage claim areas which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	Pohnpei RISC representatives	RISC	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2015	iSTOP	Regional ISC office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of Micronesia	External donor	Low
Identify knowledge gaps for existing IAS concerns	Expand research capabilities and projects in regards to IAS	2015	College of Micronesia	External donor	Low
	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2015	College of Micronesia	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment F: Yap State Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Yap section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	YIST	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	Yap RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Yap RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including distributing a written report to the region and beyond.	continuous, yearly	State RISC Representatives and ISC	Biosecurity cost recovery system	High
Improve support and functionality of the state invasive species coordination office/position.	This office supports and assists in coordinating efforts with invasive species within the state. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that state governance is regularly updated regarding both state and regional invasive species developments.	on-going	Governor's Office	Biosecurity cost recovery system	High
	This office should serve as the main linkage between the state and the region on invasive species issues, communicating state activities to the region as well as engaging the region and beyond when feasible to support and assist with invasive species efforts within the state.	On-going	Governor's Office	Biosecurity cost recovery system	High
Coordinate with stakeholders both at the national level and with other states to support a united effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	41883	Ministry of R&D	Biosecurity cost recovery system	High
	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	41974	YIST	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Update and regularly maintain the state invasive species action plan and annually report on progress	Update current plan.	2014	YIST	Biosecurity cost recovery system	High
	Establish protocol to revisit and update every 3 to 5 years.	On-going	YIST	Biosecurity cost recovery system	Medium
	Include annual reporting on progress of the state ISAP at the MCES and development a short annual 1-2 pagers to share progress regionally and beyond (combine with similar activities for the RBP).	On-going annually	State RISC Representatives and State ISC	Biosecurity cost recovery system	High
Improve communications and ability to address biosecurity concerns between US DoD and civilian government agencies	Establish an MOU between the state and DoD regarding biosecurity within Yap in regards to DoD activities.	2015	Governor's Office	External donor	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	Yap RISC representatives and the Governor's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	Yap RISC representatives and the Yap ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support state efforts with engaging external resources to support state invasive species efforts.	As soon as the office can be established	Yap RISC representatives and the Yap ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Assistance with protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support with establishing ER &RR capacity.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Yap ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Support the development of guidelines and regulations.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Seek and coordinate regional funding.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Yap ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Support management, response, and eradication efforts.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Yap ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.</p>	<p>As soon as the office can be established</p>	<p>Yap RISC representatives and the Yap ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to support outreach and education efforts within the state.	As soon as the office can be established	Yap RISC representatives and the Yap ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve capacity to identify biosecurity intercepts and organisms detected post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity such as SPC) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	Yap Invasive Species Coordinator	Biosecurity cost recovery system	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Yap Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	College of Micronesia	External donor	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of Micronesia	External donor	Low
	Support the development of an algal risk assessment for the region.	2014	Office of the Governor	SPC	High
	Support the development of an arthropod risk assessment for the region.	2015 and on-going	YIST	Regional ISC office	Low
	Request that SPC develop a biosecurity position specifically for supporting the region.	2015 and on-going	YIST	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2016	Yap Invasive Species Coordinator	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2016	Yap Invasive Species Coordinator	External donor	Medium
	Support the development of a weeds risk assessment for the region.	2016	College of Micronesia	External donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Yap RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Yap RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	Yap RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Yap RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Yap RISC representatives	NA	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Yap RISC representatives	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Prevention</i>					
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 support national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	Biosecurity cost recovery system	High
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve border security	Support national government efforts to acquire X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Support national government efforts to ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	Support national government efforts to ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support 100% x-ray of all arriving passenger baggage.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support the development of a canine pest detection program for items such as snakes, fruits, and vegetables. Consider the potential to combine this program with similar programs for detection of illicit materials such as drugs.	2016 hold national consultation on the need for a biosecurity canine program; 2017 establish program if deemed appropriate	Ministry of Resources and Development	Initial support might have to be sought in the form of external donor funding; once the program is established, it should be supportable under an appropriately managed cost recovery system for biosecurity	Low
	Develop specific regulations and enforcement SOPs for imported seeds. All imported and viable seeds should require completed risk assessments and permitting.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support biosecurity cross training of staffs from agencies which are involved in border inspection processes.	implement in 2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Develop appropriate inspection facilities including a biosecure inspection facility at the seaport large enough for sea containers and wash-down areas with appropriate retention and treatment facilities for waste water produced.	2017	Ministry of Resources and Development	External donor	Medium
	Establish a centralized facility for quarantine offices, including quarantine areas (plant and animal and aquatic organisms), treatment areas, laboratory space, offices, and equipment storage.	2017	Ministry of Resources and Development	External donor	Medium
	Ensure that quarantine freezer facilities are restricted used (only quarantine should have access to these) and that they are functional back up power supplies.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that inspectors have access to freezers and incinerators at both air and sea ports for destroying pests and other materials as needed.	2015	Ministry of Resources and Development	Equipment may best come from external donors; Space and maintenance of equipment will need to be under agreements with local port authorities	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection. Mail should be inspected via x-ray and visual inspections (as well as by canine teams if possible) and should be standardized, not only by request from Customs (which is the current procedure).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, etc.).	on-going	Ministry of Resources and Development	SPC	Medium
	Support development of quarantine exchange programs with New Zealand, Australia, and/or U.S. biosecurity agencies as a mechanism for improving inspector capacity and further development of the nation's biosecurity program.	2016	Ministry of Resources and Development	External donor	High
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Develop a lab for quarantine and ensure that appropriate support linkages are in place with USDA, SPC, and others to support pest intercept identification.	2017	Ministry of Resources and Development	External donor	Medium
	Support efforts to ensure that FSM quarantine is appropriate funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts in all 4 states).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Address IAS concerns as they relate to smuggled goods by developing appropriate SOPs, enhancing inspections, instituting fines and other actions such as confiscation and destruction of smuggled goods. Efforts should be both border and pre-border and will need the support of both national and state offices to ensure the best level of protection possible.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Support development of legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2016	Ministry of Resources and Development	SPC, Regional ISC Office	Low
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	SPC, Regional ISC Office	Medium
	Support national efforts to address the lack of marine biosecurity oversight by FSM quarantine. Need to build legislation to support FSM quarantine having marine biosecurity capacity.	should be added to current draft legislation 2014	Ministry of Resources and Development	External donor	High
	support the establishment of national standards for the importation and use of GMO and LMO.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve overall post border biosecurity	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2017	YIST	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve overall post border biosecurity (continued)	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	2017	YIST	External donor	Low
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2016	YIST	External donor	Medium
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the state.	2015	YIST	Biosecurity cost recovery system	Medium
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species	2015	Ministry of Resources and Development	External donor	Medium
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replace of WPM with recycled plastics.	on-going	Ministry of Resources and Development	External donor	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering Yap should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	SPC	Medium
	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Develop and institute standards which would increase pre-departure inspections. Visual inspections are conducted pre-departure which focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture. All jurisdictions should add quarantine inspections to the SOP of departing materials.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Improve biosecurity for intra-state and inter-state away from the main air and seaports	Develop biosecurity standards for ports throughout the state, potentially including having FSM quarantine staff in Woleai, Ulithi, and Satwal.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve biosecurity for intra-state and inter-state away from the main air and seaports (continued)	Implement and enforce biosecurity standards at ports throughout the state.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct an state wide consultation regarding intrastate biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	YIST	Biosecurity cost recovery system	Medium
	Conduct risk assessments for outer islands for terrestrial and aquatic concerns.	commence planning in 2015; risk assessments should be completed by 2018	Yap Agriculture and State Marine Resources office	External donor	Low
	Helicopters and private planes (or small scale commercial ventures) can be used to move passengers and cargo and where they exist or where there are plans for their use, they should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	External donor	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015	Ministry of Health	External donor	Low
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns	Develop a state endorsed white list of species permitted for import.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update white list.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop a state endorsed black list of prohibited species.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update black list.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve national capacity to regulate the importation of live organisms, including ensuring that national capacity supports state concerns (continued)	Support national level efforts to ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts to the state. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list. The state does this now for plant species proposed for import.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Support national government with developing and updating public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via existing FSM government website and linked to state websites.	Implement in 2015; update annually once implemented	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a state/national biosecurity advisory committee to review proposals for the importation of exotic species. There is currently a national risk assessment process but no specific protocol in place.	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery biosecurity system	High
	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	FSM Office of the Attorney General	Biosecurity cost recovery system	High
	Improve capacity and infrastructure regarding animal health. There should be a national veterinarian with support staff (para-vets?) in each state.	2016	Ministry of Resources and Development	Animal health cost recovery system	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop biosecurity standards for small scale, private citizen aquaculture set-ups and enforce these standards.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national government efforts to establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct a national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Develop plan for containment and control measures in regards to exotic farmed and traded species.	2015	YIST	Biosecurity cost recovery system	Medium
	Improve screening and reporting system for lawful export of live organisms.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	Yap Invasive Species Coordinator	External donor	Low
Support the national government efforts with establishing and enforcing biofouling standards	Support establishment of standards and regulations regarding biofouling, including inspection and certification for all vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government efforts with establishing and enforcing biofouling standards (continued)	Support establishment of additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support establishment of additional regulations for impounded vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support development of capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	Ministry of Resources and Development	External donor	High
	Support establishment of regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	Ministry of Resources and Development	External donor	Medium
	Support the establishment of criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support establishment of the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	External donor	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government with establishing and enforcing biofouling standards (continued)	Review and revise (as needed) legal authority to implement a biofouling management program.	2014: this should be included in the current draft biosecurity legislation; May need to update and expand in 2016-17 as elements come online	FSM Office of the Attorney General	Biosecurity cost recovery system	High
	Support ensuring that regulations include the ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	Ministry of Resources and Development		Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	USCG	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
Support the national government with establishing and enforcing ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national level participation and enforcement of globally ballast water requirements including discharge 200nm from shore and inspection of ship logs for compliance.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the national government with establishing and enforcing ballast water standards (continued)	Support of establishment of ballast water management and reporting requirements for all vessels utilizing ballast water.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support development of capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2017	Ministry of Resources and Development	External donor	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support national level adoption of proposed USCG regulations to move to in hull sanitation of ballast water.	2016	Ministry of Resources and Development	USCG	Medium
Increase marine system protection from invasive species	Support the establishment of biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Increase marine system protection from invasive species (continued)	Establish biosecurity practices and requirements for fishing vessels that operate in jurisdictional waters to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Address climate change linkages to invasive pests		Framework should be in place by 2016	YIST	US AID	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address food security for the state in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of Micronesia	FAO	Low
Early detection and rapid response					
Improve early detection and rapid response capacity	Consider linking invasive species ED & RR capacity with the State disaster management office.	2014	YIST	NA	Medium
	State agriculture office should be an active part of the disaster management team.	2014	Yap Agriculture	NA	Medium
	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	YIST	External donor	High
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	YIST	External donor	Medium
	Develop taxa specific ERPs as needed.	On-going	YIST	External donor	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	YIST	Biosecurity cost recovery system	High
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2015	YIST	Biosecurity cost recovery system	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2015	YIST	Biosecurity cost recovery system	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2015	YIST	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	YIST	Regional ISC Office	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	YIST	Regional ISC Office	High
	Hold consultations to determine what agency(s), office(s) and/or groups will be responsible for surveillance programs.	2015	YIST	Biosecurity cost recovery system	Medium
	Develop and institute surveillance programs for non-established species consider high risk of arrival such as CRB, alien snakes, fruit flies, tramp ants, etc.	2015	YIST	Biosecurity cost recovery system	High
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	YIST	Regional ISC Office	Low
	Work with police to develop MOU to assist with enforcing internal quarantine if needed during a response action.	2015	YIST	Biosecurity cost recovery system	Low
Management and eradication					
Increase management and control of established invasive species	Determine which established invasive species are actionable and proceed with developing management strategies.	conduct consultations 2015; develop strategies 2016	YIST	External donor	Medium
	Create GIS layers regarding the distribution of established IAS and use to support biosecurity and IAS management efforts.	2015	College of Micronesia	External donor	Low
	Key staff need to receive GIS training both in regards to field data collection and the utilization of GIS databases and computer systems.	2015	College of Micronesia	External donor	Low
	Key offices need resources to support electronic mapping efforts (GIS), including computers, software, and GPS units.	2015	Yap Agriculture	External donor	Low
	Train natural resource staffs at the local level in regards to IAS management support.	2015	YIST	Regional ISC Office	Low
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	2015	YIST	Regional ISC Office	Low
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2015	Yap Agriculture	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase management and control of established invasive species (continued)	Develop standardized SOPs for IAS monitoring and surveys.	2015	YIST	External donor	Low
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distribution is current.	2015	Yap Agriculture	External donor	Low
	Conduct surveys to determine the extent of the Tilapia invasion.	2015	YIST	External donor	High
	Determine what species/hybrids of Tilapia are present and extent of the range of each if more than one.	2015	YIST	External donor	High
	Re-engage rodent control efforts throughout the state.	2016	Yap Health Office	External donor	Medium
	Develop and implement a Tilapia management/eradication plan (increased awareness in local communities will need to be a significant part of this program).	2016	YIST	External donor	High
	Develop control plan for mile a minute vine (<i>Mikania micrantha</i>).	2015	YIST	External donor	High
	Implement action against mile a minute vine.	2016	YIST	External donor	High
Increase efforts to eradicate targeted species	Conduct surveys and hold stakeholder consultations to determine what established species are viable candidates for eradication efforts.	2015 consultations; 2016 develop strategy; 2017 implement	YIST	External donor	Low
	Develop strategies to conduct eradication campaigns including securing funding streams to support these efforts.	2016	YIST	External donor	Low
	Develop resources to respond to new pest incursions beyond ED & RR, including conducting delimiting surveys and potential eradication efforts.	2016	YIST	External donor	Medium
	Eradicate small and feasible invasive species incursions promptly, while it is most feasible, least expensive, and before extensive damage has occurred.	Develop capacity by 2017; process should be on-going from that point	YIST	External donor	Medium
Increase export potential	Support national efforts to establish produce export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support national efforts to establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Improve capacity to export crops, including betelnut, which will involve finding/establishing markets with trade partners.	2016	Yap Agriculture	SPC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase export potential (continued)	train and certify state agricultural staff to support local farmers with enhancing the potential for export crops.	2016	Yap Agriculture	SPC	Medium
	Support local farms with capacity development to increase potential to export crops.	2016	Yap Agriculture	SPC	Medium
	Ensure that fumigation for export crops is available and appropriate used.	2016	Yap Agriculture	SPC	Medium
	State officials should work with proposed external trade partners to ensure that export crops of interest are permitted for importation (example: betelnut).	2015	Yap Agriculture	SPC	High
	Improve ability to meet import standards imposed by trade partners in regards to agricultural produces and processed foods.	2015	Yap Agriculture	SPC/USDA	High
	Increase protection of export crops from invasive pests by better management of established species and improved border security to reduce the introduction of new pests to the state.	on-going	Yap Agriculture	SPC	High
	Ensure that all proposed agricultural exports go through an establish protocol to ensure cleanliness before entering the shipping lines to reduce the potential for transport of unwanted pests.	2016	Yap Agriculture	SPC	High
Improve usage and better regulation of pesticides used for both agricultural purposes and to treat specific pest infestations (termites, etc.)	Pesticide training courses should be held to provide farmers and others with basis skills in pesticide use. Use of restricted pesticides should be done by licensed applicators only.	2015	Yap Agriculture	External donor	Medium
	Support development of a regional standard in pesticide labelling (US pesticides are already labelled, but those coming from Asia typically are not). US Mainland standards may not be appropriate for the region and therefore while they should be consider, they should not necessarily be the final determination.	2016	Yap Invasive Species Coordinator	FAO may in fact being developing something similar and they should be consulted and worked with in this regard	Medium
	Educational materials regarding pesticides are needed for distribution to assist farmers and others with appropriate use of chemicals, but also to better inform the public regarding pesticide use. UH extension has already developed posters for chemical education which could be used once verbiage in local language(s) is add to these posters.	2016	Yap Agriculture	University of Hawaii	Low
Increase alien snake detection capacity	FSM quarantine officers and state counterparts should be trained in alien snake inspection SOPs, detection and response.	2015	Ministry of Resources and Development	Regional ISC Office	High
	Install a snake proof fence at main seaport.	2016	Port Authority	External donor	Low
	Institute snake sentinel trapping at main ports.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Awareness</i>					
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and state wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	YIST	External donor	High
	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the state from unwanted pests.	2015	YIST	External donor	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	YIST	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	YIST	External donor	High
	Coordinate existing outreach efforts.	2015	YIST	External donor	Medium
	Support adding invasive species education as a standard part of school curriculums region wide.	2017	YIST/Ministry of Education	External donor	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2016	YIST/Ministry of Education	External donor	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	on-going	YIST	External donor	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	On-going	YIST	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	Yap Invasive Species Coordinator	Regional ISC office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	YIST	External donor	Medium
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	Yap RISC representatives	RISC	Medium
	Develop a wildlife reference collection (i.e., taxidermy mounts, computer photo files, etc.) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.	2016	Yap Agriculture	External donor	Low
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials in Yap, including the potential loss of business if invasive species are permitted to establish.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2015	YIST	Regional ISC office	Medium
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of Micronesia	External donor	Low
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2015	College of Micronesia	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Restoration</i>					
Increase restoration efforts of native systems where IAS management and/or eradication efforts are underway or have been successful.	Implement investigations into firefly and dragonfly declines (may be associated with IAS).	2015	Yap Agriculture	External donor	Low
	Improve documentation of native species declines.	2015	Yap Agriculture	External donor	Low
	Investigate primary causes of mangrove die offs which reported have been extended by wind damage.	2015	Yap Agriculture	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment G: Federated States of Micronesia National Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the FSM section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	FSM RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	FSM RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report shared with the region and beyond.	continuous, yearly	RISC Representatives and National ISC	Biosecurity cost recovery system	Medium
Establish a national invasive species coordination office that is tasked with supporting nation wide IAS efforts across agencies and offices as well as working regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the national invasive species coordination position.	2015	Ministry of Resources and Development	This should be part of the cost recovery biosecurity system	Medium
	Once established this office should support and assist in coordinating efforts with invasive species within the nation. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that the heads of government are regularly updated regarding both national and regional invasive species developments.	2015	Ministry of Resources and Development	This should be part of the cost recovery biosecurity system	Medium
	Once established this office should serve as the main linkage between the nation and the region on invasive species issues, communicating national activities to the region as well as engaging the region and beyond when feasible to support and assist with invasive species efforts within the nation.	2015	Ministry of Resources and Development	This should be part of the cost recovery biosecurity system	Medium
Coordinate with stakeholders both national and state levels to support a united effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of R&D	NA	High
	Add GMO and LMO coverage to the draft bill.	Complete by August 2014	Ministry of R&D	NA	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	Complete by September 2014	Ministry of R&D	NA	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Coordinate with stakeholders both national and state levels to support a united effort towards moving draft biosecurity legislation forward (continued)	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	Complete by December 2014	FSM ISC	NA	High
Improve communication and information sharing in regards to IAS and biosecurity	Develop SOPs at the national level to facilitate communication and information sharing between offices and agencies at both national and state levels in regards to invasive species and biosecurity.	2015	FSM ISC	Biosecurity cost recovery system	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	FSM RISC representatives and President's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	FSM RISC representatives and the FSM ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.	As soon as the office can be established	FSM RISC representatives and the FSM ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support capacity building, training, and advice.	As soon as the office can be established	FSM RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office with supporting protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>FSM RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting establishing ER & RR capacity.</p>	<p>As soon as the office can be established</p>	<p>FSM RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>FSM RISC representatives and the FSM ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.</p>	<p>As soon as the office can be established</p>	<p>FSM RISC representatives and the Ministry of Resources and Development</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.</p>	<p>As soon as the office can be established</p>	<p>FSM RISC representatives and the FSM ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued)	Engage the regional invasive species coordination office to support management, response, and eradication efforts.	As soon as the office can be established	FSM RISC representatives and the FSM ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	As soon as the office can be established	FSM RISC representatives and the FSM ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts.	As soon as the office can be established	FSM RISC representatives and the FSM ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve capacity to identify biosecurity intercepts and organisms detected post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity such as SPC) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	FSM Invasive Species Coordinator	Biosecurity cost recovery system	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	FSM Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going, finalize by 2018	College of Micronesia	External donor	Low
	Support the development of an algal risk assessment for the region.	2016	College of Micronesia	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of Micronesia	External donor	Low
	Support the development of an arthropod risk assessment for the region.	2016	College of Micronesia	External donor	Medium
	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	FSM Office of Foreign Affairs	SPC	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	FSM ISC	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going		Regional ISC office	Low
	Support the development of a weeds risk assessment for the region.	2016	College of Micronesia	External donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	FSM RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	FSM RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	FSM RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	FSM RISC representatives	RISC	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve the functionality of RISC	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	FSM RISC representatives	NA	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	FSM RISC representatives	External donor	Medium
Prevention					
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 Hold national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	External donor	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	Biosecurity cost recovery system	High
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security	Acquire and install X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	Ministry of Resources and Development	External donor	High
	ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Institute 100% x-raying of all arriving passenger baggage.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Consider developing SOPs for incoming baggage and cargo inspections which are based on successful models (such as New Zealand); would require hiring and training additional personnel, installing appropriate equipment (X-ray, etc.), training additional canine teams for detection of specific high risk IAS (reptiles, fruits, meats, etc.); insuring appropriate data collection and development and maintaining of databases to track efforts and interceptions.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that inspections process while targeting high risk goods also ensure random sampling of all imports, travelers, and baggage in order to better detect hitchhiker pests.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	An area not well covered by biosecurity currently is the use of the internet for trade. Regulated and prohibited goods arrive in the region via the mail pathway with bogus labelling from people buying on the internet. A plan will be needed to address this pathway. Of significant concern in this regard is the potential for shipping of pets such as reptiles and plant material via the mail system with little ability to detect and intercept these organisms by current biosecurity systems within the region. Trained detector dogs, visual inspections and X-ray machines could all be utilized to reduce the potential for illicit mail trade, but appropriate regulations need to be established which would permit the potential inspection of most if not all arriving mail.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Ensure that restrictions on soil importation are backed up with regulations supported by legislation.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Establish a canine pest detection program for items such as snakes, fruits, and vegetables. Consider the potential to combine this program with similar programs for detection of illicit materials such as drugs.	2016 hold national consultation on the need for a biosecurity canine program; 2017 establish program if deemed appropriate	Ministry of Resources and Development	Initial support might have to be sought in the form of external donor funding; once the program is established, it should be supportable under an appropriately managed cost recovery system for biosecurity	Low
	All imported animal products, including food items should be check for compliance with international standards (or national standards if they exist). Standards should be enforced equally and items found to be non-compliant should be either turn away or destroyed.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Implement advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, identification of livestock, wildlife and poultry diseases and pests, etc.).	on-going	Ministry of Resources and Development	SPC	Medium
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Ensure that restrictions on soil importation are applied to all soils, including bags of soil and other similar items which can also harbor live organisms. If pre-bagged soil and soil like materials are going to be imported, then they should be pre-treated to insure that they are sterile on arrival.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	External donor	Low
	ensure that the national quarantine office is appropriate funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts nation wide).	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Hire and train additional quarantine staff as needed. Should be based on needs assessment. An inspections database should be able to document existing needs.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Develop legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Protocols need to be established regarding quarantine inspection of arriving vessels: manifest should be check, cargo, ships stores, galleys, garbage, and cabins should all be inspected. Distinct SOPs are most likely needed for a variety of vessel types including aircraft, fishing vessels, support ships, cargo ships, tankers, yachts, barges. Non-compliance with regulations should be noted and appropriate follow-up actions should be taken including fines, confiscations, and turning away cargo and possibly entire vessels if needed. Inspection data should be collected and recorded into a system wide database.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Establish an electronic database for quarantine inspection data that can be searched and data extracted for analysis. Such a database would support better targeting of vectors and pathways, permit tracking of known violators, provide documentation regarding interceptions, fee and penalty payments, demonstrate appropriate use of resources, quantify gaps and needs in current system, assist in determining pathways associated with post border detections, tracking of live imported species and number of individuals, tracking changes in vector arrivals and embarkation locations, etc.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Training quarantine staff in data collection, entry, management and analysis, develop appropriate field inspection forms, conduct quality control of data systems, ensure that field data is entered into system in a scheduled manner to prevent backlogging, ensure that the data system is appropriately and regularly backed up to prevent systematic losses.	2015	Ministry of Resources and Development	SPC	High
	Protocols should be established by quarantine for documenting interceptions and final disposition of materials. These reports should be entered into a database and information should be shareable to assist all locations within the FSM to better protect borders but also with other jurisdictions of the region to better protect the region. Protocols should be established regarding how and when (how often) this type of	2015	Ministry of Resources and Development	should be covered by the cost recovery system	High
	Institute quarterly reporting on quarantine inspections based on database information and ensure that reports are appropriate shared.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop regulations regarding garbage as it pertains to arriving vessels. Regulations need to be enforce and systems need to be developed and in place to deal with regulated garbage. Protocols for regulated garbage should include specifics on handling, where it will be take, how it will be transported, and how it will be handled once it has arrived at final location (burned?, buried? Or treated?). Regulated garbage because of its potential of harboring IAS needs to be kept separate from other trash and needs to be sterilized in some fashion.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Develop and institute quarantine exchange programs with New Zealand, Australia, and/or U.S. biosecurity agencies as a mechanism for improving inspector capacity and further development of the nation's biosecurity program.	2016	Ministry of Resources and Development	External donor	High
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	SPC, Regional ISC Office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Address the lack of marine biosecurity oversight. Need to build legislation to support national quarantine having marine biosecurity capacity.	should be added to current draft legislation 2014	Ministry of Resources and Development	External donor	High
	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2016	Ministry of Resources and Development	SPC, Regional ISC Office	Low
	Establish national standards for the importation and use of GMO and LMO. GMOs and LMOs should be labelled as such.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Low
	Conduct a national review of GMOs and LMOs regarding if and how they may be covered by intellectual property rights.	2014	Ministry of Resources and Development	External donor	Low
	Develop MOU's between the national quarantine office and other agencies involved in border inspections (such as customs) so that these offices/agencies can support the quarantine office with biosecurity aspects.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop SOPs regarding specifics of how other agencies and offices can support the role of the national quarantine office during border inspection process.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Institute biosecurity cross training of staffs from agencies which are involved in border inspection processes.	2015	Ministry of Resources and Development	Regional ISC office	Low
	Review official ports of entry for the nation to better determine if and how biosecurity aspects can be expanded to include additional ports.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Review field ship ports of call and develop biosecurity standards for field ships and other conveyances that operate within the nation or internationally.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Develop regulations regarding biosecurity and visiting cruise ships. These ships, if visiting multiple sites within the nation should fund having a biosecurity office on board during the period that they within national waters, provide for inspection services at all ports of call, cover all travel expenses for the biosecurity officer, and coordinate with the national quarantine office to ensure that the inspector's home port does not experience a drop in quarantine services during their absence (this may include paying for overtime).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	Ministry of Resources and Development	External donor	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering the FSM should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
Improve ability to better enforce pre-departure sanitation	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	SPC	Medium
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Ministry of Resources and Development	should be covered by the cost recovery system	Medium
	Develop and institute standards which would increase pre-departure inspections. Visual inspections are conducted pre-departure which focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture. All jurisdictions should add quarantine inspections to the SOP of departing materials.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Low
Address the fact that humans can serve as vectors of invasive species	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address the fact that humans can serve as vectors of invasive species (continued)	National health authorities should work with CDC to determine what, if any, role DoD can support in the advent of a human pathogen outbreak. For example, could CDC direct DoD to transport sick patients to appropriate support facilities either within or outside of the national in the case of a human pathogenic outbreak?	2015	Ministry of Health	External donor	Low
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015: Develop agreements with shippers for medical services (consider working with airlines and/or DoD)	Ministry of Health	External donor	Medium
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update white list on a regular basis.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop a government endorsed black list of prohibited species.	2014	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Update black list on a regular basis.	annually	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	Implement in 2015; update annually once implemented	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a national biosecurity advisory committee to review proposals for the importation of exotic species.	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery biosecurity system	High
	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	FSM Office of the Attorney General	External donor	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Ministry of Resources and Development	External donor	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Improve capacity and infrastructure regarding animal health. There should be a national veterinarian with support staff (para-vets?) in each state.	2016	Ministry of Resources and Development	Develop a cost recovery system that supports national animal health services	Medium
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct an national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	FSM ISC	External donor	Low
Increase export potential	Establish produce export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Establish and enforce biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish standards and regulations regarding biofouling, including inspection and certification for all vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establish additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish additional regulations for impounded vessels.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	Ministry of Resources and Development	External donor	High
	Establish regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	External donor	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	External donor	High
	Ensure that regulations include ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a biofouling management program	2014: this should be included in the current draft biosecurity legislation; May need to update and expand in 2016-17 as elements come on line	FSM Office of the Attorney General	Biosecurity cost recovery system	High
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase marine system protection from invasive species	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for fishing vessels that operate in Micronesia to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
Establish and enforce ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Adopt and enforce international ballast water regulations (discharge at least 200nm off shore). Inspection of ship logs for compliance.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Establish ballast water management and reporting requirements for all vessels utilizing ballast water.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2017	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support national level adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	Ministry of Resources and Development	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	NA	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	USCG	Medium
Address climate change linkages to invasive pests		Framework should be in place by 2016	FSM ISC	US AID	Medium
Address food security for the nation in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of Micronesia	FAO	Low
Awareness					
Increase outreach and education on biosecurity and invasive species	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the nation from unwanted pests.	2015	FSM ISC	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	FSM ISC	External donor	High
	Coordinate existing outreach efforts.	2015	FSM ISC	External donor	Medium
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	FSM ISC	External donor	High
	Add invasive species education as a standard part of school curriculums.	2016	FSM ISC/Ministry of Education	External donor	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2015	FSM ISC/Ministry of Education	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Develop an educational strategy that is long term, extensive and nation wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	FSM ISC	External donor	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	2016	FSM ISC	External donor	Low
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts	on-going	FSM ISC	External donor	Low
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	FSM ISC	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	FSM ISC	Regional ISC office	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2014	FSM ISC	External donor	Medium
	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	FSM ISC	RISC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish.	Start in 2014	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
<i>Research</i>					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of Micronesia	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment H: Republic of the Marshall Islands Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the RMI section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	MIIST	Biosecurity cost recovery program should fund this activity	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	MIIST	Regional ISC office	Medium
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	MIIST	Regional ISC office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCEES, including a written report shared with the region and beyond.	continuous, yearly	RISC Representatives and National ISC	NA	High
Establish a jurisdictional invasive species coordination office that is tasked with supporting nation wide IAS efforts across agencies and offices as well as working regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the invasive species coordination position.	2015	MIIST	This should be a long term position with funding and other resources coming from the port biosecurity cost recovery program	High
	Once established this office should support and assist in coordinating efforts with invasive species within the nation. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that the heads of government are regularly updated regarding both national and regional invasive species developments.	continuous	RMI Invasive Species Coordinator	This should be a long term position with funding and other resources coming from the port biosecurity cost recovery program	High
	Once established this office should serve as the main linkage between the nation and the region on invasive species issues, communicating national activities to the region as well as engaging the region and beyond when feasible to support and assist with invasive species efforts within the nation.	continuous	RMI Invasive Species Coordinator	This should be a long term position with funding and other resources coming from the port biosecurity cost recovery program	High
Coordinate with stakeholders to provide a united and active effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by August 2014	Ministry of Resources and Development	NA	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Coordinate with stakeholders to provide a united and active effort towards moving draft biosecurity legislation forward (continued)	Add GMO and LMO coverage to the draft bill.	Complete by August 2014	Ministry of Resources and Development	NA	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	2014	Ministry of Resources and Development	NA	High
	Ensure that supporters of the bill are advocating for it with the legislature and president's office on a regular basis with the expectation that it will be passed before the end of the calendar year.	2014	MIIST	NA	High
Update and regularly maintain the national invasive species action plan (ISAP) and annually report on progress	Update current plan.	in progress completed July 2013	Office of Environmental Planning and Policy Coordination	External donor	High
	Establish protocol to revisit and update every 3 to 5 years.	On-going	MIIST	NA	High
	Include annual reporting on progress of the national ISAP at the MCES and development a short annual 1-2 pagers to share progress regionally and beyond (combine with similar activities for the RBP).	On-going annually	RISC Representatives and RMI ISC	NA	High
Improve communications and ability to address biosecurity concerns between US DoD and the RMI civilian government agencies	Establish an MOU between the RMI and DoD regarding biosecurity within the RMI in regards to DoD activities and facilities.	2015	Ministry of Foreign Affairs	NA	High
Improve communication and information sharing in regards to IAS and biosecurity	Develop SOPs at the national level to facilitate communication and information sharing between offices and agencies in regards to invasive species and biosecurity.	2015	MIIST	RMI Biosecurity Cost Recovery system	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	RMI RISC representatives and President's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	RMI RISC representatives and the RMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.	As soon as the office can be established	RMI RISC representatives and MIIST	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support capacity building, training, and advice.	As soon as the office can be established	RMI RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office with supporting protocol and methods development.	As soon as the office can be established	RMI RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office with supporting establishing ER & RR capacity.	As soon as the office can be established	RMI RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.	As soon as the office can be established	RMI RISC representatives and the RMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.	As soon as the office can be established	RMI RISC representatives and the Ministry of Resources and Development	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.	As soon as the office can be established	RMI RISC representatives and the RMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support management, response, and eradication efforts.	As soon as the office can be established	RMI RISC representatives and the RMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	As soon as the office can be established	RMI RISC representatives and the RMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts.	As soon as the office can be established	RMI RISC representatives and MIIST	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve capacity to identify biosecurity intercepts and organisms detection post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity such as SPC) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	RMI Invasive Species Coordinator	Biosecurity cost recovery system	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	RMI Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going	College of the Marshall Islands	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of the Marshall Islands	External donor	Low
	Support the development of an algal risk assessment for the region.	2016	College of the Marshall Islands	External donor	Medium
	Support the development of an arthropod risk assessment for the region.	2016	College of the Marshall Islands	External donor	Medium
	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	Office of Environmental Planning and Policy Coordination	SPC	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	Office of Environmental Planning and Policy Coordination	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Office of Environmental Planning and Policy Coordination	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region.	2016	College of the Marshall Islands	External donor	Medium
Improve the functionality of RISC	RISC members should work with national governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	RMI RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the invasive species community and governance.	Reviews should correspond with turn over in Government	RMI RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	RMI RISC representatives	RISC	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve the functionality of RISC (continued)	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	RMI RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	on-going	RMI RISC representatives	NA	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	RMI RISC representatives	External donor	Medium
Prevention					
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 Hold national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve pre-border sanitation efforts (continued)	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
Improve border security	Acquire and install X-ray machines for biosecurity at all ports of entry.	2015	Ministry of Resources and Development	External donor	Medium
	ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2015	Ministry of Resources and Development	External donor	Medium
	ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2015	Ministry of Resources and Development	External donor	Medium
	Institute 100% x-raying of all arriving passenger baggage.	2015	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	Medium
	Consider developing SOPs for incoming baggage and cargo inspections which are based on successful models (such as New Zealand); would require hiring and training additional personnel, installing appropriate equipment (X-ray, etc.), training additional canine teams for detection of specific high risk IAS (reptiles, fruits, meats, etc.); insuring appropriate data collection and development and maintaining of databases to track efforts and interceptions.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	Medium
	Ensure that inspections process while targeting high risk goods also ensure random sampling of all imports, travelers, and baggage in order to better detect hitchhiker pests.	2015	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	Medium
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	Medium
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Ministry of Resources and Development	External donor	Low
	Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	An area not well covered by biosecurity currently is the use of the internet for trade. Regulated and prohibited goods arrive in the region via the mail pathway with bogus labelling from people buying on the internet. A plan will be needed to address this pathway. Of significant concern in this regard is the potential for shipping of pets such as reptiles and plant material via the mail system with little ability to detect and intercept these organisms by current biosecurity systems within the region. Trained detector dogs, visual inspections and X-ray machines could all be utilized to reduce the potential for illicit mail trade, but appropriate regulations need to be established which would permit the potential inspection of most if not all arriving mail.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	Medium
	All imported animal products, including food items should be check for compliance with international standards (or national standards if they exist). Standards should be enforced equally and items found to be non-compliant should be either turn away or destroyed.	2015	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	Medium
	Implement advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, identification of livestock, wildlife and poultry diseases and pests, etc.).	on-going	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	Medium
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	Review relevant APHIS guidelines 2014; Develop and implement RMI guidelines 2015	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity; technical support from the Regional ISC Office and SPC	Medium
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should including materials previously treated or cleaned (due to the potential for recontamination after treatment).	Immediate	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2015	Ministry of Resources and Development	External donor	Medium
	ensure that the national quarantine office is appropriately funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts nation wide).	Conduct a national review in 2015; move forward with planning and development of cost recovery system in 2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	High
	Hire and train additional quarantine staff as needed. Should be based on needs assessment. An inspections database should be able to document existing needs.	Conduct needs assessment 2014; Hire and train additional staff in 2015 as indicated by the needs assessment	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	High
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	on-going	Ministry of Resources and Development	External donor	Low
	Protocols need to be established regarding quarantine inspection of arriving vessels: manifest should be checked, cargo, ships stores, galleys, garbage, and cabins should all be inspected. Distinct SOPs are most likely needed for a variety of vessel types including aircraft, fishing vessels, support ships, cargo ships, tankers, yachts, barges. Non-compliance with regulations should be noted and appropriate follow-up actions should be taken including fines, confiscations, and turning away cargo and possibly entire vessels if needed. Inspection data should be collected and recorded into a system wide database.	Draft protocols 2014; review and finalize before end of 2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Establish an electronic database for quarantine inspection data that can be searched and data extracted for analysis. Such a database would support better targeting of vectors and pathways, permit tracking of known violators, provide documentation regarding interceptions, fee and penalty payments, demonstrate appropriate use of resources, quantify gaps and needs in current system, assist in determining pathways associated with post border detections, tracking of live imported species and number of individuals, tracking changes in vector arrivals and embarkation locations, etc.	Consultation on this topic should occur no later than early 2015; design and development should begin before the end of 2015; Database should be in place and staff trained in its use and up keep before the end of 2016	Ministry of Resources and Development	External donor	High
	Training quarantine staff in data collection, entry, management and analysis, develop appropriate field inspection forms, conduct quality control of data systems, ensure that field data is entered into system in a scheduled manner to prevent backlogging, ensure that the data system is appropriately and regularly backed up to prevent systematic losses.	Should be developed in tandem with the biosecurity database	Ministry of Resources and Development	External donor	High
	Protocols should be established by quarantine for documenting interceptions and final disposition of materials. These reports should be entered into a database and information should be shareable to assist all locations within the RMI to better protect borders but also with other jurisdictions of the region to better protect the region. Protocols should be established regarding how and when (how often) this type of information is shared. Information collected and stored should include date of incident, inspector in charge, what was intercepted, what IAS were found, numbers of pests found, origin of the material in question, disposition of the material(s) and specimen(s), what remedial actions (if any) were taken against the shipper, and if fines were instituted, were they collected.	Should be developed in tandem with the biosecurity database	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	High
	Establish of national standards for the importation and use of GMO and LMO. GMOs and LMOs should be labelled as such.	2015	Ministry of Resources and Development	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Institute quarterly reporting on quarantine inspections based on database information and ensure that reports are appropriately shared.	Reports should be forthcoming before the end of 2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.	Review USDA user fee structure 2014; On passage of the RMI biosecurity legislation (2014), specific regulations regarding fees should follow	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	High
	Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.	Consult with the region 2014; Develop and implement fee 2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Develop regulations regarding garbage as it pertains to arriving vessels. Regulations need to be enforce and systems need to be developed and in place to deal with regulated garbage. Protocols for regulated garbage should include specifics on handling, where it will be take, how it will be transported, and how it will be handled once it has arrived at final location (burned?, buried? Or treated?). Regulated garbage because of its potential of harboring IAS needs to be kept separate from other trash and needs to be sterilized in some fashion.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system would ideally cover the costs of these needs. Until this system is functional, other funding sources may be required to fill the funding gap	Medium
	Develop and institute quarantine exchange programs with New Zealand, Australia, and/or U.S. biosecurity agencies as a mechanism for improving inspector capacity and further development of the nation's biosecurity program.	2015	Ministry of Resources and Development	External donor	Low
	Institute biosecurity cross training of staffs from agencies which are involved in border inspection processes.	2015	Ministry of Resources and Development	SPC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Address the lack of marine biosecurity oversight. Need to build legislation to support national quarantine having marine biosecurity capacity.	2014 should be added to the current draft biosecurity legislation under consideration	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Security protocols for ports should be established, enforced and applied equally to all. For example having a badge system with gated entry to all ports should be established and appropriately utilized.	2014	Port Authorities	RMI Biosecurity Cost Recovery system	High
	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2014	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Conduct a national review of GMOs and LMOs regarding if and how they may be covered by intellectual property rights.	2014	Ministry of Resources and Development	External donor	Medium
	Develop MOU's between the national quarantine office and other agencies involved in border inspections (such as customs) so that these offices/agencies can support the quarantine office with biosecurity aspects.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop SOPs regarding specifics of how other agencies and offices can support the role of the national quarantine office during border inspection process.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Establish a centralized joint facility for customs and quarantine offices, including quarantine areas, treatment areas, laboratory space, offices, and equipment storage.	Further develop planning and coordination for this effort in 2015; develop facilities in 2016-17	Ministry of Resources and Development	External donor	Medium
	Enforce biosecurity regulations, including the collection of fines and fees.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	High
	Develop a mechanism so that fines, fees and other monies are placed into a revolving fund that is used specifically to support biosecurity activities.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Establish a taskforce amongst RMI offices involved in border protection. This taskforce could coordinate activities and develop options for improving overall border protection including determining where offices can assist each other with joint tasks. Currently, all RMI border offices seem to have similar problems (lack of funding, staff, capacity, and resources). A joint taskforce could establish more clearly what needs to be done to improve the situation across the board, how the RMI could best address these issues and then find funding to support efforts to move forward with development, training, and implementation. Generally RMI offices need improved resource availability, increased staffing, and increased training.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop a system in which arriving sea vessels submit pre-clearance biosecurity information and wait to receive approval prior to entering lagoons or be turned away. Such information	2016	Ministry of Resources and Development	External donor	Medium
	Review official ports of entry for the nation to better determine if and how biosecurity aspects can be expanded to include additional ports.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop national biosecurity standards. For example, quarantine inspectors must be present to clear arriving containers.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	High
	Review field ship ports of call and develop biosecurity standards for field ships and other conveyances that operate within the nation or internationally.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2014	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop regulations regarding biosecurity and visiting cruise ships. These ships, if visiting multiple sites within the nation should fund having a biosecurity office on board during the period that they within national waters, provide for inspection services at all ports of call, cover all travel expenses for the biosecurity officer, and coordinate with the national quarantine office to ensure that the inspector's home port does not experience a drop in quarantine services during their absence (this may including paying for overtime).	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
Improve overall post border biosecurity	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	on-going	MIIST	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve overall post border biosecurity (continued)	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2016	Office of Environmental Planning and Policy Coordination	External donor	Medium
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	Office of Environmental Planning and Policy Coordination	External donor	Medium
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the nation: develop guidelines and implement policy including inspections and follow-up as required.	2014	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop a local depository for pest information including an intercept reference collection.	Set up depository by 2016; continuously update once established	College of the Marshall Islands	External donor	Low
	Support development of a regional depository for pest information.	2017	RMI Invasive Species Coordinator	External donor	Low
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	MIIST	External donor	Medium
	Require treatment of all WPM according to ISPM No. 15. All WPM entering the RMI or moving between islands within the RMI should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of wood packaging material (WPM) (continued)	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
Improve ability to better enforce pre-departure sanitation	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Ministry of Resources and Development	SPC	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop and institute standards which would increase pre-departure inspections. Visual inspections are conducted pre-departure which focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture. All jurisdictions should add quarantine inspections to the SOP of departing materials.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
Improve capacity for internal biosecurity	Develop biosecurity standards for ports other than those at Majuro Atoll and Kwajalein Atoll.	2016	Ministry of Resources and Development	External donor	Medium
	Implement and enforce biosecurity at ports other than those at Majuro and Kwajalein Atolls.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Conduct a nation wide consultation regarding internal biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	Ministry of Resources and Development	External donor	High
	Conduct risk assessments for outer islands for terrestrial and aquatic concerns.	this should be an on-going process	Office of Environmental Planning and Policy Coordination	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve capacity for internal biosecurity (continued)	Helicopters and private planes (or small scale commercial ventures) can be used to move passengers and cargo and where they exist or where there are plans for their use, they should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import.	2014	MIIST	Biosecurity cost recovery system	High
	Update white list.	annually	MIIST	Biosecurity cost recovery system	Medium
	Develop a government endorsed black list of prohibited species.	2014	MIIST	Biosecurity cost recovery system	High
	Update black list.	annually	MIIST	Biosecurity cost recovery system	Medium
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	Ministry of Resources and Development oversees risk assessment process and determines if it is sufficient and rules on outcome	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	Implement in 2015; update annually once implemented	MIIST	Biosecurity cost recovery system	Low
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a national biosecurity advisory committee to review proposals for the importation of exotic species.	2015	Ministry of Resources and Development	This should be supported by user fees as part of the cost recovery biosecurity system	High
	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Ministry of Resources and Development	External donor	Medium
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	RMI Office of the Attorney General	External donor	High
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	Office of Environmental Planning and Policy Coordination	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Office of Environmental Planning and Policy Coordination	External donor	Medium
	Improve capacity and infrastructure regarding animal health, including development of quarantine/holding facilities and hiring of a national veterinarian.	2016	Ministry of Resources and Development	External donor	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Establish a certification system for the movement (domestic and international) of live organisms.	2015 conduct a national consultation; 2016 develop draft system; 2017 implement system nation wide	Ministry of Resources and Development	Biosecurity cost recovery system	Medium
	Develop biosecurity standards for small scale, private citizen aquaculture set-ups and enforce these standards.	2015		Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Ministry of Resources and Development	Biosecurity cost recovery system	High
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	RMI Invasive Species Coordinator	External donor	Low
Establish and enforce biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Ministry of Resources and Development	External donor	Medium
	Establish standards and regulations regarding biofouling, including inspection and certification for all vessels.	2017	Ministry of Resources and Development	External donor	High
	Establish additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	Ministry of Resources and Development	External donor	Medium
	Establish additional regulations for impounded vessels.	2017	Ministry of Resources and Development	External donor	Medium
	Develop capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Establish regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	Ministry of Resources and Development	External donor	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Ministry of Resources and Development	External donor	Medium
	Establish the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Establishment biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	External donor	Medium
	Review and revise (as needed) legal authority to implement a biofouling management program	2014: this should be included in the current draft biosecurity legislation; May need to update and expand in 2016-17 as elements come on line	RMI Office of the Attorney General	External donor	High
	Ensure that regulations include ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	Ministry of Resources and Development	External donor	Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	External donor	Medium
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Ministry of Resources and Development	Technical support: USCG	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Ministry of Resources and Development	Technical support: USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	Technical support: USCG	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Develop capacity to deal with grounded and/or abandoned vessels (continued)	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Ministry of Resources and Development	Technical support: USCG	Medium
Establish and enforce ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Ministry of Resources and Development	External donor	Medium
	Adopt and enforce international ballast water regulations (discharge at least 200nm off shore). Inspection of ship logs for compliance.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Establish ballast water management and reporting requirements for all vessels utilizing ballast water.	2015	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	High
	Support national level adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	Ministry of Resources and Development	External donor	Medium
Increase marine system protection from invasive species	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase marine system protection from invasive species (continued)	Establish biosecurity practices and requirements for fishing vessels that operate in Micronesia to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2017	Ministry of Resources and Development	RMI Biosecurity Cost Recovery system	Medium
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	External donor	Medium
	National health authorities should work with CDC to determine what, if any, role DoD can support in the advent of a human pathogen outbreak. For example, could CDC direct DoD to transport sick patients to appropriate support facilities either within or outside of the national in the case of a human pathogenic outbreak?	2015	Ministry of Health	NA	Low
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved (i.e. donors need to be have dependable and rapid shipping available for medical supplies, etc. if such a situation was to arise).	2015: Develop agreements with shippers for medical services (consider working with airlines and/or DoD)	Ministry of Health	Emergency response	Medium
Address climate change linkages to invasive pests		2015 develop framework	Office of Environmental Planning and Policy Coordination	US AID	Medium
Address food security for the nation in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	College of the Marshall Islands	FAO	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Early detection and rapid response</i>					
Improve early detection and rapid response capacity	Establish a watch list of high-risk non-native species that are known or thought to pose significant ecological, economic, social, or cultural impacts	2015	MIIST	External donor	Medium
	Develop a detection program and response plan for new incursions by a few focal non-native species on the watch list of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	MIIST	External donor	Medium
	Develop taxa specific ERPs as needed.	on-going	MIIST	RMI Biosecurity Cost Recovery system	High
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	MIIST	RMI Biosecurity Cost Recovery system	High
	Develop a generic national emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	MIIST	External donor	High
	Establish a watch list of high-risk non-native species that are known or thought to pose significant ecological, economic, social, or cultural impacts.	2015	MIIST	External donor	Medium
	Develop a detection program and response plan for new incursions by a few focal non-native species on the watch list of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	MIIST	External donor	Medium
	Develop taxa specific ERPs as needed.	on-going	MIIST	RMI Biosecurity Cost Recovery system	High
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	MIIST	RMI Biosecurity Cost Recovery system	High
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2015	MIIST	RMI Biosecurity Cost Recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Ensure that the public reporting system is fully functional including supported by trained staff.	2015	MIIST	RMI Biosecurity Cost Recovery system	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	this should be an on-going process	MIIST	RMI Biosecurity Cost Recovery system	High
	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	MIIST	RMI Biosecurity Cost Recovery system	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	MIIST	Regional ISC office	High
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	this should be an on-going process	MIIST	External donor	Low
Management and eradication					
Increase management and control of established invasive species	Create GIS layers that delineate management zones, land tenure, and current distribution of established IAS and use to support biosecurity and IAS management efforts.	2015	College of the Marshall Islands	External donor	Low
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	on-going, start in 2015	RMI Invasive Species Coordinator	SPC, regional ISC office	Low
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2016	College of the Marshall Islands	SPC	Low
	Develop standardized SOPs for IAS monitoring and surveys.	2015	MIIST	External donor	Medium
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distributions are current.	on-going	MIIST	External donor	Medium
	Determine if the explosive algal growth seen on the ocean side of some areas of Majuro Atoll is due to an invasive species or a native species experiencing release. Once the species and its context is known, develop a control/management program to get it under control or possibly eradicate if it is in fact invasive.	2014	College of the Marshall Islands	External donor	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase management and control of established invasive species (continued)	Work with stakeholders and experts on a long term rodent management and control program for the country. Consider contracting outside experts (if needed) to assist with both the program development and implementation of specific aspects of the program as warranted. Specific components of the rodent control program should include: enforcement of the use of rat excluders on all mooring lines when vessels are docked, developing monitoring strategies, implement trapping strategies to reduce current rodent densities, and to ensure that port areas are clean and waste free.	Hold national consultancy (consider including outside experts) 2015; Develop planning 2016; implement program 2017	Ministry of Health/MIIST	External donor	Medium
	Determine which established invasive species are actionable and proceed with developing management strategies	Hold national consultancy 2016; Select actionable elements and develop management strategies 2017; implement 2018	MIIST	External donor	Medium
	Train natural resource staffs at the local level in regards to IAS management support.	on-going, start in 2015	Office of Environmental Planning and Policy Coordination	SPC, regional ISC office	Low
Increase efforts to eradicate targeted species	Conduct surveys and hold stakeholder consultations to determine what established species are viable candidates for eradication efforts.	2016	Office of Environmental Planning and Policy Coordination	External donor	Medium
	Develop strategies to conduct eradication campaigns including securing funding streams to support these efforts.	2016	Office of Environmental Planning and Policy Coordination	External donor	Medium
	Develop resources to respond to new pest incursions beyond ED & RR, including conducting delimiting surveys and potential eradication efforts.	2016	Office of Environmental Planning and Policy Coordination	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase efforts to eradicate targeted species (continued)	Develop and implement an eradication effort for the Majuro non-native caterpillar.	2014	MIIST	External donor	High
	Develop and implement an eradication effort for the Red-vented Bulbul.	2015	MIIST	External donor	High
	Eradicate small and feasible invasive species incursions promptly, while it is most feasible, least expensive, and before extensive damage has occurred.	should be an ongoing effort	Office of Environmental Planning and Policy Coordination	External donor	Medium
Awareness					
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and nation wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	MIIST/College of the Marshall Islands	External donor	High
	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the nation from unwanted pests.	2015	MIIST/College of the Marshall Islands	External donor	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	MIIST/College of the Marshall Islands	External donor	High
	Establish long term funding to support core outreach and educational efforts.	2016	MIIST/College of the Marshall Islands	NA	High
	Coordinate existing outreach efforts.	2015	MIIST/College of the Marshall Islands	NA	Medium
	Add invasive species education as a standard part of school curriculums.	2016	Ministry of Education/College of the Marshall Islands	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2015	Ministry of Education/ College of the Marshall Islands	External donor	Medium
	Develop posters, brochures and other print media to support invasive species awareness campaigns. Insure that these types of items are tied into the larger outreach strategy for the nation.	2016	MIIST/College of the Marshall Islands	External donor	Low
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	on-going	MIIST/College of the Marshall Islands	External donor	Low
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2015	MIIST/College of the Marshall Islands	External donor	Medium
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2014	Ministry of Resources and Development	Biosecurity cost recovery program should fund this activity	High
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	RMI Invasive Species Coordinator	RISC	High
	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations.	2015	RISC representatives	RISC	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2014	RMI Invasive Species Coordinator	Regional ISC office	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish.	Start in 2014	RMI Invasive Species Coordinator	External donor	Medium
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2015	College of the Marshall Islands	External donor	Low
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the nation that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts.	2016	College of the Marshall Islands	External donor	Low
Policy					
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations.	2014	Ministry of Resources and Development	NA	High
	Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2014	Ministry of Resources and Development	External donor	High
Restoration					
Increase restoration efforts of native systems where IAS management and/or eradication efforts are underway or have been successful.		on-going	Office of Environmental Planning and Policy Coordination	External donor	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment I: Republic of Palau Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Palau section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	Palau NISC	Biosecurity cost recovery program	Medium
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	Palau RISC representatives	Regional ISC Office	Medium
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Palau RISC representatives	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report shared with the region and beyond.	continuous, yearly	RISC Representatives and Palau NISC	NA	Medium
Improve support and functionality of the national invasive species coordination office/position.	This position should work country wide with appropriate offices, agencies, and NGOs involved in biosecurity efforts as well as internationally within the region and broader scope as needed.	on-going	President's Office	Funding should be in part from the biosecurity cost recovery system, in part from natural resources funding, and in part from donor grants	Medium
	This position/office should be adequately funded and supported technically and politically to ensure that Palau's needs in regards to IAS are being appropriate addressed and that the support for regional concerns is maximized.	on-going	President's Office	Funding should be in part from the biosecurity cost recovery system, in part from natural resources funding, and in part from donor grants	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve support and functionality of the national invasive species coordination office/position (continued).	Palau has a National Invasive Species Coordinator position, but not a separate office – the Coordinator reports to the Director of the Bureau of Agriculture at the present time. Consideration should be given to whether or not this is the best organizational structure. When the Coordinator position was first created, it sat in the Office of Environmental Response and Coordination with the President’s Office. The Palau National Invasive Species Committee (PNISC) recommended this location so that the Coordinator could work with all Ministries without being part of one Ministry or another.	2015	President's Office	Funding should be in part from the biosecurity cost recovery system, in part from natural resources funding, and in part from donor grants	Low
	Ensure that the Palau National Invasive Species Coordination position is a long term endeavor.	2014	President's Office	Funding should be in part from the biosecurity cost recovery system, in part from natural resources funding, and in part from donor grants	High
Coordinate with stakeholders to provide a united and active effort towards moving draft biosecurity legislation forward	Ensure that the current draft legislation is adequate specifically in regards to aquatic concerns.	Complete by April 2014	Palau NISC	NA	High
	Ensure that final draft legislation, including any updating, is available for appropriate authorities, including the national legislature to review and consider.	Complete by April 2014	Palau NISC	NA	High
	Ensure that supporters of the bill are advocating for it with the legislature and president’s office on a regular basis with the expectation that it will be passed before the end of the calendar year.	Complete by April 2014	Palau NISC	NA	High
Improve communications and ability to address biosecurity concerns between US DoD and civilian government agencies	Establish an MOU between Palau and DoD regarding biosecurity responsibilities and actions within the nation pertaining to mitigation of DoD activities and facilities.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	NA	Medium
	Establish SOPs on aspects of how DoD and Palau’s civilian agencies work together regarding biosecurity inspection process, etc. Turn over at DoD facilities in Palau is frequent and having established SOPs would assist with keeping processes in place.	2015	BOA	Biosecurity cost recovery program	High
Improve communication and information sharing in regards to IAS and biosecurity	Develop SOPs at the national level to facilitate communication and information sharing between offices and agencies at both national and state levels in regards to invasive species and biosecurity.	2015	Palau NISC	NA	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.</p>	<p>Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.</p>	<p>2014 - 2015</p>	<p>Palau RISC representatives and President's office</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and Palau NISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and BOA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office with supporting protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and BOA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office with supporting establishing ER &RR capacity.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and BOA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and BOA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>
	<p>Engage the regional invasive species coordination office to support management, response, and eradication efforts.</p>	<p>As soon as the office can be established</p>	<p>Palau RISC representatives and BOA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>Medium</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	As soon as the office can be established	Palau RISC representatives and BOA	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	Medium
	Engage the regional invasive species coordination office to support outreach and education efforts.	As soon as the office can be established	Palau RISC representatives and Palau NISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	Medium
Improve capacity to identify biosecurity intercepts and organisms detection post border, including micro organisms and viruses	Develop linkages with Hawaii (or other proximal locations with established capacity) for rapid shipment of specimens for testing and identification. SOPs should be developed once agreements with testing and identification facilities have been established.	2015	Palau Invasive Species Coordinator	Biosecurity cost recovery program	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2015	Ministry of Resources and Development	This should be covered as part of the biosecurity cost recovery system	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Palau Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going, establish by 2018	Palau Community College	external donor support	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	Palau Community College	external donor support	Low
	Support the development of an algal risk assessment for the region.	2016	Palau Community College	external donor support	Medium
	Support the development of an arthropod risk assessment for the region.	2016	Palau Community College	external donor support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Request that SPC develop a biosecurity position specifically for supporting the region.	2014	Palau Office of Foreign Affairs	SPC	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	Palau ISC	external donor support	Medium
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Palau ISC	Regional ISC office	Medium
	Support the development of a weeds risk assessment for the region.	2016	Palau Community College	external donor support	Low
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bi-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Palau RISC representatives	RISC	Medium
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Palau RISC representatives	RISC	Medium
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance).	Within 1 month of the December MCES on an annual basis	Palau RISC representatives	RISC	Medium
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Palau RISC representatives	RISC	Medium
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Palau RISC representatives	NA	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Palau RISC representatives	external donor support	Low
Prevention					
Improve pre-border sanitation efforts	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 Hold national consultation including review of pertinent models (New Zealand); 2016 Develop draft national standards; 2017 implement standards	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP. This concept was utilized already in Palau when gravel was brought in for the compact road and should be used as an example of what should be done across the board to better protect the nation from IAS. As an example, all imported plywood should meet minimal sanitation levels.	Should track with the preceding action item	BOA	Biosecurity cost recovery program	Medium
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo through cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	BOA	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security	Acquire and install X-ray machines for biosecurity at all ports of entry.	2016	BOA	external donor support	High
	ensure appropriate capacity for the use of X-ray machines for biosecurity at all ports of entry.	2016	BOA	external donor support	High
	ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	BOA	external donor support	High
	Institute 100% x-raying of all arriving passenger baggage.	2016	BOA	Biosecurity cost recovery program	High
	Consider developing SOPs for incoming baggage and cargo inspections which are based on successful models (such as New Zealand); would require hiring and training additional personnel, installing appropriate equipment (X-ray, etc.), training additional canine teams for detection of specific high risk IAS (reptiles, fruits, meats, etc.); insuring appropriate data collection and development and maintaining of databases to track efforts and interceptions.	2016	BOA	Biosecurity cost recovery program	High
	Re-establish fumigation capacity specifically for re-conditioning items like cut flowers on arrival if they are found to harbor pests.	2016	BOA	TBD	High
	Develop a canine pest detection program for items such as snakes, fruits, and vegetables. Consider the potential to combine this program with similar programs for detection of illicit materials such as drugs.	2017	BOA	external donor support	Medium
	Develop a wildlife reference collection (i.e., taxidermy mounts, computer photo files, etc.) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.	2016	BOA	external donor support	Medium
	Ensure that quarantine has access to freezers and incinerators at ports. Freezers need to have back up power supplies to ensure functionality. Freezers need to be restricted access for quarantine only.	2015	BOA	Biosecurity cost recovery program	High
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Bins should be placed so as to support use (not directly in front of quarantine stations). Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	BOA	Biosecurity cost recovery program	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Ensure that port authorities are working with quarantine in regards to use and placement of amnesty bins. Standard trash bins should also be located in appropriate areas and well signed so that passengers don't use amnesty bins for regular trash.	2015	BOA	Biosecurity cost recovery program	High
	Develop appropriate inspection facilities including a biosecure inspection facility at the seaport large enough for sea containers and wash-down areas with appropriate retention and treatment facilities for waste water produced.	2017	BOA	external donor support	Medium
	Ensure that inspections process while targeting high risk goods also ensure random sampling of all imports, travelers, and baggage in order to better detect hitchhiker pests.	2015	BOA	Biosecurity cost recovery program	High
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2015	BOA	Biosecurity cost recovery program	High
	Develop and institute quarantine exchange programs with New Zealand, Australia, and/or U.S. biosecurity agencies as a mechanism for improving inspector capacity and further development of the nation's biosecurity program.	2016	BOA	external donor support	Medium
	An area not well covered by biosecurity currently is the use of the internet for trade. Regulated and prohibited goods arrive in the region via the mail pathway with bogus labelling from people buying on the internet. A plan will be needed to address this pathway. Of significant concern in this regard is the potential for shipping of pets such as reptiles and plant material via the mail system with little ability to detect and intercept these organisms by current biosecurity systems within the region. Trained detector dogs, visual inspections and X-ray machines could all be utilized to reduce the potential for illicit mail trade, but appropriate regulations need to be established which would permit the potential inspection of most if not all arriving mail.	2015	BOA	Biosecurity cost recovery program	Medium
	Ensure ability to implement fines and collect fees to recover costs of re-conditioning when this option is utilized.	2015	BOA	Biosecurity cost recovery program	High
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	BOA	external donor support	Medium
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	BOA	Biosecurity cost recovery program	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Implement advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, identification of livestock, wildlife and poultry diseases and pests, etc.).	on-going	BOA	SPC, regional ISC Office, UH, others	High
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	BOA	Biosecurity cost recovery program	High
	Ensure that quarantine officers have adequate day to day resources such as computers, phones, vehicles, etc.	2015	BOA	Biosecurity cost recovery program	High
	Ensure that the national quarantine office is appropriately funded and that all biosecurity elements have adequate funding and day to day operational resources. Support the establishment of a cost recovery system for biosecurity so that any efforts beyond standard inspections have costs covered by the party or parties involved in the importation/shipping and that these costs as paid go directly to support the national biosecurity system (revolving fund that is used to support biosecurity efforts nation wide).	2015	BOA	Biosecurity cost recovery program	Medium
	Improved biosecurity standards in regards to mail services, including inspection of mail at port of arrival rather than at postal facilities which are post border. All mail should pass through biosecurity inspection.	2016	BOA	Biosecurity cost recovery program	High
	Hire and train additional quarantine staff as needed. Should be based on needs assessment. An inspections database should be able to document existing needs. Hired staff should need to meet minimal qualifications set by the oversight office (Bureau of Agriculture) and come through appropriate channels.	2016	BOA	Biosecurity cost recovery program	Medium
	Institute quarterly reporting on quarantine inspections based on database information and ensure that reports are appropriate shared.	2016	BOA	Biosecurity cost recovery program	Medium
	Review (and update if necessary) penalty assessment structure for noncompliance with biosecurity regulations.	2015	BOA	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	<p>Protocols need to be established regarding quarantine inspection of arriving vessels: manifest should be check, cargo, ships stores, galleys, garbage, and cabins should all be inspected. Distinct SOPs are most likely needed for a variety of vessel types including aircraft, fishing vessels, support ships, cargo ships, tankers, yachts, barges. Non-compliance with regulations should be noted and appropriate follow-up actions should be taken including fines, confiscations, and turning away cargo and possibly entire vessels if needed. Inspection data should be collected and recorded into a system wide database.</p>	2015	BOA	Biosecurity cost recovery program	Medium
	<p>Establish an electronic database for quarantine inspection data that can be searched and data extracted for analysis. Such a database would support better targeting of vectors and pathways, permit tracking of known violators, provide documentation regarding interceptions, fee and penalty payments, demonstrate appropriate use of resources, quantify gaps and needs in current system, assist in determining pathways associated with post border detections, tracking of live imported species and number of individuals, tracking changes in vector arrivals and embarkation locations, etc.</p>	2016	BOA	Cost recovery biosecurity system	Medium
	<p>Training quarantine staff in data collection, entry, management and analysis, develop appropriate field inspection forms, conduct quality control of data systems, ensure that field data is entered into system in a scheduled manner to prevent backlogging, ensure that the data system is appropriately and regularly backed up to prevent systematic losses.</p>	2016	BOA	Biosecurity cost recovery program	High
	<p>Develop legislation to create a user fee structure similar to that employed by USDA to support biosecurity efforts.</p>	2015	BOA	Biosecurity cost recovery program	Medium
	<p>Consider implementation of a visitor's fee to support biosecurity efforts. A standardized fee employed throughout the region would be ideal.</p>	2015	BOA	Biosecurity cost recovery program	Low
	<p>Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.</p>	2015	BOA	Biosecurity cost recovery program	High
	<p>Address the lack of marine biosecurity oversight. Need to build legislation to support national quarantine having marine biosecurity capacity.</p>	2015	BOA	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	<p>Protocols should be established by quarantine for documenting interceptions and final disposition of materials. These reports should be entered into a database and information should be shareable to assist all locations within the Palau to better protect borders but also with other jurisdictions of the region to better protect the region. Protocols should be established regarding how and when (how often) this type of information is shared. Information collected and stored should include date of incident, inspector in charge, what was intercepted, what IAS were found, numbers of pests found, origin of the material in question, disposition of the material(s) and specimen(s), what remedial actions (if any) were taken against the shipper, and if fines were instituted, were they collected.</p>	2016	BOA	Biosecurity cost recovery program	Medium
	<p>Consider developing a national tax on imports to support biosecurity development in Palau. A tax similar to the Green Fee but levied on certain imports (high risk items?) is desirable. This would basically be a user fee. Funds collected in this manner should be held separate and made available to support enhance biosecurity capacity.</p>	2015	BOA	Biosecurity cost recovery program	Low
	<p>Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.</p>	2015	BOA	Biosecurity cost recovery program	High
	<p>Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.</p>	2015	BOA	Biosecurity cost recovery program	Medium
	<p>Develop MOU's between the national quarantine office and other agencies involved in border inspections (such as customs) so that these offices/agencies can support the quarantine office with biosecurity aspects.</p>	2015	BOA	Biosecurity cost recovery program	High
	<p>Support the development and implementation of regional standards for biosecurity inspections and data collection and management.</p>	2015	BOA	SPC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Develop SOPs regarding specifics of how other agencies and offices can support the role of the national quarantine office during border inspection process.	2015	BOA	Biosecurity cost recovery program	Medium
	Institute biosecurity cross training of staffs from agencies which are involved in border inspection processes.	2015	BOA	SPC	Medium
	Establish a centralized facility for quarantine offices, including quarantine areas (plant and animal and aquatic organisms), treatment areas, laboratory space, offices, and equipment storage.	2017	BOA	external donor support	High
	Develop regulations regarding biosecurity and visiting cruise ships. These ships, if visiting multiple sites within the nation should fund having a biosecurity office on board during the period that they within national waters, provide for inspection services at all ports of call, cover all travel expenses for the biosecurity officer, and coordinate with the national quarantine office to ensure that the inspector's home port does not experience a drop in quarantine services during their absence (this may including paying for overtime).	2015	BOA	Biosecurity cost recovery program	Medium
	Develop specific regulations and enforcement SOPs for imported seeds. All imported and viable seeds should require completed risk assessments and permitting.	2015	BOA	Biosecurity cost recovery program	Medium
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2015	BOA	Biosecurity cost recovery program	High
	Undertake to implement more comprehensive data collection and better data management on IAS vectors and pathways, including detailed inspection processes, intercept records, preservation and compiling of voucher specimens, detailed records on where shipments, etc. are arriving from and specifically what is known to have harbored IAS and where it come from and how it arrived. Ensure that records are entered into a useable database and that data is analyzed and shared with partners as warranted. The tracking of live organisms would be better enabled with a data collection systems which tracked not only shipments but species and number of individuals as well.	2017	BOA	Biosecurity cost recovery program	Medium
Improve overall post border biosecurity	Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2017	Palau NISC	external donor support	Medium
	Conduct localized risk assessments of terrestrial, freshwater, and marine systems as feasible.	2017	Palau NISC	external donor support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve overall post border biosecurity (continued)	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	Palau NISC	external donor support	Medium
	Ensure proper cleaning of all large equipment and construction materials prior to moving between sites within the state.	2015	BOA	Biosecurity cost recovery program	Medium
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry in regards to invasive species.	2015	BOA	Biosecurity cost recovery program	Medium
	Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of locally sourced plants, preferably native plants. If non-natives are going to be used for landscaping, insure that they are non-invasive species. If plants will be brought into an area from outside for landscaping, insure that they are pest free. This code of conduct should encourage businesses: to make their staff knowledgeable about invasive plants, to inform their customers about invasive plants, to report immediately any likely exotic pest organisms found on their premises, and to use native or non-invasive plants locally sourced.	2015	Palau NISC	external donor support	Medium
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replace of WPM with recycled plastics.	on-going	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering Palau should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	BOA	Biosecurity cost recovery program	Medium
	Do not permit the unloading of noncompliant WPM.	2015	BOA	Biosecurity cost recovery program	High
	Treat or destroy any noncompliant WPM that is offloaded.	2015	BOA	Biosecurity cost recovery program	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of wood packaging material (WPM) (continued)	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	BOA	Biosecurity cost recovery program	High
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	BOA	Biosecurity cost recovery program	High
Improve ability to better enforce pre-departure sanitation	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	BOA	Biosecurity cost recovery program	Medium
	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping. Currently rented containers are inspected for internal cleanliness before departure. This should be expanded to include all containers and both internal and external surfaces.	2015	BOA	SPC	Medium
	Develop and institute standards which would increase pre-departure inspections. Visual inspections are conducted pre-departure which focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture. All jurisdictions should add quarantine inspections to the SOP of departing materials.	2016		Biosecurity cost recovery program	Medium
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	BOA	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2015	BOA	Biosecurity cost recovery program	Medium
Improve intra-state biosecurity and foreign arrivals at ports other than the main air and sea ports	Develop biosecurity standards for ports other than the main air and sea ports.	2016	BOA	Biosecurity cost recovery program	Medium
	Implement and enforce biosecurity at ports other than the main air and sea ports.	2016	BOA	Biosecurity cost recovery program	Medium
	Conduct a nation wide consultation regarding intrastate biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	BOA	Biosecurity cost recovery program	Medium
	Conduct risk assessments for outer islands for terrestrial and aquatic concerns.	2017	Palau NISC	external donor support	Medium
	States should develop biosecurity (kayangel is doing this now) others states should consider following suite, especially the outlying states.	2016	Individual States	NA	Medium
	Helicopters and private planes (or small scale commercial ventures) can be used to move passengers and cargo and where they exist or where there are plans for their use, they should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	BOA	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Ministry of Health	external donor support	Low
	National health authorities should work with CDC to determine what, if any, role DoD can support in the advent of a human pathogen outbreak. For example, could CDC direct DoD to transport sick patients to appropriate support facilities either within or outside of the national in the case of a human pathogenic outbreak?	2015	Ministry of Health	external donor support	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015: Develop agreements with shippers for medical services (consider working with airlines and/or DoD)	Ministry of Health	external donor support	Medium
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import.	Dec-14	BOA	Biosecurity cost recovery program	Medium
	Update white list on a regular basis.	annually	BOA	Biosecurity cost recovery program	Medium
	Develop a government endorsed black list of prohibited species.	Dec-14	BOA	Biosecurity cost recovery program	High
	Update black list on a regular basis.	annually	BOA	Biosecurity cost recovery program	Medium
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	BOA	Importer pays for all aspects of the risk assessment (regardless of outcome)	Medium
	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	2015	BOA	utilize student support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a national biosecurity advisory committee to review proposals for the importation of exotic species.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Funding: should be part of the biosecurity cost recovery system; technical support SPC/FAO	High
	Palau is currently considering importing shrimp from the CNMI and should be aware of what potential diseases, etc. may be associated with the CNMI stock and which if any of these are not yet established within the state and therefore should be kept out.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Funding: should be part of the biosecurity cost recovery system; technical support SPC/FAO	High
	Improve reporting and screening systems for import of live organisms, such that all live organisms to be imported need to be fully vetted with written documentation on species, numbers, origin, anticipated final disposition, pre-arrival sanitation inspection and health check, arrival inspection and health check are all clearly documented. Additionally live imports should receive prior approve for importation and any new species will need to go through a risk assessment process to be paid for by the user.	2015	BOA	Funding: should be part of the biosecurity cost recovery system; technical support SPC/FAO	Medium
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	BOA	external donor support	High
	Develop plan for containment and control measures in regards to exotic farmed and traded species.	2015	BOA	Biosecurity cost recovery program	Medium
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	BOA	Biosecurity cost recovery program	Medium
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2014, should be included in the current draft biosecurity legislation	Palau Office of the Attorney General	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	High
	Develop specific guidelines for unwanted pets. PAWS has something that should be review and further expanded as needed.	2015	BOA	NA	Medium
	Improve capacity and infrastructure regarding animal health. Koror State does have a veterinarian and perhaps this office should be engaged to support national efforts.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Develop biosecurity standards for household aquaculture set ups and enforce these standards. Small scale crab farming is currently developing.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Get support from FAO	Medium
	Develop guidelines for cages.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish a certification system for the movement (domestic and international) of live organisms. Might be difficult to do for the entire nation but may be feasible for outlying islands.	2015 conduct an national consultation; 2016 develop draft system; 2017 implement system nation wide	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	BOA	NA	High
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	Palau Invasive Species Coordinator	external donor support	Medium
Increase export potential	Establish produce and live organism export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	BOA	FAO	Low
	Establish processed foods export standards. Appropriate sanitation and consistency over time will be essential to insuring long term external market engagement.	2016	BOA	FAO	Low
	Improve capacity to export crops, which will involve finding/establishing markets with trade partners.	2016	BOA	FAO/SPC	Medium
	Train and certify agricultural staff to support local farmers with enhancing the potential for export crops.	2015	BOA	SPC	Medium
	Support local farms with capacity development to increase potential to export crops.	2016	BOA	SPC	Medium
	Ensure that fumigation for export crops is available and appropriate used.	2015	BOA	SPC	Medium
	Work with proposed external trade partners to ensure that export crops of interest are permitted for importation (example: betelnut).	2016	BOA	FAO	Medium
	Improve ability to meet import standards imposed by trade partners in regards to agricultural produces and processed foods.	2016	BOA	SPC/USDA	Medium
	Increase protection of export crops from invasive pests by better management of established species and improved border security to reduce the introduction of new pests to the state.	2015	BOA	external donor support	Medium
	Support appropriate development of slaughter house for pork product production. If appropriate established and sanitation guidelines are develop and established then it might be feasible to consider exportation in regards to this on-going development.	2015	BOA	FAO	Medium
Ensure that all proposed agricultural exports go through an establish protocol to ensure cleanliness before entering the shipping lines to reduce the potential for transport of unwanted pests.	2015	BOA	SPC	Medium	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish standards and regulations regarding biofouling, including inspection and certification for all vessels. Inspections can be trained to inspect hulls from top side with mirrors. If further inspection is warranted, then the craft pays for divers to inspect and make a report. If determined to be dirty, then the craft must either be cleaned or leave port and jurisdictional waters. Self clean outside of jurisdictional waters could be an option. Hull needs to be clean of all organisms, as the ability to identify all marine organisms is not available.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish additional regulations for impounded vessels.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium
	Develop capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Ensure that regulations include ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Review and revise (as needed) legal authority to implement a biofouling management program.	2014. This should be included in the current draft biosecurity legislation; May need to update	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Develop capacity to deal with grounded and/or abandoned vessels	Determine what agency has the legal authority for removal of grounded and/or abandoned vessels.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	USCG	Medium
	Develop a response plan for grounded and abandoned vessels that includes assessment and removal of non-native species in a timely manner to reduce the potential of incursions.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	USCG	Medium
	Establish a core team of responders (likely from a variety of agencies) with established SOPs for use in the advent of a grounded or abandoned vessel.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	USCG	High
	Ensure that funding is in place and can be utilized without delay in the case of a grounded or abandoned vessel.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	USCG	High
Increase marine system protection from invasive species	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium
	Biosecurity inspection of vessels (including the hull) before entering the rock islands should be added to the current permitting process. Permits already required, so why not ensure vessels are clean before departing for this protected area. Koror State could run this program. They have divers already and could do the inspections themselves.	2015	Koror State	Funding should come from entry fees	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase marine system protection from invasive species (continued)	Establish biosecurity practices and requirements for fishing vessels that operate in Micronesia to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
Establish and enforce ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	external donor support	Medium
	Adopt and enforce international ballast water regulations (discharge at least 200nm off shore). Inspection of ship logs for compliance.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Establish ballast water management and reporting requirements for all vessels utilizing ballast water.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2017	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
	Support national level adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium
Address climate change linkages to invasive pests		2016	Palau NISC	US AID	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address food security for the nation in regards to invasive pests.	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2016	Palau Community College	FAO	Medium
Early detection and rapid response					
Improve early detection and rapid response capacity	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	Palau NISC	external donor support	High
	The Palau national emergency framework includes IAS and has a process for mobilizing funding. Consider utilizing this framework as the basis for the IAS ED and RR efforts. Stakeholders need to be fully engaged in this framework if it is to be utilized as such.	2015	Palau NISC	NA	Medium
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	Palau NISC	external donor support	Medium
	Develop taxa specific ERPs as needed.	On-going	Palau NISC	Biosecurity cost recovery program	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	Palau NISC	Biosecurity cost recovery program	Medium
	Ensure that the public reporting system is fully functional including supported by trained staff.	2015	Palau NISC	Biosecurity cost recovery program	Medium
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2015	Palau NISC	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
improve early detection and rapid response capacity (continued)	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2015	Palau NISC	Biosecurity cost recovery program	Medium
	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	Palau NISC	Biosecurity cost recovery program	Medium
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2015	Palau NISC	Regional ISC office	Medium
	Hold consultations to determine what agency(s), office(s) and/or groups will be responsible for surveillance programs.	2015	Palau NISC	external donor support	Medium
	Develop and institute surveillance programs for non-established species consider high risk of arrival such as alien snakes, fruit flies, tramp ants, etc.	2015	Palau NISC	external donor support	Medium
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	Palau NISC	Regional ISC office	Medium
Management and eradication					
Increase management and control of established invasive species	Determine which established invasive species are actionable and proceed with developing management strategies. Covered in part by national ISAP.	2015	Palau NISC	ISSAP	Medium
	Create GIS layers regarding the distribution of established IAS and use to support biosecurity and IAS management efforts.	2015	Palau Community College	external donor support	Medium
	Train natural resource staffs (including protected areas staffs) at the local level in regards to IAS management support.	2015	Palau NISC	Regional ISC office	Medium
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	2015	Palau NISC	Regional ISC office	Medium
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2015	Palau NISC	external donor support	Low
	Develop standardized SOPs for IAS monitoring and surveys.	2015	Palau NISC	external donor support	Medium
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distribution is current.	2015	BOA	external donor support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase management and control of established invasive species (continued)	Create community funding sources for local (village level) programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2016	Palau NISC	external donor support	Medium
	Conduct terrestrial and aquatic risk assessments for all protected areas.	2016	Palau Conservation Society	Palau Green Fund or external funding sources	Medium
Increase efforts to eradicate targeted species	Conduct surveys and hold stakeholder consultations to determine what established species are viable candidates for eradication efforts.	2016	Palau NISC	external donor support	Medium
	Develop strategies to conduct eradication campaigns including securing funding streams to support these efforts.	2016	Palau NISC	external donor support	Medium
	Develop resources to respond to new pest incursions beyond ED & RR, including conducting delimiting surveys and potential eradication efforts.	2016	Palau NISC	external donor support	Medium
	Continue with Tilapia eradication efforts and document. Report to the region on outcome. Continue to monitor for Tilapia.	2014	Palau NISC	external donor support	High
	Continue with management efforts with invasive primates established in specific areas within the country.	2014	Palau NISC	external donor support	Medium
	Develop and conduct surveys for primates in areas where primates have been reported but currently are not known to exist.	2015	Palau NI	external donor support	Medium
	Eradicate small and feasible invasive species incursions promptly, while it is most feasible, least expensive, and before extensive damage has occurred. Covered in part by national ISAP.	2016	Palau NISC	external donor support	Medium
Awareness					
Increase outreach and education on biosecurity and invasive species	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	Palau NISC	external donor support	Medium
	Conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the nation from unwanted pests.	2015	Palau NISC	external donor support	Medium
	Establish long term funding to support core outreach and educational efforts.	2016	Palau NISC	external donor support	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species(continued)	Develop an educational strategy that is long term, extensive and nation wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	Palau NISC	external donor support	Medium
	Coordinate existing outreach efforts.	2015	Palau NISC	external donor support	Medium
	Add invasive species education as a standard part of school curriculums.	2016	Palau NISC/Palau Ministry of Education	external donor support	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2015	Palau NISC/Palau Ministry of Education	external donor support	Medium
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	2016	Palau NISC	external donor support	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	on-going	Palau NISC	external donor support	Medium
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2016	Palau NISC	external donor support	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2015	Palau ISC	Regional ISC office	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2015	Palau ISC	RISC	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges. Create awareness of the potential legal consequences of violating biosecurity regulations. Palau could develop their section of the video or their own entire video with the support of the PVA.	Start in 2014	Palau ISC	external donor support	High
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish.	2015	Palau NISC	external donor support	Medium
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Conduct baseline surveys.	2016	Palau Community College	external donor support	Medium
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2015	Palau Community College	external donor support	Low
Policy					
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations.	2015	Palau NISC	Biosecurity cost recovery program	Medium
	Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2015	Palau Ministry of Natural Resources, Environment, and Tourism	Biosecurity cost recovery program	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance (continued)	Current system of fines and penalties needs to be improved to better support biosecurity efforts.	2015	BOA	Biosecurity cost recovery program	High
<i>Restoration</i>					
Increase restoration efforts of native systems where IAS management and/or eradication efforts are underway or have been successful.		2016	Palau Conservation Society	external donor support	Medium

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment J: Commonwealth of the Northern Mariana Islands Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Support</i>					
Increase funding for biosecurity	Ensure adequate long-term funding is available for biosecurity equipment and infrastructure.	2016	Quarantine	External donor	High
	Ensure sufficient funding for agriculture and wildlife disease and pest exclusion activities by developing legislation to create a user fee structure similar to that employed by the DHS and USDA.	2016	Quarantine	Biosecurity cost recovery system	High
	Consider developing and institution user fees for passengers and baggage inspections.	2016	Quarantine	Biosecurity cost recovery system	High
	Visitors to the CNMI should be able to support biosecurity efforts via user fees. Any fees which are collected should go to the appropriate biosecurity agency for each jurisdiction and should be held in a revolving fund and utilized as needed to support biosecurity work. It would be ideal if a Micronesia wide fee schedule was established.	2016	Quarantine	Biosecurity cost recovery system	High
	Identify and establish dedicated, long-term and short-term funding to implement the various biosecurity recommendations. In addition to advancing individual objectives, there is a critical need to sustain biosecurity as a long-term and vital activity, just as customs and border security (for goods and people) is an ongoing activity. To sustain biosecurity and provide long-term continuity requires some core level of activities, personnel, and coordination, which will require dedicated funding.	2017	Quarantine	TBD	Medium
	Ensure sufficient funding to conduct routine surveillance, implement response plans, and provide outreach and education, in addition to port of entry exclusion activities and training for inspectors.	2016	Quarantine	Biosecurity cost recovery system	High
	Increased funding for regional biosecurity so necessary efforts to prevent, control, and eradicate animal and plant pests and diseases throughout the region are effective.	2017	CNMI RISC representatives	TBD	Low
	Identify funding and mechanisms to assess and respond to biosecurity threats across a broad geographic range in the CNMI. Efforts should include resources to also support efforts in Tinian, Rota, Aguigan, Pagan and even the Monument Islands of Uracas, Maug and Asuncion.	2017	TBD	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the CNMI section of the RBP on a regular basis and share regionally.	continuous, at least every 5 years	CNMI Invasive Species Task Force	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Develop a region wide communication plan for biosecurity and IAS. Examine the potential of using existing models for the plan development including that which was produced for Oahu recently (maybe 4 years ago). The Oahu plan was ultimately not utilized but it potentially could serve as a model for networking regionally.	2015	CNMI RISC representatives	Regional ISC Office	High
	Establish communication and coordination system for information derived from outreach programs, port inspections, pest identifications, and reports from the public of sightings or encounters with suspected invasive species or illegal movements of foods, plants, animals, insects, etc.	2016	CNMI Invasive Species Task Force	External donor	High
	Implement more comprehensive data collection and better data management on IAS vectors and pathways, including detailed inspection processes, intercept records, preservation and compiling of voucher specimens, detailed records on where shipments, etc. are arriving from and specifically what is known to have harbored IAS and where it come from and how it arrived. Ensure that records are entered into a useable database and that data is analyzed and shared with partners as warranted.	2016	CNMI Quarantine	Biosecurity cost recovery system	High
	Develop a region wide net of experts to support IAS efforts throughout the region. The general concept would be for each jurisdiction to have an IAS coordinator who could work extensively with RISC. Additionally a regional IAS coordinator should be developed to support and assist as well as coordinate efforts both within and between jurisdictions. Agreements with key thematic experts could then be developed and utilized as needed to support regional and jurisdictional activities.	2016	CNMI RISC representatives	Regional ISC Office	Medium
Improve communications and ability to address biosecurity concerns between US DoD and civilian government agencies	Establish an MOU detailing responsibilities, actions and cooperative agreements between the CNMI and DoD to work jointly on biosecurity issues related to DoD activities and mitigation within the CNMI.	2015	DNLR	DoD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish a jurisdictional invasive species coordination office that is tasked with supporting commonwealth wide IAS efforts across agencies and offices as well as working nationally and regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the invasive species coordination position(s), possibly having a coordination position for each island (Rota, Tinian, and Saipan).	2015	Governor's Office	Biosecurity cost recovery system	High
	Once established this office should support and assist in coordinating efforts with invasive species within the CNMI. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that governance is regularly updated regarding both commonwealth and regional invasive species developments.	2015	Governor's Office	Biosecurity cost recovery system	High
Improve communication and information sharing in regards to IAS and biosecurity	Although areas outside Micronesia and Hawaii are understandably not included in the RBP, information sharing outside the area should be better developed in regards to biosecurity and IAS. In particular, communication and info sharing from Micronesian governments and biosecurity authorities/organizations to other entities outside the region (with respect to notification about species that will or might be problematic and which could originate from within the region) should be developed. Establishing a regional IAS office would facilitate these efforts.	2016	CNMI Invasive Species Task Force	External donor	Low
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	CNMI RISC representatives and the Governor's office	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.</p>	<p>As soon as the office can be established</p>	<p>CNMI RISC representatives and the CNMI ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>As soon as the office can be established</p>	<p>CNMI RISC representatives and the CNMI ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>CNMI RISC representatives and the CNMI ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting establishing ER &RR capacity.</p>	<p>As soon as the office can be established</p>	<p>CNMI RISC representatives and the CNMI ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support management, response, and eradication efforts.	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts	As soon as the office can be established	CNMI RISC representatives and the CNMI ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	CNMI Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	College of the Northern Mariana Islands	External donor	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	College of the Northern Mariana Islands	External donor	Low
	Support the development of an algal risk assessment for the region.	2016	College of the Northern Mariana Islands	External donor	Medium
	Support the development of an arthropod risk assessment for the region.	2016	College of the Northern Mariana Islands	External donor	Medium
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	CNMI Invasive Species Coordinator	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	CNMI Invasive Species Coordinator	Regional ISC office	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of a weeds risk assessment for the region.	2016	College of the Northern Mariana Islands	External donor	Medium
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	CNMI RISC representatives	External donor	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC bills and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	CNMI RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	CNMI RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance)	Within 1 month of the December MCES on an annual basis	CNMI RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	CNMI RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	CNMI RISC representatives	NA	High
Improve regional coordination regarding biosecurity and IAS	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2015	CNMI RISC representatives	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Prevention</i>					
Improve pre-border biosecurity	Emphasis should be directed towards audited off-shore hygiene systems such as those utilized very successfully in Australia and New Zealand. This is ultimately the best way to prevent IAS incursions.	2015 Hold jurisdictional consultation including review of pertinent models (New Zealand); 2016 Develop draft standards; 2017 implement standards	Quarantine	Biosecurity cost recovery system	High
	Large, used machines such as tanks and bulldozers intended for importation should be cleaned and inspected for IAS at points of origin immediately prior to shipping.	2015	Quarantine	Biosecurity cost recovery system	High
	Insure proper cleaning of all large equipment such as construction and military items according to APHIS guidelines prior to entry.	2015: consider establishing guidelines based on existing USDA-APHIS materials	Quarantine	Biosecurity cost recovery system	High
Improve border security	Develop SOPs for border inspections.	2015	Quarantine	Biosecurity cost recovery system	High
	Improve capacity for IAS detection and interception at/within the transport pathways as well as ports of entry.	2016	Quarantine	Biosecurity cost recovery system	Medium
	Create and institute a mixed model biosecurity approach based on both vector sanitation and focusing on key high risk species for terrestrial, freshwater, and marine habitats.	2015	Quarantine	Biosecurity cost recovery system	High
	Consider developing SOPs for incoming baggage and cargo inspections which are based on successful models (such as New Zealand); would require hiring and training additional personnel, installing appropriate equipment (X-ray, etc.), training additional canine teams for detection of specific high risk IAS (reptiles, fruits, meats, etc.); insuring appropriate data collection and development and maintaining of databases to track efforts and interceptions.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Institute 100% x-raying of all arriving passenger baggage.	2016	Quarantine	Biosecurity cost recovery system	Medium
	Follow up consideration should be given to current agricultural imports and importer locations to adjust the risk assessment results to the current situation. The same is true for exports.	2016	DLNR	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Provide essential equipment to inspection services, including x-ray machines, computer, communication devices, etc. and support for both the use and maintenance of this equipment.	2015	Quarantine	External donor	High
	Develop appropriate vector management with feedback and monitoring mechanisms.	2016	Quarantine	Biosecurity cost recovery system	High
	Establish decontamination sites for cleaning both military and civilian equipment.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Improve capacity to inspect and track permitted imports. Consider enhancing quarantine requirements for specific species or taxon groups when imported (need to develop facilities for this in most cases) which would help with disease detection and control.	2015	Quarantine	Biosecurity cost recovery system	High
	Insure proper cleaning of all large equipment such as construction and military items according to APHIS guidelines prior to moving between sites (islands or locations on specific islands).	2015	DLNR	Biosecurity cost recovery system	High
	Establish a protocol which will permit the inspection of US, and all other types of mail, including private courier items.	2016	Quarantine	Biosecurity cost recovery system	Medium
	Provide quarantine agents with the necessary legal authority, training, and support to enforce requirements at border entry and post-border locations (e.g. aquaculture facilities and sales outlets).	2015	Quarantine	Biosecurity cost recovery system	High
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	Quarantine	External donor	Low
	Develop a plan to address the IAS introduction pathway of mail. Of significant concern in this regard is the potential for shipping of pets such as reptiles via the mail system with little ability to detect and intercept these organisms by current biosecurity systems within the region. Trained detector dogs, visual inspections and X-ray machines could all be utilized to reduce the potential for illicit mail trade, but appropriate regulations need to be established which would permit the potential inspection of most if not all arriving mail.	2016	Quarantine	Biosecurity cost recovery system	Medium
	Develop/enhance the tracking system for all cargo with unique identifiers for cargo shipments. Include an electronic system for tracking, identifying, and collecting data from manifests for containerized commercial cargo arrivals to the CNMI to streamline the import process while maintaining biosecurity.	2017	Quarantine	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Develop a wildlife reference collection (i.e., taxidermy mounts or computer photo files with APHIS-WS) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.	on-going	DLNR	External donor	Low
	Programs could be established that would allow passengers of airlines or ships to be able to surrender any potentially invasive animals with assurances that there would be no prosecution (excluding illegally smuggled animals protected by law, such as species listed under CITES). Similar to "honor bins" placed in some airports that allow passengers to anonymously dispose of contraband, such as fruit or other plant products, mechanisms could be established that would allow travelers to surrender nonindigenous species that have been transported in luggage. Such an option could be disseminated by means of mass media outlets as part of public outreach.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Conduct sanitary inspections of all incoming construction materials including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	Quarantine	Biosecurity cost recovery system	High
	Conduct annual invasive species awareness and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect, capture, or detain the invasive species upon discovery at the port, and point of contact to report an incident.	2015	DLNR	Biosecurity cost recovery system	Low
	Conduct biosecurity inspection for all arriving conveyances, military and non-military, for plant pests and animal contamination. Inspection must include a thorough search of the exterior and the interior of the conveyance for plant and animal pests and wildlife of concern. CNMI quarantine officers must be allowed to inspect military vessels as USDA-APHIS cooperators.	2015	Quarantine	Biosecurity cost recovery system	High
	Helicopters and private planes (or small scale commercial ventures) should be considered as possible IAS vectors and therefore a biosecurity threat that needs to be appropriate monitored and inspected.	2015	Quarantine	Biosecurity cost recovery system	Low
	Ensure that the biosecurity system is tracking changes in aircraft arrivals, especially as new linkages are established and/or additional carriers are added.	2015	Quarantine	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests. Follow all APHIS policies and guidelines as applicable (or establish similar guidelines). Evaluate the effectiveness of current cleaning methods, and improve as appropriate.	2015	Quarantine	Biosecurity cost recovery system	High
	Improve detection methods for rodents and other wildlife on vessels and in cargo. Rodents and other wildlife have been implicated in the transmission of zoonotic diseases. Methods may include trapping, monitoring for signs, etc. Rodent detection methods are not well developed and other wildlife detection methods have not been well documented.	2016	DLNR	External donor	Low
	Vessels need to have SOPs for safe keeping of garbage and basic standards in regards to garbage need to be enforced. Port inspectors should include insuring garbage is in an enclosed bin and secured. In proper garbage management should be addressed ASAP and fines levied to better insure future compliance.	On-going	Quarantine	Biosecurity cost recovery system	High
Improve regulation and compliance of wood packaging material (WPM)	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign, military and non-military WPM entering the Micronesia Region should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	on-going	Quarantine	Biosecurity cost recovery system	Medium
	Do not permit the unloading of noncompliant WPM.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Conduct phytosanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign, military and non-military WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Support a regional approach to switch from WPM to other options such as recycled plastics; interim solution is the enforce certification of WPM and to inspect regularly.	2014	Quarantine	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2016	Quarantine	Biosecurity cost recovery system	Low
	Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging processes prior to arrival as imported cargo or after arrival when staged for loading for inland transport. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for labeling, packing, and transport prior to arrival and for eventual staging and loading for inland transport after arrival. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places, especially for BTS detection by canine inspection teams.	2016	Quarantine	Biosecurity cost recovery system	Medium
	Establish and utilize container racks at all locations where containers are stored for preloading, etc. and establish SOPs with shippers for pre-departure cleanliness in regards to containers.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2016	Quarantine	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve ability to better enforce pre-departure sanitation (continued)	Adopt standards which would increase pre-departure inspections. In the CNMI, commercial airline baggage is screened by Transportation Security Administration (TSA) agents/airline employees immediately prior to departure using X-ray machines. These pre-departure inspections focus on searching for weapons and other prohibited items, but during these inspections, inspectors could potentially find and confiscate live organisms. These inspectors should receive training in IAS detection and capture.	2018	Quarantine	Biosecurity cost recovery system	Medium
Improve overall post border biosecurity	Provide training and support to DFW to conduct post border inspections and follow-up activities.	2016	DFW	Biosecurity cost recovery system	Medium
	Develop and/or improve capacity to carry out investigations and effective enforcement beyond ports of entry.	2016	DFW	Biosecurity cost recovery system	Medium
	Develop jurisdictional capacity in regards to post-border IAS concerns. Train natural resource staffs at the local level in regards to IAS management support. Train interested citizens to support IAS management efforts.	2016	DLNR	External donor	Medium
	Conduct periodic surveys of ethnic markets, pet stores, and grocery stores to identify and intercept prohibited animals and animal and plant products following the model of the USDA-APHIS-PPQ Smuggling, Interdiction, and Trade Compliance program.	On-going	Quarantine	Biosecurity cost recovery system	Low
	Establish and develop relationships with key industrials such as landscaping and pet stores to help develop their ability to institute internal standards to support IAS prevention.	2016	DLNR	TBD	Medium
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	DLNR	TBD	Medium
	Improve capacity to identify biosecurity intercepts and organisms detection post border, including micro organisms and viruses.	2016	DLNR	External donor	Medium
	Ensure that funding mechanisms are established and that funding is available as needed to support IAS specimen sampling, testing, and identification.	2016	DLNR	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve overall post border biosecurity (continued)	Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of locally sourced plants, preferably native plants. If non-natives are going to be used for landscaping, insure that they are non-invasive species. If plants will be brought into an area from outside for landscaping, insure that they are pest free. This code of conduct should encourage businesses: to make their staff knowledgeable about invasive plants, to inform their customers about invasive plants, to report immediately any likely exotic pest organisms found on their premises, and to use native or non-invasive plants locally sourced.	2015	Quarantine and Forestry	TBD	Low
Increase agricultural biosecurity/food security	Conduct background surveys as soon as possible to establish baselines for plant pests and livestock and wildlife populations and diseases.	2017	DLNR	External donor	Medium
	Implement initial surveillance and monitoring strategy to prevent introduction of livestock, poultry, and wildlife diseases and to determine whether measures perform adequately. These measures then should adjust to improve biosecurity.	2017	DLNR	External donor	Medium
	The collection and analysis of baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained. In a similar fashion collecting and analyzing data regarding both existing pests and pests at high risk of invasion should be a continuous effort. Information gathered should be shared on a regular basis within the region and beyond. There are existing models at least for some components of this process that should be considered and utilized where appropriate.	2017	DLNR	External donor	Medium
Improve internal biosecurity	Conduct a jurisdictional review and consultation period to determine: A. need for internal biosecurity, B. if needed, how it could best be implemented, and C. Follow up with recommendations which come from this process.	2016	DLNR	Biosecurity cost recovery system	High
	Determine best methods for protecting currently uninhabited islands such as Pagan from additional IAS incursions and consider options for IAS management on these islands in regards to already established species.	2017	DLNR	Biosecurity cost recovery system	High
Increase alien snake detection capacity	Develop a BTS quarantine facility for the island of Rota as well as develop resources to enhance the BTS detection capacity for the island.	2017	DLNR	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Department of Health	External donor	Medium
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import.	2014	Quarantine	Biosecurity cost recovery system	High
	Update white list on a regular basis.	annually	Quarantine	Biosecurity cost recovery system	Medium
	Develop a government endorsed black list of prohibited species.	2014	Quarantine	Biosecurity cost recovery system	High
	Update black list on a regular basis.	annually	Quarantine	Biosecurity cost recovery system	Medium
	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	2015	Quarantine	utilize student support	Low
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	Quarantine	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Improve reporting and screening systems for import of live organisms.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Improve tracking of live plant and animals imports. Importers should list the types and numbers of each species in each shipment, and such information should be recorded by border agents, retained in an electronic database, and shared as appropriate.	2016	DLNR	Biosecurity cost recovery system	Medium
Reduce risk associated with live traded species	Establish a formal risk analysis process/guidelines for all organisms used or proposed for live trade.	2015	DLNR	This should be supported by user fees as part of the cost recovery biosecurity system	High
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	DLNR	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	Development of strict contingency plans/emergency preparedness programs regarding possible escapees of exotic organisms being farmed or traded.	2015	DLNR	Biosecurity cost recovery system	High
	Ensure that specific quarantine facilities are available (will need to build) and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species). Facilities need to include quarantine facilities for terrestrial and aquatic species, examination and inspection areas. Facilities are best located proximal or within port areas to reduce on island transit prior to reach quarantine.	2016	Quarantine	External donor	Medium
	Improve disease diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	DLNR	Biosecurity cost recovery system	Medium
	Ensure that all aquaculture facilities are secure including from natural disasters.	2015	DLNR	Biosecurity cost recovery system	High
	Support regional and international cooperation on the responsible use and control of exotic species.	continuous	CNMI Invasive Species Coordinator	External donor	Medium
	Develop standards for backyard aquaculture set ups and enforce as feasible.	2015	DLNR	Biosecurity cost recovery system	Low
	Develop specific guidelines for the adequate disposal of unwanted pets.	2015	DLNR	External donor	Low
Increase existing biosecurity capacity by providing adequate day to day resources	Provide training to increase inspection and identification expertise. Safeguarding inspectors (both civilian and military) should receive regular adequate training in proper techniques for detecting, collecting, recognizing, and identifying pests. A communication network for continuous sharing of new information is recommended.	2015	Quarantine	Biosecurity cost recovery system	High
	Increase capacity and training of both current and new quarantine inspectors to better enable them to handle current and future inspection levels, identify key IAS of concern, collect and enter data, and insure that all regulations are being equally applied to all (there should be no exceptions in regards to border security regardless of person or position).	2015	Quarantine	Biosecurity cost recovery system	High
	Train inspectors specifically in livestock, wildlife, and poultry diseases and pests.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Hire and train biosecurity staff in order to meet current inflow levels and any anticipated near term increases. This applies across the board: inspections, management and control operations, and early detection and rapid response.	2015	Quarantine	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase biosecurity surveillance measures at both military and commercial airports and harbors including all entry points and screening check points.	Keep a well-documented process of pest and disease prioritization, surveillance, data collection, and record keeping. Specific surveillance methodology should be appropriate for target species (i.e. modifying sampling programs to account for behavioral differences in diurnal and nocturnal lifestyles).	2016	Quarantine	Biosecurity cost recovery system	High
	Communicate survey results among all island mitigation programs.	2017	Quarantine	Biosecurity cost recovery system	High
	Utilize systematic surveillance for plant pests following the model of the Cooperative Agriculture Pest Surveys (CAPS), and include both military and civilian properties as appropriate.	2017	Quarantine	Biosecurity cost recovery system	High
	Biosecurity surveillance system should include routine surveillance for wildlife, livestock, and poultry diseases and vectors as well as plant pests.	2017	Quarantine	Biosecurity cost recovery system	Medium
Establish and enforce biofouling standards	Establish biosecurity criteria (requirements) for acceptable levels of hull biofouling for all commercial vessels (including cargo ships, cruise ships, passenger ships, barges, dredges, fishing vessels, and other vessel types).	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish reporting requirements on hull husbandry practices and operational characteristics for commercial vessels (including cargo ships, cruise ships, passenger ships, barges, dredges, fishing vessels, and other vessel types).	2017	DNLR	Biosecurity cost recovery system	Medium
	Establish requirements for routine inspection and certification of biofouling levels for any commercial vessel with a long port residence time or lay-up.	2017	DLNR	Biosecurity cost recovery system	Medium
	Review and establish criteria for in-water cleaning methods for commercial vessels that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	DLNR	Biosecurity cost recovery system	Medium
	Develop the capacity to (a) assess the extent to which commercial vessels achieve acceptable levels of biofouling, and (b) respond to high-risk commercial vessels (i.e., those with high biofouling) that arrive to a port.	2017	DLNR	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement biofouling management program for commercial ships.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of biofouling management requirements for commercial ships.	2017	DLNR	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Implement inspections of any impounded vessel (a) assess level of hull biofouling and (b) treat vessels (if needed) to reduce biofouling to acceptable level.	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat (if necessary) recreational vessels to reduce associated biofouling to an acceptable level.	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for recreational vessels to reduce the transfer of biofouling organisms.	2017	DLNR	Biosecurity cost recovery system	Medium
	Review and establish criteria for in-water cleaning methods for hull fouling that do not post a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement targeted outreach and administrative tools to increase compliance with biofouling requirements for military and civilian vessels.	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within the CNMI.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the fishing industry, ports, and resource management agencies of biofouling management requirements for fishing vessels.	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within the CNMI to reduce associated biofouling to an acceptable level.	2017	DLNR	Biosecurity cost recovery system	Medium
Establish and enforce ballast water standards	Plan for in-hull treatment of ballast water with support from the USCG in regards to developing biosecurity for marine organisms. USCG has proposed to change regulations from ballast water exchange to in hull treatment. Matson's new ship builds already have treatment inline for ballast water.	2017	DLNR	USCG	Medium
	Implement a system for U.S. Navy ships to report ballast water discharge, modeled after that used by USCG, such that the data are compiled electronically at a centralized database.	2017	DLNR	DoD	Medium
	Establish ballast water management and reporting requirements for all commercial vessels (including cargo ships, cruise ships, passenger ships, barges, and any other vessel that can carry ballast water).	2017	DLNR	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce ballast water standards (continued)	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance by commercial vessels.	2017	DLNR	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement ballast water management program for commercial ships.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for commercial ships.	2017	DLNR	Biosecurity cost recovery system	Medium
Increase marine system protection from invasive species	Ensure the marine biosecurity regulations, inspections, quarantine, and outreach efforts are appropriate.	2017	DLNR	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within the CNMI.	2017	DLNR	Biosecurity cost recovery system	Medium
	Ensure capacity building training to inspectors regarding aquatic biosecurity and develop SOPs for inspections regarding both marine and freshwater biosecurity.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program for DoD and civilian populations with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within the CNMI.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program for DoD and civilian populations with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within the CNMI.	2017	DLNR	Biosecurity cost recovery system	Medium
	Implement a long-term monitoring program for key harbor and marina areas including other high use mooring and anchorage areas like those below the preposition ships.	2017	TBD	Biosecurity cost recovery system	Medium
Address climate change linkages to invasive pests		2017	DLNR	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Early detection and rapid response</i>					
Improve early detection and rapid response capacity	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	CNMI Invasive Species Task Force	External donor	High
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	DLNR	Biosecurity cost recovery system	High
	Develop taxa specific ERPs as needed (Little Fire Ant, Coconut Rhinoceros Beetle, etc.).	On-going	DLNR	External donor	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	CNMI Invasive Species Task Force	TBD	High
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable). This would be similar to 28-SNAKE but would be developed for all organisms, not just snakes.	2016	DLNR	Biosecurity cost recovery system	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2016	DLNR	Biosecurity cost recovery system	High
	Develop and institute surveillance programs for non-established species consider high risk of arrival such as CRB, alien snakes, fruit flies, tramp ants, etc.	2015	DFW, Forestry, and Quarantine	Biosecurity cost recovery system	High
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	DFW, Forestry, and Quarantine	Biosecurity cost recovery system	Low
Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2016	DLNR	Biosecurity cost recovery system	High	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve early detection and rapid response capacity (continued)	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2016	DLNR	Biosecurity cost recovery system	High
	Training and maintain a core group of ED & RR staff from local agencies/stakeholder groups.	2016	DLNR	Biosecurity cost recovery system	High
	Hold consultations to determine what agency(s), office(s) and/or groups will be responsible for surveillance programs.	2015	DLNR	External donor	Medium
Management and eradication					
Increase management and control of established IAS	Eradicate small and feasible IAS incursions promptly.	on-going	DFW, Quarantine, and Forestry	External donor	High
	Create GIS layers that delineate management zones, land tenure, and current distribution of established IAS.	2015	College of the Northern Mariana Islands	External donor	Low
	Develop and implement more control and management programs to deal with existing IAS and to reduce the potential of spreading them to non-infected locations both within and outside of the CNMI.	on-going	DLNR	External donor	Medium
	Improve surveillance and monitoring of existing invasive species.	2015	DLNR	External donor	Medium
Awareness					
Evaluate social, cultural, economic, and ecological values that may be impacted negatively by non-native species.	Establish a watch list of high-risk non-native species that are known or thought to pose significant ecological, economic, social, or cultural impacts.	2015	DLNR	External donor	Medium
	Raising awareness about the potential negative ecological, cultural, economic, and human health effects of invasive species is an important component of both prevention and early detection. The following measures could heighten public awareness among the military and the public: surveys of the current level of understanding of IAS and their impacts as well as more specific surveys on the procurement and use of plants, animals, and their products by local communities, transient workers, and visitors are all needed.	2016	DLNR	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and nation wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	CNMI Invasive Species Task Force	External donor	High
	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the nation from unwanted pests.	2015	CNMI Invasive Species Task Force	External donor	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	CNMI Invasive Species Task Force	External donor	Medium
	Establish long term funding to support core outreach and educational efforts.	2016	CNMI Invasive Species Task Force	External donor	High
	Coordinate existing outreach efforts.	2015	CNMI Invasive Species Task Force	External donor	High
	Add invasive species education as a standard part of school curriculums.	2017	CNMI Invasive Species Task Force/Department of Education	External donor	Medium
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2017	CNMI Invasive Species Task Force/Department of Education	External donor	Medium
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	2016	CNMI Invasive Species Task Force	External donor	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	2016	CNMI Invasive Species Task Force	External donor	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2016	CNMI Invasive Species Task Force	External donor	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2016	CNMI Invasive Species Task Force	External donor	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2016	CNMI Invasive Species Task Force	External donor	High
Research					
Prioritize IAS research for the CNMI	Develop standardized SOP's for IAS monitoring and implement surveys.	2016	DLNR	External donor	High
	More specific localized risk assessments should be conducted for all habitat types.	2018	DLNR	External donor	Low
	Identify experts in IAS taxonomy and proactively develop agreements with them for processing and identifying samples. Details should include preservation requirements and turnaround times.	2017	DLNR	External donor	Low
Policy					
Improve ability to address invasive species and biosecurity	Establish an IAS council, committee, or taskforce that is endorsed by and works with the governance.	2015	Governor's Office	Biosecurity cost recovery system	High
	Develop a comprehensive IAS SAP for the CNMI, including priority species, current capacity, and recommendations to address existing gaps.	2015	CNMI Invasive Species Task Force	Biosecurity cost recovery system	High
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance.	Conduct a review of existing laws and regulations governing biosecurity in the CNMI, particularly as they pertain to import from foreign countries and export to other areas of Micronesia and Hawaii.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Review relevant biosecurity related guidelines and SOPs to insure they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Update existing guidelines and SOPs as needed. Develop guidelines or SOPs for specific activities if they are lacking.	2015	Quarantine	Biosecurity cost recovery system	Medium
	Expand existing or create new regulations (as needed) and SOP to encompass all potential IAS including terrestrial (agricultural and non-agricultural), freshwater, and marine concerns. Current systems are mainly based on agriculture and a handful of high risk species such as the Brown Treesnake.	2016	Quarantine	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Ensure that appropriate biosecurity regulations are in place and enforced. Regulations should support the issuance of penalties and fines to enforce compliance (continued).	Review (an update if necessary) penalty assessment structure for noncompliance with regulations covering animal and plant health as a source of additional funding.	2015	Quarantine	Biosecurity cost recovery system	Medium

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment K: State of Hawaii Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Hawaii section of the RBP regularly and share regionally.	continuous, at least every 5 years	HISC	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	HISC	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	HISC	Regional ISC Office	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report shared with the region and beyond.	continuous, yearly	HISC	Biosecurity cost recovery system	High
Improve Statewide biosecurity and coordination	Develop statewide IAS SAP with input from stakeholders of the state (may be possible to utilize HISC strategic plan and HDOA biosecurity plan).	2014-15	HISC, HDOA	HISC, HDOA	High
	Update risk assessment for terrestrial IAS using current HDOA data.	2015	HDOA	TBD	Medium
	Rebuild biosecurity capacity at HDOA to at least 2009 levels (Fill vacated position, provide training to get staff up to speed).	2016	HDOA	Biosecurity cost recovery system	High
	Need to move forward with hiring and training staff members to meet current and future expected needs within HDOA quarantine.	2016	HDOA	Biosecurity cost recovery system	High
	HDOA should consider creating and filling a position that will be focused on IAS issues. This position may serve as the ISC for HDOA. Could be similar to the DOFAW IS coordinator and might serve as the primary point of contact for IS issues with the HDOA.	2016	HDOA	Biosecurity cost recovery system	Medium
	Document and analyze numbers and types of interceptions from all pathways and made available to appropriate agencies and staffs.	2015	HDOA	Biosecurity cost recovery system	Medium
	Hire and allocate additional staff and resources to support intra-island biosecurity efforts.	2017	HDOA	Biosecurity cost recovery system	High
	Create and institute a mixed model biosecurity approach based on both vector sanitation and focusing on key high risk species for all habitats.	2015	HDOA	Biosecurity cost recovery system	High
	Develop appropriate vector management with feedback and monitoring mechanisms. If INVICTA becomes fully operational it could serve as the feedback mechanism.	2015	HDOA, DOT, DOH	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve Statewide biosecurity and coordination (continued)	Implement a more comprehensive data collection and better data management on IAS vectors and pathways, including detailed inspection processes, intercept records, preservation and compiling of voucher specimens, detailed records on where shipments, etc. are arriving from and specifically what is known to have harbored IAS and where it come from and how it arrived.	2015	HDOA	Biosecurity cost recovery system	Medium
	Enter records into database, analysis and share results with partners as warranted.	2015	HDOA	Biosecurity cost recovery system	High
	Consider helicopters and private planes (or small scale commercial ventures) as possible IAS vectors and therefore a biosecurity threat that needs to be appropriately monitored and inspected.	2015	HDOA, DOT	Biosecurity cost recovery system	Low
	Identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of cargo staging facilities.	2016	HDOA	Biosecurity cost recovery system	Low
	Review relevant biosecurity related guidelines and SOPs to insure they are clear, complete, detailed, and in compliance with appropriate laws and regulations.	2015	HDOA, HISC	Biosecurity cost recovery system	Medium
	Update existing guidelines and SOPs as needed.	2015	HDOA	Biosecurity cost recovery system	Medium
	Improve communication between different levels of government, agencies, and others involved in biosecurity work.	2015	HISC, HDOA		Medium
	Document the cost of IAS control and management compared to prevention is needed.	on-going	HISC, HDOA	USFWS/USDA/DoD	Medium
	Hawaii state should implement an electronic inspection system.	2015	HDOA	TBD	High
	Better direct use of limited resources based on interception records.	2015	HDOA	Biosecurity cost recovery system	High
	Provide sufficient funds to conduct routine surveillance, implement response plans, and provide outreach and education, in addition to port of entry exclusion activities and training for inspectors.	2016	HDOA, HISC	Biosecurity cost recovery system	High
	Identify and establish dedicated, long-term and short term funding to implement the various biosecurity recommendations.	2016	HDOA, HISC	Biosecurity cost recovery system	High
	Identify a core level of activities, personnel, and coordination to sustain biosecurity and provide long-term continuity.	2016	HDOA, HISC	Biosecurity cost recovery system	High
	Support increased funding for regional biosecurity so that necessary efforts to prevent, control, and eradicate animal and plant pests and diseases throughout the region are effective.	2015	HISC	External donor	Medium
	Implement user fees attached to military related passengers and baggage inspections (as needed).	2015	HDOA, HISC	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve Statewide biosecurity and coordination (continued)	Conduct Hawaii port and hot spot risk assessments and tie into the RBP once completed.	2015	USDA, HDOA	TBD	Medium
	Conduct an aquatic plant risk assessment that includes potential impacts from Micronesia as this aspect is not well covered in the RBP risk assessments.	2016	DLNR, HDOA, HISC	USFWS/USDA/DoD	Medium
	HDOA and federal agencies should continue to work together on redevelopment of the HDOA detector dog program for port inspections.	on-going	HDOA, USDA	USFWS	High
	Ensure that the State of Hawaii continues to work with DoD to ensure that biosecurity needs are appropriately addressed regarding the potential movement of DoD components from Okinawa to Hawaii and any other DoD activities.	2015	HDOA	DoD	High
	Finalize process of merging State and Federal IAS risk lists and establish MOAs so that federal agents can react to and enforce state concerns.	2015	HDOA, CGAPS, HISC, USDA	USDA	High
	Ensure adequate long-term funding is available for equipment and infrastructure.	2016	HDOA	Biosecurity cost recovery system	High
Improve communications and ability to address biosecurity concerns between US DoD and civilian government agencies	Establish an MOU between Hawaii and DoD regarding biosecurity actions, responsibilities and mitigation in regards to DoD activities and facilities. In 2013 a MOU was developed between DoD and HDOA which is a good start but needs to be expanded.	2015	HDOA/DoD	DoD	Medium
	Establish SOPs on aspects of how DoD and Hawaii's civilian agencies work together regarding biosecurity inspection process, response actions and other activities as needed in response to increased DoD activities.	2015	DoD	DoD	Medium
Improve regional coordination regarding biosecurity and IAS	Establish a central repository for plant pathogens information for the region.	2017	University of Hawaii	TBD	Low
	Join RISC directly or minimally participate in RISC activities as an outside Micronesia stakeholder.	2014	HISC	RISC	High
	Develop pre-entry requirements for certain commodity imports from high-risk areas to reduce the likelihood of pest and invasive species introductions for a Regional monitoring and surveillance program.	2015	USDA, HDOA	Biosecurity cost recovery system	High
	Establish a biosecurity surveillance system to serve as an early detection program for plant, animal, and zoonotic pests and pathogens emerging in Pacific Rim countries.	2016	HDOA	Biosecurity cost recovery system	Low
	Support development of standardized SOPs for IAS monitoring and implement surveys throughout the region.	2016	USDOI, RISC	External donor	Low
	Strengthen regional and international cooperation on the responsible use and control of exotic species.	2016	RISC	External donor	Medium
	Develop eradication programs for extremely harmful species already present in Hawaii.	2016	DLNR, HDOA, HISC	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.</p>	<p>Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office</p>	<p>ideally this office would be up and running before the end of 2015</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office with supporting protocol and methods development</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting establishing ER &RR capacity</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting the development of guidelines and regulations</p>	<p>As soon as the office can be established</p>	<p>Hawaii RISC representative(s) and HISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office with both seeking for and coordinating regional funding	As soon as the office can be established	Hawaii RISC representative(s) and HISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support management, response, and eradication efforts	As soon as the office can be established	Hawaii RISC representative(s) and HISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information	As soon as the office can be established	Hawaii RISC representative(s) and HISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts	As soon as the office can be established	Hawaii RISC representative(s) and HISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	HISC	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going; finalized by 2018	University of Hawaii	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	University of Hawaii	TBD	Low
	Support the development of an algal risk assessment for the region.	2016	University of Hawaii	TBD	Medium
	Support the development of an arthropod risk assessment for the region.	2016	University of Hawaii	TBD	Medium
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	University of Hawaii	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	University of Hawaii	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region (Hawaii already has one, which could be used possibly as a model).	2016	University of Hawaii	TBD	Medium
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Hawaii RISC representative(s)	TBD	Medium
Prevention					
Improve pre-border biosecurity	Improve pre-departure cleanliness of items shipped to Hawaii. Orchids from Thailand were on item which was pointed out as needing improved pre-arrival sanitation.	2016	HDOA	Biosecurity cost recovery system	High
	Implement the use of pre-border sanitation compliance agreements with shippers and contractors. Consider using HACCP as a model.	Should track with the preceding action item	HDOA, USDA	Biosecurity cost recovery system	High
	All large, used machines (bulldozers, etc.) which are to be imported should be required to undergo thorough cleaning and inspection for invasive species immediately prior to shipping.	2015: consider establishing guidelines based on existing USDA-APHIS materials	HDOA	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve pre-border biosecurity (continued)	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized in Australia and New Zealand. Preventing the arrival of potential IAS is ultimately the most cost effective way to ensure appropriate biosecurity levels are in place and they offer the best protection from the potential hazards which IAS could cause.	2015 Hold state consultation including review of pertinent models (New Zealand); 2016 Develop draft standards; 2017 implement standards	HDOA	TBD	High
	Develop stronger pre-border regulations regarding the movement of non-native species.	2016	HDOA	Biosecurity cost recovery system	Medium
Improve WPM capacity	Require treatment of all domestic and foreign, military and non-military WPM entering Hawaii according to ISPM No. 15.	2015	HDOA	Biosecurity cost recovery system	Medium
	Conduct phytosanitary inspection of WPM.	2015	HDOA	Biosecurity cost recovery system	Medium
	Inspect thoroughly an adequate percentage of all domestic and foreign, military and non-military WPM accompanying agricultural and nonagricultural cargo for pests.	2015	HDOA	Biosecurity cost recovery system	Medium
	Require consistent inspection methods within SOPs.	2015	HDOA	Biosecurity cost recovery system	Medium
	Document all inspections and interceptions.	2015	HDOA	Biosecurity cost recovery system	Medium
	Record pest interceptions in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2016	HDOA	Biosecurity cost recovery system	Medium
	Prohibit the unloading of noncompliant WPM.	2015	HDOA	Biosecurity cost recovery system	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	HDOA	Biosecurity cost recovery system	Medium
	Treat or destroy infested WPM.	2015	HDOA	Biosecurity cost recovery system	High
	Treat Infested WPM as regulated garbage and incinerated or sterilized.	2015	HDOA	Biosecurity cost recovery system	High
	Support a regional approach to switch from WPM to other options such as recycled plastics.	2017	HDOA	External donor	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve agriculture biosecurity and food security	Collect, analyze, establish and maintain baseline data regarding key crops and animal stocks for internal consumption as well as for export	2016	HDOA	USDA	Low
	Collect and analyze data regarding both existing pests and pests at high risk of invasion.	2015	HDOA	Biosecurity cost recovery system	Low
	Share information on a regular basis within the region and beyond.	2015	HISC	TBD	Medium
	Conduct periodic surveys of ethnic markets, pet stores, and grocery stores to identify and intercept prohibited animals and animal and plant products following the model of the USDA-APHIS-PPQ Smuggling, Interdiction and Trade Compliance program.	2015	HDOA	Biosecurity cost recovery system	Low
Improve intra-state biosecurity and foreign arrivals at ports other than the main air and sea ports	Develop biosecurity standards for ports other than the main air and sea ports.	2017	HDOA, DOT, DOH	Biosecurity cost recovery system	High
	Implement and enforce biosecurity at ports other than the main air and sea ports	2017	HDOA, DOT, DOH	Biosecurity cost recovery system	High
	Conduct a state wide consultation regarding intrastate biosecurity before attempting to develop capacity and regulations to determine what is actually needed and what the citizenry will support.	2015	HDOA, DOT, DOH	Biosecurity cost recovery system	High
	Develop a comprehensive reporting system for intra-state biosecurity efforts.	2016	HDOA, DOT, DOH	Biosecurity cost recovery system	High
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a state biosecurity advisory committee to review proposals for the importation of exotic species.	2015	State agencies with support from feds	Biosecurity cost recovery system	High
	Improve reporting and screening systems for import of live organisms. Currently done for most marine organisms and should be expanded to all live organisms.	2015	State agencies with support from feds	Biosecurity cost recovery system	High
	Ensure that specific quarantine facilities are available and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species).	2016	State agencies with support from feds	TBD	High
	Develop plan for containment and control measures in regards to exotic farmed and traded species.	2015	State agencies with support from feds	Biosecurity cost recovery system	Medium
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	State agencies with support from feds	Biosecurity cost recovery system	High
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2015	HDOA/DLNR	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	HDOA, UH	Biosecurity cost recovery system	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	HDOA, DAR	Biosecurity cost recovery system	High
Develop biosecurity standards for household aquaculture set ups and enforce these standards.	2015	HDOA	Biosecurity cost recovery system	Medium	

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Reduce risk associated with live traded species (continued)	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	State agencies with support from feds	Biosecurity cost recovery system	Medium
	Develop specific guidelines for unwanted pets.	2015	State agencies	TBD	Low
	Establishment lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	USFWS, HDOA, DLNR	Biosecurity cost recovery system	Low
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	USDA	TBD	Low
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import.	2014	HDOA	Biosecurity cost recovery system	High
	Update white list on a regular basis.	annually	HDOA	Biosecurity cost recovery system	Medium
	Develop a government endorsed black list of prohibited species.	2014	HDOA	Biosecurity cost recovery system	High
	Update black list on a regular basis.	annually	HDOA	Biosecurity cost recovery system	Medium
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	HDOA	Importer pays for all aspects of the risk assessment (regardless of outcome)	High
	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	2015	HDOA	utilize student support	Low
Increase biosecurity surveillance measures and interception at both military and commercial airports and harbors including all entry points and screening check points	Address regulations to permit HDOA PQ to inspect containers as needed.	2015	HDOA	Biosecurity cost recovery system	High
	Find working solution to improve overall inspection levels of goods arriving to Hawaii from domestic ports.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Find working solution to improve inspection levels of housing goods arriving to Hawaii from Guam (both directly and indirectly).	2015	HDOA	DoD	High
	Train personnel in identifying high-risk cargo and handling to reduce contamination.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Track changes in aircraft arrivals, especially as new linkages are established and/or additional carriers are added.	2015	HDOA, USDA	Biosecurity cost recovery system	High
	Develop staging areas for safeguarding high and low risk cargo.	2015	HDOA, USDA	TBD	Medium
	Inspect shipping containers and other vessels holding goods as vectors for hitch-hiker IAS.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Provide training in proper techniques for detecting, collecting, recognizing, and identifying pests to increase inspection and identification expertise.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Increase biosecurity surveillance measures and interception at both military and commercial airports and harbors including all entry points and screening check points (continued).	X-ray all incoming passengers baggage.	2016	HDOA, USDA	Biosecurity cost recovery system	Medium
	Train inspectors specifically on livestock, wildlife, and poultry diseases and pests.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Training TSA inspectors in IAS detection and capture.	2015	HDOA/TSA	Biosecurity cost recovery system	Medium
	Develop a biosecurity surveillance system for improved data collecting, reporting, and information sharing.	2016	HDOA	(may already have with INVICTA)	Medium
	Follow a well-documented process of pest and disease prioritization, surveillance, data collection, and record keeping.	2016	HDOA	Biosecurity cost recovery system	Medium
	Include routine surveillance for wildlife, livestock, and poultry diseases and vectors as well as plant pests in biosecurity system.	2016	HDOA	Biosecurity cost recovery system	High
	Modify surveillance methodology as appropriate for targeted species, (i.e. modifying sampling programs to account for behavioral differences in diurnal and nocturnal lifestyles).	2016	HDOA	Biosecurity cost recovery system	Medium
	Utilize systematic surveillance for plant pests following the model of the Cooperative Agriculture Pest Survey (CAPS), and include both military and civilian properties as appropriate.	2015	State Government	Biosecurity cost recovery system	Medium
Improve mail biosecurity	Find a working solution which will permit the inspection of US mail (and all other mail types).	2016	HISC, USDA, Postal Service	Biosecurity cost recovery system	High
Improve biosecurity for the movement of vehicles and equipment	Develop functional cleaning facilities (wash racks, etc.) at all DoD installations where warranted and provide appropriate training for military personnel to utilize these facilities.	2015	HDOA, DoD	DoD	High
	Utilize APHIS training courses or manuals to support wash down efforts.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Clean containers and conveyances that arrive contaminated with soil and/or exotic plant pests	2015	HDOA, USDA	Biosecurity cost recovery system	High
	Evaluate the effectiveness of current cleaning methods, and improve as appropriate.	2015	HDOA, USDA	Biosecurity cost recovery system	High
	Conduct inspections of all incoming construction materials including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Clean and inspect large, used machines such as tanks and bulldozers intended for importation for IAS at points of origin immediately prior to shipping.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve biosecurity for the movement of vehicles and equipment (continued)	Insure proper cleaning of all large equipment such as construction and military items according to APHIS guidelines prior to entry.	2015	HDOA, USDA	Biosecurity cost recovery system	Medium
	Insure proper cleaning of all large equipment such as construction and military items according to APHIS guidelines prior to moving between sites.	2015	HDOA, USDA	Biosecurity cost recovery system	High
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests.	2015	HDOA, USDA	TBD	Medium
	Implement "clean" practices at construction sites, including the minimization of land disturbance which may contribute to the spreads plant pests.	2015	HDOA	TBD	Medium
Establish and enforce biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish additional regulations for impounded vessels.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish standards and regulations regarding biofouling, including inspection and certification for all vessels. Inspections can be trained to inspect hulls from top side with mirrors. If further inspection is warranted, then the craft pays for divers to inspect and make a report. If determined to be dirty, then the craft must either be cleaned or leave port and jurisdictional waters. Self clean outside of jurisdictional waters could be an option. Hull needs to be clean of all organisms, as the ability to identify all marine organisms is not available.	2017	DLNR DAR	Biosecurity cost recovery system	High
	Develop capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2017	DLNR DAR	TBD	High
	Establish regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	DLNR DAR	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Establish the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2017	DLNR DAR	TBD	High
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Ensure that regulations include ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2017	DLNR DAR	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a biofouling management program	2014: this should be included in the current draft biosecurity legislation; May need to update and expand in 2016-17 as elements come online	DLNR DAR	Biosecurity cost recovery system	High
Increase marine system protection from invasive species	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	DLNR DAR	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Establish and enforce ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	DLNR DAR	Biosecurity cost recovery system	High
	Establish ballast water management and reporting requirements for all vessels utilizing ballast water.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	DLNR DAR	Biosecurity cost recovery system	High
	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to support a ballast water management program.	2016	DLNR DAR	Biosecurity cost recovery system	High
	Support adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	DLNR DAR	Biosecurity cost recovery system	Medium
Address climate change linkages to invasive pests		2017	University of Hawaii, PICCC, HISC	TBD	Low
Early detection and rapid response					
Improve early detection and rapid response capacity	Increase BTS inspection of goods and conveyances arriving from Guam both directly and indirectly.	2015	HDOA	OIA	High
	Increase ability to respond effectively to alien snake encounter reports, through improved communication and cooperation with agencies on the ground as well as external supporters, by increasing the numbers of trained responders available on all vulnerable islands, by insure that trained responders received appropriate update training, and by insuring that there are sufficient support staff to assist primary trained responders.	2016	HDOA	OIA	High
	Re-instate mosquito vector monitoring for infectious diseases throughout the state.	2016	DOH, HISC	USFWS	Low
	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	HISC	USFWS/USDA/DoD	High
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2015	ISCS	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve early detection and rapid response capacity (continued)	Develop taxa specific ERPs as needed.	On-going	HISC	TBD	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	HISC	TBD	High
	Develop and institute surveillance programs for non-establish species consider high risk of arrival such as CRB, alien snakes, fruit flies, tramp ants, etc.	2016	HISC, ISCs	USFWS	Medium
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities.	2015	ISCs	TBD	Low
Management and eradication					
Increase management and control of established invasive species	Determine which established invasive species are actionable and proceed with developing management strategies. Covered in part by national ISAP.	2015	HISC	ISAP	Medium
	Train natural resource staffs (including protected areas staffs) at the local level in regards to IAS management support.	2015	HISC	TBD	Medium
	Train interested citizens to support IAS management efforts (volunteer citizen scientists).	2015	HISC	TBD	Low
	Conduct surveys on the procurement and use of plants, animals, and their products by local communities.	2015	HDOA	Biosecurity cost recovery system	Low
	Develop standardized SOPs for IAS monitoring and surveys.	2015	DLNR	USFWS	Medium
	Conduct regular background field surveys to ensure that knowledge of established invasive species and their distributions are current.	on-going	DLNR	USFWS	Medium
	Create community funding sources for local (village level) programs to promote environmental awareness and stewardship through local training, education, and eradication efforts.	2016	HISC	TBD	Low
	Support Little fire ant management and eradication efforts with funding and resources.	on-going	HISC, HDOA, DLNR, UH	TBD	High
	Conduct delimiting surveys for CRB, followed immediately by a well-developed management strategy and possibly eradication efforts.	2014	HDOA	TBD	High
	Provide funding and other resources immediately for the best possible chance at CRB eradication success.	2014	HDOA, USDA	TBD	High
	Address rats, especially their parasites, such as <i>Agrostrongylus patenetus</i> which is a major concern for public health.	2015	DLNR, USFWS	TBD	Medium
	Improve detection methods for rodents and other wildlife on vessels and in cargo.	2017		TBD	Low
	Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of locally sourced plants, preferably native plants.	2015	CGAPS and HDOA	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Increase management and control of established invasive species (continued)	Encourage businesses to make their staff knowledgeable about invasive plants, to inform their customers about invasive plants, to report immediately any likely exotic pest organisms found on their premises, and to use native or non-invasive plants locally sourced.	2015	TBD	TBD	Low
	Establish and develop relationships with key industrials such as landscaping and pet stores to help develop their ability to institute internal standards to support IAS prevention.	2015	DLNR	TBD	Low
	Improve capacity to carry out investigations and effective enforcement beyond ports of entry.	2016	HDOA	Biosecurity cost recovery system	Medium
Awareness					
Increase outreach and education on biosecurity and invasive species	Develop an educational strategy that is long term, extensive and nation wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	HISC	TBD	High
	conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the nation from unwanted pests.	2015	CGAPS	TBD	High
	Conduct follow-up surveys and tweak system accordingly to insure long term viability and usefulness of the educational strategy	Every 3-5 years	CGAPS	TBD	High
	Provide information to local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	CGAPS	TBD	High
	Establish long term funding to support core outreach and educational efforts.	2016	HISC	TBD	High
	Increase coordinate existing outreach efforts.	2015	HISC, PCSU	TBD	High
	Add invasive species education as a standard part of school curriculums.	2016	CGAPS/Department of Education	TBD	High
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2016	CGAPS/Department of Education	TBD	High
Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2016	HISC	Regional ISC Office	Medium	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2016	CGAPS	TBD	High
	Advertise amnesty/honor bin option by means of mass media outlets as part of public outreach.	2015	CGAPS	TBD	Medium
	Create awareness of the potential legal consequences of violations.	2016	CGAPS	TBD	Medium
	Distribute multi-lingual biosecurity poster free to pet shops, grade schools, universities, sporting goods stores, gardening stores, naturalist clubs, parks and natural areas, military facilities, air and sea ports, community centers and perhaps even seafood stores, farmers' markets and restaurants.	2016	CGAPS	TBD	Medium
	Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers to inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers.	2016	CGAPS	TBD	Medium
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials,	2016	CGAPS	TBD	Medium
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted by invasions by non-native species.	Conduct baseline surveys.	2015	University of Hawaii	TBD	High
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the state that can be shared with universities and others. Such a list could be a positive influence in engaging research groups to support management efforts within the state.	2015	University of Hawaii	TBD	Low
Policy					
Improve laws and regulations	Conduct a review of both state and federal biosecurity regulations as they apply to Hawaii.	2015	CGAPS, HISC	Biosecurity cost recovery system	Medium
	Agriculturally driven regulations should be reviewed and revised to better address invasive pests whether they are agriculturally related or not.	2015	HDOA/USDA	Biosecurity cost recovery system	High
	Expand existing or create new regulations (as needed) and SOPs to encompass all potential IAS include terrestrial (agricultural and non-agricultural), freshwater, and marine concerns.	2016	HDOA, CGAPS	Biosecurity cost recovery system	High
	Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law.	2016	CGAPS, HDOA, DLNR	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/ Resources	Priority
Improve laws and regulations (continued)	Ensure that appropriate biosecurity regulations are in place and enforced.	2016	HDOA, USDA	Biosecurity cost recovery system	High
	Issue penalties and fines to enforce compliance.	2015	HDOA, DLNR	Biosecurity cost recovery system	High
<i>Restoration</i>					
Improve efforts to restore native ecosystems and species	Increase restoration efforts of native systems where IAS management and/or eradication efforts have been successful.	should be an on-going process	DLNR and UH	USFWS/DoD	Low
	Localized risk assessments should be conducted for all habitat types.	start process in 2016 as needed	DLNR and UH	TBD	Low

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment L: Territory of Guam Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the Guam section of the RBP regularly and share regionally.	continuous, at least every 3 years	GISAC	Biosecurity cost recovery system	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	Guam RISC representatives	Regional ISC Office	High
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2015	Guam RISC representatives	Regional ISC Office	Medium
	Work with managers and advisory councils of the Pacific Marine National Monuments (including the Mariana Trench Marine National Monument) to collaboratively address marine biosecurity threats.	2015	NOAA / USFWS	TBD	Medium
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report shared with the region and beyond.	Yearly	Guam RISC representatives	TBD	High
Establish a jurisdictional invasive species coordination office that is tasked with supporting territory wide IAS efforts across agencies and offices as well as working nationally and regionally with IAS stakeholders to ensure appropriate levels of communication and support.	Develop funding to support the invasive species coordination position.	2015	Governor's Office	Biosecurity cost recovery system	High
	Hire and establish jurisdictional coordination office. Consider housing this office at the Governor's complex under direct supervision of the Governor's Office to insure its ability to work across offices and agencies on Guam.	2015	Governor's Office	Biosecurity cost recovery system	High
	Once established this office should support and assist in coordinating efforts with invasive species within the territory. Part of this effort will be ensure that information regarding emerging issues is appropriate disseminated and that governance is regularly updated regarding both territorial and regional invasive species developments.	2015	Governor's Office	Biosecurity cost recovery system	High
Improve communications and ability to address biosecurity concerns between US DoD and civilian government agencies	Establish an MOU between Guam and DoD regarding biosecurity within the territory in regards to DoD activities and facilities.	2015	GDOA	DoD	High
	Establish SOPs on aspects of how DoD and Guam's civilian agencies work together regarding biosecurity inspection process, etc.	2015	GDOA	DoD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.</p>	<p>Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.</p>	<p>2015</p>	<p>Guam RISC representatives and the Governor's office</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office with supporting protocol and methods development.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting establishing ER &RR capacity.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.</p>	<p>2015</p>	<p>Guam RISC representatives and the Guam ISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.	2015	Guam RISC representatives and the Guam ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support management, response, and eradication efforts.	2015	Guam RISC representatives and the Guam ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	2015	Guam RISC representatives and the Guam ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts.	2015	Guam RISC representatives and the Guam ISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	Guam Invasive Species Coordinator	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	University of Guam	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	University of Guam	TBD	Low
	Support the development of an algal risk assessment for the region.	2016	University of Guam	TBD	Medium
	Support the development of an arthropod risk assessment for the region.	2016	University of Guam	TBD	Medium
	Documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	Guam Invasive Species Coordinator	Regional ISC office	Low
	Documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	Guam Invasive Species Coordinator	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region	2016	University of Guam	TBD	Medium
Improve the functionality of RISC	RISC members should work with state governance to review the RISC by-laws and re-establish or enhance ties between appointed RISC members and jurisdictional leadership in order to facilitate communication between council members and leadership ensuring closer working relations.	2014	Guam RISC representatives	RISC	High
	Ensure that RISC membership is regularly reviewed and that council members are known to the state invasive species community and governance.	Reviews should correspond with turn over in Government	Guam RISC representatives	RISC	High
	RISC members should provide an annual overview of MCES activities regarding biosecurity to state stakeholders (both thematic and governance)	Within 1 month of the December MCES on an annual basis	Guam RISC representatives	RISC	High
	Support development of a clearly defined role for RISC to improve the council's ability to support biosecurity and invasive species efforts. RISC as a council established by and for the chief executives of Micronesia can and should play a major role in biosecurity of the region. RISC's ability to facilitate regional biosecurity and IAS initiatives needs to be improved.	2014	Guam RISC representatives	RISC	High
	Support participation of Hawaii in the RISC.	By the end of 2014 Hawaii should be part of RISC	Guam RISC representatives	NA	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve territorial IAS/biosecurity coordination	Share information between biosecurity offices at different levels of government between agencies as well as with DoD in regards to pathways, vectors, inspections, interceptions, and enforcement actions taken. Consider utilizing a joint agency work group to facilitate communication and sharing.	2014	GDOA, GCQA, UOG	Current funding	High
	Improve communication and coordination between GCQA and GDOA through establishment and utilization of Guam Biosecurity Division as dictated by Guam Public Law 31-43.	2014	GDOA, GCQA	Biosecurity Fee	High
	Develop list of recommended plants for landscaping	2015	GDOA - Division of Forestry	TBD	Medium
	Enhance collaboration between USFWS and GCQA through quarterly meetings and training.	2014	GCQA	USFWS	High
	Increase effectiveness of interdiction capabilities and inspections for wildlife and their products at the ports of entry to prevent the introduction of animal and zoonotic diseases by increasing rate of inspections and coordinating efforts of GCQA and other agencies with port-of-entry inspection responsibilities with USFWS.	2014	GCQA, Port Authority of Guam	USFWS	High
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	Guam RISC representatives	TBD	Medium
Support increased Federal assistance with biosecurity	Re-evaluate the operation and staffing needs of the Guam Plant Inspection Station.	2014	GDOA	USDA - APHIS	High
	Relocate the Guam Plant Inspection Station within the airport fence in order to limit the extent to which uninspected items need to be transported prior to inspection.	2015	GDOA	USDA - APHIS	Medium
	Train TSA inspectors in IAS detection and capture. An initial training for existing staff with yearly joint follow-up training with other agencies (GCQA, GDOA) would be appropriate. Train new cohorts as they are coming on board. Such training could be facilitated by SPC and/or UOG and/or USDA.	2015	GDOA, GCQA, UOG	TSA	Medium
	Ensure that the Guam Plant Inspection Station has adequate resources on hand for necessary day to day activities and the full range of inspections which may be required.	2015	GDOA	Biosecurity Fee	Medium
	The USDA-APHIS office on Guam needs to increase inspection and oversight of inspection processes.	2015	GDOA, GCQA	USDA - APHIS	Medium
	Increase USDA-WS pre-departure inspections of for brown treesnakes to enable WS to inspect 100% of all departing cargo and vessels as well as establishing enforcement standards and penalties for non-compliance.	2014	GCQA	USDA - WS, DOI	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support increased Federal assistance with biosecurity (continued)	Hire an additional federal wildlife inspector to increase the percentage of shipments which USFWS can inspect with goal of 100% inspection.	2015	GDOA - Biosecurity Division	USFWS	Medium
	Require that imported organisms be held in quarantine for a brief period to provide time to examine each shipment.	2015	GDOA - Biosecurity Division	USFWS	Medium
	Coordinate USDA-APHIS agreements with commercial air cargo shipping agencies to prevent invasive species transportation.	2015	GDOA - Biosecurity Division	USDA - APHIS	Medium
	Continue to improve partnering with the military (in each location where DoD has facilities) in regards to biosecurity, including when necessary working on DoD lands. The military should have their own staff at each DoD facility working in conjunction with local authorities to monitor for pests, to conduct biosecurity inspections, to respond to incursions, and to implement management efforts as needed. Where staff are in place, as they are at most facilities, improvements to existing systems, communication, and partnering with local civilian agencies should continue to be advanced.	2015	GDOA, GCQA	TBD	High
	Coordinate with agencies responsible for the Pacific Marine Monuments to address marine IAS prevention efforts.				Medium
Support efforts to increase marine and aquatic biosecurity efforts in the region	Raise awareness of potential threats from marine and aquatic IAS. With particular attention on inreach to local and federal decision makers and resource managers.	2015 and on-going	TBD	TBD	Medium
	Support capacity building to establish marine and aquatic IAS programs in the region.	2015 and on-going	TBD	TBD	Medium
	Establish and support monitoring efforts for marine and aquatic IAS.	2015 and on-going	TBD	TBD	Medium
	Increase collaboration between local and federal agencies working on marine and aquatic invasive species.	2015 and on-going	TBD	TBD	Medium
	Seek funding support for marine and aquatic IAS prevention and response.	2015 and on-going	TBD	TBD	Medium
Prevention					
Improve pre-border biosecurity	Utilize trapping, monitoring for signs, etc. to improve detection methods for rodents, insects and other wildlife on vessels and in cargo.	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	Develop risk assessments for Guam by identifying where guest workers, construction materials, and food stuffs will be coming from and then investigating both general and specific IAS concerns for these areas.	2015	GDOA, GCQA	TBD	Medium
	Develop risk assessments for Guam by identifying where guest workers, construction materials, and food stuffs will be coming from and then investigating both general and specific IAS concerns for these areas.	2015	GDOA, GCQA	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve pre-border biosecurity (continued)	Develop audited off-shore hygiene systems such as those utilized very successfully in Australia and New Zealand.	2015 Hold jurisdictional consultation including	GDOA - Biosecurity Division	Biosecurity Fee	High
	Develop the capacity to pre-screen vessels arriving at the seaport	2014	GDOA - Biosecurity Division, Port Authority of Guam	Biosecurity Fee	High
	Ensure inspection of gravel and other construction materials and equipment to be imported into Guam prior to shipping.	2015	GDOA - Biosecurity Division, Port Authority of Guam	USDA - APHIS	Medium
	Contracting efforts and language should establish minimal sanitation standards for all construction equipment and materials to be shipped to Guam and provide entry level training for guest workers in terms of how to assist in assuring that they are not bringing in invasive species.	2015	GDOA - Biosecurity Division, Port Authority of Guam	Biosecurity Fee	High
	Ensure that only companies which can ensure levels of biosecurity similar to HACCP guidelines should be considered for those who will need to bring in guest workers and materials from foreign ports. Check with Federal Acquisitions Regulation and legal to see if this type of restriction already exists.	2015	GDOA, GCQA	TBD	Medium
	Develop standardized SOPs as per HACCP guidelines to improve IAS surveillance and monitoring.	2014	GDOA, GCQA, UOG	Current funding	High
Improve border security	Develop an SOP that allows PPQ, GCQ, GDOA, and other authorities responsible for inspection and identification to react to changing risks based on countries of origin of arriving travelers and cargo.	2015	PPQ, GCQA, GDOA	Current funding	Medium
	Establish a communication and coordination system for information derived from outreach programs, port inspections, pest identifications, and reports from the public of sightings or encounters with suspected invasive species or illegal movements of foods, plants, animals, insects, etc.	2014	GCQA, GDOA, UOG, GISAC	Current funding	High
	Acquire and install X-ray machines for biosecurity at all ports of entry.	2016	Biosecurity Division	Biosecurity cost recovery system	Medium
	Ensure staff is appropriate trained for use of X-ray machines at all ports of entry.	2016	Biosecurity Division	Biosecurity cost recovery system	Medium
	Ensure appropriate long term maintenance for X-ray machines used for biosecurity.	2016	Biosecurity Division	Biosecurity cost recovery system	Medium
	Ensure that port authorities are working with quarantine in regards to use and placement of amnesty bins. Standard trash bins should also be located in appropriate areas and well signed so that passengers don't use amnesty bins for regular trash.	2015	Biosecurity Division	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Develop SOPs for incoming baggage and cargo inspections which are based on successful models (such as New Zealand); would require hiring and training additional personnel, installing appropriate equipment (X-ray, etc.), training additional canine teams for detection of specific high risk IAS (reptiles, fruits, meats, etc.); ensuring appropriate data collection and development and maintaining of databases to track efforts and interceptions.	2016	Biosecurity Division	Biosecurity cost recovery system	Medium
	Support the development of a canine pest detection program for items such as fruits, and vegetables. Consider the potential to combine this program with similar programs for detection of illicit materials.	2018	Biosecurity Division	Biosecurity cost recovery system	Medium
	Ensure that amnesty bins are available at ports and that they are well signed (identified) and are cleaned immediately after each arrival. Bins should be placed so as to support use (not directly in front of quarantine stations). Items deposited in amnesty bins should be treated as restricted garbage and destroyed promptly and on site to reduce the potential of spread of pests associated with anything within the bins.	2015	Biosecurity Division	Biosecurity cost recovery system	High
	Develop appropriate inspection facilities including a biosecure inspection facility at the seaport large enough for sea containers and wash-down areas with appropriate retention and treatment facilities for waste water produced.	2017	Biosecurity Division	Biosecurity cost recovery system	High
	Ensure that inspections process while targeting high risk goods also ensure random sampling of all imports, travelers, and baggage in order to better detect hitchhiker pests.	2015	Biosecurity Division	Biosecurity cost recovery system	High
	Improve compliance, enforcement and fee and penalty issuance and collection in regards to biosecurity measures.	2016	GDOA	Biosecurity cost recovery system	High
	Implement advanced on-site capacity training of quarantine officers such as specific taxon identification, data collection and entry, improved inspection methods, and new method/criteria based on updated regulations (such as training for tramp ant identification, inspection of aquatic conveyances, reporting on ballast water documentation, identification of livestock, wildlife and poultry diseases and pests, etc.)	on-going	GDOA	Biosecurity cost recovery system	Medium
	Clean containers and conveyances that arrive with soil and/or exotic plant pests. Establish guidelines similar to those used by APHIS in the US. Evaluate the effectiveness of current cleaning methods, and improve as appropriate. Importers/shippers should be required to pay for costs (cost recovery system).	2015	Biosecurity Division	Biosecurity cost recovery system	Medium
	Inspect all incoming construction materials and equipment as high risk for transporting pest species. Inspections should including materials previously treated or cleaned (due to the potential for recontamination after treatment).	2015	Biosecurity Division	Biosecurity cost recovery system	Medium
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	GDOA	TBD	Low
	Hire and train additional quarantine staff as needed. Should be based on needs assessment. An inspections database should be able to demonstrate needs.	2015	GCQA	Biosecurity cost recovery system	High
	Institute fines for soil packages if they continue to arrive harboring non-native species.	2015	GCQA/DOA	Biosecurity cost recovery system	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Establish an electronic database for quarantine inspection data that can be searched and data extracted for analysis. Such a database would support better targeting of vectors and pathways, permit tracking of known violators, provide documentation regarding interceptions, fee and penalty payments, demonstrate appropriate use of resources, quantify gaps and needs in current system, assist in determining pathways associated with post border detections, tracking of live imported species and number of individuals, tracking changes in vector arrivals and embarkation locations, etc.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Enforce the Guam law prohibiting the importation of soils for all soil and similar materials, specifically the bags of soil and soil like products soil in hardware stores. Either these items should not be imported or should need to be sterilized prior to import.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Train quarantine staff in data collection, entry, management and analysis, develop appropriate field inspection forms, conduct quality control of data systems, ensure that field data is entered into system in a scheduled manner to prevent backlogging, ensure that the data system is appropriately and regularly backed up to prevent systematic losses.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Institute quarterly reporting on quarantine inspections based on database information and ensure that reports are shared.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Protocols should be established by GCQA for documenting interceptions and final disposition of materials. These reports should be entered into a database and information should be shareable to assist Guam offices and agencies with improving border protection but also with other jurisdictions of the region to better protect the region. Protocols should be established regarding how and when (how often) this type of information is shared. Information collected and stored should include date of incident, inspector in charge, what was intercepted, what IAS were found, numbers of pests found, origin of the material in question, disposition of the material(s) and specimen(s), what remedial actions (if any) were taken against the shipper, and if fines were instituted, were they collected.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Support the development and implementation of regional standards for biosecurity inspections and data collection and management.	2017	Biosecurity Division	SPC	Low
	Conduct annual invasive species awareness, first detector training and outreach training sessions for port-of-entry workers. Training sessions should include basic biology of target pest species, point of origin and host materials associated with the invasive species. Provide participants with general means to collect capture or detain the invasive species upon discovery at the port, and point of contact to report an incident.	2015	UOG, GDOA, GISAC	USDA, SPC	Medium
	Develop MOU's between GCQA and other agencies involved in border inspections so that these offices/agencies can support the quarantine office with biosecurity aspects.	2016	GCQA	existing funding	Low
	Develop SOPs regarding specifics of how other agencies and offices can support the role of quarantine office during border inspection process.	2016	GCQA	existing funding	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Institute biosecurity cross training of staffs from agencies which are involved in border inspection processes.	2016	GCQA	existing funding	Low
	Treat all materials in amnesty bins as restricted garbage and appropriate destroyed.	2015	GCQA/DOA	existing funding	High
	Establish programs that would allow passengers of airlines or ships to be able to surrender any potentially invasive animals with assurances that there would be no prosecution (excluding illegally smuggled animals protected by law, such as species listed under CITES).	2016	Biosecurity Division	Biosecurity cost recovery system	Low
	Ensure that biosecurity regulations are applied to all equally (there should be no exceptions for diplomatic status or otherwise).	2015	Biosecurity Division	Biosecurity cost recovery system	Medium
	Develop multi-agency MOU to train USDA/APHIS and military personnel and authorize them to conduct border inspections for Guam.	2016	Biosecurity Division	Biosecurity cost recovery system	Medium
	Build physically secure facilities at the Guam Commercial Seaport with ample warehouse space and equipment and resources required to unload cargo and conduct agricultural inspections in order to centralize inspection of maritime cargo.	2017	Port Authority of Guam, GCQA	Biosecurity cost recovery system	Medium
	Conduct biosecurity inspection for all arriving conveyances, military and non-military, for plant pests and animal contamination.	2015	GCQA	Biosecurity cost recovery system	Medium
	Allow GCQA officers to inspect military vessels as USDA-APHIS cooperators.	2015	GCQA	Biosecurity cost recovery system	Medium
	Maintain secure areas for storage of vehicles and cargo at the air and sea facilities to prevent the dissemination of plant pests and reduce risks of cross contamination of other cargo items.	2015	GCQA	Biosecurity cost recovery system	Medium
	Establish decontamination sites for cleaning both military and civilian equipment.	2015	GCQA	Biosecurity cost recovery system	Medium
	Update the Port Authority of Guam Master Port Plan to address equipment and other resources needed to handle regulated international garbage properly.	2015	GCQA	Biosecurity cost recovery system	Medium
	Standardize methods similar to those of the APHIS-PPQ Agriculture Quarantine Inspection Monitoring program for random container searches.	2015	GCQA	Biosecurity cost recovery system	Medium
	Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected.	2015	GCQA	Biosecurity cost recovery system	Medium
	Automate paperwork for air cargo shipments arriving in crates and containers for more rapid selection of containers to be screened.	2015	GCQA	Biosecurity cost recovery system	Medium
	Develop SOPs regarding container hygiene to support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping.	2015	GCQA	Biosecurity cost recovery system	Medium
	Provide essential equipment to inspection services, including computers, communication devices, etc. and support for both the use and maintenance of this equipment.	2015	GCQA/DOA	Biosecurity cost recovery system	High
	Standardize inspection practices between Guam and U.S. mainland.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve border security (continued)	Treat cargo shipments (import and export) as foreign in regards to inspection practices.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Biosecurity surveillance system should include routine surveillance for wildlife, livestock, and poultry diseases and vectors as well as insect and plant pests.	2015	GDOA - Biosecurity Division	Biosecurity cost recovery system	Medium
	Specify surveillance methodology to be appropriate for targeted species , (i.e. modifying sampling programs to account for behavioral differences in diurnal and nocturnal lifestyles).	2015	GDOA - Biosecurity Division	Biosecurity cost recovery system	Medium
	Utilize systematic surveillance for plant pests following the model of the Cooperative Agriculture Pest Survey (CAPS), and include both military and civilian properties as appropriate.	2015	GCQA	Biosecurity cost recovery system	Medium
	Standardize the use of reconditioning practices for both inter-state and international commodities arriving on Guam.	2015	GDOA	Biosecurity cost recovery system	Medium
	Create and institute a mixed model biosecurity approach based on both vector sanitation and focusing on key high risk species for terrestrial, freshwater and marine habitats.	2015	Biosecurity Division	Biosecurity cost recovery system	High
	Develop appropriate vector management with feedback and monitoring mechanisms.	2015	Biosecurity Division	Biosecurity cost recovery system	High
Improve post border biosecurity	Develop an IAS action plan for Guam and update regularly (every 3 to 5 years). This plan should be inclusive of all environments and taxa and be developed by all stakeholders (not only active GISAC members).	2014	GISAC	Current funding	High
	Develop and implement new IAS control and management programs to supplement current work and reduce the potential of spreading them to non-infected locations.	2014	GDOA, GCQA, UOG, GISAC	Biosecurity Fee	High
	Develop jurisdictional capacity where gaps exist through training or added resources.	2015	GDOA, GCQA, UOG, GISAC	Biosecurity Fee	Medium
	Eradicate small (new) IAS incursions promptly that are feasible and can be accomplished through current program limitations and funding.	2015	GDOA, GCQA, UOG, GISAC	Biosecurity Fee	Medium
	Eradicate population of Java Sparrows.	2015	GDOA	TBD	High
	Develop and enforce best management practices for contractors and construction sites. To include, the minimization of land disturbance and ensuring the proper cleaning of all construction items according to APHIS guidelines.	2014	GDOA, GCQA, UOG, GISAC	Current funding	High
	Ensure proper cleaning of all large equipment is treated prior to moving between sites on Guam or preparation for departure from Guam.	2014	GCQA, Port Authority of Guam, A.B. Wood Pat	TBD	High
	Consider helicopters and private planes (or small scale commercial ventures) as possible IAS vectors and therefore a biosecurity threat that needs to be monitored and inspected as per USDA/APHIS guidelines.	2015	GCQA, A.B. Wood Pat International Airport Authority	Biosecurity Fee	Medium
	Consider small boats and yachts (including small scale commercial ventures) as possible IAS vectors and determine if monitoring and inspection may be necessary to prevent IAS introduction or spread.	2015	TBD	TBD	
	Determine the extent of the little fire ant infestation and then to manage and/or eradicate this species.	2014	UOG, GDOA, GISAC	USFWS	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve post border biosecurity (continued)	Improve enforcement and enforcement capacity regarding smuggled animals.	2014	GCQA, GDOA, GISAC	USFWS	High
	Create GIS layers that delineate the distribution of established IAS and integrate them with other GIS layers such as land ownership, management areas, etc. to improve capacity to manage and control existing established invasive species.	2015	UOG, GDOA, GISAC	BSP, UOG	Medium
	Continue with Coconut Rhinoceros Beetle rearch and management efforts.	2014	CRB Eradication Team/ Task Force	Current funding	High
	Establish and develop relationships with key industrials such as landscaping, pet stores and fish hatcheries to develop their ability to institute internal standards to prevent IAS and curtail smuggling and create safe avenues for import (i.e. no imports or sales of prohibited animals or plant pests).	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	Train landscaping company staff to be knowledgeable about invasive plants, to inform their customers about invasive plants, to ensure only pest free plants are used, to report immediately any likely exotic pest organisms found on their premises, and to use native or non-invasive plants locally sourced. This could be a yearly training event run by a local agencies or with support from an external group such as SPC.	2014	GDOA - Division of Forestry	TBD	High
	Conduct periodic surveys of fish hatcheries, ethnic markets, pet stores, and grocery stores to identify and intercept prohibited animals and animal and plant products following the model of the USDA-APHIS-PPQ Smuggling, Interdiction and Trade Compliance program.	2015	GDOA - Biosecurity Division	USDA - APHIS, PPQ	Medium
	Develop and/or improve capacity through the addition of resources such as staff, training, equipment etc. to carry out investigations and effective enforcement beyond ports of entry.	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	Create an Island-wide green waste management program to reduce the amount of green waste breeding sites for CRB.	2014	CRB Eradication Team/ Task Force	Current funding	High
	Formalize the local production of bio-control options (GMF and virus) for the management of CRB on Guam.	2014	CRB Eradication Team/ Task Force	TBD	Medium
	Incorporate new/improved tools as they become available in regards to Brown Treesnake control and management activities.	2014	GDOA	OIA, USFWS, USDA	High
Improve biosecurity in regards to wood packaging material (WPM)	Require and enforce treatment of all WPM according to ISPM No. 15.	on-going	GQCA	Biosecurity cost recovery system	Medium
	Inspect an adequate percentage of all domestic and foreign, military and non-military WPM accompanying agricultural and nonagricultural cargo for pests. 100% inspection would be ideal but many not be feasible given capacity limitations and time constraints.	2015	GQCA	Biosecurity cost recovery system	Medium
	Prohibit the unloading of noncompliant WPM.	2015	GQCA	Biosecurity cost recovery system	Medium
	Incinerate or sterilize any noncompliant or infested WPM that is offloaded; it should be treated as regulated garbage .	2014	GQCA	Biosecurity cost recovery system	Medium
	Support a regional approach to switch from WPM to other options such as recycled plastics; interim solution is the enforce certification of WPM and to inspect regularly.	2014	GQCA	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase agricultural biosecurity/food security	Update terrestrial biosecurity risk assessment in regards to agricultural commodities.	2016	GDOA - Biosecurity Division	Biosecurity Fee	Low
	Update list of commodities and importer countries.	2016	GDOA - Biosecurity Division	Biosecurity Fee	Low
	Conduct background surveys for plant pests and livestock and wildlife populations and diseases.	2015	GDOA, UOG	TBD	Medium
	Implement initial surveillance and monitoring for the prevention of livestock, poultry, and wildlife diseases and determine whether measures perform adequately. Adjust efforts as needed to improve and ensure that potential gaps are addressed.	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	Collect and analyze baseline data regarding key crops and animal stocks for internal consumption as well as for export need to be established and maintained.	2015	GDOA, UOG	TBD	Medium
	Analyze biosecurity intercept data.	On-going	GDOA, UOG, GCQA	Current funding	Medium
	Share information gathered quarterly within the region and beyond via a working group. Create region communication network to facilitate information sharing.	On-going	GDOA, UOG, GCQA, RISC representative(s)	Current funding	High
Address the fact that humans can serve as vectors of invasive species.	Screening of humans either during the arrival or departure process needs to be considered. Even with screening in place the potential for missed detections is high and therefore dependence on rapid response to initial localized outbreaks of human disease vectors is essential and must be appropriately planned for and supported.	2015	Department of Health	TBD	Medium
	National health authorities should work with US DoD to determine what, if any, role DoD can support in the advent of a human pathogen outbreak. For example, could DoD transport sick patients to appropriate support facilities either within or outside of the national in the case of a human pathogenic outbreak?	2015	Department of Health	TBD	Medium
	Shipping conditions of medical items needs to support potential invasive pathogenic outbreaks must be improved.	2015	Department of Health	TBD	Medium
Improve capacity to regulate the importation of live organisms	Develop a government endorsed white list of species permitted for import.	2014	GQCA/DOA	existing funding	High
	Update white list on a regular basis.	annually	GQCA/DOA	existing funding	Medium
	Develop a government endorsed black list of prohibited species.	2014	GQCA/DOA	existing funding	High
	Update black list on a regular basis.	annually	GQCA/DOA	existing funding	Medium
	Ensure that all species proposed for import that are neither black or white listed undergo appropriate risk assessment to determine potential impacts. Organisms which are deemed potential harmful should be added to the black list. Organisms which are deemed non-harmful should be added to the white list.	Continuous	GDOA	Importer pays for all aspects of the risk assessment (regardless of outcome)	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve capacity to regulate the importation of live organisms (continued)	Develop and update regularly public dissemination of white and black lists as well as a details on the risk assessment process for proposed species imports. This could likely be done via an existing government website.	2015	GQCA/DOA	utilize student support	Low
Reduce risk associated with live traded species	Establish formal risk analysis process/guidelines for all organisms used or proposed for live trade. Institute a territorial biosecurity advisory committee to review proposals for the importation of exotic species.	2015	GDOA	Biosecurity cost recovery system	High
	Standardize reporting and screening systems for the importation of live organisms.	2015	GDOA	Biosecurity cost recovery system	High
	Regulations regarding the importation of pets and other animal species need to be standardized, applied to all equally, and enforced.	2015	GDOA	Biosecurity cost recovery system	Medium
	Develop plan for containment and control measures in regards to exotic farmed and traded species.	2015	GDOA	Biosecurity cost recovery system	Medium
	Develop emergency preparedness procedures regarding possible escape of exotic organisms being farmed or trade.	2015	GDOA	Biosecurity cost recovery system	High
	Ensure that specific quarantine facilities are available and establish specific quarantine SOPs for the movement of live organisms (plant and animal, including aquatic species).	2016	GDOA	Biosecurity cost recovery system	High
	Establish legal instruments/framework regarding the responsible use and control of exotic species.	2015	GDOA	Biosecurity cost recovery system	High
	Improve diseases diagnosis and monitoring, as well as epidemiological surveillance implementation for farmed organisms.	2015	GDOA	Biosecurity cost recovery system	Medium
	Ensure that all aquaculture, mariculture, and other captive breeding facilities of non-native species are secure including from natural disasters.	2015	GDOA	Biosecurity cost recovery system	High
	Develop biosecurity standards for household aquaculture set ups and enforce these standards.	2015	GDOA	Biosecurity cost recovery system	Low
	Establish explicit aquaculture biosecurity practices (e.g. control of stocking densities, use of all-male populations, use of triploids, etc.).	2015	GDOA	Biosecurity cost recovery system	Medium
	Require all health certificates and necessary permits accompany imported livestock, poultry, and other animals.	2014	GDOA	Biosecurity cost recovery system	Medium
	Ensure that all imported animals are subject to health inspection by the territorial veterinarian and appropriately quarantined as required.	2014	GDOA	Biosecurity cost recovery system	Medium
	Improve the regulation of the importation of exotic animals for zoos and aquaria.	2015	GDOA	Biosecurity cost recovery system	Low
	Develop specific guidelines for unwanted pets.	2015	GDOA	Biosecurity cost recovery system	Low
	Require all aquaculture shipments entering Guam must have an import permit, certificate of origin, and health certificate, and undergo physical inspection for amphibians and their eggs.	2014	GDOA	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Reduce risk associated with live traded species (continued)	enhancing quarantine requirements for specific species or taxon groups when imported (need to develop facilities for this in most cases) which would help with disease detection and control.	2016	GDOA	Biosecurity cost recovery system	Medium
	Establish lists of countries and competent authorities in regards to introduction and trade of exotic species.	2015	GDOA	Biosecurity cost recovery system	Low
	Support regional and international cooperation on the responsible use and control of live exotic species.	continuous	GDOA	Biosecurity cost recovery system	Medium
Increase export biosecurity	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pest from entering or being stuck to the outside of containers prior to shipping. Currently rented containers are inspected for internal cleanliness before departure. This should be expanded to include all containers and both internal and external surfaces.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Preferentially load conveyances in a way that minimizes pest entry whenever possible, for example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times. Develop SOPs to support this practice and train workers accordingly.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Enforce the use of container racks for all loading and unloading areas to ensure that containers are kept dirt free when loading and to facilitate inspections during unloading.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Institute pre-departure biosecurity inspections for more than just BTS.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Develop staging areas to safeguard high and low risk cargo.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
	Identify the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of staging facilities.	2015	Biosecurity Division	Biosecurity cost recovery system	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase export biosecurity (continued)	Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, canine inspection, and final loading.	2015	Biosecurity Division	Biosecurity cost recovery system	Low
Increase quarantine capabilities	Implement the Biosecurity fee at the port and hire biosecurity officer positions to staff the Biosecurity Division of DOA.	2014	GDOA, GCQA, Guam Legislature	Biosecurity cost recovery system	High
	Ensure that the Biosecurity Division is appropriately staffed and funded and that it has adequate resources to conduct day to day operations.	2014	GDOA, GCQA, Guam Legislature	Biosecurity Fee	High
	Define clear roles for proposed biosecurity division which dovetail with GCQA and GDOA's roles.	2014	GDOA, GCQA, Guam Legislature	Biosecurity Fee	High
	Provide preliminary training for biosecurity staff and then insure that advanced trainings are provided to improve capacity over time.	2014	GCQA	Current funding	High
	Increase coordination to address marine and aquatic IAS including GDOA, GEPA, UOGML, NOAA, USFWS and others.	2014	UOG	NOAA	
Improve biosecurity for the movement of vehicles/equipment	Inspect, clean, and treat, if needed, vehicles, construction materials and equipment, and other commercial equipment at the port of entry.	2014	Port Authority of Guam, GCQA	Biosecurity cost recovery system	High
	Ensure that vehicles are cleaned prior to shipping.	2014	Port Authority of Guam, GCQA	USDA - APHIS	High
	Clean containers and conveyances that arrive with soil and/or exotic plant pests according to APHIS guidelines.	2014	Port Authority of Guam, GCQA	USDA - APHIS	High
	Evaluate the effectiveness of current cleaning methods, and improve as appropriate.	2015	GDOA - Biosecurity Division	Biosecurity Fee	High
	Ensure that used machines such as wood chippers and bulldozers are cleaned and inspected at point of departure immediately prior to shipping.	2014	GCQA, Port Authority of Guam	Biosecurity Fee	High
	Ensure that all vessels and equipment, including barges, dry docks, and dredging equipment, are free of fouling organisms before introduction to Guam's waters.	2015	TBD	TBD	
Improve importation protocols	Develop/enhance the system for tracking cargo in order to streamline the importation process and improve biosecurity.	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	For the shipment of live organisms, require importers to list the types and numbers of each species in each shipment. This information should be recorded by border agents, retained in an electronic database, and shared as appropriate.	2015	GDOA - Biosecurity Division	Biosecurity Fee	Medium
	Importation of house plants should be restricted and controlled or prohibited as per USDA regulations (especially on plants coming from the Caribbean and Florida).	2015	GDOA - Biosecurity Division	USDA	Medium
	Improve capacity to monitor, inspect, treat or restrict and track permitted imports including all plants and propagative material. Require and enforce the use of USDA or GDOA VS import permits for restricted animal products.	2014	GDOA - Biosecurity Division	Biosecurity Fee, USDA, USFWS	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve biosecurity elements at the Guam International Airport	Reconsider the layout of the arrival area, including replacing the temporary barriers erected to segregate arriving passengers from departing passengers in accordance with Homeland Security regulations with a more permanent solution.	2015	GCQA, A.B. Won Pat International Airport Authority	Biosecurity Fee	Medium
	Ensure primary inspection facilities for arriving air passengers and goods are located within the secure zone internal to the perimeter fence to reduce the potential for the spread of IAS during transit from entry points to inspection facilities.	2015	GCQA, A.B. Won Pat International Airport Authority	Biosecurity Fee	Medium
	GCQA personnel should be stationed with DHS, Transportation Security Administration (TSA) personnel in order to better develop expertise in screening transiting passengers for restricted or prohibited materials or all transiting passengers should be routed through GCQA inspection before they move to the departure area.	2015	GCQA, Guam Homeland Security/Office of Civil Defense	DHS, TSA	Medium
	Provide sufficient inspection facilities for express courier operations at the airport.	2015	GCQA, A.B. Won Pat International Airport Authority	Biosecurity Fee	Medium
	Consider all garbage within the passenger sterile area for incoming and transiting passengers at the A.B. Won Pat International Airport to be regulated garbage.	2014	GCQA, A.B. Won Pat International Airport Authority	Biosecurity Fee	High
	Ensure that the biosecurity system is tracking changes in aircraft arrivals, especially as new linkages are established and/or additional carriers are added.	2015	GDOA - Biosecurity Division, A.B. Won Pat International Airport Authority	Biosecurity Fee	Medium
	Institute 100% x-raying of all incoming passengers baggage to reduce illegal importations.	2014	GDOA - Biosecurity Division, A.B. Won Pat International Airport Authority	TSA, Biosecurity Fee	High
Improve mail inspections	Develop a plan to address the IAS introduction pathway of mail. Of significant concern in this regard is the potential for shipping of pets such as reptiles via the mail system with little ability to detect and intercept these organisms by current biosecurity systems within the region.	2014	GDOA - Biosecurity Division	USPS	High
	Find and implement a working solution which will permit and increase the inspection of US mail (and all other mail types including private courier services) including mail arriving at both civilian and military facilities. Appropriate regulations should be established which would permit the potential inspection of most if not all arriving.	2014	GDOA - Biosecurity Division	USPS	High
	Use current x-ray technology for all foreign-origin mail. Ensure that it is in working order and operable.	2015	GDOA - Biosecurity Division	USPS	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve mail inspections (continued)	Utilize trained detector dogs, visual inspections and X-ray machines to reduce the potential for illicit mail trade.	2015	GDOA - Biosecurity Division	USPS	Medium
Establish and enforce biofouling standards	Establish criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish standards and regulations regarding biofouling, including inspection and certification for all vessels. Inspections can be trained to inspect hulls from top side with mirrors. If further inspection is warranted, then the craft pays for divers to inspect and make a report. If determined to be dirty, then the craft must either be cleaned or leave port and jurisdictional waters. Self clean outside of jurisdictional waters could be an option. Hull needs to be clean of all organisms, as the ability to identify all marine organisms is not available.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish additional regulations for impounded vessels.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Develop capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a biofouling management program.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Establish and enforce biofouling standards (continued)	Ensure that regulations include ability to levy and collect fines and/or require vessels to depart national waters for repeat offenders and for non-compliance with treatment requirements.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Ensure that any required in-depth inspections or treatments are funding in full by the owner/operator. Consider developing a cost recovery system.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Implement targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
Increase marine ecosystem protection from invasive species	Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Implement a targeted outreach program with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Inspection of boats travelling inter-island from the CNMI especially during fishing derby.	2015	GDOA - DAWR	Guam Fisherman's Coop, GOSA	Medium
	Establish biosecurity practices and requirements for fishing vessels that operate in Micronesia to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
Establish and enforce ballast water standards	Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Establish ballast water management and reporting requirements for all vessels utilizing ballast water.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Review and revise (as needed) legal authority to implement a ballast water management program.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Ensure that regulations include ability to levy and collect fines for non-compliance.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
	Support national level adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	GCQA/DOA	Biosecurity cost recovery system	Medium
Address climate change linkages to invasive pests		2018	Governor's Office	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Early detection and rapid response</i>					
Improve early detection and rapid response capacity	Develop an SOP for communication between agencies within various levels of government in regards to risk detection and response.	2015	GDOA	existing funding	High
	Design and implement a public reporting system for new or suspected non-native species incursions (a 24 hour pest hotline is advisable).	2015	GDOA	existing funding	High
	Develop a generic state emergency response plan (ERP) that is funded and approved by key agencies and governance. The generic ERP should be readily modifiable to utilize for terrestrial, freshwater, and marine incursions. The ERP should list necessary actions in sequence, authorities, partners and available resources, including funding sources which can be brought to bear immediately for a response action. Ensure that all appropriate authorities are involved in the development and planning process including public health authorities for diseases with serious animal and/or human health and zoonotic potential.	2015	GDOA	existing funding	High
	Develop a detection(surveillance) program and response plan for new incursions by a few focal non-native species of high-risk non-native species, ensuring that these specific plans cover freshwater, marine, and terrestrial systems.	2016	GDOA	TBD	Medium
	Develop taxa specific ERPs as needed.	On-going	GDOA	TBD	Medium
	Update all ERPs (both generic and species specific) to ensure that they current and functional.	annually	GDOA	existing funding	High
	Ensure that the public reporting system is fully functional including supported by trained staff.	2015	GDOA	existing funding	High
	Ensure that the public reporting system is appropriately advertised and that the citizenry and visitors are aware of its existence, its purpose and how to utilize it.	2015	GDOA	existing funding	High
	Develop protocols for responding the non-native species reports in a timely manner including interview policies, interview formats, timelines, ground truthing, and field action response time.	2015	GDOA	existing funding	High
	Train and maintain a core group of early detection & rapid response staff from local agencies/stakeholder groups, including aquatic and marine IAS detection and response.	2015	GDOA	existing funding	High
	Hold consultations to determine what agency(s), office(s) and/or groups will be responsible for surveillance programs.	2015	GDOA	existing funding	High
	Develop and institute surveillance programs for non-established species consider as high risk for arrival.	2015	Guam DOA	TBD	Medium
	Provide training to interested citizens with regards to supporting ED & RR efforts. Frequency of training events would depend on interest levels but minimally there should be one such course per year that can be used to train and refresh volunteers from local communities. Such trainings could be developed and run with the assistance of the regional invasive species coordination office.	2015	GISAC	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Awareness					
Increase outreach and education on biosecurity and invasive species	Conduct a pre-education survey of residents, visitors, transient workers and other stakeholders to gauge their understanding of invasive species, their potential impacts, biosecurity regulations, and the role of citizens and visitors in regards to protecting the territory from unwanted pests.	2015	GNA/GISAC	TBD	High
	Develop an educational strategy that is long term, extensive and territory wide, reaching school students as well as all communities. Ensure that outreach efforts are extensive and engage citizenry to support and promote biosecurity and management efforts describing approaches to be used to reach the citizenry, organizations, businesses, and visitors (including visiting work forces and foreign business ventures) about potential risks from invasive species and methods to prevent, report, and control their introduction. In order to improve and expand outreach and awareness efforts, a coordinated approach must be utilized to guide activities between the various groups and agencies involved in outreach and awareness activities.	2015	Guam Nature Alliance (GNA), GISAC	TBD	High
	Improve overall coordination of existing IAS and biosecurity outreach and ensure that information is reaching local communities, businesses and visitors about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread.	2016	GNA/GISAC	TBD	High
	Establish long term funding to support core outreach and educational efforts.	2016	GNA/GISAC	TBD	High
	Work with the school systems and support efforts to provide educators with tools and services to support IAS awareness development as part of standard curriculums.	2017	GNA/GISAC/ Department of Education	TBD	High
	Develop posters, brochures and other print media to support invasive species awareness campaigns (minimally these types of outreach materials should be updated and distributed on a yearly basis both as part of systematic outreach efforts and as part of special events/circumstances).	2016	GNA/GISAC	TBD	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts.	2016	GNA/GISAC	TBD	Medium
	Develop invasive species informational videos which can be show on local TV stations. One such video could explain the potential problems which could arise from releasing pet species into the wild (especially non-native aquarium fish).	2016	GNA/GISAC	TBD	Medium
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity.	2016	Guam Invasive Species Coordinator	Regional ISC Office	Medium
	Increase engagement of donors and other support programs to develop and conduct additional outreach efforts.	2016	GNA/GISAC	TBD	High
	Advertise amnesty/honor bin option by means of mass media outlets as part of public outreach.	2015	GCQA	existing funding	Medium
Designate an agency or working group to be responsible to the Government of Guam for developing high-priority outreach messages about invasive species and their pathways and fund efforts.	2015	GCQA, GDOA, UOG, GISAC, GNA	existing funding	High	

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Increase outreach and education on biosecurity and invasive species (continued)	Support the development of a regional video to be shown on air flights prior to arrival which includes information on amnesty bins and documents the concern with invasive species asking visitors and residents to support biosecurity efforts to reduce the movement of pest species. Videos should be developed in multiple languages and could also be shown in departure and arrival lounges.	2015	Guam RISC representatives	external funding	Medium
	Create awareness of the potential legal consequences of violations.	2015	GCQA	existing funding	Medium
	Provide reports and newsletters to educators, journalists, lawmakers, and business and community leaders.	2016	GNA/GISAC	TBD	Medium
	Distribute multi-lingual biosecurity poster free to pet shops, grade schools, universities, sporting goods stores, gardening stores, naturalist clubs, parks and natural areas, military facilities, air and sea ports, community centers and perhaps even seafood stores, farmers' markets and restaurants.	2016	GNA/GISAC	TBD	Medium
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish.	2016	GNA/GISAC	TBD	Medium
	Develop IAS service learning opportunities for students to get hands on IAS experience.	2017	GDOE/GNA/GISAC	TBD	Medium
	Provide information on ways to prevent the spread of plant and animal pests and diseases to the public.	2015	DOA	TBD	Medium
Research					
Evaluate social, cultural, economic, and ecological values that may be impacted by invasions of non-native species.	Conduct baseline surveys.	2015	University of Guam	TBD	Low
Identify knowledge gaps for existing IAS concerns	Develop a priority research list for the territory that can be shared with universities and others. A list could be a positive influence in engaging research groups to support management efforts within the territory.	2015	University of Guam	TBD	Low
Policy					
Improve laws, regulations and guidelines	Coordinate laws and regulations for post-border biosecurity In order to manage IAS effectively.	2015	GQCA/DOA	existing funding	Medium
	Expand existing or create new regulations (as needed) and SOP to encompass all potential IAS include terrestrial (agricultural and non-agricultural), freshwater, and marine concerns.	2016	GQCA/DOA	existing funding	Medium
	Review relevant biosecurity related guidelines and SOPs to ensure they are clear, complete, detailed, and in compliance with appropriate laws and regulations.	2015	GQCA/DOA	existing funding	Medium
	Update existing guidelines and SOPs as needed.	2015	GQCA/DOA	existing funding	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve laws, regulations and guidelines (continued)	Ensure that biosecurity regulations are in place and enforced.	2016	GQCA/DOA	existing funding	Medium
	Include GDOA Division of Forestry into the building permitting process to review the landscaping component and ensure invasive plants are not being used.	2015	GDOA - Division of Forestry	TBD	Medium
	Issue penalties and fines to enforce compliance.	2015	GQCA/DOA	existing funding	Medium
Restoration					
Improve native ecosystems restoration efforts	Continue and move forward with restoration efforts of native systems where IAS management and/or eradication efforts have been successful.	2015	GDOA - DAWR	USFWS, State Wildlife Grant	Medium
	Specific localized risk assessments should be conducted for all habitat types.	2015	GDOA, UOG	TBD	Medium

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment M: United States Department of Defense Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Support</i>					
Ensure long term support for biosecurity efforts within the region	INRMP's (JRM, NRH, KWAJ, Wake, Palau Seabees) shall depict IAS monitoring and surveillance, detection, rapid response actions for all taxa to ensure biosecurity efforts are planned and funding is requested.	on-going	TBD	TBD	High
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the DoD section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year	DoD	TBD	High
Improve communication, facilitation, and joint biosecurity activities with civilian counterparts	Establish agreements (MOUs) between DoD and local agencies tasked with IAS control and management in specific jurisdictions where DoD operates. If not already in place, it should become SOP for DoD and specific jurisdictions to communicate and work in tandem to ensure appropriate biosecurity mechanisms are in place for all DoD activities related to individual jurisdictions. Activities covered by the MOU should include but not be limited to the facilitation of response planning, identification of command structure, and support of response actions to biosecurity threats posed by DoD activities.	End of 2015	JRM/DoD	TBD	High
	Create a Unique Defense Transportation Regulation for the Hawaiian Marine Monument, applicable to all DoD entities. Ensure the regulation mimics current civilian standards for air and marine traffic within the Hawaiian marine monument.	2016	DoD/OPNAV	TBD	Medium
	Continue to improve partnering with civilian agencies (in each location where DoD has facilities) in regards to biosecurity. The military should have at least one invasive species biologist, in addition to a supporting pest control shop or equivalent contract team at each DoD facility working in conjunction with local authorities to monitor for pests, to conduct biosecurity inspections, to respond to incursions, and to implement management efforts as needed. Improvements to existing systems, communication, and partnering with local civilian agencies should continue to be advanced.	2015	JRM	TBD	High
	Complete support capability analysis to determine and quantify the DoD's ability to afford or provide support to severe outbreak scenarios. The scenarios shall attempt to model low, medium, high risk situations, to best determine the "support gaps" or elements out of DoD ability or jurisdictional abilities.	2015	DoD (partnering with the CDC and jurisdictions)	TBD	Low
	Establish a MOU between USDA-APHIS and Pacific Military Commands to facilitate a role for APHIS as it pertains to offshore biosecurity, specific to military pre-clearance and self inspection training.	2015	PACOM/JRM	TBD	High
	Develop and update on a regular basis, the JRM and Navy Region Hawaii instructions for offshore and onshore biosecurity. Ensure that Quality Control processes are included in the instruction to ensure the efficacy is addressed.	On-going for relocation projects	TBD	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve communication, facilitation, and joint biosecurity activities with civilian counterparts (continued)	Include biosecurity requirements and provisions in contracts to reduce the risk of introduction of animal and plant pests and diseases. Provisions should include: 1) contractor-provided education for employees on import requirements and penalties associated with non-compliance; such educational materials should be developed in collaboration with regional SME's from private and government sectors; 2) contractor compliance with all import requirements [import permits, procedures at port of entry and beyond, etc.]; and 3) company-driven pre-inspection of their own materials for plant pests. Minimize pest contamination of containers and WPM by: Minimizing outdoor storage, Sealing storage site surfaces, Keeping storage sites clean, Controlling pests around storage sites, Limiting use of nighttime lighting around storage sites, and Treat storage areas with molluscicides or install barriers to prevent mollusks from infesting WPM and shipping containers. Remove weeds and other contaminants from container and WPM storage areas. Storage areas should be hard surface or gravel.	on-going	DoD, for DoD funded projects	TBD, funded by the individual project or where appropriate the Biosecurity Fee on Guam	High
Improve communication, facilitation, and joint biosecurity activities with civilian counterparts (continued)	Revise and update military guidelines and SOPs for biosecurity. In some cases, the military uses outdated guidance with inaccurate information. For example, the OPNAVINST 6210.2 lists only the States, District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands as the U.S., notably excluding the CNMI and American Samoa (7 CFR § 330.400[a] and 9 CFR § 94.5[a]).	2016	OPNAV	TBD	High
	Live animal imports by military personnel and dependents should follow civilian regulations in each jurisdiction. Review and continue to support these regulations. All health certificates and necessary permits should accompany imported animals. Ensure that all imported animals are subject to health inspection by appropriate animal health offices and appropriate quarantine periods are enforced.	On-going	JRM	TBD	Medium
	Utilize input and market research from Government biosecurity service providers, in addition to regulatory subject matter experts when developing biosecurity instructions and guidance for active duty and civilian DoD employees, in addition to DoD contractors.	2016 develop planning strategy	TBD	TBD	High
	Finalize and utilize the Joint Region Marianas Instruction: Brown Treesnake control and interdiction.	2015	JRM	TBD	High
Support regional biosecurity and invasive species control efforts	Provide assessment of outcomes and update DOD portion of the strategic implementation plan every 3-5 years.	3-5 years	TBD	Regional ISC office	High
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.)	2015 and on-going	TBD	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	TBD	Regional ISC office	Low
	Support the development of a weeds risk assessment for military installations in Hawaii and Micronesia. Share results with cooperating territorial and state agencies.	2016	TBD	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional biosecurity and invasive species control efforts (continued)	Support the development of a regional biosecurity coordination office. Establish an IAS regional management office minimally with an invasive species coordinator who is tasked with assisting individual jurisdictions as well as the region as a whole with IAS and biosecurity concerns. This position would need to be tied in closely with the RISC and the jurisdictional IAS coordinators. This office would play a key role with insuring appropriate, long term regional communication and support and could assist both individual jurisdictions and the region with IAS issues such as funding, regulatory development guidance, capacity development, linking existing resources including subject matter experts, and facilitating the coordinate of biosecurity efforts between jurisdictions.	2015	TBD	TBD	High
	Support development of a region-wide communication plan for biosecurity and IAS. Examine the potential of using existing models for the plan development including that which was produced for Oahu recently. The Oahu plan was ultimately not utilized but it potentially could serve as a model for networking regionally.	2016	TBD	TBD	High
	All jurisdiction should develop well thought out plans for response to incursions of IAS. In areas where DoD has facilities or otherwise operates, DoD should work with local authorities to insure that DoD actions and activities are adequately covered response planning.	2016	TBD	TBD	High
	Support establishment of a centralized regional group with representatives from each country within the Micronesia Region to develop sustainable funding streams for efforts to manage interrelated risks that cross political boundaries. There should be sufficient funds to conduct routine surveillance, implement response plans, and provide outreach and education, in addition to port of entry exclusion activities and training for inspectors.	2016	TBD	TBD	High
Support improvement to biosecurity elements of partnering militaries	Risks of IAS carried by foreign military vessels and aircraft entering the region needs to be addressed. Partnering countries includes (but may not be limited to) Singapore, Philippines, Japan, and Australia. These and other countries military vessels and aircraft may enter the region to take part in training and joint exercises with the DoD. Differences in specific country practices and protocols may include actions that would not meet US biosecurity standards. Support establishing SOPs which require partner countries to comply with local/regional standards when operating within any part of the region may be appropriate. Mechanisms for driving this would likely need to be between specific jurisdictions or countries and the DoD partners which would like to train in specific jurisdictions. Monitor visiting countries and their military forces ability to abide by the JRM/NRH Biosecurity Instruction.	2015	PACOM/JRM/civilian authorities	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Prevention</i>					
Improve border security	Construction and other commercial equipment must be inspected, cleaned, and washed down at the port of entry. Tracked vehicles can be cleaned on shore only if they can be reloaded without recontamination of the treads; otherwise they should be cleaned on the ship's well-deck. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to shipment from the port of departure. Vehicles may be cleaned at the port of entry provided wastewater soil is collected and drained fully into an approved collection system.	2016	TBD	TBD	High
	Construction materials are currently inspected as part of the build-up efforts to improve biosecurity. Inspection of construction materials should be instituted as standard policy for all activities throughout the region (not only the build-up).	2016	TBD	TBD	High
	Military aircraft and other military vehicles arriving as maritime cargo should be inspected, cleaned, and washed down at a retrograde wash facility before entry. Wash down procedures for military vehicles should target soil, plants, insects, and other wildlife. Tracked vehicles can be cleaned on shore only if they can be reloaded without recontamination of the treads; otherwise they should be cleaned on the ship's well-deck. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to shipment from the port of departure. Vehicles may be cleaned at the port of entry provided wastewater soil is collected and drained fully into an approved collection system.	2016	DoD	TBD	High
	Support the development of sanitation standards, targeting methods and diagnostic and identification tools for non-visible pests.	on-going	TBD	TBD	Low
	Ensure that appropriate biosecurity policies and procedures such as HACCP are in place and enforced.	2015	TBD	TBD	High
	Establish appropriate decontamination sites for cleaning both military and civilian equipment associated with military activities	2015	TBD	TBD	High
	Inspect and clean all incoming containers, conveyances and construction materials that arrive through DoD controlled ports of entry with soil and/or exotic plant pests including materials previously treated or cleaned if recontaminated after treatment.	On-going	TBD	TBD	High
	Create a multi service invasive species database to track the impelmentation efficacy of HACCP for military exercises and construction in Hawaii and Micronesia. Information tracked by unique project in such a database shall include: detailed inspection processes, intercept records, preservation and compiling of voucher specimens, detailed records on where shipments, etc. are arriving from and specifically what is known to have harbored IAS and where it come from and how it arrived.	On-going, for relocation projects	TBD	TBD	High
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	JRM	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of wood packaging material (WPM) (continued)	Require treatment of all WPM according to ISPM No. 15 under DoD MOU with APHIS-PPQ. All domestic and foreign WPM should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	APHIS-PPQ	TBD	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in a database to be available for analysis that may contribute to safeguarding improvements and quality control.	on-going	APHIS-PPQ	TBD	Medium
	Do not permit the unloading of noncompliant WPM.	on-going	APHIS-PPQ	TBD	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	on-going	APHIS-PPQ	TBD	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	on-going	APHIS-PPQ	TBD	High
Improve biosecurity elements in regards to garbage	Ensure that appropriate garbage disposal mechanisms are in place before any DoD activities within the region.	2015	TBD	TBD	Medium
Improve pre-departure biosecurity	All departing vehicles, equipment and materials should be properly inspected, cleaned, and washed at laydown area prior to departure. Subject to wash down and canine inspection requirements, vehicles should be loaded on to transport vessels for immediate transport.	2015	TBD	TBD	High
	On Guam, if staging of vehicles is required, cleared vehicles should be placed in a BTS barrier to prevent ingress of BTS after inspection and clearance, or canine inspections performed again prior to loading for transport.	2015	TBD	TBD	High
	Capacity training on sea container hygiene and the development of SOPs regarding container hygiene would support better compliance with acceptable standards such as where to place containers and preventing pests from entering or being stuck to the outside of containers prior to shipping.	2015	TBD	TBD	Medium
	Support the establishment of a biosecurity pre-clearance program in Okinawa, Japan for materials associated with the relocation departing Okinawa for Guam, Hawaii, and the CNMI	2015	TBD	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve pre-departure biosecurity (continued)	Develop and implement specifications for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Contamination can occur during the packing, handling, and staging processes prior to export. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Develop and implement specifications for palletized cargo, including procedures for staging, labeling, packing, loading and transport. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places. Identify the appropriate agency tasked with the regulatory actions to be performed as well as the enforcement of any violations contrary to the law. In addition, staging areas need to be developed for safeguarding high and low risk cargo. Need to identify and include in the development process the appropriate office(s) that would be responsible for the planning, development, construction and maintenance of such facilities.	2015	TBD	TBD	Medium
Improve biosecurity elements on AAFB	Increase the foreign inspection area for passenger clearance in the main terminal at Andersen AFB to a sufficient size for physical inspections of passenger baggage. Ensure that it is compliant with Home Land Security and Guam CBP.	2015	DoD	DoD	Medium
	Provide space, lighting, and equipment (e.g., x-ray equipment, tables, and materials for collecting samples) sufficient to enable GCQA to complete all aspects of inspection. Amnesty bins are also need if not already in place.	2014	DoD	DoD	High
Improve specifics in regards to biosecurity and the proposed build-up in the Mariana islands	Extend outreach programs, such as the RARE project, to contract workforce involved in DoD construction to ensure private firms working on DoD projects are aware of the federal and territorial laws which are in place on Guam. Bi-lingual delivery of information is advised to ensure all labor personnel is aware of their on and off duty impacts as it pertains to invasive species.	2015	TBD	TBD	High
Improve pre-arrival biosecurity	Biosecurity emphasis should be directed towards audited off-shore hygiene systems such as those utilized very successfully in Australia and New Zealand. As an example, all large equipment such as construction and military items intended for importation should be cleaned and inspected for IAS prior to loading. Treat (clean) if necessary immediately prior to shipping.	2016 Support development	TBD	TBD	High
Improve ballast water standards and compliance	Conduct an initial comprehensive analysis of current ballast water discharge and management patterns by U.S. military vessels, including those operated under MSC and all branches of the DoD, for Micronesia and Hawaii.	2015	TBD	TBD	Medium
	Assess the extent of ballast water treatment (both in terms of percentage of vessel arrivals and discharge volumes) prior to discharge by U.S. Navy and other military vessels	2016	TBD	TBD	Medium
	Evaluate the locations and volumes of seawater operations (including both uptake and discharge) for compensating fuel tanks discharged	2016	TBD	TBD	Medium
	Establish a program that implements targeted outreach and administrative tools to increase compliance with ballast water treatment requirements for military and non-military vessels associated with the DoD.	2016	TBD	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve hull fouling standards and compliance	Evaluate the extent (including especially total abundance and species composition) of biofouling on all types of DoD and U.S. Navy vessels operating in the region, including amphibious vessels and vessels operated under MSC.	2016	TBD	TBD	Medium
	Implement (a) inspection of vessels operated under DoD with high biofouling potential, due to extended periods of lay ups or port residence times, and (b) cleaning for those that are heavily fouled prior to their movement into, out of, or within the region	2016	TBD	TBD	High
	Once developed, hull fouling regulations should be applied to all vessels operating under the various branches of the military, both military owned and civilian owned under contract.	2017	TBD	TBD	Medium
	Assess the extent to which vessels operating in the region under DoD achieve acceptable levels of biofouling, once regulations have been instituted.	2018	TBD	TBD	Medium
	Track and evaluate changes in vessel traffic patterns and operations (including vessel types, geographic regions visited, port residence times, and speed) for all types of DoD and U.S. Navy vessels operating in the region, including amphibious vessels and vessels operated under MSC.	2017	TBD	TBD	Medium
	Support USCG establishing specific biosecurity criteria (requirements) for acceptable levels of hull biofouling for all types of DoD and U.S. Navy vessels, including amphibious vessels and vessels operated under MSC.	2017	DoD, USCG	TBD	High
	Support USCG extending DoD biosecurity requirements for acceptable levels of hull biofouling to include vessels under contract to any branch of the U.S. military, such as barges, dredges, and other vessels.	2017	DoD, USCG	TBD	Medium
	Support USCG extending hull fouling requirements to all military vessels operating in Micronesia and Hawaii, including those operating under MSC and other branches of the military.	2017	DoD, USCG	TBD	Medium
	Ensure JRM/NRH Biosecurity Instruction includes guidance as it applies to hull fouling, ballast exchange, and the risks associated with the intentional and/or unintentional movement of marines IAPS.	2018	TBD	TBD	Medium
Management and eradication					
Improve facilities IAS management	Enhance training for military personnel and their dependents about phytosanitary and general sanitary regulations and the risks of sending or receiving agricultural and wildlife materials in the mail.	2016	TBD	TBD	Medium
	Develop and maintain current IAS management plans for each DoD facility within the region. A publication that reviews 12 case studies of invasive species on military bases and lays out some basic recommendations for the military was prepared for the DoD by the National Wildlife Federation (Westbrook et al. 2005). Among the recommendations is the inclusion of an invasive species management plan in a base's Integrated Natural Resource Management Plan. Recommend that DoD implements the recommendations established in Westbrook et al. (2005).	2016	JRM	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve facilities IAS management (continued)	Create GIS layers that delineate the current distribution of established IAS and utilize to improve management.	on-going	TBD	TBD	Low
	Utilize the Guam Landscaping Guidelines (June 2011). Revise facilities' landscape plans so that these dovetail with facilities' IAS management plans (this should be done throughout the region). New plantings should be locally sources, non-invasive, and preferably native species, with a minimum of 50% native species be planted for an individual project. Existing plant species, which are either known to be invasive or at least thought to have invasive potential, should be removed or managed.	on-going	TBD	TBD	Medium
	Develop best management practices for contractors and construction sites, working with the construction industry to gain support with preventing the introduction and spread of non-native plant pests. Implement "clean" practices at construction sites, including the minimization of land disturbance that may contribute to the spread of plant pests. This is part of the HACCP process already implemented on Guam. These practices should be considered for region wide implementation.	2015	TBD	TBD	High
	Ensure JRM/NVH Biosecurity Instruction addresses proper cleaning of equipment and materials prior to moving between sites within a jurisdiction (example: movement of vehicles between training sites and storage facilities within the state of Hawaii).	2014	TBD	TBD	High
	Increase efforts to eradicate targeted IAS. Improving this ability should be a long term commitment. Species targeted for eradication should be identified in each facilities IAS management plan.	2015	TBD	TBD	High
	Eradication is a biosecurity tool (removing incursion fate for a network of pathways users) and DoD should support the planning and execution of invasive species eradications on those installations where complete removal of a species is feasible or has been shown to be feasible elsewhere with similar target species.	2015	TBD	TBD	High
	Develop cleaning facilities (wash racks, etc.) at all DoD installations where warranted and provide appropriate training for military personnel to utilize these facilities.	2016	TBD	TBD	High
Awareness					
Improve awareness of biosecurity and invasive species	Develop appropriate, comprehensive education and awareness programs within DoD for biosecurity including IAS prevention. This should cover military personnel and their families as well as contracted workers and their dependents. Such programs shall be extended into DoD schools.	on-going	JRM	O&M Appropriations	High
	Support coordination of existing outreach efforts in jurisdictions where DoD has facilities. Coordination should occur between each jurisdiction and DoD.	2015; on-going on Guam	TBD	TBD	High
	Support development of posters, brochures and other print media to support invasive species awareness campaigns.	On-going	TBD	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve awareness of biosecurity and invasive species (continued)	Implement a targeted outreach program for DoD installations in Micronesia and Hawaii. Ensure program addresses active duty and civilian workforce, and includes specific guidelines on the methods known to minimize species transfers associated with small boats, jet skis, other water sports gear, and diving gear. In addition to providing guidance on marine related actions, ensure the program also addresses guidelines to follow as it applies to terrestrial items of interest, such as the movement of household goods, cars, and other pack out items.	2015	JRM	O&M Appropriations	Medium
	Utilize local media sources such as newspapers and TV and radio programs to enhance invasive species awareness efforts	On-going	TBD	TBD	Medium
	Create two forms of video guidance and education. Video 1: Guidance on the implementation of the JRM and Navy Region Hawaii instruction (in regards to biosecurity and invasive species) for DoD civilians, active duty, and contractors. Video 2: Video providing guidance for families and off base recreation focusing and on what to be aware of, and how to protect the environment from invasives when not on duty. Video 2, could be shown on public stations as well, given its applicability to a wider audience.	On-going	TBD	TBD	Low
	Support regional coordination of invasive species awareness efforts to improve overall regional biosecurity	2015	TBD	TBD	Low
	Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials, including the potential loss of business if invasive species are permitted to establish. Institute Contractor education program on installations in Hawaii and Micronesia. All DoN contracts shall, include invasive species contractor education as a task for the contractor to complete in each scope.	2015	TBD	TBD	High

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment N: United States Regional Biosecurity Recommendations*

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<i>Support</i>					
Improve funding and funding support for biosecurity within the region	Increase availability of funding specific for biosecurity activities including pre-border, border, and post-border elements.	2015	TBD	USFWS/USDA/NOAA	High
<i>Coordination and collaboration</i>					
Ensure that the RBP remains relevant by updating recommendation components on a regular basis (add new recommendations and remove completed elements)	Update the US section of the RBP implementation strategy every 3 years and share updates regionally.	continuous, every 3rd year minimally	NISC	TBD	High
Improve regional communication on invasive species and biosecurity issues and support of jurisdictional and regional efforts	Support development of a regional communication plan for invasive species issues. This plan should be based on existing and proposed IAS infrastructure such as the RISC, jurisdictional ISC, and the regional ISC office.	2015	USFWS	TBD	Medium
	Support development of a regional net of thematic experts to support efforts with invasive species. This net should include (but not be limited to) experts in human health, food security, border security, education, planning, IAS management and control, IAS eradication, IAS detection and response, and resource development (funding, etc.).	2016	USFWS	TBD	Low
	Report (to the region) on a yearly basis progress on RBP recommendations via MCES, including a written report shared with the region and beyond.	continuous, yearly	NISC	TBD	High
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region.	Assist with and support regional efforts to develop, fund, and staff a regional invasive species coordination office.	ideally this office would be up and running before the end of 2015	NISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office as the focal point for regional communication and dissemination of invasive species information.	As soon as the office can be established	NISC and USDA	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office to support efforts with engaging external resources to support invasive species efforts.</p>	<p>As soon as the office can be established</p>	<p>NISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support capacity building, training, and advice.</p>	<p>As soon as the office can be established</p>	<p>NISC and USDA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting protocol and methods development.</p>	<p>As soon as the office can be established</p>	<p>NISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting establishing ER &RR capacity.</p>	<p>As soon as the office can be established</p>	<p>NISC and USDA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
<p>Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).</p>	<p>Engage the regional invasive species coordination office to improve information sharing with trade partners outside the region in regards to biosecurity and IAS with respect to notification about species that will or might be problematic and which could originate from within the region.</p>	<p>As soon as the office can be established</p>	<p>NISC and USDA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with supporting the development of guidelines and regulations.</p>	<p>As soon as the office can be established</p>	<p>NISC and USDA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office with both seeking for and coordinating regional funding.</p>	<p>As soon as the office can be established</p>	<p>NISC</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>
	<p>Engage the regional invasive species coordination office to support management, response, and eradication efforts.</p>	<p>As soon as the office can be established</p>	<p>NISC and USDA</p>	<p>initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners</p>	<p>High</p>

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment of a regional invasive species coordination office. The regional IAS coordination office would serve as a focal point, coordinating body, communication and information center, and training resource for biosecurity activities throughout the region (continued).	Engage the regional invasive species coordination office to serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information.	As soon as the office can be established	NISC and USDA	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
	Engage the regional invasive species coordination office to support outreach and education efforts.	As soon as the office can be established	NISC	initial support might come from the US and the region. Ultimately this office might be supported in part by grants from various donor partners	High
Improve local and federal coordination of biosecurity elements	Each jurisdiction should work with federal counterparts to clarify and establish biosecurity SOPs (this should include listing out clearly what offices/agencies are responsible for each biosecurity aspect whether federal or local) and information exchange programs which are functional and followed up on a regular basis.	2015	USDA-APHIS	TBD	High
	Federal law enforcement supporting local regulations (in regards to quarantine and biosecurity) might be a workable solution for the CNMI, Guam, and Hawaii. This should be supported by MOUs between the jurisdictions and federal counterparts.	2015	USFWS-LE	TBD	High
	Local agencies should develop a standard updating mechanisms for PPQ to improve PPQs ability to assist within each jurisdiction including navigation of regulations.	2015	PPQ	Jurisdictional biosecurity cost recovery systems	Medium
	Utilize the APHIS-PPQ port manuals and training as guidance in locations with APHIS cooperators as appropriate to support jurisdictional biosecurity. The manuals contain information on port operations and commodity regulatory decision making designed to enhance biosecurity at the ports of entry.	2015	PPQ	Jurisdictional biosecurity cost recovery systems	Medium
	Improve ability to conduct broad based risk assessments that address more than agricultural concerns.	on-going	USDA-APHIS	TBD	Medium
	Implementation of an electronic manifest system could be used to assign risk levels for containerized cargo based upon the declared commodity, origin of shipment, and name and address of shipper and importer.	2016	USDA-APHIS	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve local and federal coordination of biosecurity elements (continued)	The manifest system should be used to target random inspections that will provide assessment and control of containerized cargo via water transport.	2016	USDA-APHIS	TBD	Medium
	Manifest system should be sharable amongst federal and local biosecurity offices.	2016	USDA-APHIS	TBD	High
	Agencies responsible for enforcing USDA-APHIS regulations should have access to the APHIS permits system for assistance in clearance of restricted agricultural materials. APHIS import permits may be required, in conjunction with local import permits, for various agricultural commodities imported into Guam and CNMI. All officers acting under an MOU with APHIS inspecting for agricultural commodities need access to the permits system to validate APHIS import permits presented with incoming shipments.	2016	USDA-APHIS	TBD	High
	Local authorities should be able to develop their own pest watch lists and be able to react appropriately and federal agencies should be permitted to support these efforts including having federal inspectors inspect for pest of local concern during international inspection processes. Jurisdictions should not be tied to federal APHIS agricultural lists of known federal pests.	2015	USDA-APHIS	TBD	Medium
Support regional biosecurity and invasive species control efforts	Support the regional updating of the RBP every 3 to 5 years.	3-5 years	NISC	Regional ISC office	Medium
	Support the establishment of a regional DNA barcoding library so that DNA analysis can become a more useful tool in identifying non-native organisms.	on-going with possible establishment by 2018	USGS, NOAA, USDA and USFWS	TBD	Low
	Support the development of molecular assisted alpha taxonomy surveys with standardized protocols which can and are used throughout the region (this would be most useful with cryptic marine species).	on-going process	USDA, NOAA	TBD	Low
	Support the development of an algal risk assessment for the region.	2016	NOAA	TBD	Medium
	Support the development of an arthropod risk assessment for the region.	2016	USDA-PPQ	TBD	Medium
	Support national and regional biosecurity development by documenting and sharing success stories with pest species (significant interceptions, eradications, successful management strategies, impacts prevented or reduced, etc.).	2015 and on-going	NISC	Regional ISC office	Low
	Support national and regional biosecurity development by documenting and sharing information regarding actual IAS prevention costs and comparing these costs with the costs of IAS control and management.	2015 and on-going	NISC	Regional ISC office	Low
	Support the development of a weeds risk assessment for the region.	2016	USDA	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support regional agreements to limit the movement of known harmful species	There are no international conventions prohibiting or regulating trade that focus explicitly on non-native species and the region should consider developing such regulations for the region which would be supported by all jurisdictions and prohibit the movement of specific organisms between jurisdictions and possible between islands within jurisdictions. If the region could develop such agreements it might be a step towards developing broader Pacific agreements and even global recognized conventions.	Consultation regarding regional agreement 2015; Development of regional agreement 2017	NISC	TBD	Medium
Prevention					
Improve pre-border biosecurity	APHIS should increase its work with various jurisdictions (when feasible) to certify pre-clearance facilities (internationally).	2016	USDA-APHIS	Ultimately cost for such programs should be bore by the imports/shippers as part of cost recovery programs	High
	Local authorities should work with APHIS and international trade partners to develop pre-border programs.	2016	USDA-APHIS	Ultimately cost for such programs should be bore by the imports/shippers as part of cost recovery programs	High
	In regards to large shipments of potentially high risk materials (such as construction materials related to the build-up) PPQ officers can be on the ground at international locations to ensure that items are clean prior to shipping.	2016	USDA-APHIS	Ultimately cost for such programs should be bore by the imports/shippers as part of cost recovery programs	Medium
	Extension agents (from land grant Universities) could work with international trade partner countries to improve pre-clearance sanitation. USDA should work with jurisdictions to facilitate this type of support from land grant institutions.	2016	USDA	Ultimately cost for such programs should be bore by the imports/shippers as part of cost recovery programs	Medium
Improve border biosecurity	Increase training.	2016	USDA-APHIS	TBD	High
	Increase resource availability.	2016	USDA-APHIS	TBD	High
	Increase oversight.	2016	USDA-APHIS	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve regulation and compliance of wood packaging material (WPM)	Support a regional effort to switch from WPM to recycled plastics. The technology exists, and new standards/compliance could be phased in with a multi-year approach to reach 100% replacement of WPM with recycled plastics.	on-going	USDA-APHIS	TBD	Low
	Require treatment of all WPM according to ISPM No. 15. All domestic and foreign WPM entering the region should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.	2015	USDA-APHIS	Biosecurity cost recovery systems	Medium
	Conduct sanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.	2015	USDA-APHIS	Biosecurity cost recovery systems	Medium
	Do not permit the unloading of noncompliant WPM.	2015	USDA-APHIS	Biosecurity cost recovery systems	Medium
	Treat or destroy any noncompliant WPM that is offloaded.	2015	USDA-APHIS	Biosecurity cost recovery systems	Medium
	Treat or destroy infested WPM. Infested WPM should be treated as regulated garbage and incinerated or sterilized.	2014	USDA-APHIS	Biosecurity cost recovery systems	High
Support improving biosecurity for DoD activities	Establish MOU between APHIS and DoD Pacific Command (similar MOUs already exist between APHIS and US Military in other regions of the world) to facilitate the role APHIS (and possibly APHIS's partners) can provide in supporting biosecurity for DoD related activities.	2015	USDA-APHIS	DoD	High
Improve capacity building and maintenance within biosecurity agencies	Develop jurisdiction wide (inclusive of all relevant agencies and offices both federal and local) capacity building and maintenance plans.	2016	USDA-APHIS	TBD	Medium
	There needs to be appropriate refresher training on general biosecurity procedures for front line offices of each jurisdiction so that important biosecurity issues can be reinforced.	2016	USDA-APHIS	TBD	High
	There needs to be advanced update training to support building capacity of biosecurity officers.	2016	USDA-APHIS	TBD	High
Improve biosecurity in regards to mail and private couriers	Develop secure procedures for opening international mail when warranted without customer witnesses and which are acceptable under US law.	2017	USDA-APHIS	TBD	Low
	Use canine teams to inspect mail and private courier items on arrival at each jurisdiction as feasible.	2018	USDA-APHIS	TBD	Low

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Improve biosecurity in regards to mail and private couriers (continued)	Record and analyze data on pest interceptions in mail. Analysis should improve targeting of phytosanitary and general sanitary hazards. Make information available on a regular basis to other offices that are involved in biosecurity.	2015	USDA-APHIS	TBD	High
	Mail and courier items should be inspected at arrival ports whenever feasible (rather than transported to a secondary location before inspection).	2016	USDA-APHIS	TBD	Medium
	Permit immediate detailed inspection of mail and private courier items if a canine team indicates on a specific item. This ability would assume that an indication would be sufficient probably cause to move forward with more detailed inspection.	2018	USDA-APHIS	TBD	Medium
Address climate change linkages to invasive pests		2018	TBD	TBD	Medium
Support improvements in regards to regulated garbage	Support development of jurisdictional SOPs on the handling and treatment of regulated garbage.	2016	USDA	TBD	High
	Support enforcement of regulations which apply to regulated garbage.	2016	USDA	TBD	High
	Unannounced monitoring of APHIS-regulated garbage compliance agreement holders should be conducted at least quarterly. Appropriate agency representatives must be trained to conduct enforcement visits to compliance agreement holders to monitor whether they follow required procedures.	2016	USDA	TBD	High
	Train appropriate agency representatives to conduct enforcement visits to APHIS Compliance Agreement holders handling regulated garbage. The number of personnel trained to monitor compliance agreement holders for functional equipment and appropriate procedures in handling regulated garbage is insufficient.	2016	USDA	TBD	High
	Enforce current swine health protection regulations requiring cooking of certain types of food waste (heating to an internal temperature of 212°F for 30 minutes) before feeding to pigs. The proper cooking of food waste will prevent the dissemination of foreign animal diseases of concern (9 CFR § 166).	2016	USDA	TBD	High
Support efforts to increase marine and aquatic biosecurity efforts in the region	Raise awareness of potential threats from marine and aquatic IAS.	2015 and on-going	TBD	TBD	Medium
	Support capacity building to establish marine and aquatic IAS programs in the region.	2015 and on-going	TBD	TBD	Medium
	Establish and support monitoring efforts for marine and aquatic IAS.	2015 and on-going	TBD	TBD	Medium
	Increase collaboration between local and federal agencies working on these issues.	2015 and on-going	TBD	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support efforts to increase marine and aquatic biosecurity efforts in the region (continued)	Seek funding support for marine and aquatic IAS prevention and response.	2015 and on-going	TBD	TBD	Medium
	Work with managers and advisory councils of the Pacific Marine National Monuments (including the Mariana Trench Marine National Monument) to collaboratively address marine biosecurity threats.	2015	NOAA / USFWS	TBD	Medium
Support the establishment and enforcement of biofouling standards	Address concern regarding the listing of marine species under the federal endangered species act. 66 species of coral have been proposed for listing under the US ESA. The listing of these species, may actually impede biosecurity efforts i.e. A fouled hull could potentially be protected under the ESA on entering US waters if these species were assumed to be present on the hull in question.	2016	USFWS/NOAA	TBD	High
	Support establishment of criteria for in-water cleaning methods for hull fouling that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2016	USCG/NOAA	TBD	High
	Support establishment of standards and regulations regarding biofouling, including inspection and certification for all vessels.	2016	USCG/NOAA	TBD	High
	Support establishment of additional regulations for vessels with long port residency periods. Long lay ups increase biofouling potential.	2016	USCG/NOAA	TBD	High
	Support the establishment of additional regulations for impounded vessels.	2016	USCG/NOAA	TBD	High
	Support development of capacity (personnel, training, and data management infrastructure) to conduct hull inspections (including diving as necessary). Consider establishing agreements with private industry to support hull inspection processes. For example, if a visual inspection determines that further hull examination is required, then the ship owner may need to hire local dive operators (that are government certified) to inspect the entire hull.	2016	USCG/NOAA	TBD	High
	Support establishment of regulations and facilities for hull cleaning including hull out facilities, associated waste disposal, and setting shoreline proximity limits for in-water cleaning.	2016	USCG/NOAA	TBD	High
	Support establishment of biosecurity practices and requirements for recreational vessels that operate within jurisdictional waters to reduce the transfer of biofouling organisms.	2016	USCG/NOAA	TBD	High
	Support establishment of the capacity to inspect and treat recreational vessels that operate within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	USCG/NOAA	TBD	High
	Support review and revision (as needed) of legal authority to implement a biofouling management programs throughout the region.	2016	USCG/NOAA	TBD	High

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support the establishment and enforcement of biofouling standards (continued)	Support the establishment of biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within jurisdictional waters.	2016	USCG/NOAA	TBD	High
	Support establishment of the capacity (personnel, training, and data management infrastructure) to inspect and treat (if necessary) in-water structures that are being moved into or within jurisdictional waters to reduce associated biofouling to an acceptable level.	2016	USCG/NOAA	TBD	High
	Support the development of regulations to address the need to levy and collect fines and/or require vessels to depart jurisdictional waters for repeat offenders and for non-compliance with treatment requirements.	2016	USCG/NOAA	TBD	High
	Review and establish criteria for in-water cleaning methods that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.	2016	USCG	TBD	Medium
	Address hull fouling concern with development of standards, regulations, and enforcement.	2016	USCG	TBD	High
	Support targeted outreach to inform the shipping industry, fishing industry, ports, and resource management agencies of biofouling management requirements for ships operating within jurisdictional waters.	2016	USCG/NOAA	TBD	High
Support improved ballast water standards and enforcement	Support targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements for ships operating within jurisdictional waters.	2016	USCG/NOAA	TBD	High
	Support establishment of ballast water management and reporting requirements for all vessels utilizing ballast water.	2016	USCG/NOAA	TBD	High
	Support development of the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance.	2016	USCG/NOAA	TBD	High
	Support review and revision (as needed) of legal authorities to implement ballast water management programs throughout the region.	2016	USCG/NOAA	TBD	High
	Support development of regulations to address programmatic needs, including the ability to levy and collect fines for non-compliance.	2016	USCG/NOAA	TBD	High
	Implement a system for U.S. Navy ships to report ballast water discharge per port arrival, modeled after that used by USCG, such that the data are compiled electronically at a centralized database.	2016	USCG	TBD	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Support improved ballast water standards and enforcement (continued)	propose a rule in the federal register to mandate compliance for all vessels with the 200nm ballast water exchange that is in place for civilian shipping. Attention should also be given to sea mounds and other near surface structures that may require further adjustment to the standardized 200nm limitation.	2016	UUSCG	TBD	High
	Support adoption of proposed USCG regulations to move to in hull ballast water treatment.	2016	USCG/NOAA	TBD	High
	Once developed, ballast water treatment regulations should be applied to all vessels operating under the various branches of the military, both military owned and civilian owned under contract.	2018	USCG	TBD	Medium
	Extend a ballast water reporting requirement and reporting system to all military vessels operating in Micronesia and Hawaii, including those operating under MSC and other branches of the military.	2015	USCG	TBD	Medium
	Develop standards for compensating fuel tank discharges which are equivalent to the ballast water requirements.	2016	TBD	TBD	Medium
Early detection and rapid response					
Support improved rapid response capabilities for both military and civilian lands for each jurisdiction. Improved rapid response measures could prevent the establishment of IAS. Rapid response takes place at and within the border at levels ranging from federal to local community involvement.	Review existing rapid response capacity for each jurisdiction.	2015	TBD	TBD	Medium
	Improve capacity as needed (which likely will involve better communications, increased training, improved resources, and ensuring that dedicated funding is available for field actions.	2016	TBD	TBD	Medium
Management and eradication					
Better support management and control of the Brown Treesnake (BTS) , one of the top invasive alien species (IAS) already established in the region (Guam) which threatens all other jurisdictions. The US has developed an extensive management and control program for the BTS which depends on interagency cooperation and which relies on the expired BTS control and eradication act as one of its underlying directives.	The BTS Control and Eradication Act (2004-2009) should be reauthorized to provide specific instructions and allow for additional efforts to prevent the spread of BTS from Guam. This 5-year BTS Control and Eradication Act expired in 2009. Renewal of this important regulatory driver has not yet been accomplished. Regulations pertaining to prevention, mitigation, and management of BTS that are contained in the Act are pertinent for protecting areas exposed to BTS from trade, travel, and tourism. Further, the act directs USDA and US DOI to establish rules structured to improve and expand BTS interdiction efforts. Once reauthorized, other federal agencies including the Departments of Defense, Homeland Security, and Transportation could better assist in preventing the further spread of BTS.	2015	USFWS	BTS Working Group	High
	Consideration should be given to the USDA pre-departure BTS inspections for Guam and if they are to be mandated as required and whether a fee could be associated with these inspections to cover their costs.	2015	USDA	BTS Working Group	Medium

Recommendation	Action Item	Time Line	Lead	Potential Funding/Resources	Priority
Better support management and control of the Brown Treesnake (BTS) , one of the top invasive alien species (IAS) already established in the region (Guam) which threatens all other jurisdictions. The US has developed an extensive management and control program for the BTS which depends on interagency cooperation and which relies on the expired BTS control and eradication act as one of its underlying directives (continued).	Currently USDA conducts voluntary pre-departure inspections on Guam in an attempt to intercept BTS before they are accidentally transported from the island. This effort appears to be highly successful but is based on a voluntary inspection process. Consideration should be given to whether this effort should be mandated so as to better insure 100% coverage of pre-departure inspections for BTS for the island of Guam. DoD has military instructions that mandate BTS pre-departure inspections.	2015	USDA	BTS Working Group	Medium
	Consideration should be given to the USDA pre-departure BTS inspections on Guam in regards to whether items inspected could be effectively tagged/sealed after inspection to facilitate identification of what items have passed this inspection by front line inspectors at ports of arrival else where.	2015	USDA	BTS inspection cost recovery system	Medium
	Improve awareness of BTS and BTS related issues throughout the region at all levels. Specific focus should be directed to understanding both the historic context and the current situation on Guam and how the current situation on Guam has the potential to impact other locations if interdiction efforts are not maintained.	on-going	BTS Working Group	TBD	Medium
	Improve communications and partnering with Micronesian agencies or organizations not part of the BTS Working Group to increase BTS awareness, control and management efforts.	2015	BTS Working Group	TBD	Medium
Awareness					
Develop jurisdiction specific IAS education and awareness programs that are adequately funded and otherwise supported. These programs should reach all elements of society. This should be a long term and sustained efforts. Efforts should be coordinated amongst jurisdictions in order to achieve the best possible outcomes. Regional sharing of resources and ideas and using successful programs as frameworks to establish similar programs in other locations will facilitate the growth of awareness programs throughout the region.	Conducted surveys of current awareness levels.	2015	USFWS	TBD	High
	Utilize survey results to enhance and expand existing IAS awareness programs.	2016	USFWS	TBD	High
	Integrate IAS education into school curriculums and provide teach training.	2016	USFWS	TBD	Medium
	Develop school and community volunteer programs to support appropriate IAS management actions.	2016	USFWS	TBD	Medium

*These recommendations do not create any right, obligation or legal responsibility on the part of any of the jurisdictions to fund or execute the RBP.

Attachment O: Models

RARE: Awareness via Campaigns

Overview

A. Need

With ever increasing globalization and its associated increases in vectors and pathways as trade and visitation increase throughout the region, the need for improved biosecurity systems to protect islands, environments, communities, and economies, from invasive species increases. Biosecurity efforts within each jurisdiction can only be appropriately addressed with the support of local residents and communities. To support invasive species suppression efforts, residents need to recognize the benefits of biosecurity. To garner the public support necessary to implement jurisdictional biosecurity throughout the region, educational campaigns geared towards raising local awareness regarding the benefits of biosecurity systems, changing attitudes towards biosecurity actions and promoting behaviors that reduce the potential of transporting non-native species are necessary. The following outlines the objectives and methods for creating and implementing a Jurisdictional Invasive Species Public Awareness Campaign over a three-year period based on Rare Pride Methodology (www.rare.org/rare-pride-methodology).

B. Purpose

The purpose of the Jurisdictional Invasive Species Public Awareness Campaigns is to garner the support of local residents and communities in each jurisdiction for biosecurity as expressed in the strategic recommendations of the Micronesia Biosecurity Plan.

C. Objectives

1. Collect baseline public opinion data during FY15 and FY16 to support campaign development, implementation and evaluation.
 - Develop questions for pre-campaign survey.
 - Contract marketing firm or utilize volunteers to implement pre-campaign survey and analyze results.
 - Identify action items and prepare campaign project plan.
2. Direct a focused, public awareness campaign during the latter half of FY15 and FY16 that addresses core issues identified by the systematic baseline surveys.
 - Implement campaign.
 - Develop and design appropriate media. Contract vendors when necessary.
 - Conduct presentations and public events to identified target audiences.
 - Distribute collateral materials to identified target audiences.
3. Collect post-campaign public opinion data during FY17 and FY18 to support campaign development, implementation and evaluation.

- Contract marketing firm or utilize volunteers to implement post-campaign survey and analyze results.
- Identify action items for follow-up campaign project plan.

D. Approach

For a regional campaign to be successful, objectives, target audiences, messages, methods, threats and barrier removal strategies must be localized to the specific jurisdiction. Hence, a regional manager could coordinate various jurisdictional campaigns with similar objectives or goals but possibly influence different target audiences and utilize different messages and methods. For example, to improve biosecurity efforts, it has been suggested that a regional goal should be to incorporate IAS into school curriculums. This in fact may be an appropriate pathway for long term improvement in public awareness in regards to invasive species, but such a concept should be evaluated, including receipt of local public input in each jurisdiction before extensive planning and implementation occur. Implementation of this goal, if appropriate, will require following guidelines and restrictions specific to each of the implementing jurisdictions.

E. Expected results/benefits

The development and implementation of a focused Invasive Species Awareness Campaign within each jurisdiction will increase the public's support for regional invasive species suppression. The support of an informed public will allow biosecurity efforts throughout Micronesia to move forward as jurisdictional campaigns will complement one another. In the long term these efforts will help protect the natural resources within Micronesia for future generations. Increased public awareness and local pride in natural heritage will assist with guarding against accidental or intentional releases of unwanted species, supporting maintenance of quarantine procedures and preserving pest-free areas.

F. Timeline

Approximate Start date: TBD 2015

Weeks 1 – 9

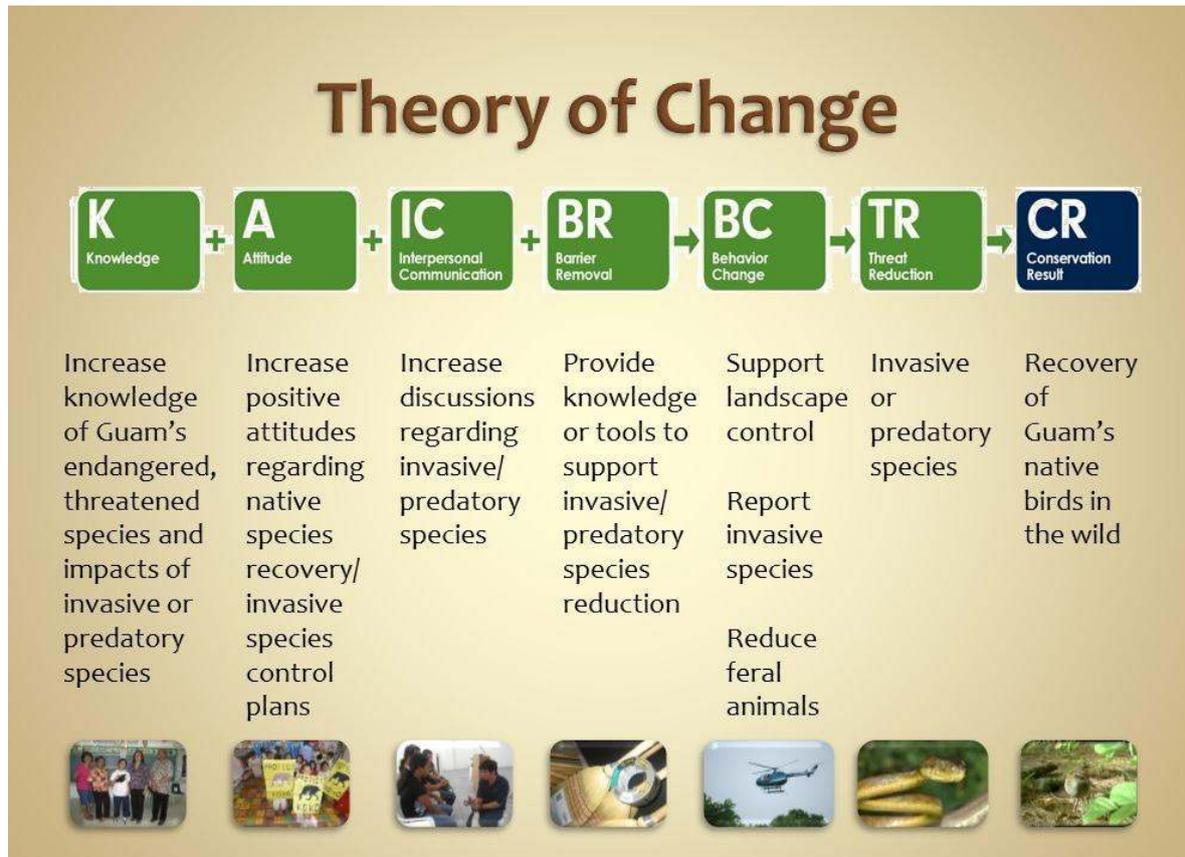
Build a comprehensive project plan, including ground truth concept models and threat ranking analysis, as well as identify potential solutions to barriers to invasive species suppression.

Weeks 10 – 35

Conduct pre-campaign survey, engage stakeholders, volunteers and technical experts, set objectives, build consensus, and finalize a draft campaign project plan for review and final approval.

Using the Go Native! Guam Social Marketing Campaigns as an example, the rationale or theory of change of a completed social marketing plan can be understood as follows:

“To protect and recover Guam’s native bird species, the threat of invasive or predatory species must be decreased by increasing the support of landscape control, reporting of invasive species and reduction of feral animals. This will be accomplished by providing knowledge or tools to support invasive species reduction in addition to increasing the knowledge, positive attitudes and interpersonal communication of biosecurity efforts within target audiences.”



(C. Calauastro, personal communication, April 7, 2014).

Weeks 36 – 40

Refine campaign plan and prepare for actual implementation, including marketing, media relations, design, advanced project management and measuring impact.

Weeks 41 – 148

Begin campaign implementation. With full technical support from agency partners, launch a multimedia public awareness campaign designed to change knowledge, attitudes and behaviors to increase support for broad-area invasive species prevention, control, and eradication.

For example, the Go Native! Guam Social Marketing Campaign utilizes a variety of mini and mass media as well as the Internet to engage target audiences:



(C. Calastro, personal communication, April 7, 2014).

Weeks 148 – 152

Conduct post-campaign survey.

Weeks 152 – 156

Prepare analysis of campaign results; build a long-term plan for sustaining impact.

Week 157 and beyond - Sustaining Impact

Seek support in the form of follow-up grants, regional networks, workshops, and peer mentoring. Work to sustain social and behavioral change in the long term with partners.

Approximate End date: TBD 2018

G. Examples Communication Vehicles (*Final marketing mix determined by pre-campaign survey*)

- Print newsletters/magazines/flyers
- Posters, banners, murals
- Web site; other web-based media: blogs, webinars, links to existing website, etc.
- News conferences
- Electronic newsletters
- Amnesty bins
- Video for airplanes
- Kiosks at airports
- Multi-media presentation to interested parties – Mayor’s Council, Village Chiefs
- Town/Village Meetings
- Lunch and learn events
- Face-to-face small meetings, workshops
- Field site events or trainings
- Special public events – concerts, free movies
- Digital advertising
- Radio spots
- General Swag: t-shirts, stickers, calendars etc.
- Use of a mascot

For more information regarding RARE visit: <http://www.rare.org/>

For more information on the Go Native! Guam Social Marketing Campaign visit:
<http://www.rareplanet.org/en/campaign/guam-terrestrial-campaign/details>

Awareness via Mass Media (recent videos):

Other specific examples of how jurisdictions and/or the region could improve IAS awareness are demonstrated in the following two scenarios. The first is a short film produced by CAB International in 2014 to create awareness of specific invasive plants in Africa. The video can be found at: <http://youtu.be/ggqseLRvlfY>. This is a clear example of the types of awareness elements that Micronesia and Hawaii should be developing. Clear, direct informational formats using mass media outlets, including the internet but also local TV, radio, and news print to build IAS awareness in the citizenry throughout the region. The second example is again a video, this one produced in Hawaii to build awareness of Little Fire Ant impacts. This video is an excellent example of awareness development to support biosecurity within the region. This video can be viewed at: <http://www.littlefireants.com/>.

New Zealand Biosecurity:

New Zealand is considered by many to have one of the best (if not the best) biosecurity system to date. The New Zealand system should be reviewed by the various jurisdictions covered in the RBP and potentially usable elements of this system should be further investigated as to the feasibility of incorporating the same or similar elements into the various biosecurity systems within the region covered by the RBP. Knowledge of functioning biosecurity models from other areas can be extremely useful and the review of biosecurity programs such as that utilized in New Zealand is encouraged, but ultimately, each jurisdiction will need to build the system that functions best for them, given their unique set of parameters. The New Zealand's biosecurity strategy can be found at: <http://www.biosecurity.govt.nz/files/biosec/sys/strategy/biosecurity-strategy.pdf>.

Perhaps a good place to start is with an understanding of what makes the New Zealand biosecurity system functional in New Zealand. And perhaps a clue to understanding the functionality of the New Zealand system is found in the opening pages of their strategy, where the importance of biosecurity to the country is clearly acknowledged. This statement, the importance of biosecurity to the country and its economy, is not just a conceptual notion. The fact is that this underlying foundational belief is born out in the support that the government and the citizenry of New Zealand provide for the protection of their country via their highly supported biosecurity system.

While buy-in from government and citizens is a big part of why the New Zealand biosecurity system functions successfully, there are other elements that contribute greatly to the overall functionality of this system. Among these other elements is a well thought-out and documented cost recovery component. Elements of the New Zealand biosecurity cost recovery component are available online and can be accessed at: <http://www.biosecurity.govt.nz/regs/fees-and-charges>. It is recommended that all jurisdictions review the clearly laid out funding strategy utilized by New Zealand to support biosecurity and consider how elements from this funding strategy can be incorporated into the biosecurity systems of Micronesia and Hawaii.

Attachment P: Biosecurity Officer Qualifications

Qualifications for biosecurity officers will vary depending on specific job duties and duty station. For example, biosecurity officers who work with detector animals, such as canines, will need additional training beyond general inspectors. But, there are minimal qualifications that all biosecurity inspectors should possess.

Minimal staff competency requirements:

1. Staff carrying out sampling should demonstrate ability to follow written procedures.
2. Inspection staff should be competent in the following areas:
 - a. Demonstrable ability to follow written procedures;
 - b. Demonstrable ability to detect pests or symptoms; and
 - c. Demonstrable ability to decide on the significance of the findings.

Along with the minimal qualifications, biosecurity inspectors should possess the following attributes: observant, tactful, reliable, and responsible. In addition, good communications skills and the ability to work with a wide variety of people from diverse cultures and backgrounds would seem highly beneficial.

While not strictly required for minimal qualification, professional experience and/or post-secondary training in an appropriate subject matter such as botany, ecology, agriculture, or marine science would be preferable.

Inspectors should have or should acquire with time in service both depth and breadth in the understanding of the basic concepts of biosecurity as well as detailed knowledge regarding specific elements of their position. Some of these skills which should be the focus of specific training for inspections follow (this list can obviously be expanded and should be for each jurisdiction):

- Taxonomic identification of specific high risk organisms
- Specimen collection and preservation
- Data collection and entry
- Professionalism
- Ability to interact appropriately and effectively with the public
- Ability to react appropriately and effectively to new situations as they arise
- A clear understanding of the critical nature of their position and how their specific duties fit into the larger biosecurity system framework

Attachment Q: Regional Biosecurity Plan Strategic Implementation Development Consultancy Visits*

26 – 30 November 2012, Majuro, Republic of the Marshall Islands (overlap with the Micronesia Chief Executives Summit and the Regional Invasive Species Council meeting)

21 – 28 May 2013, Republic of Palau

3 – 8 June 2013, Majuro, Republic of the Marshall Islands

17 – 22 June 2013, Kosrae, Federated States of Micronesia

22 – 29 June 2013, Pohnpei, Federated States of Micronesia

2 – 7 July 2013, Yap, Federated States of Micronesia

7 – 12 July 2013, Oahu, Hawaii

14 – 20 July 2013, Saipan, Tinian, and Rota, Northern Mariana Islands

24 – 27 July 2013, Chuuk, Federated States of Micronesia

2 – 6 September 2013, Majuro, Republic of the Marshall Islands (overlap with the Pacific Island Forum)

2 – 6 December 2013, Saipan, Northern Mariana Islands (overlap with the Micronesia Chief Executives Summit and Regional Invasive Species Council meeting)

9 – 15 December 2013, Oahu, Hawaii

15 – 17 January 2014, Washington D.C.

21 – 25 January 2014, Majuro, Republic of the Marshall Islands

25 – 28 January 2014, Kosrae, Federated States of Micronesia

28 – 30 January 2014, Pohnpei, Federated States of Micronesia

30 January – 1 February 2014, Chuuk, Federated States of Micronesia

4 – 9 February 2014, Republic of Palau

9 – 12 February 2014, Yap, Federated States of Micronesia

*Members of the Regional Biosecurity Plan development team reside within the Pacific Region many on the island of Guam and therefore no specific consultancy trips were made to Guam. Team members

have worked regionally with biosecurity and invasive species issues for many years and various additional site visits were made that are not listed as specific consultancy trips for this project. Additionally, much of the consultation work was conducted remotely via both email and phone conversation with stakeholders across the region.

Attachment R: Regional Biosecurity Plan for Micronesia and Hawaii Implementation Strategy Workshop Attendees List

19 - 21 May 2014

Office	Personnel
Chuuk State Chief of Staff, Office of the Governor	Wilfred S. Robert
Chuuk State Dept. of Agriculture Director, Office of the Governor	Kantito Kanas
CNMI Director of Agriculture, S\aipan	Manual A. Tenorio
CNMI Tinian Resident Department Head, Department of Lands & Natural Resources	Richard Farrell
Contractor	Else Demculinaek
Contractor	Lisa Chambers
Coordinator of the Hawaii Invasive Species Council	Joshua Atwood
Deputy Assistant Secretary of the Navy (DASN E)	Dan Cecchini
FAO	Viliami Fakava
Guam	Christine Camacho
Guam Customs and Quarantine	Jason Paulino
Guam Department of Agriculture	Brent Tibbatts
Guam Department of Agriculture	Russell Campbell
Guam DOA DAWR	Tino Aguon
Guam Legislature	Honorable Chris Duenas
Hawaii Department of Agriculture Acting Plant Quarantine Branch Chief	Darci Oishi
Hawaii Department of Agriculture Chairman	Scott Enright
Headquarters Marine Corps	Ryan Orndorff
Island Conservation	Raymond Nias
Kosrae Chief of Staff, Office of the Governor	Sweetiyona Tulensru
Kosrae Island Resource Management Authority Executive Director	Robert H. Jackson
Kosrae State Department of Resources and Economic Affairs	Mutanel Tolenna
LandCare	Phil Cowan
LandCare	John Parkes
United States National Invasive Species Council (NISC)	Phil Andreozi
Naval Facilities Engineering Command, Headquarters	Tammy Conkle
Naval Facilities Engineering Command, Marianas/Joint Region Marianas	Anne Brooke
Naval Facilities Engineering Command, Marianas/Joint Region Marianas	Steve Mosher
Naval Facilities Engineering Command, Pacific	Joel Helm
NAVFAC Marianas Commanding Officer/JRM J4 Regional Engineer	Captain Glenn Shephard
NOAA	VAL BROWN
Office of the Under Secretary of Defense - ATL	Gregory M. Beavers, CAPT USN OSD OUSD ATL (US)
Palau Chief of Staff, Office of the President	Secilil Eldebechel

Office	Personnel
Palau Minister of Natural Resources representative	King Malsol Sam
Palau National Invasive Species Coordinator, Bureau of Agriculture	Joel Miles
Pohnpei Agriculture Conservation Specialist, USDA-NRCS	Gibson Santos
Pohnpei Chief of Staff, Office of the Governor	Valerio Halens
Pohnpei Office of Economic Affairs Administrator	Kadalino Lorens
RMI Chief Fisheries Officer for the Coastal Fisheries, Marshall Islands Marine Resources Authority	Florence Edwards
RMI Chief of Agriculture & Quarantine, Ministry of Resources & Development	Henry Capelle
RMI Chief of Land, Coastal & Conservation Division, Environmental Protection Agency	Lani Milne
SPC	Josua Wainiqolo
SPC	Emil Adams
SPC	Radilaite Nawalowalo
SPC	Poasa Nauluvula
SPC	Ken Cokanasiga
The Nature Conservancy	Trina Leberer
UNDP	Johan Robinson
United States Department of Defense	Edward Lynch
United States Department of the Navy	Paul Wenninger
University of Guam	Tom Schils, Marine Lab
University of Guam	Ross Miller
University of Guam	Laura Biggs
University of Guam	President of the University of Guam Dr. Robert Underwood
University of Guam	Roland Quitigua
University of Guam	John Peterson
University of Guam	Ed Reyes
University of Guam	Frank Camacho
University of Guam	James Stanford
US Department of Navy	Coralie Cobb
US Department of Navy	Jennifer Farley
US NPS	Superintendent American Memorial Park
US NPS	Mike Gawel
USDA WS Guam	Craig Clark
USFWS ES Hawaii	Domingo Cravalho
USFWS ES Hawaii	Earl Campbell
USGS Guam	Adam Knox
Workshop Facilitator	Clifford Guzman
Yap Agriculture & Forestry Chief	Tamdad Sulog
Yap Hospital Head of Biosecurity Task Force	Jesse Haglelfeg
	Dot Harris
	John Santos
	Nicole Olmsted

2 Volume II - Fresh Water Systems

Regional Biosecurity Plan for Micronesia and Hawaii

Volume II

Prepared by:

University of Guam and the Secretariat of the Pacific Community 2014

This plan was prepared in conjunction with representatives from various countries at various levels including federal/national, state/territory/commonwealth, industry, and non-governmental organizations and was generously funded and supported by the Commander, Navy Installations Command (CNIC) and Headquarters, Marine Corps.

Executive Summary

Prepared by the National Invasive Species Council

On March 7th, 2007 the U.S. Department of Navy (DoN) issued a Notice of Intent to prepare an “Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS)” for the “Relocation of U.S. Marine Corps Forces to Guam, Enhancement of Infrastructure and Logistic Capabilities, Improvement of Pier/Waterfront Infrastructure for Transient U.S. Navy Nuclear Aircraft Carrier (CVN) at Naval Base Guam, and Placement of a U.S. Army Ballistic Missile Defense (BMD) Task Force in Guam”. This relocation effort has become known as the “build-up”. In considering some of the environmental consequences of such an undertaking, it quickly became apparent that one of the primary regional concerns of such a move was the potential for unintentional movement of invasive species to new locations in the region. Guam has already suffered the eradication of many of its native species due to the introduction of brown treesnakes and many other invasive plants, animals and pathogens cause tremendous damage to its economy and marine, freshwater and terrestrial ecosystems. DoN, in consultation and concurrence with relevant federal and territorial regulatory entities, determined that there was a need to develop a biosecurity plan to address these concerns.

It is important to note that in February 2012, the United States (U.S.) Department of the Navy (Navy) initiated a Supplemental Environmental Impact Statement (SEIS) to evaluate the environmental consequences of establishing a live-fire training range complex (LFTRC) on Guam in support of the relocation of U.S. Marine Corps (USMC or Marines) forces to Guam (the "LFTRC SEIS"). Shortly thereafter, the U.S.-Japan Security Consultative Committee (SCC) issued a joint statement announcing its decision to adjust the plans outlined in the May 2006 Realignment Roadmap. In accordance with the SCC's adjustments (the "2012 Roadmap Adjustments"), the Department of Defense (DoD) adopted a new force posture in the Pacific, providing for a substantially smaller Marine Corps relocation to Guam.

As a result of the 2012 Roadmap Adjustments, the Navy expanded the scope of the LFTRC SEIS to also evaluate the potential environmental consequences from construction and operation of a main cantonment area, including family housing, and associated infrastructure to support the relocation of a substantially reduced number of Marines than previously analyzed. The SEIS will supplement the 2010 Final Environmental Impact Statement (EIS) for the Guam and Commonwealth of the Northern Mariana Islands (CNMI) Military Relocation. The need for a comprehensive plan to address biosecurity threats posed by the proposed action has not been eliminated as a result of the changes to the force posture.

To address this identified need, DoN has joined forces with partners in other U.S. federal agencies and with local, regional and international governments and organizations to develop a comprehensive Micronesia Biosecurity Plan (MBP). Invasive species are considered the second most significant driver of biodiversity loss worldwide and are by far the number one cause on islands. They also have significant, direct negative impacts upon other critical island issues such as food security, culture, natural resources, economic development and climate change adaptation. Invasive species are spread, intentionally or unintentionally, by trade, travel and tourism. All three of these activities are projected to increase significantly as a result of the USMC relocation to Guam. The projected growth will result in an increased potential to spread

invasive species which cause or are likely to cause economic or environmental harm or harm to human health. The development of the MBP is a proactive effort to determine how to best prevent and mitigate the risks of increased invasive species damages as a result of the build-up.

The MBP is unprecedented in its scope and covers invasive species risks from all major taxonomic groups (plants, animals and pathogens) and for all major ecosystems (freshwater, marine and terrestrial) for the vast majority of the region of Micronesia – including Palau, Guam, the Commonwealth of the Northern Marianas Islands, the Federated States of Micronesia and the Republic of the Marshall Islands. Nauru and Kiribati are part of Micronesia but are not included in this analysis because they will not be impacted by the build-up. The State of Hawaii is also being addressed in this effort – but only to the extent to which it will be directly impacted by invasive species concerns related to the build-up.

To develop the MBP, DoN has provided over \$3,700,000 in direct funding to scientists and invasive species experts from the Departments of Agriculture and Interior (USDA and DOI), the Smithsonian Institute (SI), the National Invasive Species Council (NISC) and the University of Guam (UOG). The cooperating federal partners (USDA, DOI, SI and NISC) and numerous local and regional cooperators have contributed, and continue to contribute, significant time, resources and expertise to this effort above and beyond the direct funding provided.

This comprehensive approach to biosecurity for the region of Micronesia is a multi-level, multi-disciplinary, collaborative effort, aimed at preventing the introduction and establishment of additional invasive species at both regional and jurisdictional levels. Such a holistic biosecurity plan considers implementation of pre-border (such as pre-clearance), at-the-border (such as inspection and quarantine) and post-border (such as monitoring, rapid response and eradication of invasive species) measures. While all three of these measures are considered critical to an effective biosecurity plan, preventing the establishment of invasive species is most effectively undertaken via pre-border and at the border efforts. Additionally, these efforts are significantly less expensive (in terms of both capital and negative impacts) than long-term control of established invasive species. For many invasive species there are no feasible long-term control options. Left uncontrolled, invasive species and their damage to environment and economy spread and intensify.

The development of the MBP is being conducted in two phases. The overall goal of Phase 1 of the MBP is (1.) to identify terrestrial, marine and freshwater biosecurity risks posed by changes associated with the build-up in transportation and commerce to and within Micronesia and to and from Hawaii, and (2.) to document prevention, control and treatment measures for invasive species that can be incorporated by civilian and military operations. Phase 2 is an ongoing effort with high levels of interest both within and outside of the Micronesia region. It includes the development of an independent scientific peer review of Phase 1 results and creation of a regionally vetted Strategic Implementation Plan (SIP), including extensive in-person consultation with regional invasive species experts and stakeholders. This unique effort will help address both invasive species threats to the military mission and invasive species concerns raised by the Micronesian Chief Executives and federal and regional partners. Phase 1 of the MBP has been completed and this summary is focused on that effort.

Phase 1 was prepared by federal scientists from three different federal departments working in partnership with a variety of other local, territorial, state, national and international invasive species scientists and experts. Experts from the U.S. Department of Agriculture's – Animal and Plant Health Inspection Service (APHIS) addressed terrestrial invasive species concerns and conducted a variety of port examinations. The Smithsonian Institution conducted all work on marine invasive species as well as invasive freshwater plant concerns for the region. Scientists from the U.S. Department of the Interior's – U.S. Geological Survey (USGS) examined invasive issues in regards to the regions freshwater fauna. The National Invasive Species Council (NISC) served as the overall coordinating body during the development of Phase 1. A primary NISC duty was to work closely with DoD counterparts to encourage regional engagement in the MBP process and to facilitate collaboration between local and regional invasive species experts, such as the members of the Micronesia Regional Invasive Species Council, and the federal scientists.

The development of Phase 1 of the MBP marks the first time that scientists from different federal departments have collaborated on such an effort at this scale. It represents a new level of inter-departmental collaboration in invasive species studies and planning that takes advantage of the various centers of invasive species expertise throughout the federal government. The geographic range and taxonomic scope of this effort, combined with the level of intra-federal cooperation and in-depth collaboration with local, territorial, commonwealth, state, and national governments as well as regional organizations truly makes the MBP a globally unprecedented effort. As is often the case when breaking new ground, unexpected challenges and delays arose, but thanks to laudable flexibility from partners and a commitment to the overall goal, these challenges were met and overcome.

Phase 1 of the MBP is composed of a series of documents totaling over 2,000 pages in length. This Executive Summary addresses the MBP Phase 1 document as it was written – breaking it out into its component parts, then providing a synthesis of common “Take Home Messages”.

FRESHWATER ECOSYSTEMS

Macrofauna:

The risk assessment analysis and summary of management alternatives for freshwater invasive animals and their pathways was conducted by a team of scientists from the United States Geological Survey (USGS) led by Drs. Stephen J. Walsh and Leo G. Nico. The USGS Team collaborated with local and regional scientists and experts, conducted numerous field surveys on multiple islands, and examined available data to summarize the status of native and nonindigenous freshwater macrofauna in Micronesia. Using this information, they assessed the introduction risk of new invasive freshwater species into the region, evaluated the pathways by which previous introductions occurred, and identified the species of most concern- i.e., those that have the greatest potential to become invasive in the inland waters of Micronesia. These evaluations and assessments informed the development of management alternatives to prevent or reduce the likelihood of invasion and mitigate the impacts of non-native species already in the region.

The USGS risk assessment used an original data set assembled from a quantitative analysis of fish introductions to the inland waters of Guam and Hawaii. This data set contains information that is much more complete than for any other freshwater taxa or islands in the tropical Pacific. Emphasis was given to the largest islands in Micronesia with the most freshwater resources (as opposed to small islands such as coral atolls with limited or no freshwater resources).

The USGS team found that 1) the aquarium trade, 2) aquaculture, and 3) the live-food trade are the general pathways posing the greatest risk of introduction and spread of invasive freshwater macrofauna. To address these pathways, the USGS summarized 25 specific management strategies, ranked from medium to high priority. The management alternatives are assigned to applicable parties (DoD, non-DoD management and regulatory agencies in Guam and the CNMI, and foreign entities) and are placed into four categories; Prevention/Pathway Disruption, Long-term Management, Early Detection, and Rapid Response.

The analysis by USGS scientists suggested that primary emphasis should be placed on management strategies that address prevention. In order to achieve that goal, a series of actions are suggested that would dramatically improve inspection and detection programs, improve training of inspectors, and establish robust monitoring and rapid response activities. Their assessment also draws attention to the critical need for additional biological surveys, research, and data compilation to allow fuller, more refined analyses of risk and to close data gaps.

Central to all management alternatives summarized by the USGS team is the need for flexibility in implementation. As gaps in the understanding of freshwater invasive species and their impacts in Micronesia are addressed, new technologies and methodologies are developed, and additional invasive species pathways and vectors are identified, biosecurity efforts will need to remain flexible enough to incorporate and take advantage of these advancements in knowledge. USGS identifies certain pathways of special concern, such as the availability of potentially invasive freshwater species for purchase over the internet, easy potential for shipment through both the U.S. mail system and private couriers. To close these and other high-risk biosecurity loopholes may require substantial policy and management practice modifications. Lastly, USGS emphasizes the need for broad cooperation and coordination between the U.S. Military, other U.S. Federal agencies, the territorial and sovereign island governments, universities and civilian sectors in Micronesia, and international partners to achieve the biosecurity goals put forth in this document.

Plants:

The risk assessment analysis and development of recommended management practices for freshwater invasive aquatic plant species (IAPS) and their pathways was led by a team of scientists from the Portland State University (PSU) Aquatic Bioinvasion Research and Policy Institute under the leadership of Dr. Mark Sytsma. The PSU risk assessment was conducted by Paul Champion and John Clayton of the New Zealand National Institute of Water & Atmospheric Research Ltd. The PSU team used the results of an exhaustive literature review, supplemented by data collected during field visits and surveys in multiple locations throughout Micronesia, and collaboration with regional experts to inform their risk assessment process and develop their management practice recommendations.

Field visits took place in early 2010 and included surveys of freshwater systems to determine which IAPS were established as well as plants available for sale in pet stores, markets and other commercial venues. As with freshwater animal studies, emphasis is given to the largest islands in Micronesia with the most freshwater resources (as opposed to small islands such as coral atolls with limited-to-no freshwater resources). A notable result of the field surveys was the first record in Micronesia of *Monochoria vaginalis*, a federally listed noxious weed, in a small stream in southern Guam.

Leading up to a detailed discussion of recommendations and specific actions to enhance regional biosecurity for IAPS, the PSU team provides an overview of specific IAPS of concern, susceptible freshwater habitats in Micronesia, IAPS treatment and control methods and current risk management efforts and limitations in the region.

PSU notes that geographic isolation of the islands of Micronesia present unique challenges to the management of IAPS, and that effective biosecurity will need to be coordinated across jurisdictions with understood roles, regulations and opportunities for collaboration. The importance of maintaining programmatic flexibility to be able to incorporate new data and state of the art technologies and methodologies into biosecurity planning is also stressed. The PSU recommended strategic actions to enhance IAPS regional biosecurity are divided into 5 separate Objectives - each objective containing multiple strategies and each strategy with individual actions.

Objective one is to coordinate and implement a comprehensive management plan. To accomplish this objective, PSU suggests strategies to effectively coordinate and strengthen biosecurity efforts across the region, enhance funding and resources, and maintain flexibility so that regional and international lessons learned, advances in understanding and new preventative methodologies can be incorporated into regional and local biosecurity planning.

Objective two is to prevent new freshwater IAPS introductions and spread of existing species. To accomplish this objective, PSU suggests strategies to address five critical pathways of IAPS introduction: internet/mail order, ornamental water features, tourism, military equipment and personnel and air and maritime cargo. Two additional strategies focus on improvement of detection and interception of IAPS as well as the development of plans to control high-risk IAPS already present in the region.

Objective three is to detect and monitor for freshwater IAPS. To accomplish this goal, PSU suggests a strategy to implement standardized IAPS surveys of regional freshwater habitats to enable more effective prevention, eradication and control efforts.

Objective four is to coordinate and implement a comprehensive early response plan. To accomplish this objective, PSU suggests strategies to enable swift identification and response to regional IAPS incursions and to develop efficient, coordinated eradication efforts based on accurate delineation, clearly stated management goals and informed selection of eradication methods.

Objective five is to inform public, policy makers, and user groups of risks and impacts of IAPS.

To accomplish this objective, PSU suggests strategies to enhance outreach and education to three targeted groups in the region. Effective public education can decrease intentional and unintentional IAPS introductions and outreach and training provided to natural resources personnel and networks of interested citizens can be important components to early detection and monitoring efforts.

MARINE ECOSYSTEMS:

A team lead by the Smithsonian Environmental Research Center (SERC) prepared the marine ecosystems component of Phase 1 of the MBP. The SERC document outlines risks of invasion and provides recommendations to reduce the introduction, establishment and spread of marine and estuarine invasive species. In preparation of this document SERC teamed with other Marine invasive species experts from Central Queensland University, Portland State University and the Bishop Museum.

The SERC document is composed of three basic parts. Part one presents information on the present understanding of vectors (such as vessels and live trade) by which non-native marine species are transferred into Micronesia and provides a summary of current regulations and management practices to address those vectors. Part two is a risk assessment of marine invasions for Micronesia and details likelihoods and consequences of invasion. Part three provides a marine biosecurity plan for the region including specific recommendations on actions, strategies and frameworks to be implemented to minimize damages to Micronesia from marine invasions. The SERC document focuses heavily on vectors of invasion and vector management is presented as a critical component of the marine biosecurity plan itself. The risk assessment focuses on biofouling organisms – i.e. those organisms known to foul the hulls and underwater surfaces of vessels - and incorporates information on shipping traffic patterns and history of commercial and U.S. military vessels. Critical information regarding a large proportion of U.S. Navy vessels was not made available to the SERC team to evaluate, due to its sensitive nature. Data for recreational and fishing vessels was also lacking..

Unique to the SERC document is a pilot study on Micronesian societal values towards invasive species impacts. The pilot study sought to identify known and perceived values (environmental, economic, social and cultural) that may be impacted by introduced marine species and then assess the perceived change in these values if invasive marine species were to occur in the region. Typically, and especially in the U.S., risk assessments do not incorporate social and cultural impacts. This preliminary examination shows that there is concern over social and cultural impacts of marine invasive species.

The SERC marine biosecurity recommendations start off with a review of general biosecurity and marine-specific plans that have been developed or proposed in the broader Pacific, within Micronesia and for U.S. military bases. SERC then provides a conceptual framework with four components (and the interactions among them) of marine invasive species vector management ((1). Vector analysis, (2). Vector strength, (3). Vector interruption (disruption) and, (4). Efficacy), noting that a successful biosecurity program must incorporate each of these components along with necessary policy, management and research to sustain them.

SERC provides 47 marine invasive species prevention recommendations for vector management broken out by particular vectors ranging from a variety of vessel types (military, commercial, fishing, recreational, etc.) to construction materials, diving and fishing equipment and live trade of marine organisms. Recommendations for vessels are categorized into the specific issues of ballast water, biofouling and compensating fuel tanks (the last for military vessels only).

For ballast water, SERC makes a variety of recommendations to ensure consistent and coordinated data collection and reporting, treatment requirements, field-based treatment validation surveys and education efforts to ensure familiarity with goals and requirements. Of note is the need for a clear policy that clarifies what ballast water practices are required for all military vessels, regardless of military branch or port of origin, as currently there is significant uncertainty and ballast water management and discharge practices are unknown for many military vessels. Also of note is the need for sufficient personnel, training and data management infrastructure to implement and evaluate ballast water management at commercial ports throughout Micronesia.

For biofouling, SERC recommends, as the highest priority, the need for DoD to inspect all military vessels with high likelihood of biofouling (due to high port residence times) and to effectively clean all military vessels that are heavily fouled before they are allowed to move into, out of, or within Micronesia. It is also recommended that DoD determine criteria for acceptable levels of hull biofouling for all military vessels (including amphibious) as well as any vessels under contract to the military (including barges, dredges, etc.). For commercial vessels (including barges, cruise ships, yachts and fishing vessels), SERC again recommends the establishment of requirements for acceptable hull biofouling and in-water cleaning methods as well as routine biofouling inspection, certification and reporting standards. SERC also recommends that targeted outreach efforts be initiated to inform both military and commercial vessel audiences of biofouling management requirements.

SERC stresses that commercial vessel biosecurity requirements must also apply to any commercial fishing vessels that operate in Micronesia. Outreach programs should be implemented to target DoD and civilian populations on guidelines and methods to minimize biosecurity risks associated with kayaks, outriggers, diving gear, and recreational fishing gear. Biosecurity requirements and practices should also be developed for grounded vessels, in-water structures such as dry docks, drilling rigs and fish aggregating devices because they can pose a very high, if infrequent, risk of marine organism transfer to and within the region. SERC also recommends the establishment of explicit biosecurity measures for aquaculture as well as the establishment of a formal risk assessment process, quarantine facilities and effective reporting, screening and enforcement capacity throughout the region to minimize risk of marine organism transfer from live organism trade.

In order to establish effective marine invasion detection capacity, SERC stresses the fundamental need to develop standardized, quantitative and repetitive field-based surveys of non-native marine species in harbors, bays and ports throughout the region. SERC recommends the establishment of a high-risk species watch list for the region and a detection and response plan focused on a few of these identified high-risk species. Further evaluation of economic and social

values (per the pilot study initiated in this report) would enhance and refine decision processes for management and priorities for response to invasive marine species incursions.

SERC's last comments address implementation of their recommendations and development of capacity necessary for that implementation. Implementation should, where possible, be addressed as a coordinated, integrated approach across disciplines and jurisdictions. This integrated approach would allow for more efficient use of resources and greater effectiveness and consistency of efforts. For example, although the document provided separate vector management recommendations for DoD and commercial vessels, many aspects of reporting, training, infrastructure and legal frameworks could be effectively and efficiently combined. Specifically, SERC recommends creating a single Micronesia-wide program – a Micronesia Marine Biosecurity Facility – to serve as a resource center to provide training, shared protocols, outreach initiatives and to help identify funding opportunities and build capacity. SERC also recommends formal Memoranda of Agreement (MOU) between Micronesian governments and DoD departments to establish plans and command structure to respond to incipient marine invasions. SERC also recognizes that development of capacity and resources should be a major focus of the implementation plan (MBP Phase 2).

SERC ends by discussing the visionary scope of the MBP effort, noting the advancement of regional biosecurity across multiple countries and cultures provides an important model that uses “an appropriate spatial scale at which invasions operate.” Successful implementation of a cohesive regional plan to address marine invasions would make “DoD and its partners across Micronesia...world leaders in advancing marine biosecurity, especially in tropical ecosystems.”

TERRESTRIAL ECOSYSTEMS

The U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) prepared the entire terrestrial ecosystem component of the MBP. APHIS is a multi-faceted agency with a broad mission and a diverse set of expertise. To address the wide array of knowledge and disciplines necessary to comprehensively address invasive species threats to terrestrial ecosystems for the MBP, over 30 scientists and experts from three different APHIS agencies (Plant Protection and Quarantine (APHIS -PPQ), Wildlife Services (APHIS -WS) and Veterinary Services (APHIS-VS)) collaborated in developing this report.

There are multiple frameworks that scientists use to assess risks. Recommendations to prevent and mitigate invasive species risk can vary depending on the taxa under consideration and evaluation framework employed. Given the tremendous diversity and scope of evaluating all terrestrial invasive species risks, the APHIS document includes two separate sets of risk assessments and recommendations. The first risk assessment was conducted by APHIS-PPQ and informs the plant, pathogen and insect recommendations that were developed jointly by APHIS-PPQ, APHIS – VS, and APHIS-WS (wildlife disease scientists). APHIS – WS (terrestrial vertebrate scientists) conducted the second risk assessment and developed the terrestrial vertebrate recommendations. For the purposes of this Executive Summary, the work of all APHIS risk assessments and recommendations are synthesized together.

APHIS provides a thorough overview of operational considerations that should be addressed in route to developing a biosecurity program that integrates biosecurity activities in the Micronesia Region under single management framework. Cooperative, centralized management of biosecurity would improve efficiency and effectiveness of efforts by presenting opportunities for synergy, developing unified strategies and consistent outreach, and enhancing communication and cooperation amongst public, private and military sectors.

APHIS risk assessments examine impacts from the military relocation and provide evaluations and risk ratings for a variety of species of concern and pathways such as aircraft, maritime vessels, cargo, wood domestic and international mail, plant propagative material, livestock, pets and animal production. Different teams of APHIS scientists focused on different pathways and methodologies, depending on their area of focus, but all agreed that detailed information for making determinative rankings was limited – thus most risk rankings for pathways and species are qualitative.

The APHIS team developed over 200 recommendations to enhance biosecurity in the Micronesia Region. These recommendations are based on the specific risk assessments of each team and the observed state of biosecurity capabilities in the region. APHIS identifies a general lack of staffing, funding and biosecurity infrastructure in the region and recommends that sufficient funding be available at local and national levels and within the military to implement effective biosecurity region-wide. APHIS notes that user fees have been effectively used to generate funding for agriculture, wildlife disease and pest exclusion and recommends the legislative creation of a user fee structure similar to what is currently used by the USDA and the U.S. Department of Homeland Security.

APHIS draws particular attention to the need for sufficient numbers of well-trained staff and well-equipped biosecurity facilities and provides several specific recommendations to address these needs for both civilian and military attention. APHIS recommends several actions to enhance off-shore (pre-border) mitigation such as military pre-clearance facilities on Okinawa, weed risk assessments for importation of exotic plants and effective treatment of wood packing materials and imported timber products. Of particular note, APHIS recommends that military and civilian contracts include well-enforced requirements and provisions to minimize the risk of introduction of invasive species.

APHIS recommends a series of actions, including greater use of canine inspection teams and construction of necessary inspection, quarantine and wash-down facilities, to enhance point-of-entry biosecurity. APHIS also provides several recommendations in regards to the handling of cargo, mail and regulated garbage and export from and within the region which emphasize facilities, monitoring and inspection, and development of effective working relationships between regional, local, military and other U.S. Federal partners. Of highest priority is the need to maintain and enhance comprehensive brown treesnake (BTS) interdiction, control and eradication efforts on Guam. The BTS has caused massive direct and indirect impacts to the ecology and economy of Guam and APHIS provides numerous, specific recommendations, to both civilian and military sectors, to address this primary threat to the rest of Micronesia, Hawaii and other areas around the world.

In regards to regulations and compliance issues, APHIS recommends the military and civilian governments fully implement and take advantage of existing biosecurity guidelines and regulations. Specific to the military, APHIS suggests a revision of the DoN landscape plan to remove potentially invasive species from landscaping consideration and also recommends the development of a Memorandum of Understanding between DoD and all Micronesian countries to develop appropriate invasive species standard operating procedures for compliance when conducting activities in their respective jurisdictions. APHIS recommends outreach to pet stores, nurseries and landscaping companies to promote the adoption of a voluntary code of conduct to promote the use of native and non-invasive plants and to curtail smuggling of illegal, invasive pet species. APHIS also recommends that best management practices be developed for contractors and construction sites to prevent the introduction and spread of invasive plants and plant pests through their activities.

Several recommendations emphasize and support the development of invasive species training initiatives and outreach efforts to the public, military personnel and, particularly, to temporary workers who may come to the region as a result of the build-up. These efforts would raise general awareness of the potential harm that invasive species can cause and inform people of regulations, legal requirements and the consequences of violation. Outreach, effective communication and coordination are also critical components of successful monitoring and safeguarding efforts. APHIS recommends the development of an extensive biosecurity surveillance program for diseases, plants, plant pests and vertebrate invasive species that includes well developed processes and methodologies and incorporates expertise and capacity of other relevant entities in the region such as the Micronesia Challenge and other appropriate groups. APHIS highlights the need for background surveys to be conducted to establish baseline data for plants pests, invasive vertebrates, and diseases of livestock and wildlife throughout the region. This information would allow biosecurity plans to be refined and improved and should be completed as soon as possible.

Lastly, APHIS recommends a coordinated, centralized biosecurity effort for the region to maximize the effectiveness and efficiency of biosecurity activities, facilitate communication and cooperation between all public, private and military and other U.S. federal sectors involved and identify funding opportunities. Rapid or emergency response efforts should also be coordinated in a collaborative manner and APHIS recommends that rapid response capabilities as well as pre-export controls across the region should be improved – particularly at military and civilian airports and seaports on Guam, and the CNMI.

APHIS recommendations repeatedly emphasize the need for effective, meaningful collaboration amongst the various sectors, governments and partners to develop successful biosecurity efforts. Effective biosecurity requires sustained and managed funding and the flexibility to undergo regular reassessment and refinement as new information is obtained. APHIS asserts that the most cost-effective approach to protecting natural and economic resources in Micronesia is through implementing effective biosecurity measures before incursions or introductions occur.

TAKE HOME MESSAGES

In Phase 1 of the MBP, over 50 federal and university scientists collaborated with dozens of local and regional scientists, government officials and invasive species experts to develop a comprehensive set of invasive species risk assessments, recommendations and best management practices that are unprecedented in their size and scope. While the different teams of scientists used a diversity of methods and approaches to their evaluations and recommendations, a number of common themes became clear. These “Take Home Messages” are summarized below:

- **Sufficient Staffing and Facilities:** The need for sufficient numbers of well-trained staff and well-provisioned facilities is critical for all biosecurity activities. In general, staffing and facilities in the region are inadequate for current levels of need, let alone for the levels required during and after the build-up.
- **Coordination and Collaboration are Critical:** Effective biosecurity for the region will require constant, open collaboration between all levels of government in Micronesia, DoD, other U.S. federal departments, the private sector, non-profit sector and regional organizations. Coordinated efforts amongst all partners will allow the region to more efficiently address critical issues such as:
 - Strategies to identify funding opportunities and secure commitments to ensure long-term, consistent funding and capacity for biosecurity efforts in the region.
 - Adoption of Memoranda of Agreement between nations and other partners to harmonize and/or establish plans, command structures, roles and responsibilities in regards to specific biosecurity issues.
 - Establishment of clear policies and required best management practices to address a variety of marine, terrestrial and freshwater invasive species concerns.
 - Development and/or improvement of regionally coordinated efforts on:
 - Early detection and rapid response to invasive species.
 - Outreach and education to both civilian and military sectors on invasive species issues and biosecurity.
- **Information Needs:** New research and repetitive, systematic surveys are needed throughout the region to advance the science behind biosecurity and to establish baseline data on invasive species that is accurate, current and reflects the dynamics of changing situations. . . Accurate and current baseline data together with other pertinent information (such as economic analyses and societal and cultural valuation of invasive species impacts) will allow for higher quality risk assessments that will inform the development of more effective and efficient biosecurity measures.
- **A Flexible, Living Document:** The MBP must be frequently revised and updated to allow incorporation of new information (such as invasive species baseline data), technologies and methodologies that will increase the effectiveness and efficiency of biosecurity efforts.

NISC has been honored to be part of this worth-while effort. We thank our colleagues throughout Micronesia, the U.S. federal government and in the broader Pacific for their hard work and dedication in producing the MBP – an effort that will benefit all of Micronesia and set an example for other regions of the world.

Special attention needs to be brought to the role of the Micronesian Chief Executives and DoN in enabling this effort. The Micronesian Chief Executives have been proponents of the development of the MBP from its inception and publicly endorsed the effort and instructed their staffs to fully participate in its development and implementation in Resolution 17-7 of the 17th Micronesian Chief Executives' Summit. The development of the MBP also directly supports the “Green Guam” and “One Guam” pillars of the “four pillars that will shape the (build-up) strategy” – as stated by Undersecretary of the Navy Robert Work in 2011 and is prima facie evidence of DoN engaging in a meaningful way with regional partners to address issues of common concern. In supporting this effort and by acknowledging the critical role of cooperative relationships, the Micronesian Chief Executives and DoN have attempted to *proactively* address the invasive species implications of the build-up, not just for Guam and the CNMI where the build-up will happen, but for the entire region.

Regional Biosecurity Plan for Micronesia and Hawaii Freshwater Risk Assessment

The freshwater risk assessment is composed of edited elements of three reports prepared for DoN as part of the overall MBP development strategy. These reports in their entirety can be accessed at the DoN supported website.

The original reports titles are as follows:

- Assessing the risk posed to Micronesia by invasive aquatic weeds
- Biosecurity plan for freshwater invasive aquatic plants in Micronesia
- Risk analysis and management alternatives for the prevention and mitigation of nonindigenous fishes and other aquatic macrofauna in freshwater habitats of Micronesia

Introduction

Invasive alien species (IAS) are a significant threat to the integrity of freshwater systems throughout the world. Some of these threats include the alteration of ecosystem services, the loss of aquatic biodiversity, and the degradation of water quality for the human populations that rely on those waters. Identifying the pathways and vectors by which aquatic IAS may be introduced, understanding the factors that may contribute to the spread and establishment of IAS taxa is critically important to preventing the introduction of IAS and mitigating their ecological effects and ensuring that appropriate biosecurity measures are in place for the islands of Micronesia and the state of Hawaii in order to protect these jurisdictions from the negative cross-cutting effects of IAS.

Given their relative isolation, the islands of Micronesia and Hawaii may be particularly sensitive to the introduction of aquatic IAS taxa. Many of these islands are already host to a variety of non-indigenous fish, invertebrates, and macrophytes. To address these concerns, the Department of Defense has sponsored the development of risk assessments and management alternatives to minimize the introduction and spread of aquatic IAS throughout Micronesia and Hawaii.

This volume of the Micronesian Biosecurity Plan includes (1) risk assessments for invasive aquatic macrofauna and (2) management strategies to prevent the importation and spread of IAS between the different jurisdictions. The aquatic macrofauna risk assessment and management alternatives were developed by the U.S. Geological Survey (Section 1). The aquatic macrophyte risk assessment and biosecurity plan was developed by Portland State University (Section II) in partnership with the New Zealand National Institute of Water and Atmospheric Research, Ltd. (NIWA).

Prepared with cooperation and funding by the U.S. Department of the Navy

Risk Analysis and Management Alternatives for the Prevention and Mitigation of Nonindigenous Fishes and other Aquatic Macrofauna in Freshwater Habitats of Micronesia

From an original document prepared by Stephen J. Walsh, Leo G. Nico, Mark W. Miller, and Ronald A. Englund

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Conversion Factors and Abbreviations

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square meter (m ²)	0.0002471	acre
hectare (ha)	2.471	acre
square kilometer (km ²)	247.1	acre
square meter (m ²)	10.76	square foot (ft ²)
hectare (ha)	0.003861	square mile (mi ²)
square kilometer (km ²)	0.3861	square mile (mi ²)
Volume		
cubic meter (m ³)	0.0002642	million gallons (Mgal)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
 $^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$

Risk Analysis and Management Alternatives for the Prevention and Mitigation of Nonindigenous Fishes and other Aquatic Macrofauna in Freshwater Habitats of Micronesia

By Stephen J. Walsh¹, Leo G. Nico¹, Mark W. Miller¹, and Ronald A. Englund²

Executive Summary

This report provides an assessment of potential risks posed by the introduction and spread of nonindigenous freshwater organisms in Micronesia. The basis for this study is an anticipated increase of U.S. military and civilian activities on and around Guam and the Commonwealth of the Northern Mariana Islands. The focus of this effort is on invasive or potentially invasive freshwater animals, mainly fishes, and the pathways by which these aquatic organisms are introduced to regions outside their native ranges. The risk assessment analysis and accompanying management alternatives are provided as part of a biosecurity plan for the entire Micronesian region. The emphasis is on the islands of Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia (specifically, Chuuk, Kosrae, Pohnpei, and Yap), and Palau, because these are the largest islands and those with the greatest extent of freshwater resources.

The objectives of this study were to (1) summarize available information on native and nonindigenous macrofauna of freshwater systems in Micronesia; (2) identify and evaluate pathways of introduction and assess the risk of introducing nonindigenous freshwater animals into new environments of Micronesia; (3) identify those aquatic and semiaquatic animals that have the potential to become widely established or invasive in inland waters of Micronesia, and; (4) provide management options with the goals of preventing or reducing the likelihood of introduction and spread of freshwater animals into and among the islands of Micronesia as well as mitigating risks. Emphasis is placed on freshwater fishes, because more is known about this group than the others, although information is also summarized for selected non-native taxa of other groups, mostly aquatic or semiaquatic mollusks, crustaceans, amphibians, and reptiles.

Micronesia is a heterogenous subregion of Oceania, comprising thousands of small tropical islands scattered across a vast expanse of the western Pacific Ocean, from the Mariana Islands and Palau in the west to Kiribati in the east. Micronesian islands and islets are extraordinarily diverse and complex in terms of geography, physiography, geology and biology. Although individual islands in Micronesia are surrounded by ocean, many contain a diverse array of natural freshwater habitats. Whether permanent freshwater habitats are present, and, if present, their type, diversity, and extent depends on a wide range of factors, including island location and size, geologic history, and physiography (e.g., elevation and topography). These factors and

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other characteristics vary widely among the many islands and islands groups of Micronesia and the Pacific. Many islands are quite distinctive in terms of their geomorphology and aquatic habitats. In general, larger islands, especially those with the greatest topographic relief, have more extensive and diverse inland freshwater ecosystems that include an array of streams, springs, wetlands, and natural lakes. Artificial freshwater habitats are also common, especially on islands populated by humans, and typically consist of reservoirs, ponds, ditches and small canals.

Freshwater habitats on Micronesian islands support moderately diverse and unique native biological communities. Although the total number of native freshwater species on any one island group is relatively low in comparison to continental faunas, native aquatic animals present are extremely important from a global perspective. This is due to a great degree of endemism in Micronesia—many species and community assemblages that are found nowhere else in the world. The most prominent freshwater animals are fishes and macroinvertebrates, and most of the native fishes, crustaceans, and aquatic mollusks (gastropods) are amphidromous species—that is, they are derived from marine ancestors and have a unique life history in which adults spawn in rivers and streams, eggs or larvae drift to the ocean, and juveniles then return to fresh water to complete their life cycle.

Invasive and other nonindigenous aquatic species have changed or otherwise affected all or most Pacific islands containing permanent freshwater habitats. Indeed, a wide variety and large number of nonindigenous fishes and various other nonindigenous aquatic animals have been introduced to freshwater habitats of Micronesia and other islands of Oceania. As a result, nonindigenous freshwater species are common on most islands in the region that have freshwater environments. Pathways are defined here as the general route or activity by which a species can be introduced into a new locale whereas vectors are considered to be the specific mechanisms or modes of introduction. The pathways and mechanisms by which these nonindigenous organisms were introduced are varied; some were brought intentionally by humans, and many others arrived accidentally. Guam, in particular, has more nonindigenous freshwater fishes and other aquatic fauna than any other island in Micronesia and is second only to Hawaii among islands in the tropical Pacific in this regard. However, all of the large islands have been affected to some degree by the introduction of freshwater species.

The risk assessment presented herein is based on a quantitative analysis of fish introductions to inland waters of Guam and Hawaii. This data set is used because it is derived from historical and current information that is far more complete and includes records of more nonindigenous aquatic taxa than any other group of islands in the tropical Pacific. The data used in the risk assessment are based on a total of 80 species or taxa, 49 (61%) of which are known to be established (that is, have reproducing populations) on Hawaii, Guam, or both. One dependent variable (prior establishment success) and 14 independent variables, including factors that relate to propagule pressure, life-history attributes, and physiological tolerances, were used to develop 21 *a priori* and 8 *post hoc* frequentist (logistic) models to determine probabilities of establishment success. The best model derived from this analysis included three primary factors used to predict establishment success: (1) a random family (taxonomic) effect; (2) prior invasion success on tropical islands or island groups globally, and; (3) hypoxia tolerance (i.e., tolerance to low dissolved oxygen using a categorical variable with three possible states).

Results of the risk assessment have utility in that the models can be used to assign probabilities of establishment success of species or taxa not currently established in Micronesia. For instance, the Guam Division of Aquatic and Wildlife Resources (DAWR) maintains a white (or “clean”) list of aquatic species (freshwater and marine fishes, invertebrates, and plants)

that are permitted for legal importation. Our risk assessment model could be used to evaluate relative risk for species that are currently on Guam’s white list, or species that might be under consideration in the future. Although the white list is a regulatory tool that DAWR uses to manage for potential introductions of invasive species (by limiting imports), there is currently no legislation that prohibits the possession of species not on the white list, including species considered potentially invasive or injurious. Establishment pathways of freshwater species were evaluated in our risk assessment, and are also addressed in the section on management alternatives. Although all pathways pose certain risks, the general pathways identified as posing the greatest risk for introductions (and spread) of freshwater species in Micronesia include: (1) the aquarium trade and commerce in ornamental species; (2) aquaculture, and; (3) the live-food trade.

As an objective, policy-neutral, science-based agency, the USGS has no management or regulatory authority. Therefore, the USGS refrains from making recommendations that target specific management or policy actions, and terminology such as “best management practice” or “BMP” is not used. Herein, management alternatives are provided with an implicit understanding that all options have not been thoroughly vetted and strategic actions may be warranted and modified over time as new information becomes available. Many existing sources provide baseline information on strategies for mitigating deleterious ecological or socioeconomic effects of invasive species; the information provided in this report is based on sources considered reliable.

Management alternatives for the prevention and mitigation of non-native freshwater species in Micronesia involve a variety of approaches and include, but are not limited to, the following:

- Continued monitoring of imports
- Improved inspection and detection programs
- Improved training of inspectors
- Improved knowledge about propagule pressure using surveys and other information-gathering approaches
- Expanded education and outreach programs
- Independent scientific review of DAWR white list of permitted aquatic species
- Improved management of aquaculture facilities
- Improved monitoring/detection of commodities in the live-food market
- Additional biological surveys
- Establishing robust monitoring programs based on appropriate statistical approaches that incorporate detectability and occupancy models
- Establishing a rapid response strategy and contingency plan for new introductions
- Additional scientific research and data compilation to assess more fully relative risk based on multiple factors (e.g., pathways, taxonomic groups, biological attributes) and data gaps

Implementation of management options should focus foremost on prevention and remain flexible enough to deal with changes in technology, transportation, and world markets. In particular, vigilance is needed to identify existing high-risk pathways or vectors and identify

potential future pathways and vectors. For example, a wide variety of potentially invasive freshwater animals are currently available worldwide for purchase over the Internet and there is ample and easy opportunity for a person living in Guam or elsewhere in Micronesia to obtain an aquatic animal not previously introduced to the island, including organisms whose import is illegal. Use of private shippers increases the possibility that such an import might proceed undetected by custom agents. Closing the loophole of such high-risk factors may require substantial modifications to existing practices, policies, or management structure and procedures. If introduction of a harmful non-native species is not successfully prevented, then eradication or containment efforts may result, both of which are strategies that require intensive, costly planning and logistics at many levels. Improved biosecurity for non-native freshwater species in Guam and the Commonwealth of the Northern Mariana Islands (CNMI), in particular, will require cooperation and coordination between the U.S. military, various island nations and states, and civilian sectors.

Overview

The purpose of this report is to provide an assessment of potential risks posed by the introduction and spread of nonindigenous freshwater organisms in Micronesia. Increased threats posed by nonindigenous species may accompany increased U.S. military and civilian activities anticipated in and around Guam and the Commonwealth of the Northern Mariana Islands. This report focuses on invasive or potentially invasive freshwater animals, mainly fishes and selected amphibians, reptiles, and macroinvertebrates, and the pathways by which these aquatic organisms are introduced to regions outside their native ranges. Included are mitigation measures to prevent or reduce the likelihood of introduction and spread of freshwater animals into and among the islands of Micronesia.

This report constitutes a component of a broader Micronesian Biosecurity Plan (MBP) that addresses a variety of non-native organisms, including terrestrial and aquatic (marine and freshwater) animals and plants, as well as parasites and pathogens. The MBP includes comprehensive information derived from risk assessments and review of existing conditions as provided by multidisciplinary teams of biologists and other scientists representing various agencies and institutions (USDA-APHIS 2010; ABRPI 2011; Zabin et al. 2011).

Micronesia is a heterogenous subregion of Oceania, comprising thousands of small tropical islands scattered across a wide expanse of the western Pacific Ocean, from the Mariana Islands and Palau in the west to Kiribati in the east. The more than 3,000 Micronesian islands and islets are extraordinarily diverse and complex in terms of geography, physiography, geology and biotas. All Micronesian islands combined have a total surface or land area that is estimated to cover anywhere from about 2,700 to 3,227 km² (1,042 to 1,246 mi²) (Crombie and Pregill 1999; Steadman 2006). Many of the individual island groups are relatively remote and separated by great distances from their nearest neighbors. Although most of the islands are far from continental land masses, a few are relatively close to the large island of New Guinea. Because of its size and complex geography, the nomenclature of Micronesian islands and island groups, including that of their political alliances, can be confusing and cumbersome.

Background

Introductions of non-native species to the islands of Oceania began with the earliest human inhabitants. Over the past several hundred years, and especially over the past few decades, the numbers and kinds of different nonindigenous species introduced have increased substantially. Although the introduction of freshwater aquatic animals to Pacific island habitats is relatively recent in comparison to the introduction of many non-native plants and terrestrial animals, over recent decades there have been multiple introductions and spread of freshwater species throughout islands of Oceania. Taxonomic groups introduced into freshwater habitats include fishes, amphibians, reptiles, and invertebrates (primarily crustaceans and mollusks). Current knowledge about the status of nonindigenous species in freshwater habitats varies with island or island group in Micronesia, and to a large extent, corresponds to degree of study by biologists or survey efforts by government agencies and nongovernmental organizations. In general, the most complete information exists about freshwater biotas for those islands with large human populations and extensive freshwater habitats, two characteristics that are closely linked. Thus, Guam, the Commonwealth of the Northern Mariana Islands (especially Saipan), Palau (Babeldaob and Koror), and the large, high islands of the Federated States of Micronesia (Pohnpei and Kosrae) have been the most intensively explored. Nevertheless, nearly all islands are considered to be inadequately surveyed.

A number of authors have assembled lists of what they consider to be the most detrimental invasive species—those introduced organisms that commonly are introduced, become established, and thrive and dominate in new places. For example, Lowe et al. (2004) produced a list of “100 of the World’s Worst Invasive Alien Species.” Of the eight fish species listed, seven have been introduced to islands in the Pacific. Similarly, Helfman (2007) provided a list of ten freshwater fish taxa whose introductions were considered to be especially controversial, largely due to their resulting ecological or economic impacts (Table 1). At least eight of the taxa on Helfman’s list have been introduced into Micronesia, and most are established there; additionally, a moderate number of other non-native fish species have been introduced and are considered established. To a lesser extent, other non-native freshwater animals have been introduced. However, there are notable examples of highly successful and even invasive and injurious aquatic or semiaquatic species of other taxonomic groups. For example, Guam is now host to a moderate number of frogs (Christy et al. 2007a, b), including the widespread and locally abundant cane toad, *Rhinella marina* (= *Bufo marinus*). In addition, the red-eared slider (*Trachemys scripta elegans*) is a freshwater turtle that has been introduced worldwide (Kraus 2009a), and wild populations are documented as established in Guam (Leberer 2003).

Table 1. Selected controversial freshwater fish species introduced in different regions of the world, based on Helfman (2007) and references therein. [Numbers of countries and states where established considered herein to be general approximations]

Species	Number of countries where established	Number of U.S. states where established	Native distribution	Purpose of introduction ^a
<i>Cyprinus carpio</i> , common carp	49	49	Eurasia	Food, ornamental
<i>Carassius auratus</i> , goldfish	>40	49	East Asia	Ornamental
<i>Ctenopharyngodon idella</i> , grass carp	? ^b	45	East Asia	Biocontrol
<i>Oncorhynchus mykiss</i> , rainbow trout	56	48	North America	Sportfishing, food
<i>Gambusia affinis</i> , <i>G. holbrooki</i> , mosquitofish	67	35	North America	Biocontrol
<i>Poecilia reticulata</i> , guppy	34	15	South America	Ornamental, biocontrol
<i>Micropterus salmoides</i> , largemouth bass	53	43	North America	Sportfishing
<i>Lates niloticus</i> , Nile perch	3	1	East Africa	Food
Tilapiine cichlids (many species)	94	13	Africa	Food, biocontrol
<i>Cichla</i> spp., peacock cichlids	6	2	South America	Sportfishing

^a Primary purpose(s) of introduction as provided by Helfman (2007), but the authors are aware of situations where some of these species were introduced for additional reasons.

^b Helfman (2007) gives number of countries as nine, considered here to be a significant underestimate.

Goals and Objectives

The principal objectives of this study were to (1) summarize available information about native and non-native macrofaunas of freshwater systems in Micronesia, with emphasis on Guam; (2) identify and evaluate pathways of introduction and assess the risk of introducing nonindigenous freshwater animals into new environments of Micronesia; (3) identify those freshwater species or groups that have the potential to become widely established or invasive in Micronesia, and; (4) provide management options for preventing unwanted introductions and for mitigating risks. Emphasis is placed on freshwater fishes, because more is known about this group than the other faunal groups mentioned in this report. Moreover, assessment and management practices for freshwater fishes have similar applicability to other groups of aquatic and some semiaquatic animals, including vertebrates and invertebrates.

Environmental Setting: Inland Aquatic Environments

The individual islands of Micronesia (Fig. 1) are surrounded extensively by ocean, yet many contain a diverse array of natural freshwater habitats. The presence or lack of freshwater habitats, and, if present, their type, diversity, and extent depend on a wide range of factors, including island location and size, geologic history, and physiography (e.g., elevation and

topography). These factors and other characteristics vary widely among the many islands and islands groups of Micronesia and the Pacific. Steadman (2006) recognized at least seven different types of Pacific islands: (1) active volcanic islands; (2) eroded volcanic islands (e.g., Babeldaob in Palau); (3) raised limestone islands; (4) atolls; (5) "almost atoll" islands; (6) sand cays or keys; and (7) composite islands (i.e., consisting of multiple types of exposed bedrock, such as Guam, which contains outcrops of limestone and volcanic rock).

In general, surficial freshwater habitats are few in number or absent on atolls and sand cays, as well as on many of the very small, low-elevation islands and islets. In contrast, larger islands, especially those with the greatest topographic relief, typically have more extensive and diverse inland freshwater habitats that include, depending on the particular island, small and large streams, springs, wetlands, and natural lakes. Artificial freshwater habitats are also common, especially on islands populated by humans, and typically consist of reservoirs, ponds, ditches and small canals. Most natural freshwater systems on Micronesian islands are linked to the ocean either directly or through estuarine or other brackish-water transition zones. Because of the association between fresh and salt water and the general isolation of the islands from continental areas, native fishes and invertebrates present in freshwater environments of these islands have evolved from marine ancestors, and nearly all depend on marine or brackish-water habitats for certain critical parts of their life cycle; for example, for food resources, nursery habitats, or spawning (Ford and Kinzie 1982).

This report focuses on a few of the major islands and island groups of Micronesia, mainly those with substantial freshwater resources: Guam, the Commonwealth of the Northern Mariana Islands (CNMI), the Federated States of Micronesia (FSM), and Palau. Brief descriptions of these select islands/island groups and their inland freshwater environments are presented in following sections. Additional information on inland aquatic environments of Micronesia is available from the Water and Environmental Research Institute of the Western Pacific (WERI), University of Guam (<http://www.weriguam.org/>), which conducts extensive research and monitoring of aquatic resources in Guam and throughout Micronesia. The WERI, in collaboration with other organizations and agencies, has produced or reprinted many important documents about the geology and freshwater resources of Micronesia. Most of these documents are available on the institute's web site and are the source of much of the information presented here.

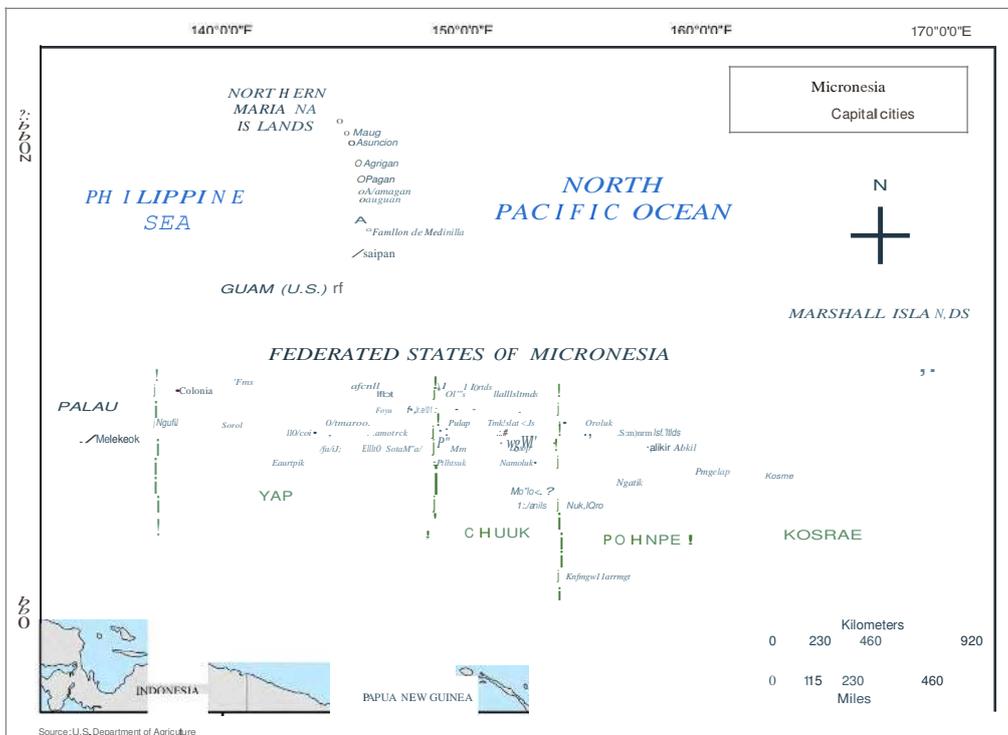


Figure 1. Map of Micronesia and political sovereignties.

Guam

Background

The climate of Guam is warm tropical, with air temperatures that are relatively uniform throughout the year; annual average temperature is about 26°C (79°F) and monthly means range from about 24° to 27°C (76° to 80°F) (<http://ns.gov.gu/climate.html>; Yeung 2005). Relative humidity ranges from about 65% during the day to 100% at night. Rainfall is the source of all fresh water in Guam and averages about 216-292 cm (85-115 inches) per year (Gingerich 2003). Rainfall recording stations differ in annual total by as much as 76 cm (30 inches) due to the island's orography and southern mountainous region. More rainfall occurs in the southern highlands in comparison to the central and coastal lowlands. Most (about 70%) of the rainfall for the entire island occurs during the wet season, from July through November or December; the pronounced dry season typically extends from January through May (Ward et al. 1965). Typhoons have historically resulted in episodic and prolonged rainfall events. In contrast, droughts in Guam are common and may be severe.

Guam has been the subject of extensive geologic and hydrogeologic investigation. The primary reference on the geology of Guam is that of Tracey et al. (1964). The first comprehensive hydrologic study of the island was by Ward et al. (1965). More recent synoptic publications that provide additional summaries of hydrogeologic research and syntheses of information about Guam's karstic features include those of Mink and Vacher (1997), Siegrist and Randall (1992), Taboroši (2000), Mylroie et al. (1999; 2001), and Taboroši et al. (2004, 2005). Karst topography is a landscape shaped by the dissolution of soluble bedrock, usually carbonate rock such as limestone or dolomite. The porous conditions commonly results in subterranean drainages with limited surface water. Guam's karst features are typically described in the framework of the Carbonate Island Karst Model (CIKM), a theoretical model that characterizes unique karstic terrain of relatively young limestones of small islands (Mylroie and Carew 1995; Mylroie and Jenson 2000).

Volcanic rock forms the foundation of Guam and is exposed over about 35% of the island; overlying this rock is limestone that is exposed over about 60% of the island. Seven major geologic units are represented, six of which lie in the southern half of the island (Fig. 2). A major fault line that extends approximately from Pago Bay on the east coast to Asan on the west coast divides the island into two basic physiographic provinces (Tracey et al. 1964; Kingston 2004; Taboroši et al. 2005). To the north of this fault is a limestone plateau consisting of carbonate island karst (eogenetic karst) that is broken by two volcanic intrusions (Tracey et al. 1964; Gingerich 2003; Taboroši et al. 2005). This limestone plateau lacks rivers or streams, but is porous, allowing percolation of rain water into an underlying freshwater-lens system that lies

above salt and brackish water (Gingerich 2003; Kingston 2004). Groundwater resources of the northern plateau provide the vast majority of freshwater supply for human use on the island. Consequently, there have been exhaustive hydrologic, geologic, and chemical studies of this region (Mink and Vacher 1997). The southern half of the island consists of seven primary physiographic provinces that can be classified into three categories: lowlands, limestone plateau, and volcanic uplands (Fig. 3).

The southern half of Guam is mountainous (Fig. 4) with a peak elevation of 406 m (1,332 ft) on Mount Lamlam. The southern mountains consist of exposed volcanic rock and soils that are relatively impervious to groundwater percolation, and karst features that are generally porous and similar to continental karst (Tracey et al. 1964; Taboroši et al. 2005).

Freshwater Habitats of Guam

Due to its more mountainous terrain, fewer exposed karst features, and wetter climate, southern Guam has many more freshwater habitats than the northern part of the island (Table 2; Appendix 1). The southern half includes about a hundred named rivers and streams (Fig. 5), 46 of which drain into the ocean (Best and Davidson 1981; DAWR 2006). The largest river system in Guam is the Talofofu River, draining an area of approximately 73 km² (28 mi²). The river originates on the eastern slopes of Mount Lamlam in southwestern Guam and flows to the northeast into the sea at Talofofu Bay. Nine of Guam's 46 rivers that drain into the ocean have true estuarine zones (DAWR 2006). A mountain ridge that extends along the western coast defines many of the drainages. With many small catchments draining directly to the ocean, watersheds of the island are grouped into 14 larger units (Fig. 5). Some of Guam's lotic systems are intermittent, with continuous flow only during periods of heavy rainfall. Extensive online spatial data and synoptic information about the natural resources of southern Guam are available on the WERI website (<http://www.hydroguam.net/watersheds-overview.php>).

Second in importance to rivers and streams in terms of their contribution to the total fresh water in Guam are habitats formed by springs, vegetated wetlands (both natural and artificial), impoundments, canals, and water-retention basins. Although dated, the review by Best (1981) provides a bibliography of inland aquatic resources of the Marianas archipelago, including documents relevant to the freshwater resources of Guam. Ellison (2009) gave a general summary of the wetland resources on islands throughout the western Pacific region. Agana Springs and Agana Swamp are two of Guam's best known spring and wetland habitats and are sites where nonindigenous aquatic species have been introduced. Hydrology of the downstream reaches of the Agana River were altered by efforts to drain the swamp as well as groundwater pumping (Randall et al. 1974); today, these sites are disturbed from encroaching development, runoff of sediments and contaminants, and invasive species.

The largest reservoir in Guam is Fena Reservoir (Fig. 5), a water-supply impoundment constructed for the U.S. Navy in 1950-1951, with a drainage area of approximately 15 km² (5.8 mi²) and surface-water area of 78 hectares (193 acres) (LaBaugh 1985). Fena Reservoir is situated on the Maagas River, a headwater tributary of the Talofofu River. The reservoir has been the site of introduction of various nonindigenous plants and animals (e.g., Brock and Takata 1956; DAWR 2006), some of which persist and others that never became established. In the past consideration was given to developing additional water-supply reservoirs, especially the

large basins of the Ugum, Ylig, Pago, and Inarajan (USACE 1979); no effort was made herein to ascertain the current status of proposed water-development projects in Guam. It is worth noting, however, that water impoundments and reservoirs are particularly susceptible to the introduction and establishment of nuisance aquatic species. Furthermore, these systems disrupt the flow regimes for native instream communities both above and below the impoundment. Thus, any planned water development projects should consider ways to mitigate against potential introductions and maintain the ecological integrity of the native instream communities.

A number of aquaculture facilities in Guam, currently inactive and active, have ponds that have also been sites where nonindigenous aquatic species have been introduced (B. Tibbatts, DAWR, oral commun., 2010). Additionally, a few golf courses have artificial impoundments that are inhabited by nonindigenous species.

Table 2. Freshwater habitats of Guam (DAWR 2006).

Habitat type	Location	Percentage of area	Relative condition	Needs
Freshwater swamps	Edges of marshes, along river courses, wet depressions in forests	0.06	Unknown	<ul style="list-style-type: none"> • Implement current management plans/laws • Control invasive species of vegetation and animals
Freshwater marshes	Common from central to southern Guam	0.29	Stable	<ul style="list-style-type: none"> • Implement current management plans/laws • Control invasive species of vegetation • Control BTS
Reservoirs	Widely through southern Guam	0.01	Unknown	<ul style="list-style-type: none"> • Implement current management plans/laws • Control invasive species of vegetation
Mangroves	Southern Guam	0.14	Stable	<ul style="list-style-type: none"> • Implement current management plans/laws • Control invasive species of vegetation • Prevent further habitat loss
Rivers	Southern Guam	0.13	Unknown	<ul style="list-style-type: none"> • Implement current management plans/laws • Reduce sedimentation • Control invasive species of vegetation

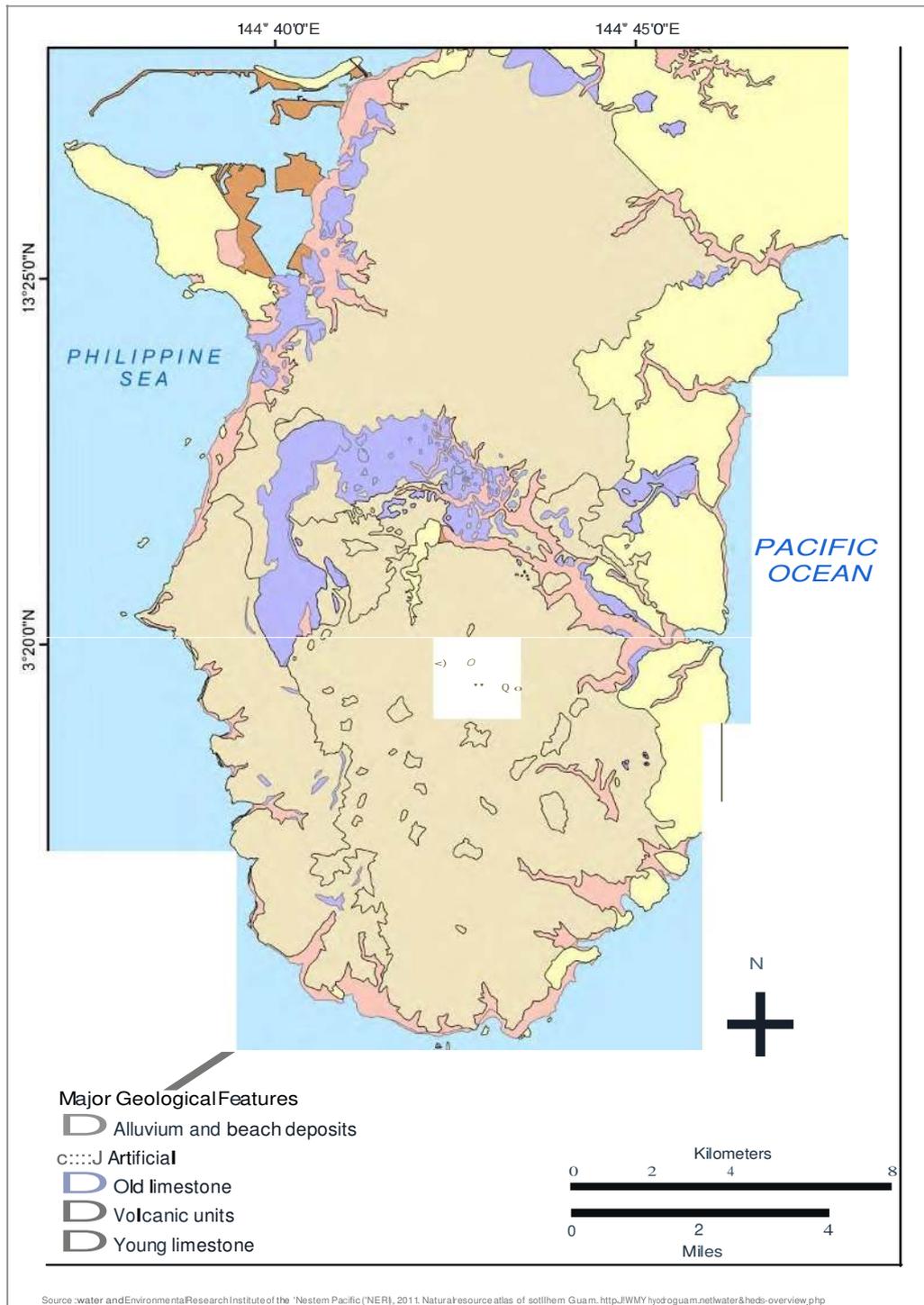


Figure 2. Major geological features of southern Guam (modified from WERI 2011).

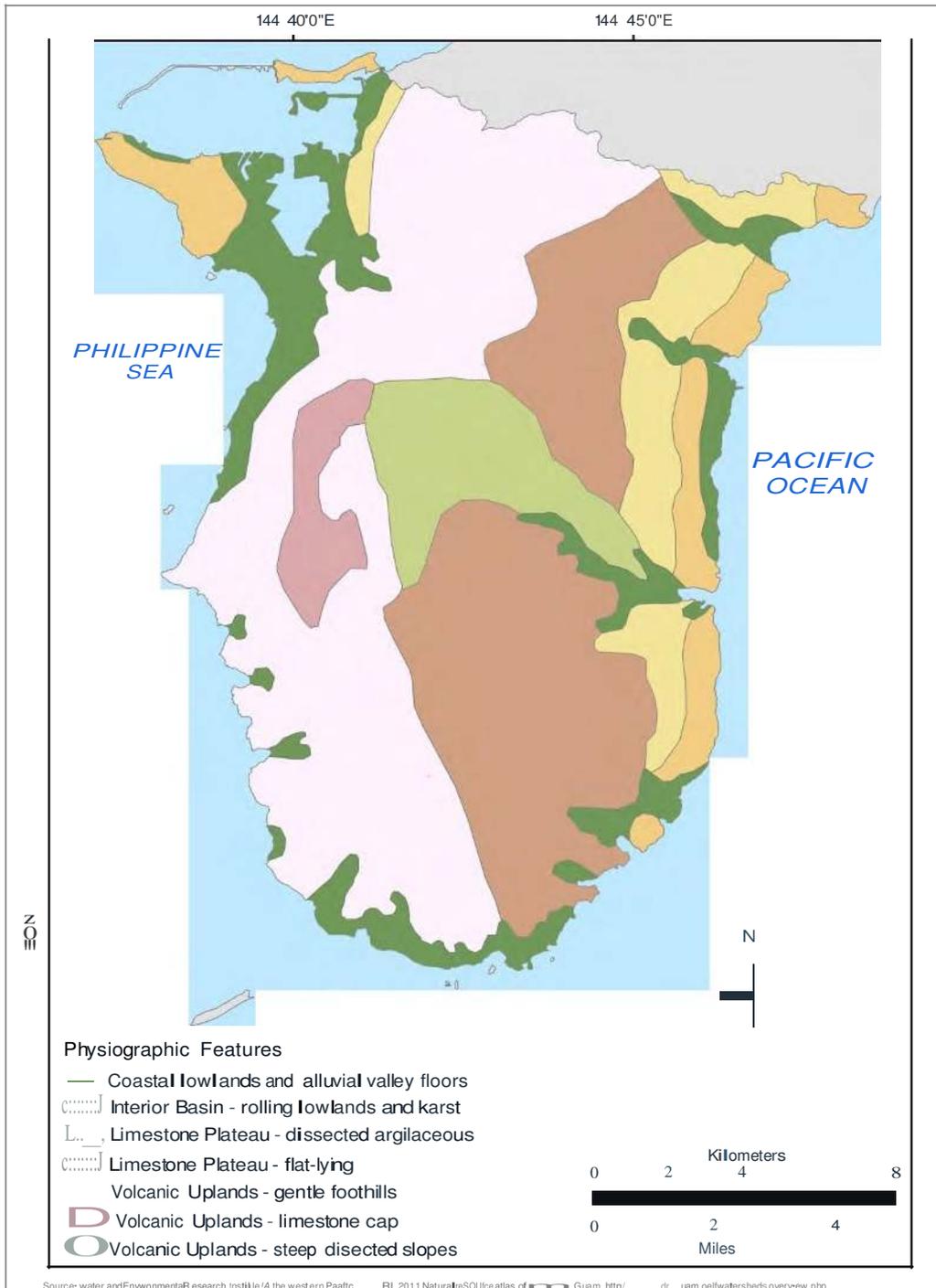


Figure 3. Physiographic provinces of southern Guam (modified from WERI 2011)

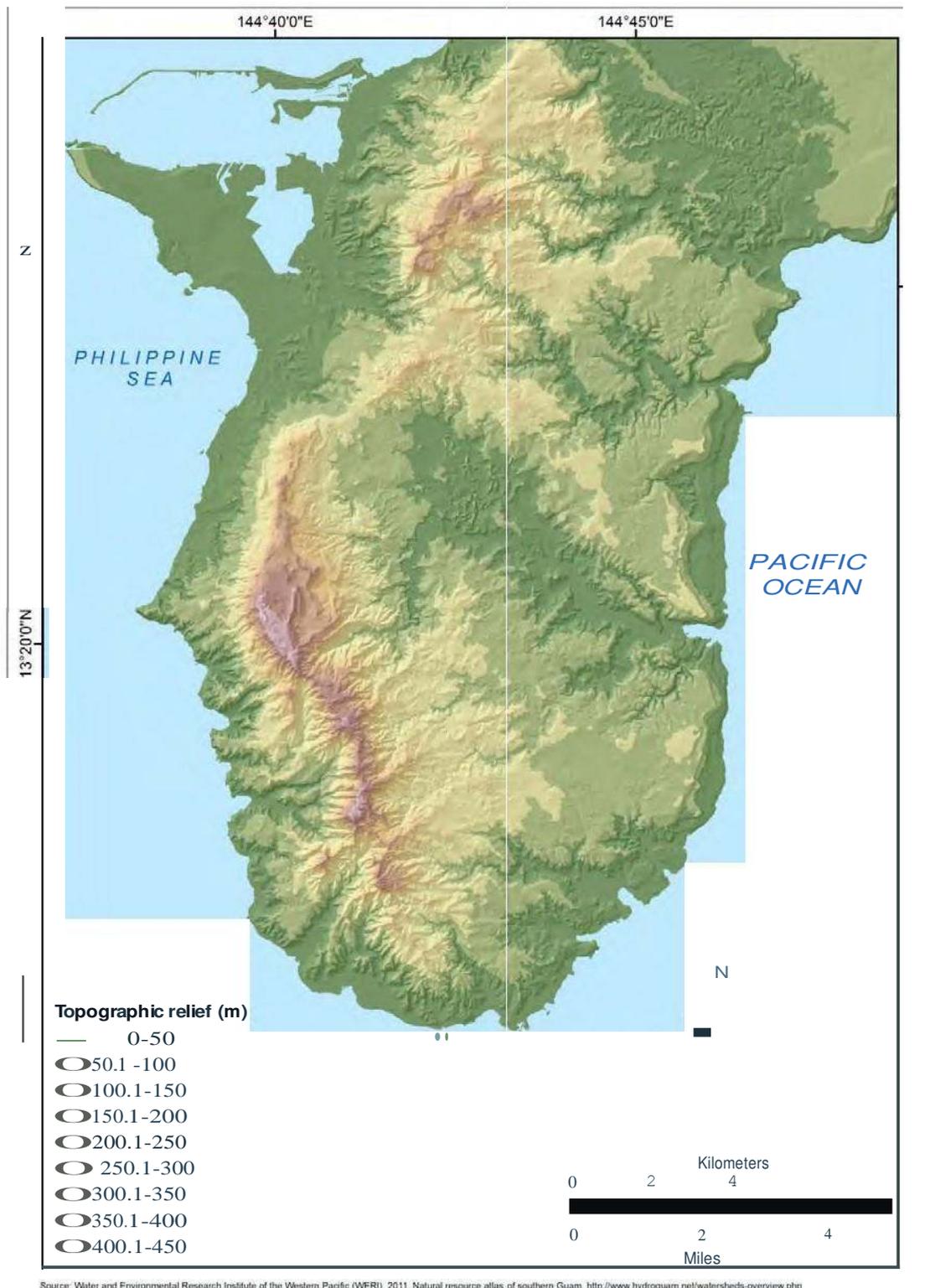


Figure 4. Topographic relief of southern Guam (modified from WERI 2011).

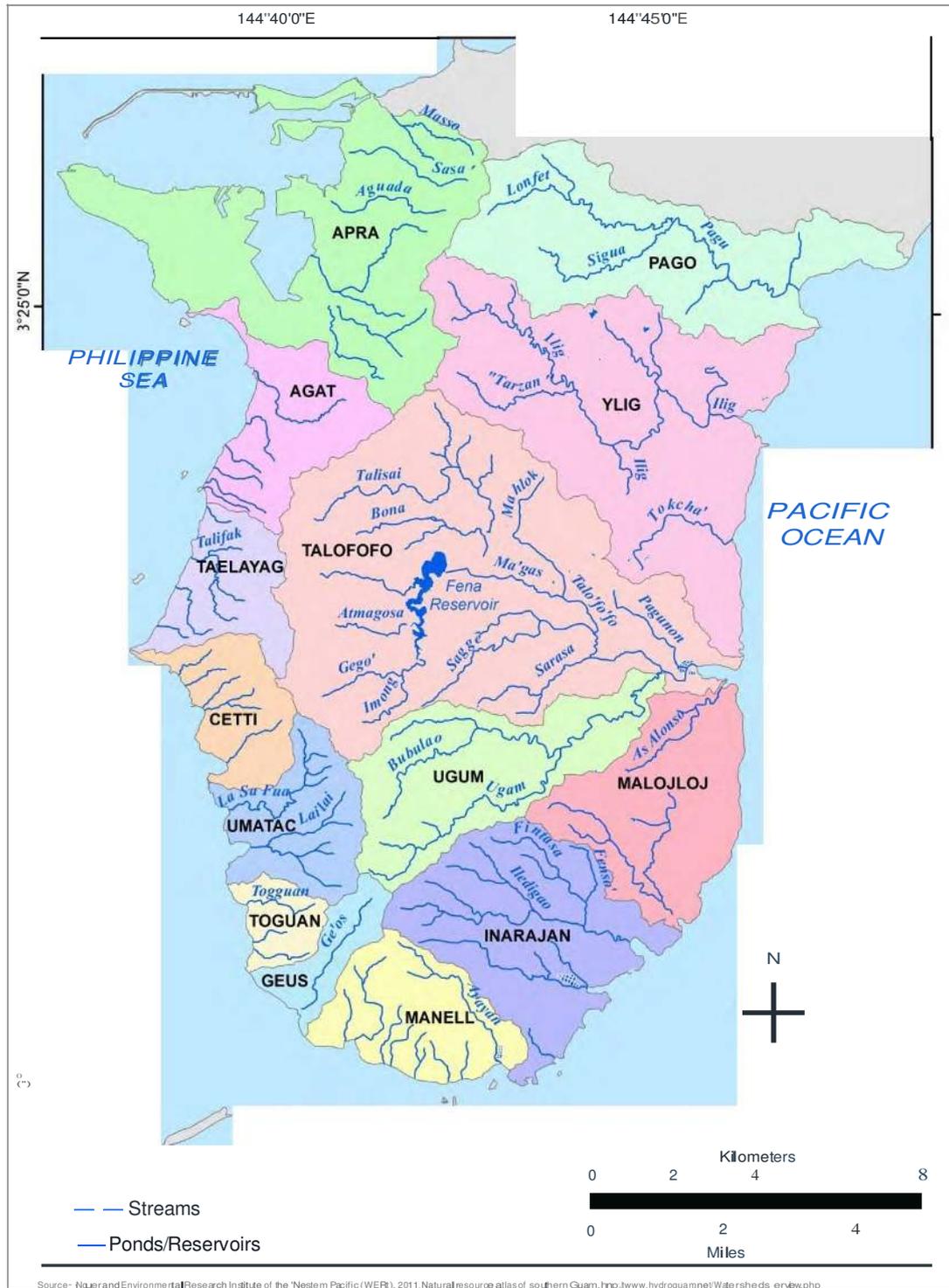


Figure 5. Streams and watersheds of southern Guam.

Commonwealth of the Northern Mariana Islands

Background

Surface-freshwater resources in the CNMI are limited primarily to the islands of Saipan and Rota. The only other island of CNMI with freshwater habitats of significance is Tinian.

Freshwater Habitats of the CNMI

Saipan

Although Saipan has no continuously perennial streams (permanently flowing to the ocean), several semi-permanent pools and perennially flowing stream sections support freshwater aquatic biota (Best and Davidson 1981). Additionally, there are several important wetlands situated largely along the Western Coastal Plain, the most significant of which is Lake Susupe, a mixed brackish and freshwater wetland approximately 17 hectares (42 acres) in surface-water extent during normal water levels; this system consists of a series of intermittent potholes that result in lake fluctuations depending on stage, but the wetland is perennial (Carruth 2003; McKagan et al. 2009). Lake Susupe and the large contiguous reed marsh and swamp on the western coastal plain of Saipan comprise over 60% of the freshwater wetlands in the CNMI (Stinson 1993).

The U.S. Geological Survey (USGS) recognizes eleven different watersheds on Saipan based on a 14-digit Hydrologic Unit Code (HUC) scale (CNMI-UWAWG 1998). Historical

information on freshwater habitats and associated aquatic fauna of Saipan is relatively limited (Best 1981; Best and Davidson 1981). A recent comprehensive survey documented the status of these habitats and the distribution and relevant biology of both introduced and native species (McKagan et al. 2009).

Rota

About five streams originate from limestone caves on the southern area of Rota, yet there is confusion about the names of some of these streams (Best and Davidson 1981). The maximum elevation of Rota is 491 m (1,612 ft) on Mount Manira. The karst geology and groundwater resources of Rota have been investigated (Stafford et al. 2002; Carruth 2005), but there appear to be few studies of surface water resources.

Tinian

Lake Hagoi is a natural open-water and wetland area with a surface area of about 17 hectares (36.3 acres) located near the northern end of the island. Other than Lake Hagoi, there are no perennial or intermittent streams or lakes on Tinian (Best and Davidson 1981).

Federated States of Micronesia

Background

Climate throughout the region is warm tropical and rainfall is generally abundant. Thus, climatic conditions combined with topography contributes to complex and diverse freshwater ecosystems. A series of hydrologic studies conducted by the USGS in cooperation with FSM institutions provide detailed baseline information about freshwater resources of the region (van der Brug 1983a, b, 1984a, b; Anthony 1991, 1992, 1993; Anthony and Spengler 1993; Hamlin and Takasaki 1996). A bibliography of FSM water resource studies was compiled by Winter (1993).

Surficial freshwater resources on these islands are primarily associated with those having high topographic relief, principally the main islands of each of the legislative states: Chuuk, Kosrae, Pohnpei, and Yap. The main freshwater resources of the FSM are rivers and streams. Wetlands of the FSM were reviewed by Dahl (1993) and include mangrove forests (85% of a total of about 100 km² [38.7 m²] for all islands combined), swamp forests (7%), freshwater marshes (6%), ivory nut palm forests (1.4%), and saline marshes (<1%).

Freshwater Habitats of FSM: Chuuk State

Within the five island groups of Chuuk State, the Chuuk Island group is the largest, and is a complex of volcanic, mountainous islands surrounded by smaller, low-lying islands; these mountainous islands contain the greatest extent of surficial freshwater habitats, mostly streams, with relatively small drainage areas. The highest elevation is the summit of Mount Winipot, at 445 m (1,460 ft) above mean sea level on the island of Tol. The other four major island groups are clusters of coral atolls that lack surface water runoff but have groundwater lenses that fluctuate with rainfall and freshwater infiltration (Hamlin and Takasaki 1996). Water supply on the inhabited outer islands is obtained through rainwater catchment systems and shallow wells that provide fresh to brackish water.

Freshwater Habitats of FSM: Kosrae State

The island has streams that drain radially from the interior, many with large drainage size relative to the area of the island. Data pertaining to drainage areas, elevation and geocoordinates of gaging stations, and discharge of rivers on Kosrae were summarized by van der Brug (1984a).

Freshwater Habitats of FSM: Pohnpei State

The topography of Pohnpei Island and heavy rainfall results in steep-gradient streams that flow to the coasts, and many of the streams have spectacular cascading waterfalls. Extensive data for air and stream temperatures, rainfall, and river discharge were summarized by van der Brug (1984b).

Freshwater Habitats of FSM: Yap State

Streams on Tomil-Gagil are perennial, but streams on Yap Island are dry about three months of the year. The dry season extends from December through April, and July through October is the wettest period. Hydrologic and other physical information for the island group was summarized by van der Brug (1983b). Nutrient characteristics of various inland water bodies of Yap Island were examined by Sanger and Hopper (1989).

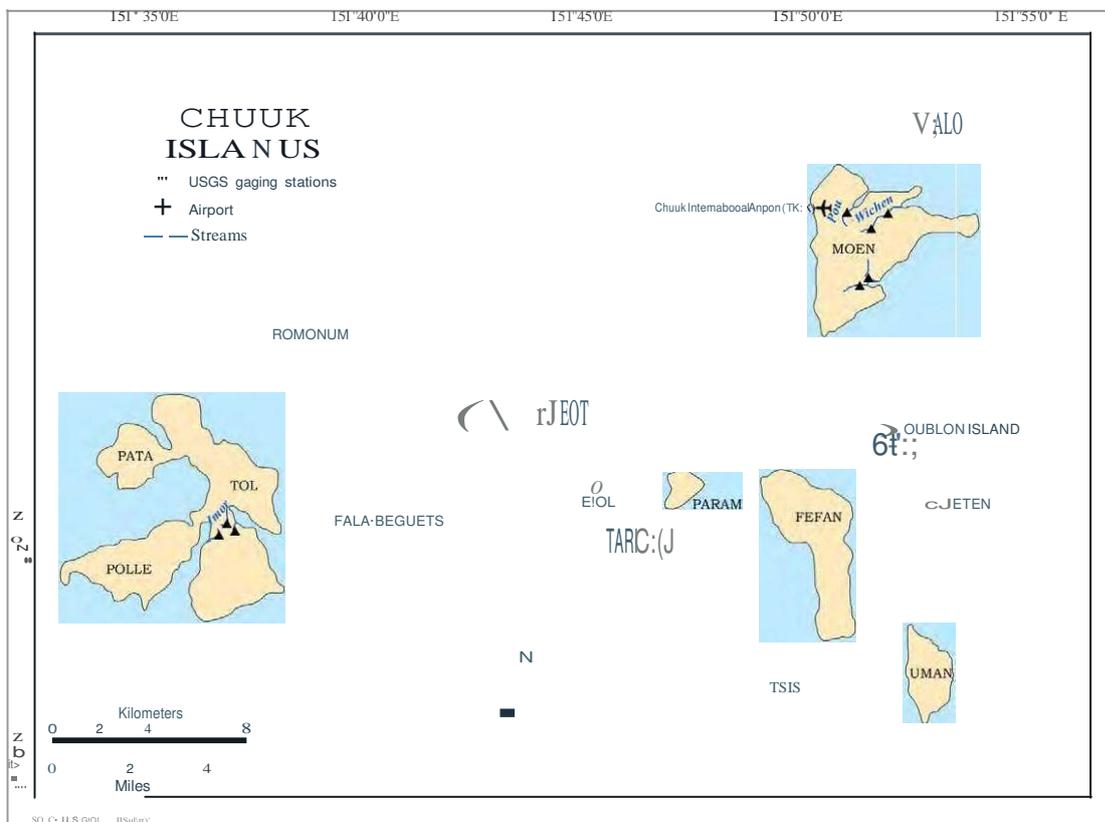


Figure 6. Chuuk Islands and location of U.S. Geological Survey gaging stations where streamflow data were obtained as summarized by van der Brug (1983a).

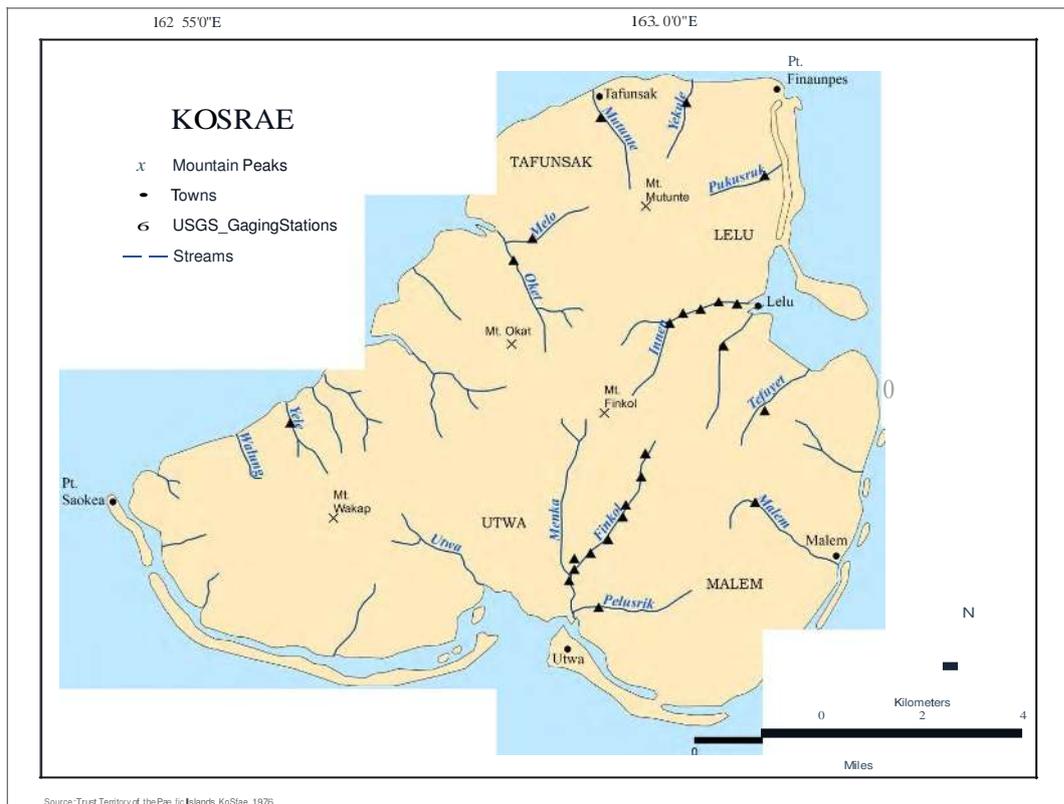


Figure 7. Streams of Kosrae and location of U.S. Geological Survey gaging stations where streamflow data were obtained as summarized by van der Brug (1984a).

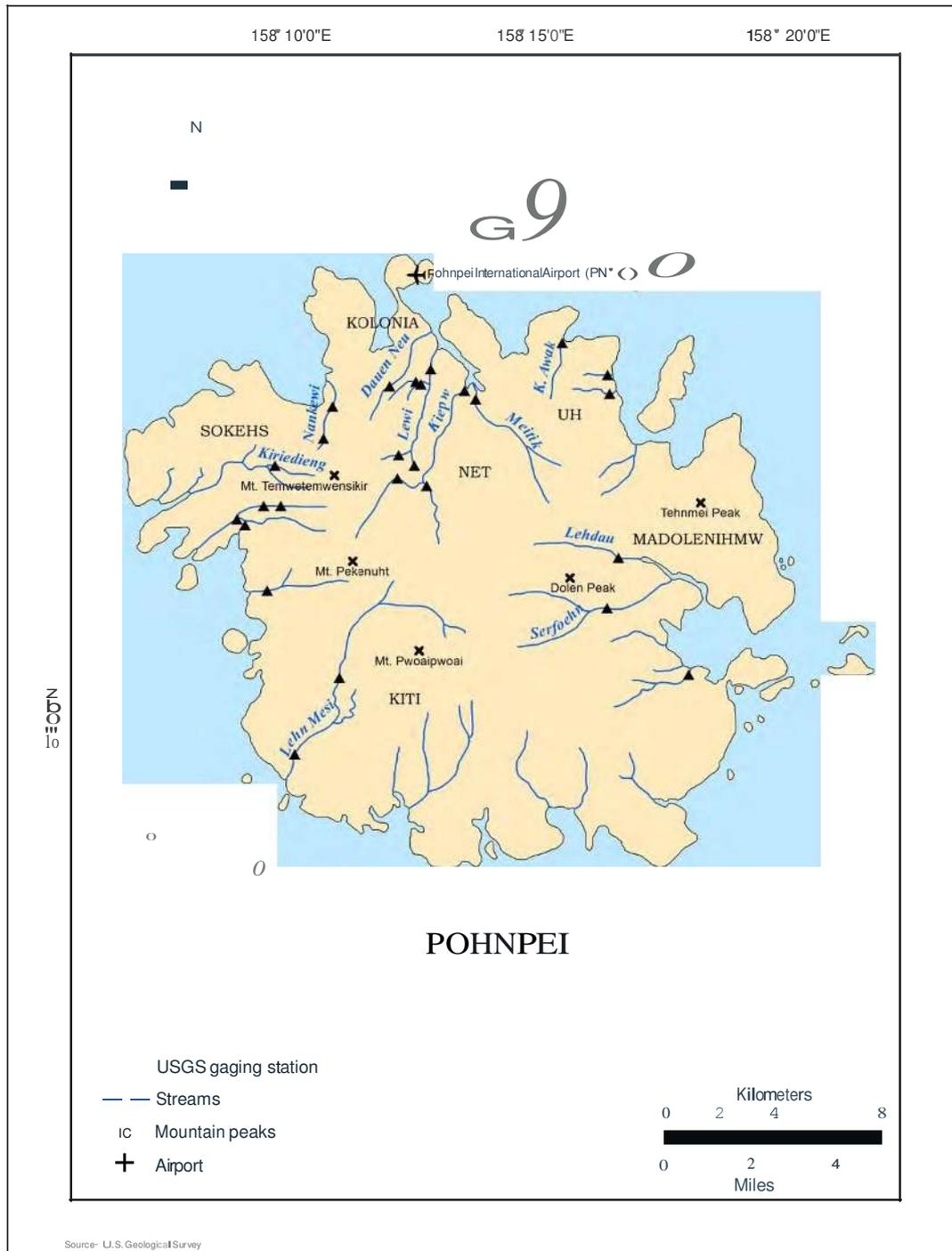


Figure 8. Major streams of Pohnpei and location of U.S. Geological Survey gaging stations where streamflow data were obtained as summarized by van der Brug (1984b).

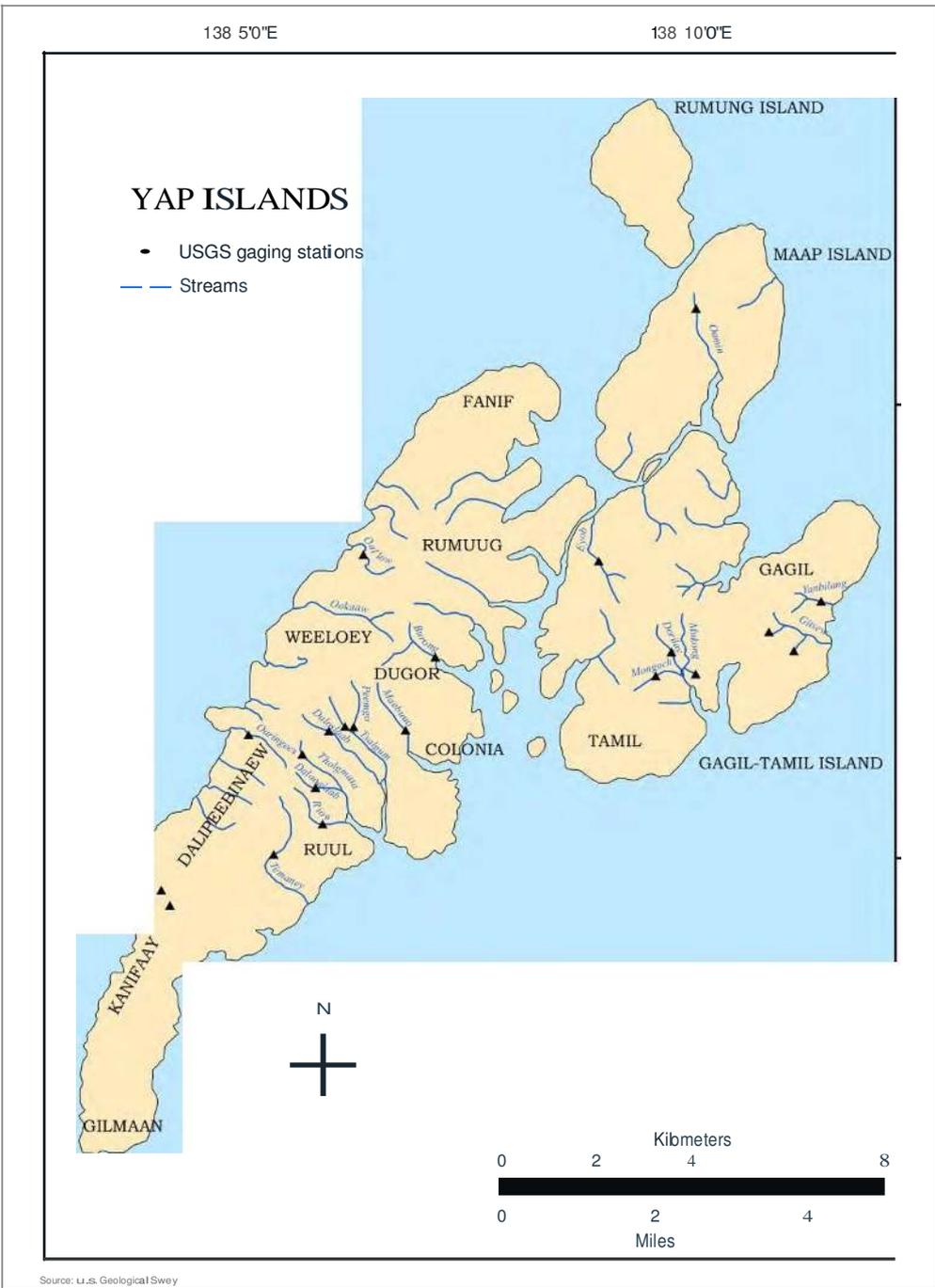


Figure 9. Yap Islands and location of U.S. Geological Survey gaging stations where streamflow data were obtained as summarized by van der Brug (1983b).

Palau

Freshwater Habitats of Palau

In Palau, streams are present only on the volcanic islands and are most highly developed on Babeldaob; streams on the other islands are small and usually dry part of the year. The largest lotic system is Ngerdorch River on Babeldaob, with a drainage area of about 47 km² (18 mi²). Lake Ngardok on the North Fork of the Ngerdorch River is the largest natural lake in Micronesia, with a length of about 732 m (2,400 ft), maximum width of about 183 m (600 ft), depth of about 2.7 m (8.9 ft), and a total surface area of about 493 hectares (1,218 acres).

Lake Ngardok and the surrounding streams, marshes, and swamp forests have been collectively designated as a Ramsar Convention on Wetlands international site (RCS 2006) and are part of a conservation reserve to protect indigenous species, including a small breeding

population of the Convention on International Trade in Endangered Species (CITES)-listed estuarine crocodile, *Crocodylus porosus*, numerous birds, fruit bats, freshwater fishes, aquatic plants, and other fauna and flora. The natural wetlands of Palau are diverse and include freshwater marshes, savannah wetlands, lowland swamps with low or high canopy, riparian wetlands, coastal saline marshes, mangrove forests, and cultivated wetlands used to grow taro (Scott 1993). There are also a number of artificial water bodies, including flooded bomb craters and phosphate quarries, roadside ditches, ponds, and reservoirs. The majority of the population in Koror is supplied by water from the Koror/Airai Public Water System (PWS) in southern Babeldaob; the main source of water is from the 75,000 m³ (20-million-gallon) capacity Ngerimel Dam and Reservoir (Kingston 2004).

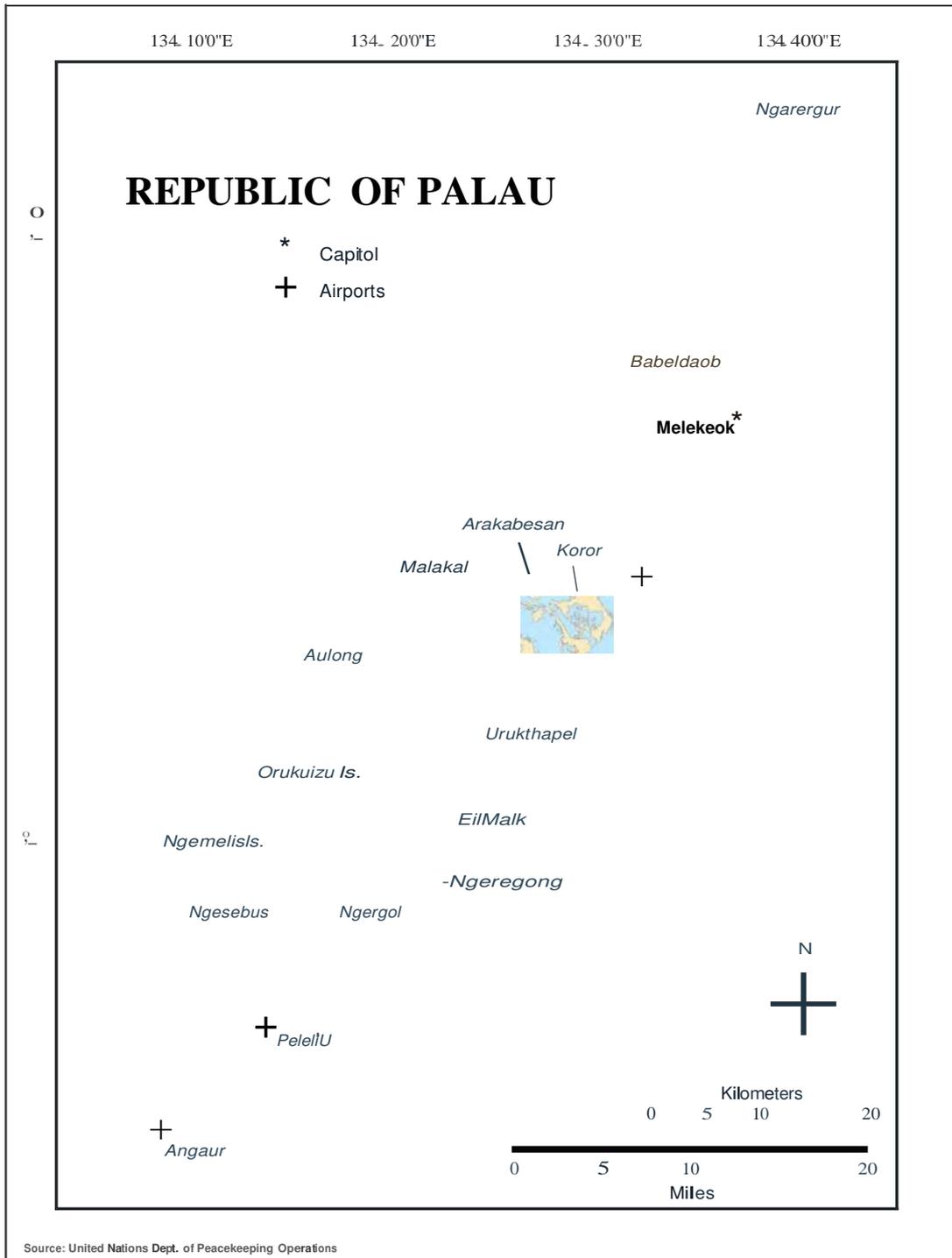


Figure 10. Republic of Palau, western Caroline Islands.

Native Freshwater Fauna

Natural freshwater habitats of Micronesian islands have relatively depauperate aquatic faunas in comparison to continental faunas, yet endemism is generally high. The most prominent freshwater animals are fishes and macroinvertebrates. The family Gobiidae is the most common and diverse group of native fishes present in freshwater streams of the Micronesian islands. This group is also the most species-rich fish family in the world, and one that has colonized many inland waters on islands throughout the tropical Pacific (Ryan 1991). The most diverse and abundant invertebrates in streams and rivers of Micronesian islands are primarily atyid and palaemonid shrimps, neritid and thiarid gastropods, and larval insects.

Most of the fishes, mollusks, and crustaceans inhabiting Micronesian inland waters are migratory, euryhaline, or primarily marine. Euryhaline species normally inhabit estuaries or the open sea, but commonly enter fresh water. In contrast, primarily marine species are those that only occasionally or very rarely enter fresh waters. Those species that complete part of their life cycle in freshwater are diadromous; they use both freshwater and marine or brackish habitats during their life cycle. Most of the diadromous fish, decapod crustaceans and gastropod mollusks in Micronesia exhibit a distinctive form of diadromy referred to as amphidromy. Amphidromous species have the following characteristics: adult reproduction in fresh water; downstream passage or drifting of eggs or newly hatched larvae to the sea; a period of feeding and growing at sea; and juveniles or adults that return to fresh water to spend additional time feeding, growing, maturing, and reproducing (e.g., McDowall 1988; Kinzie 1990; Keith 2003; McDowall 2004; Evenhuis and Fitzsimons 2005; Fitzsimons et al. 2007; Iguchi 2007; McDowall 2007).

In contrast to amphidromy, some diadromous species are catadromous, spawning at sea and migrating up streams and rivers as juveniles or adults where they feed and mature. Many of the amphidromous and catadromous species that inhabit the Pacific islands have exceptional abilities to ascend rivers, often reaching high elevations above waterfalls (Fitzsimons et al. 2007). However, lack of anatomical and behavioral specializations in some species precludes them from ascending above the first impassable waterfall of a system, thereby limiting their freshwater occurrence to downstream segments of streams or rivers.

The presence of a marine larval stage of development has profound implications for the genetic connectivity of Micronesian stream fauna within and between islands. Donaldson and Myers (2002) analyzed the native fish faunas of different Micronesian islands, comparing differences in taxonomic richness and faunal similarities relative to island size and topographic relief. Patterns of species richness and similarity were compared using cluster analyses with pooled groups of (1) amphidromous, catadromous, euryhaline, and marine (ACEM) species; and (2) amphidromous and catadromous (ACFW) species. The taxonomic richness of both ACEM and ACFW assemblages was found to be greatest on large islands with high elevations compared to smaller islands with high elevations and islands of all sizes with low elevations only (Table 3). A comparison of similarity indices for ACEM species revealed two faunal components consisting of high and low islands, with two additional components partitioned between a Mariana Islands cluster and a Caroline Islands cluster (Fig. 11). However, the analysis of islands based on ACFW species was more complex, consisting of a cluster of low islands and small high islands in the Carolines island chain, with limited freshwater habitat, and a second cluster partitioned into high islands and low islands that reflected the influence of both size and geography. In terms of their ecology, behavior, and distribution within the

river-sea continuum, the anadromous and catadromous fishes throughout Oceania (encompassing Hawaii and Micronesia) are quite similar and share taxonomic affinities (Fitzsimons et al. 2002).

Table 3. Species richness of fishes from insular localities in Micronesia (Donaldson and Myers 2002).

	Palau	Yap	Ifaluk/Woleai	Chuuk	Pohnpei	Kapingamarangi	Kosrae	Marshalls	Marianas	Total
Amphidromous and catadromous	55	8	2	4	21	1	19	19	0	77
Euryhaline	50	10	8	5	23	7	6	24	9	65
Marine	8	4	0	2	7	1	4	18	0	24
Total species	113	22	10	11	52	9	29	61	9	166

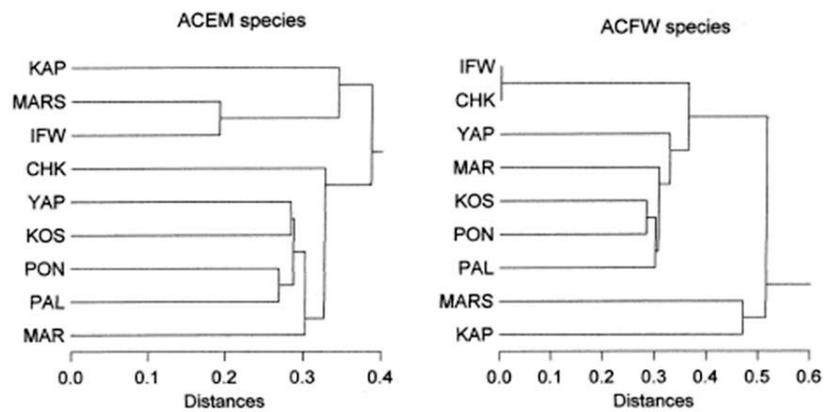


Figure 11. Cluster dendrograms among island groups indicating faunal similarities of native fishes occurring in Micronesian fresh waters, based on Sorensen Qualitative Similarity Index, a method robust for qualitative presence/absence data (Donaldson and Myers 2002). ACEM: amphidromous, catadromous, euryhaline, marine; ACFW: amphidromous and catadromous only.

Mariana Islands

Myers and Donaldson (2003) provided a comprehensive, annotated checklist of fishes of the Mariana Islands and adjacent territorial waters. They reported a total of 1,106 species, of which 1,020 were inshore or epipelagic, represented mainly by coral reef inhabitants. Only nine species were reported as occurring exclusively in fresh water as adults, representing four families (Anguillidae, Eleotridae, Gobiidae, and Kuhlidae), but when all sources are considered, 12 species of these groups are listed for freshwater habitats of the Mariana Islands (Table 4). Many additional species that primarily occur in marine or estuarine habitats occasionally or regularly penetrate streams within or beyond the tidal zone, in some cases, naturally dispersing as far upstream as the first major downstream waterfall. There is uncertainty as to how many different species require freshwater habitats as part of their life history, because it is unclear as to which and how many species of *Eleotris* may occur in these habitats in the Mariana Islands (Table 4, footnote). Of the freshwater species, two gobies (*Stiphodon* sp. and *Sicyopus* sp.) are distributed only in the southern Mariana Islands and one (*Stenogobius* sp.) has been reported only from Guam; the other species are likely distributed throughout the remainder of the Mariana Islands. *Awaous ocellaris* is included in Guam's Comprehensive Wildlife Conservation Strategy (DAWR 2006). However, Watson (1992) noted misidentifications of *Awaous* species associated with the Pacific Plate; *A. ocellaris* is known from French Polynesia westward to the Solomon Islands, whereas *A. guamensis* ranges from Hawaii and the Mariana Islands southward to Vanuatu, New Caledonia, and Fiji.

The crustacean fauna of freshwater habitats in the Mariana Islands is dominated by small (< 4 mm), amphidromous shrimps of the family Atyidae (nine species, although a few may not be valid taxa). Other decapod crustaceans inhabiting inland waters of the Mariana Islands include members of the shrimp family Palaemonidae (two species) and members of the crab family Varunidae (three species) (Chace 1983; Leberer and Cai 2003; Paulay et al. 2003) (Table 5). At least six atyid shrimp species are found on the island of Guam (Leberer and Cai 2003). Most of the atyids present on Guam and other Mariana Islands are also found on islands throughout the Indo-Pacific region. The atyids are herbivores or detritivores and occur in a wide range of habitats, including inland fresh water, brackish and anchialine sites (Leberer and Cai 2003). Species of *Atyoida* and *Atyopsis* occur in shallow-water areas with high current, whereas *Caridina* species are found in slow-moving, deeper waters (DAWR 2006). There are at least two hypogean atyids found in caves and sinkholes on Guam (including anchialine caves). The two native palaemonid prawn species known from fresh waters of the Mariana Islands belong to the genus *Macrobrachium* (Table 5). These shrimp are omnivores and capable of surviving in intermittent headwaters, often representing the only aquatic fauna in such locations. Crabs in freshwater habitats of the Mariana Islands are an under-studied and inconspicuous component of the fauna (DAWR 2006), but there appear to be at least three species representing the family Varunidae (Paulay et al. 2003).

The gastropods of Guam were reviewed by Roth (1976) and Smith (2003). Inland waters of the island have at least 17 species of native prosobranch snails in two families, the Neritidae and Thiaridae (Table 6) (Smith 2003; DAWR 2006). The neritids are amphidromous, and adults in freshwater are herbivorous, feeding on algae and diatoms growing on hard substrates. The thiarids are typically found on sand or soft substrates, are omnivorous and feed on both plant and animal matter, and complete their entire life cycle in fresh water.

During the course of this study, aquatic insects were surveyed from a variety of habitats on Guam; a total of 35 aquatic insect species were collected. Three species of aquatic Heteroptera collected are island endemics: *Limnogonus lundbladi*, *Microvelia mariannarum*, and *Saldula guamensis*. A complete list of species, collecting sites, and other summary information for this insect survey is provided in **Appendix 3**.

The Mariana Islands have no native amphibians or aquatic or semi-aquatic reptiles.

Table 4. Native fishes of inland waters of the Mariana Islands (Kami et al. 1968; Myers and Donaldson 2003; DAWR 2006).

Family	Species	Common name
Anguillidae	<i>Anguilla bicolor pacifica</i> Schmidt 1928	Indian short-finned eel
	<i>Anguilla marmorata</i> Quoy & Gaimard 1824	marbled freshwater eel
Eleotridae	<i>Eleotris fusca</i> ^a (Bloch & Schneider 1891)	dusky sleeper
	<i>Eleotris</i> sp. ^b	---
	<i>Oxyeleotris</i> sp. ^c	---
Gobiidae	<i>Awaous guamensis</i> (Valenciennes 1837)	Guam goby
	<i>Awaous ocellaris</i> (Broussonet 1782)	---
	<i>Sicyopterus lagocephalus</i> (Pallas 1774)	red tailed goby
	<i>Sicyopus</i> sp.	red belly freshwater goby
	<i>Stenogobius</i> sp.	Marianas goby
	<i>Stiphodon percnopterygionus</i> Watson & Chen 1998	dark finned goby
	<i>Stiphodon</i> sp.	emerald river goby
Kuhliidae	<i>Kuhlia rupestris</i> (Lacepède 1802)	rock flagtail

^a Taxonomic identification and number of species of *Eleotris* occurring in fresh waters of Guam and elsewhere in Micronesia is in question (B. Tibbatts, DAWR, written commun., 2011). Most early accounts cite presence of *E. fusca*. Myers and Donaldson (2003) listed *E. fusca* as presumed misidentification under *E. acanthopoma* Bleeker 1853 but did not treat this species as occurring exclusively in fresh waters as adults.

^b Hypogean species reported from a single cave on Guam.

^c Collected from Guam during present study; provisional identification.

Table 5. Native decapod crustaceans of inland waters of the Mariana Islands (Leberer and Cai 2003; Paulay et al. 2003). [See footnotes for alternative nomenclature as provided by the Integrated Taxonomic Information System (ITIS; <http://www.itis.gov/>). Common names from ITIS database]

Family	Species	Common name
Atyidae	<i>Antecaridina lauensis</i> Edmondson 1935 ^a	Lauan anchialine shrimp
	<i>Atyoida pilipes</i> (Newport 1847) ^b	koros shrimp
	<i>Atyoida serrata</i> (Bate 1888) ^c	
	<i>Atyopsis spinipes</i> (Newport 1847) ^d	soldier brush shrimp
	<i>Caridina brachydactyla</i> (de Man 1908) ^e	
	<i>Caridina mertonii</i> Roux 1911 ^f	
	<i>Caridina typus</i> H. Milne-Edwards 1837 ^g	
	<i>Halocaridinides trigonophthalma</i> (Fujino & Shokita 1975) ^h	
	<i>Halocaridinides</i> sp. ⁱ	
Palaemonidae	<i>Macrobrachium lar</i> (Fabricius 1798)	monkey river prawn
	<i>Macrobrachium</i> sp. ^j	
Varunidae	<i>Orcovita mollitia</i> Ng, Guinot, Iliffe 1996	
	<i>Ptychognathus</i> sp.	
	<i>Varuna litterata</i> (Fabricius 1798)	

^a A hypogean species in anchialine caves; widespread in Indo-Pacific region; name not included in ITIS.

^b Recorded from Mariana Islands in general; as *Atya pilipes* Newport 1847 in ITIS.

^c Dubious record possibly based on misidentification; name not included in ITIS.

^d Dubious record possibly based on misidentification; as *Atya spinipes* Newport 1847 in ITIS.

^e Previously recorded from Guam as *C. longirostris* H. Milne-Edwards 1837 and in need of further study; considered by some authors as a variety of *C. nilotica*; name not included in ITIS.

^f Previously recorded from Guam as *C. nilotica* (Roux 1833), *C. weberi* de Man 1892, and *C. serratiostris* de Man 1892; name not included in ITIS.

^g Recorded from Mariana Islands in general without specific island identified.

^h A hypogean species; Leberer and Cai (2003) speculated that individuals of this taxon reported by Maciolek (1983) likely represented the undescribed congeneric species; name not included in ITIS.

ⁱ A hypogean species under study (Leberer and Cai 2003).

^j DAWR (2006) listed *M. latimanus* (Von Martens 1868) for Guam, a widespread Indo-Pacific species; however, Nelson et al. (1996) reported that this species has not been recorded from either Guam or Palau.

Table 6. Native aquatic gastropods of inland waters of Guam (Smith 2003; DAWR 2006).

Family	Species	
Neritidae	<i>Clithon corona</i> (Linnaeus 1758)	
	<i>Clithon oualaniensis</i> (Lesson 1831)	
	<i>Clithon sowerbianus</i> (Récluz 1843)	
	<i>Neritina auriculata</i> Lamarck 1822	
	<i>Neritina pullicida</i>	
	<i>Neritina pulligera</i> Linnaeus 1767	
	<i>Neritina squamipicta</i> Récluz 1843	
	<i>Neritina turrita</i> (Gmelin 1791) <i>Neritina</i>	
	<i>variegata</i> (Lesson 1831) <i>Neritodryas</i>	
	<i>subsulcata</i> (Sowerby 1836) <i>Septaria</i>	
	<i>lineata</i> (Lamarck 1816)	
	Thiaridae	<i>Melanoides riqueti</i> (Grateloup 1840)
		<i>Melanoides tuberculata</i> (Müller 1774)
<i>Stenomelania plicaria</i> (Born 1780)		
<i>Thiara granifera</i> Lamarck 1816		
<i>Thiara scabra</i> Müller 1774		

Federated States of Micronesia

The numbers of species of amphidromous and catadromous native fishes from islands groups of the FSM reported by Donaldson and Myers (2002) were as follows: Chuuk, 4 species; Yap, 8 species; Kosrae, 19 species; and Pohnpei, 21 species. However, these numbers are provisional, because information concerning taxonomy and life history is incomplete and some areas have been inadequately surveyed. As elsewhere in Oceania, gobiids and eleotrids are the most species-rich groups in inland waters. Eels of the genus *Anguilla* are the most conspicuous catadromous fish species.

The first comprehensive survey of stream macrofauna in the eastern Caroline Islands was conducted in the Nanpil Kiepw River of Pohnpei (Maciolek and Ford 1987). In that survey, 15 fish species representing five families were collected. Of seven species of Gobiidae reported by these investigators, five were previously undescribed scydiines of the genera *Sicyopterus* and *Stiphodon*, four of which were subsequently described (Parenti and Maciolek 1993). Additional surveys of Pohnpei improved documentation of the diversity, distribution, and ecology of gobies inhabiting streams of the island and revealed the presence of two others, including at least one as-yet undescribed species of *Lentipes* (Nelson et al. 1996; Buden et al. 2001b). At least three of the goby species on Pohnpei are considered endemic. The herbivorous *Stiphodon caeruleus* is the most abundant and widespread goby on the island. Nelson et al. (1996) found significant differences in density of gobies between rivers and habitats, but these investigators found no significant river-habitat interaction in their statistical analysis, indicating that fish were not randomly distributed among habitats but that their habitat use was similar between streams. Riverine fish faunas of other islands in the FSM have been less intensively studied than those of Pohnpei, but some endemism, particularly in the scydiine gobies, is known. Fish species occurring in streams and rivers of the large FSM islands are listed in Table 7.

Maciolek and Ford (1987) collected at least 28 species of invertebrates in their survey of the Nanpil Kiepw River, Pohnpei (11 crustaceans, 11 gastropods, five insects, and one annelid) (Table 8). A subsequent survey of headwater streams on Pohnpei yielded five different native shrimp taxa: two species of *Macrobrachium* and three species of atyids (Buden et al. 2001a). All of the species reported by Buden et al. (2001a) and many of those reported by Maciolek and Ford (1987) are widely distributed across the Indo-Pacific region. Maciolek and Ford (1987) noted additional insects known elsewhere on Pohnpei, typically occurring in quiet water habitats or stream areas less subjected to extreme flow fluctuations; these included odonates, caddisflies, dytiscid and hydrophilid beetles, mesoveliid bugs, and dipterans.

In recent years there have been a number of field surveys conducted on FSM islands to describe and document the odonate fauna (dragonflies and damselflies), especially of the winged adults (Buden and Paulson 2003; Paulson and Buden 2003; Buden 2004; Buden and Paulson 2007). A trend exists that corresponds with general island biogeography theory. Species richness of odonates decreases across the Micronesian archipelago from west to east (i.e., diversity diminishes farther from source areas), and larger islands have the greatest diversity (Paulson and Buden 2003). However, an exception is Pohnpei, to the east, which has high species richness, and is unique among the Caroline Islands in having six sympatric species of a single genus, *Teinobasis*. Eight of the 15 odonate species on Pohnpei are endemic (Paulson and Buden 2003). The odonate fauna of the large Micronesian island groups is summarized in Table 9.

Aquatic surveys of Yap Island provided information about native freshwater fishes, gastropods, crustaceans and insects (Nelson 1989a). At least eight native fish species representing seven families occur in Yap's streams and marshes: *Anguilla marmorata pacifica*, *Eleotris fuscus*, *Ophieleotris aporos*, *Periophthalmus vulgaris*, *Kuhlia rupestris*, *Scatophagus argus*, *Toxotes jaculator*, and *Ambassis* sp. (Nelson and Hopper 1989). Fourteen species of freshwater and brackish water gastropods were found in lotic and lentic habitats such as streams, ponds, taro plantations, mangrove swamps, and drainage ditches (Smith 1989). As throughout Micronesia, species of the families Neritidae and Thiaridae were dominant in freshwater habitats of Yap Island. *Neritina variegata*, *Melanoides plicaria*, and *Melanoides tuberculata* were the most abundant and widespread aquatic gastropods, occurring on rock, mud, and leaf-litter substrates. Likewise, the crustacean fauna of Yap Island includes at least eight species of atyid, palaemonid, and grapsid decapods. The atyid *Cardina typus* was found to be the most abundant and widespread decapod in freshwater habitats, typically occurring within about 1 to 2 km of the sea (Bright 1989). A survey of aquatic insects in freshwater habitats of Yap Island resulted in collection of about 50 species, with the greatest abundance and taxonomic richness present in lentic habitats and the lowest in streams (Schreiner and Nafus 1989). There appears to be relatively few, if any, endemic freshwater species on Yap Island, although there is need for additional surveys and critical taxonomic studies.

Freshwater faunistic studies of other FSM island groups are limited. General benthic surveys of some streams on Kosrae have been completed, but results have yet to be reported (B. Tibbatts, DAWR, and R.A. MacKenzie, U.S. Forest Service, oral commun., 2010). The freshwater faunas of the large islands of Chuuk remain poorly documented; surveys of these islands present special challenges for researchers due to logistics and various social and cultural impediments (B. Lynch, College of Micronesia, oral commun., 2010).

Table 7. Stream fishes of large islands of the Federated States of Micronesia (Maciolek and Ford 1987; Parenti and Maciolek 1993; Nelson et al. 1996; Buden et al. 2001b; Donaldson and Myers 2002). [A few species are omitted if their habitat occurrence is primarily mangrove, estuarine, or tidal reach within fresh water. Common names from FishBase® (Froese and Pauly 2011).]

Family	Species	Common name
Ambassidae	<i>Ambassis buruensis</i> Bleeker 1856	Buru glass perchlet
Anguillidae	<i>Anguilla bicolor pacifica</i> Schmidt 1928	Indian short-finned eel
	<i>Anguilla marmorata</i> Quoy & Gaimard 1824	marbled freshwater eel
Eleotridae	<i>Bunaka gyrinoides</i> (Bleeker 1853)	greenback guavina
	<i>Butis amboinensis</i> (Bleeker 1853)	olive flathead gudgeon
	<i>Eleotris fusca</i> (Forster 1801)	dusky sleeper
	<i>Ophieleotris aporos</i> (Bleeker 1854)	snakehead gudgeon
	<i>Ophiocara porocephala</i> (Valenciennes 1837)	spangled sleeper
	<i>Oxyeleotris lineolatus</i> (Steindachner 1867)	sleepy cod
Gobiidae	<i>Glossogobius celebius</i> (Valenciennes 1837)	Celebes goby
	<i>Glossogobius giurus</i> (Hamilton 1822)	tank goby
	<i>Lentipes</i> sp. (from Pohnpei)	---
	<i>Mugilogobius cavifrons</i> (Weber 1909)	mangrove goby
	<i>Redigobius bikolanus</i> (Herre 1927)	speckled goby
	<i>Redigobius tambujon</i> (Bleeker 1854) ^a	---
	<i>Sicyopterus eudentata</i> Parenti & Maciolek 1993	---
	<i>Sicyopterus lividus</i> Parenti & Maciolek 1993	---
	<i>Sicyopterus</i> sp. (from Kosrae)	---
	<i>Sicyopus nigriradiatus</i> Parenti & Maciolek 1993	---
	<i>Stenogobius</i> sp. (from Chuuk)	---
	<i>Stiphodon caeruleus</i> Parenti & Maciolek 1993	---
	<i>Stiphodon</i> sp. (from Kosrae)	---
Kuhliidae	<i>Kuhlia marginata</i> (Cuvier 1829)	dark-margined flagtail
	<i>Kuhlia rupestris</i> (Lacepède 1802)	rock flagtail
Syngnathidae	<i>Hippichthys spicifer</i> (Rüppell 1838)	bellybarred pipefish
	<i>Microphis retzii</i> (Bleeker 1856)	ragged-tail pipefish

^a Donaldson and Myers (2002) listed *Redigobius roemeri* for Pohnpei, but this species is considered a synonym of *R. tambujon* (Eschmeyer 2011).

Table 8. Native aquatic macroinvertebrates of the Nanpil Kieww River and other streams of Pohnpai reported by Maciolek and Ford (1987), updated to reflect current taxonomy and nomenclature.

Phylum/Order	Family	Taxon	Source of taxonomic authority	
Annelida-Polychaeta	Nereidae	<i>Ceratonereis</i> sp. Kinberg 1866	ITIS (http://www.itis.gov/)	
Crustacea-Amphipoda	Corophiidae	<i>Grandidierella</i> sp. Coutière 1904	ITIS (http://www.itis.gov/)	
Crustacea-Decapoda	Atyidae	<i>Atyopsis pinipes</i> (Newport 1847)	Leberer and Cai (2003)	
		<i>Atyoida pilipes</i> (Newport 1847)	Leberer and Cai (2003)	
		<i>Caridina brachydactyla</i> de Man 1908	Leberer and Cai (Leberer and Cai 2003)	
		<i>Caridina longirostris</i> H. Milne-Edwards 1837	Leberer and Cai (2003)	
		<i>Caridina typus</i> H. Milne-Edwards 1837	Leberer and Cai (2003)	
		<i>Caridina vitiensis</i> Borradaile 1898	Karge et al. (2010)	
		<i>Caridina weberi</i> de Man 1892	Leberer and Cai (2003)	
		Palaemonidae	<i>Macrobrachium lar</i> (J.C. Fabricius 1798)	ITIS (http://www.itis.gov/)
			<i>Marcobrachium latimanus</i> (Von Martens 1868)	ITIS (http://www.itis.gov/)
			Grapsidae	<i>Parasesarma</i> sp. De Man 1895
Insecta-Hemiptera	Gerridae	<i>Halobates mariannarum</i> Esaki 1924	http://www.marinespecies.org/index.php	
Insecta-Lepidoptera	Pylalidae	<i>Petrophila</i> (?) sp. ^a Guilding 1830	ITIS (http://www.itis.gov/)	
	Cosmopterigidae	Unidentified sp.		
Insecta-Diptera	Chironomidae	Unidentified spp.		
Insecta-Trichoptera	Hydrophilidae	<i>Oxyethira</i> sp. Eaton 1873	ITIS (http://www.itis.gov/)	
Mollusca-Gastropoda	Neritidae	<i>Clithon corona</i> (Linnaeus 1758)	http://neritopsine.lifedesks.org/	
		<i>Neritina petiti</i> (Récluz 1841)	http://neritopsine.lifedesks.org/	
		<i>Neritina pulligera</i> (Linnaeus 1767)	http://neritopsine.lifedesks.org/	
		<i>Neritodryas subsulcata</i> (Sowerby 1836)	http://neritopsine.lifedesks.org/	
		<i>Neritona macgillivrayi</i> (Reeve 1855)	http://neritopsine.lifedesks.org/	
		<i>Septaria lineata</i> (Lamarck 1816)	http://www.sealifebase.org/	
		<i>Septaria porcellana</i> (Linnaeus 1758)	http://neritopsine.lifedesks.org/	
		<i>Septaria sanguisuga</i> (Reeve 1856)	http://neritopsine.lifedesks.org/	
		<i>Vittina variegata</i> (Lesson 1831)	http://neritopsine.lifedesks.org/	
		Thiaridae	<i>Melanoides tuberculatus</i> (Müller 1774)	ITIS (http://www.itis.gov/)
			<i>Thiara scabra</i> Müller 1774	http://www.sealifebase.org/

^a Given as *Parargyactis* (?) sp. In Maciolek and Ford (1987); genus cited as junior synonym in ITIS.

Table 9. Native species of Odonata in Micronesia and distribution by island group (Paulson and Buden 2003).

Family	Species	Palau	Yap	Chuuk	Pohnpei	Kosrae
Platycnemididae	<i>Drepanosticta palauensis</i> Lieftinck 1962	X				
	<i>Agriocnemis femina femina</i> (Brauer 1868)	X	X			
	<i>Ischnura aurora</i> (Brauer 1865)	X	X	X	X	X
	<i>Ischnura heterosticta</i> (Burmeister 1839)	X				
	<i>Pseudagrion palauense</i> Lieftinck 1962	X				
	<i>Teinobasis aerides</i> Lieftinck 1962				X	
	<i>Teinobasis ariel</i> Lieftinck 1962				X	
	<i>Teinobasis budeni</i> Paulson 2003				X	
	<i>Teinobasis carolinensis</i> Lieftinck 1962			X		
	<i>Teinobasis fortis</i> Lieftinck 1962				X	
	<i>Teinobasis nigrolutea</i> Lieftinck 1962				X	
	<i>Teinobasis palauensis</i> Lieftinck 1962	X				
	<i>Teinobasis ponapensis</i> Lieftinck 1962				X	
Aeshnidae	<i>Anaciaeschna jaspidea</i> (Burmeister 1839)	X	X			
	<i>Anax guttatus</i> (Burmeister 1839)	X			X	X
Cordulidae	<i>Hemicordulia erico</i> Asahina 1940					X
	<i>Hemicordulia haluco</i> Asahina 1940				X	
	<i>Hemicordulia lulico</i> Asahina 1940	X	X			
Libellulidae	<i>Agrionoptera cardinalis</i> Lieftinck 1962	X				
	<i>Agrionoptera insignis yapensis</i> Lieftinck 1962		X			
	<i>Agrionoptera sanguinolenta sanguinolenta</i> Lieftinck 1962				X	
	<i>Agrionoptera sanguinolenta pusilla</i> Lieftinck 1962			X		
	<i>Diplacodes bipunctata</i> (Brauer 1865)	X	X	X	X	X
	<i>Macrodiplax cora</i> (Brauer 1867)	X	X			
	<i>Neurothemis terminata</i> Ris 1911	X	X			
	<i>Pacificothemis esakii</i> Asahina 1940				X	
	<i>Pantala flavescens</i> (Fabricius 1798)	X	X		X	X
	<i>Rhyothemis phyllis vitellina</i> Brauer 1868	X	X			
	<i>Tholymis tillarga</i> (Fabricius 1798)	X	X	X	X	X
	<i>Tramea loewii</i> Brauer 1866		X			
	<i>Tramea transmarina euryale</i> Selys 1876	X	X			
<i>Tramea transmarina propinqua</i> Lieftinck 1962			X	X	X	
<i>Zyxomma petiolatum</i> Rambur 1842	X					
Total species		18	13	6	15	7

Palau

Fehlmann (1960) conducted a detailed study that provided information on the identification and distribution of fishes and invertebrates inhabiting Arakitaoch Stream on the island of Babeldaob. Based on faunal gradient and stream characteristics, four different reaches or zones were recognized: mangrove, lower graded, cascade, and source. Subsequent to Fehlmann's study, a synoptic checklist of the inland fishes of Palau was published in which a total of 43 native species representing 18 families were enumerated, including four introduced species (Bright and June 1981) (Table 10). Several of the species listed by these authors are primarily marine or estuarine; their occasional occurrence in rivers is confined to downstream tidal reaches and mangrove areas. Species richness was greatest for gobies (12 species) and sleepers (9 species). As noted by Bright and June (1981), the most extensive habitat suitable for diadromous or freshwater species in Palau are the streams and rivers of Babeldaob. However, there are also intermittent streams on Koror and Arakabesang, and on all three islands there are additional freshwater habitats that support aquatic communities.

An intensive, quantitative survey of freshwater fishes was conducted in the upper reaches of Babeldaob's Ngermeskang River, one of Palau's largest inland drainages (Nelson et al. 1995). These investigators obtained density estimates for 13 species, based largely on visual surveys conducted by snorkelers (although a few specimens were collected with nets and a backpack electroshocker) to aid in verifying visual survey identifications. Maximum densities of selected gobiid fish ranged from 0.4 individuals per m² for *Redigobius bikolanus* to more than 11.0 individuals per m² for female *Stiphodon elegans*, with the highest mean density of 5.2 individuals per m² for the latter. There was a distinct difference in community composition between river segments below and above the large Ngermeskang Waterfall (Table 11). Fishes (e.g., *Kuhlia* spp.) incapable of ascending steep waterfalls were confined to the downstream reaches. Nelson et al. (1995) provided quantitative evidence to support the qualitative observations of Fehlmann (1960) that habitat type defined by relative water column velocity (riffle, run, and pool) as well as substrate (cobble, boulder, and bedrock) are determinants of the distribution and abundance of native fishes in these high-gradient rivers and streams.

Fehlmann (1960) documented the invertebrate fauna of Arakitaoch Stream, principally in the mangrove, lower graded, and cascade sections. Several species of crustaceans and mollusks, including all bivalves collected, were only present in mangrove areas. As in other regions of Micronesia, the freshwater fauna was dominated by atyid and palaemonid shrimps and thiarid and neritid snails. The atyid shrimps present were composed of only one or a few species of *Atya* or a related genus, and these were found to be most abundant in the cascade zone (Fehlmann 1960). Palaemonids were identified as one or two species of *Macrobrachium* (most likely including *M. lar*). Gastropods in the lower graded zone were limited to *Neritina pulligera*, in moderate abundance, and *Thiara amarula* in low abundance. The cascade zone had the greatest snail species richness, which in decreasing order of abundance was as follows: *Neritina pulligera*, *N. cornea*, *N. variegata*, *Stenomelania* sp. cf. *hastula*, and *T. amarula*. Only *N. cornea* was found in the source zone and was in lower abundance than in the cascade zone.

During the course of this study, aquatic insects were surveyed from a variety of habitats on Palau, mostly Babeldaob streams; we collected a total of 28 aquatic insect species. We conservatively estimated that at least four island endemics were present, including three damselflies (*Drepanosticta palauensis*, *Pseudagrion palauense*, and *Teinobasis palauensis*) and

a gyrid (whirligig) beetle, *Dineutus (Spinodineutes) sp. cf. heterandrus*. An *Ischnura* damselfly found in lentic habitats on Palau was not identified conclusively, but, because it is not a widespread species such as *Ischnura aurora* or *Agriocnemus femina femina*, it is likely that it at least is indigenous if not possibly endemic to Palau. A complete list of species, collecting sites, and other summary information for this insect survey is provided in Appendix 3.

Palau has Micronesia's only native amphibian, the Palau frog *Platymantis pelewensis*, found throughout all but the southwest islands and endemic to the Palau archipelago, from Kayangel Atoll in the north to Angaur in the south. Although not considered to be aquatic (there is no tadpole stage and breeding is in terrestrial habitats), the species is common to abundant and is found in a variety of habitats, thriving in human-inhabited areas and often reaching very high densities in caves and abandoned war bunkers (Crombie and Pregill 1999). The Palau frog has direct development (Atoda 1950), but detailed information about reproduction and other aspects of its natural history is limited (Crombie and Pregill 1999).

The saltwater or estuarine crocodile (*Crocodylus porosus*) is native to Palau, although its numbers have declined in recent history. In the 1960s, there were systematic efforts to eradicate saltwater crocodiles from Palau as a result of attacks on humans. There have been persistent rumors that other crocodile species are present on Palau, presumably based partly on the possibility that some non-native crocodiles imported to the island in the 1930s may have escaped (Crombie and Pregill 1999). There are a few confirmed and some unconfirmed reports of saltwater crocodiles in the Caroline Islands outside of Palau. Their presence on these other islands is likely the result of natural dispersal (island hopping) across expanses of sea as waifs. Such events are considered rare; for example, there is a single record of a 380 cm (12.5 ft) male crocodile captured on the island of Pohnpei, about 1,360 km (845 mi) to the north of the Bismark Archipelago and 2,400 km (1,490 mi) to the east of Palau where this species is native (Allen 1974; Eldredge 1994; Crombie and Pregill 1999; Buden 2000).

Table 10. Native and nonindigenous fish species reported by Bright and June (1981) from inland waters of Palau, updated to reflect changes in taxonomy and nomenclature. [Nonindigenous species shaded in gray]

Family	Species	Common name
Albulidae	unidentified larvae	---
Ambassidae	<i>Ambassis interruptus</i> Bleeker 1852	long-spined glass perchlet
Anguillidae	<i>Anguilla bicolor pacifica</i> Schmidt 1928	Indian short-finned eel
	<i>Anguilla marmorata</i> Quoy & Gaimard 1824	giant mottled eel
Antennariidae	<i>Antennarius nummifer</i> (Cuvier 1817)	spotfin frogfish
Cobitidae	<i>Misgurnus anguillicaudatus</i> (Cantor 1842)	Oriental weatherfish
Cyprinidae	<i>Puntius sealei</i> (Herre 1933)	---
Eleotridae	<i>Bunaka gyrinoides</i> (Bleeker 1853)	greenback guavina
	<i>Butis amboinensis</i> (Bleeker 1853)	olive flathead gudgeon
	<i>Eleotris fusca</i> (Forster 1801)	dusky sleeper
	<i>Eleotris melanosoma</i> Bleeker 1852	broadhead sleeper
	<i>Giuris margaritacea</i> (Valenciennes 1837)	snakehead gudgeon
	<i>Hypseleotris cyprinoides</i> (Valenciennes 1837)	tropical carp gudgeon
	<i>Hypseleotris guentheri</i> (Bleeker 1875)	rainbow gudgeon
	<i>Ophiocara porocephala</i> (Valenciennes 1873)	spangled sleeper

Table 10. Native and nonindigenous fish species reported by Bright and June (1981) from inland waters of Palau, updated to reflect changes in taxonomy and nomenclature. [Nonindigenous species shaded in gray]

Family	Species	Common name
	<i>Oxyeleotris</i> sp. ^a	---
	<i>Xenisthmus</i> sp.	---
Gobiidae	<i>Awaous grammepomus</i> (Bleeker)	scribbled goby
	<i>Glossogobius celebius</i> (Valenciennes 1837)	Celebes goby
	<i>Mugiligobius</i> sp.	---
	<i>Pandaka</i> sp.	---
	<i>Pseudogobius javanicus</i> (Bleeker 1856)	---
	<i>Redigobius balteatus</i> (Herre 1935) ^b	rhinohorn goby
	<i>Redigobius bikolanus</i> (Herre 1927)	speckled goby
	<i>Redigobius oyensi</i> (de Beaufort 1913) ^c	---
	<i>Redigobius tambujon</i> (Bleeker 1854) ^c	---
	<i>Sicyopterus micrurus</i> (Bleeker 1853)	clinging goby
	<i>Sicyopus zosterophorus</i> (Bleeker 1857)	ornate goby
	<i>Smilocycopus fehlmanni</i> (Parenti & Maciolek 1993)	---
	<i>Stenogobius fehlmanni</i> (Valenciennes 1837)	chinstripe goby
	<i>Stiphodon elegans</i> (Steindachner 1879)	---
Kraemeriidae	<i>Kraemia cunicularia</i> Rofen 1858	transparent sand dart
Kuhliidae	<i>Kuhlia marginata</i> (Cuvier 1829)	dark-margined flagtail
	<i>Kuhlia rupestris</i> (Lacepède 1802)	rock flagtail
Megalopidae	<i>Megalops cyprinoides</i> (Broussonet 1782)	Indo-Pacific tarpon
Moringuidae	<i>Moringua</i> sp.	---
Mugilidae	<i>Liza melinoptera</i> (Valenciennes 1836)	otomebora mullet
Muraenidae	<i>Gymnothorax polyuranodon</i> (Bleeker 1853)	freshwater moray
Poeciliidae	<i>Poecilia reticulata</i> (Peters 1859)	guppy
	<i>Xiphophorus maculatus</i> (Günther 1866)	southern platyfish
Scatophagidae	<i>Scatophagus argus</i> (Linnaeus 1766)	spotted scat
Synbranchidae	<i>Ophisternon bengalense</i> McClelland 1844	Bengal eel
Syngnathidae	<i>Hippichthys spicifer</i> (Rüppell 1838)	bellybarred pipefish
	<i>Microphis brachyurus</i> (Bleeker 1853)	short-tailed pipefish
	<i>Microphis brevidorsalis</i> (de Beaufort 1913)	stream pipefish
	<i>Microphis leiaspis</i> (Bleeker 1853)	barhead pipefish

^a Provisional identification based on specimens collected from the present study; not reported by Bright and June (1981) or Fehlmann (1960).

^b Listed by Larson (2010) from Palau; not reported by Bright and June (1981).

^c Bright and June (1981) included both *R. tambujon* and *R. sapangus*, but these two species are considered to be synonyms (Eschmeyer 2011).

Table 11. Distribution of native freshwater fishes in the Ngermeskang River, Palau, along a habitat gradient spanning a major waterfall. [Data based on results of field surveys conducted by Nelson et al. (1995). Methods involved visual census conducted by shoreline observers and by underwater observers using mask and snorkel. Occurrence by reach based on whether species was detected during survey: +, present; -, absent.]

Family	Species	Below Fall	Above Fall	Headwaters
Anguillidae	<i>Anguilla marmorata</i>	+	+	-
Eleotridae	<i>Bunaka gyrinoides</i>	-	+	-
Eleotridae	<i>Giuris margaritacea</i>	-	+	+
Gobiidae	<i>Glossogobius celebius</i>	+	+	+
	<i>Redigobius bikolanus</i>	+	-	-
	<i>Sicyopus</i> sp.1 (red male)	+	+	+
	<i>Sicyopus</i> sp. 2 (striped male)	-	+	-
	<i>Sicyopus</i> spp. (females)	+	+	+
	<i>Sicyopus zosterophorum</i>	-	+	-
	<i>Stiphodon caeruleus</i> ^a	-	+	+
	<i>Stiphodon elegans</i>	+	+	+
Kuhliidae	<i>Kuhlia marginata</i>	+	-	-
	<i>Kuhlia rupestris</i>	+	-	-
Toxotidae	<i>Toxotes jaculatrix</i>	+	-	-

^a Species described from Pohnpei (Parenti and Maciolek 1993); identification requires confirmation by qualified taxonomist.

Introduced Freshwater Fauna

Mollusks

A variety of nonindigenous aquatic mollusks, mostly gastropods (snails), have been introduced to inland waters of Pacific islands. Recent reviews of mollusk introductions to the region summarized information on both terrestrial and aquatic nonindigenous snails and on the single nonindigenous freshwater bivalve introduced to the region, the Asian freshwater clam (*Corbicula fluminea*) (Cowie 2000b, a). Considerable evidence indicates that many of the native Pacific insular gastropod faunas are being homogenized by the introduction and spread of invasive snails (Cowie 1998a, 2000b). Among nonindigenous species, some have been introduced intentionally and others accidentally. By virtue of their diversity, endemism, and limited dispersal capabilities, the native terrestrial gastropod faunas of tropical Pacific islands are disappearing, and are particularly threatened by nonindigenous mollusks. In contrast to native terrestrial snails, the native freshwater snail fauna of tropical Pacific islands consist of relatively few species and many have wider geographic distributions. Consequently, the native freshwater snail fauna is generally less imperiled overall than that of the terrestrial fauna; however, they also are threatened by introduced species and other factors.

The most notable introductions of freshwater gastropods in the Pacific are apple snails (Ampullariidae) of the genera *Pomacea* and *Pila*. Among terrestrial and aquatic mollusks, “channeled” or “golden” apple snail, *Pomacea canaliculata* is considered an especially harmful pest (Cowie et al. 2009). The taxonomy of ampullarids is inadequately resolved; some species are difficult to distinguish based on morphology, and species identifications of some introduced populations, when investigated closely, may reveal greater diversity and more complex history of introductions than initially recognized (Rawlings et al. 2007). Apple snails (especially *P. canaliculata*) have been widely introduced around the world as food and for aquaculture (Eldredge 1994; Cowie 1998b; Lach and Cowie 1999; Cowie 2000b; Cowie et al. 2007). They are also popular among aquarists (Perera and Walls 1996). Both aquatic and terrestrial species may also be associated with transport via the horticulture industry. When introduced to tropical areas outside of their native ranges, apple snails may become serious agricultural pests on cultivated crops such as taro and rice (Naylor 1996; Cowie 2002; Qiu and Kwong 2009). Apple snails in Micronesia are present on Guam and in the CNMI; on Guam they were first observed in the 1980s (Smith 2003). The ampullarid snail *Pila conica* was introduced to Palau in the mid-1980s, but was thought to have been eradicated by 1987 (Eldredge 1994). Both *Pomacea canaliculata* and *Pila conica* are intermediate hosts for several parasites of humans and their potential as vectors of human disease should not be overlooked.

Additional freshwater snail species have been introduced to Guam, including *Fossaria viridis* (Quoy and Gaimard) and at least one viviparid and two planorbid species (Eldredge 1994; Cowie 2000b). Most of these introductions are thought to have been accidental or intentional releases associated with the aquarium trade.

Invasive snails and other mollusks receive relatively little attention, but they can have important impacts on agriculture, biodiversity, and human health, and can become major public nuisances (Cowie et al. 2009). Negative impacts to native species on Pacific islands appear varied but are generally not well studied. Some predatory terrestrial snails have been intentionally introduced in misguided efforts to use them as biocontrol agents, resulting in severe depredation of native species (Cowie 1998b). Introduced snails in all habitats are also implicated in the decline of native snails through competition. Additionally, concerns often arise over

introductions of gastropods due to the fact that many species may serve as intermediate hosts for parasites that are transmissible to humans or livestock (Madsen and Frandsen 1989; Eldredge 1994).

No records were found to indicate that bivalve mollusks have been introduced to Micronesia. However, the freshwater Asiatic clam *Corbicula fluminea* is known from Hawaii (Cowie 2000b), and it has an extensive nonindigenous distribution in North America. Introductions of *C. fluminea* may have substantial ecological as well as economic impacts.

Crustaceans

A small number of freshwater decapod crustacean species have been introduced to inland waters of Pacific islands. At least five are considered established on at least one Pacific island: the giant river prawn (or giant freshwater prawn) *Macrobrachium rosenbergii* and giant Malaysian prawn *Macrobrachium lar* (both of the family Palaemonidae); the shrimp *Neocaridina denticulate sinensis* (Atyidae); the red swamp crawfish *Procambarus clarkii* (Cambaridae); and the Australian redclaw crayfish *Cherax quadricarinatus* (Parastacidae). To date, the only established wild populations are known from Hawaii (4 species) and New Caledonia (1 species). A few introductions have occurred on islands in Micronesia, including Guam and Palau, but without evidence of establishment in the wild (Eldredge 2000). The introduction of freshwater crustaceans to Pacific islands has typically been associated with aquaculture and the aquarium trade (Eldredge 2000).

The species of greatest interest in aquaculture has been the giant river prawn *Macrobrachium rosenbergii*, due to its large size and advanced culture technology. There has been long-standing confusion with its nomenclature that has been partly resolved by examination of morphological characters and use of modern genetic analyses (Wowor and Ng 2007; Iketani et al. 2011). Wowor and Ng (2007) recognized two distinct species for what has historically been regarded as the single species *M. rosenbergii* (and two subspecies according to some researchers), and distinguished them using discernible morphological characters. *Macrobrachium rosenbergii* (in the strict sense) occurs in Australia, Papua New Guinea, eastern Indonesia, and the Philippines. *Macrobrachium dacqueti*, an important food species extensively cultured in captivity and harvested from the wild, occurs throughout southern and southeastern Asia.

Eldredge (1994, 2000) provided a history of intentional introductions of *Macrobrachium* associated with aquaculture for Hawaii, Guam, Palau, and other regions of the Pacific. Movements of species have been in different directions. For instance, shipments of *M. rosenbergii* for aquaculture that originated in Hawaii (with original stock from Malaysia, and possibly elsewhere) were shipped to Guam, Palau, and a few South Pacific islands. Conversely, *M. lar*, which is native to Micronesia, was shipped from Guam to Hawaii, where it became established and now potentially competes with Hawaii's only native freshwater prawn, *M. grandimanus*.

Hawaii has other species of introduced crustaceans that are potentially of concern as possible risk to Micronesian islands. Atyid shrimps native to Southeast Asia are present on Oahu and likely escaped or were released by means of the aquarium trade (Englund and Cai 1999; Eldredge 2000). The freshwater crayfish *Procambarus clarkii* is also established in Hawaii, where it has had agricultural impacts (Eldredge 2000). Invasive crayfishes have had deleterious

ecological and economic impacts in places where they have been introduced outside of their native ranges (Gherardi 2007). Thus, from a biosecurity perspective for Micronesia, crayfishes should be considered high risk and subject to scrupulous monitoring.

Amphibians

Micronesia has only one native amphibian species, the Palau frog, *Platymantis pelewensis*, which is endemic to various islands of Palau where it is associated with freshwater environments, and reportedly, certain slightly brackish-water habitats (Crombie and Pregill 1999). However, a number of nonindigenous amphibians, mostly anurans (frogs and toads), have been introduced to Micronesia and several have become established, mostly on Guam (Table 12). The pathways by which nonindigenous amphibians have been introduced throughout many areas of the Pacific, as elsewhere in the world, are varied (Eldredge 1994; Pitt et al. 2005; Christy et al. 2007b; Kraus 2009b; USDA-APHIS 2010).

The first nonindigenous anuran to be introduced to the Pacific, and now one of the most widespread terrestrial vertebrates in the world, is the cane or marine toad, *Rhinella marina* (Easteal 1981; Eldredge 1994, 2000; Lever 2003; Kraus 2009a). In the Pacific, cane toads were first introduced to Hawaii, and were subsequently distributed extensively, and mostly intentionally, for biocontrol of various insect pests and garden slugs (e.g., *Veronicella leydigii*). Detailed historical accounts of introductions in Oceania have been summarized by various authors (e.g., Eldredge 1994; Crombie and Pregill 1999; Eldredge 2000; Lever 2003). The cane toad is now established virtually everywhere on the main island groups of Micronesia, and in some places it is extremely abundant. An extensive body of literature exists concerning the cane toad's global redistribution and its effects on native species and humans. The cane toad is not established on all islands within Micronesia and preventing its further spread may be valuable to consider.

There is general consensus that in many places where it has been introduced *R. marina* has had significant economic, ecological, and human-health impacts (Easteal 1981; Lever 2003). Ecological impacts include the following: (1) predation by cane toads on native invertebrates and vertebrates; (2) toxicity to native species that eat or come into contact with cane toads; (3) direct competition between cane toads and native species for food, spawning sites, and other resources; and (4) reduced native populations of species that provide natural controls of other pest species (Lever 2003). The list of impacts on human welfare is extensive, including, but not limited to the following: (1) pollution of potable water supplies, swimming pools, and other water resources; (2) blocking of drains by dead, decomposing toads; (3) death of domestic pets, and, although rare, humans; (4) erosion of earthen dams and berms by burrowing toads; (5) spread of human parasites, diseases, and other pathogens transmissible to humans (e.g., dysentery, *Salmonella*); (6) traffic hazards from dead toads on roadways; and (7) high costs of environmental monitoring, control, and mitigation programs.

Since 1937, at least 13 species of anurans have been introduced to Guam, six of which are known to have breeding populations. Eight species were reported for the first time from Guam between 2003 and 2005 (Christy et al. 2007a, b). The probable areas from which anuran species originated include Hawaii, Asia, Australia, the Philippines, and the continental United States. *Rhinella marina* is the only anuran that was intentionally introduced to Guam. The other species arrived by means of different vectors. Four species (*Kaloula picta*, *K. pulchra*, *Polypedates leucomystax*, and *Litoria fallax*) are known or suspected to have been transported on maritime or air-transport vessels. Two species that have direct development (i.e., with no aquatic

tadpole stage) are presumed to have been transported by means of the horticultural trade:

Eleutherodactylus coqui (not established) and *E. planirostris* (established). Specimens of *Pseudacris regilla* were recovered from shipments of Christmas trees and other agricultural products (it is also appropriate to note that other non-anuran amphibians [newts and salamanders] have reached Guam by means of this vector; D. Vice, DAWR, oral commun., 2010).

Analysis of commerce for the aquarium trade and for aquaculture suggested that the most likely means of introduction of five species, all of which are established on Guam, was by means of the aquaculture sector: *Fejervarya cancrivora*, *F. limnocharis*, *Microhyla pulchra*, *Polypedates megacephalus*, and *Rana guentheri* (Christy et al. 2007b). Most, if not all, of the introductions suspected to be associated with aquaculture likely arrived as unintended contaminants of broodstock fish or other aquaculture species, although the possibility of illegal introductions for use in the food trade cannot be dismissed.

Christy et al. (2007b) considered horticulture and aquaculture to be the primary pathways of concern for frogs arriving to Guam and potentially being disseminated to other Pacific islands. For these pathways, the life-history attributes of frogs may predispose them differentially to transport mechanisms and establishment success. Species without an aquatic larval stage may be readily transported as either eggs or adults in the absence of standing water (e.g. with horticultural products). Species with a tadpole stage could be transported in water (as eggs or larvae) as part of the transport vector (e.g., by means of the pet trade or aquaculture), and some of these could also be transported as adults on non-aqueous materials.

The Animal and Plant Health Inspection Service (APHIS) terrestrial wildlife team prepared a detailed risk assessment for nonindigenous frogs, other amphibians, and selected aquatic or semi-aquatic reptiles of greatest concern (USDA-APHIS 2010). In that assessment, the pet and food trade were identified as pathways of high risk for these taxonomic groups.

Reptiles

At least six species or subspecies of turtles that normally inhabit freshwater habitats have been introduced to Micronesia; most are confirmed as established on at least some islands (Table 13) (Leberer 2003). Mechanisms of introduction are varied; at least one species (*Pelodiscus sinensis*) was intentionally imported for food by means of the aquaculture pathway, whereas most others were likely released or escaped pets. Additionally, specimens of the terrestrial three-toed box turtle (*Terrapene carolina triunguis*), a species native to the southeastern continental United States, have been observed on Guam (McCoid 1992; Leberer 2003).

The most widespread nonindigenous turtle in Micronesia is the red-eared slider (*Trachemys scripta elegans*), a freshwater taxon native to the southern United States and subspecies of a species broadly distributed in the western hemisphere. The red-eared slider has become one of the most widespread reptiles in the world, largely as a result of its popularity, abundance, and broad dissemination in the pet trade (Lever 2003; Kraus 2009a). The first appearance of the red-eared slider in inland habitats on Guam is not clearly documented. Lever (2003), citing McCoid (1992) and Eldredge (1994), noted that it was first recorded from the municipality of Mangilao in 1991. However, McCoid (1999) speculated that it may have been introduced to Guam as early as the 1950s, whereas Leberer (2003) stated that this turtle may have been introduced to the island in the 1970s. Whether the authors were distinguishing between imported turtles versus occurrence in the wild is uncertain. Currently, the red-eared

slider is common in the wild throughout southern Guam, is regularly sold and traded as a pet, and even “used as prizes at island fiestas” (Leberer 2003). In addition to Guam, the red-eared slider is known from Lake Susupe on Saipan, where its status is uncertain (McCoid 1992; McKagan et al. 2009). A single specimen of this turtle subspecies was captured in the wild (at a dump site) on Pohnpei in 1997, without evidence of establishment (Buden 2000; Buden et al. 2001c). The red-eared slider has been present on the Hawaiian island of Oahu since 1980 where it is established in both lotic and lentic habitats (Devick 1991).

The Chinese softshell turtle (*Pelodiscus sinensis*; formerly known as *Trionyx sinensis sinensis*) was imported from Taiwan to Guam for aquaculture (FitzGerald 1982; Eldredge 1994; Leberer 2003; Lever 2003). The commercial venture to produce turtles for food failed within a year, and the surviving stock was either deliberately released or accidentally escaped. The species is now established in central and southern Guam (McCoid 1993; Eldredge 1994; Leberer 2003; Lever 2003).

There are reports, many unconfirmed, of other aquatic or semi-aquatic freshwater turtles from Guam, including common snapping turtle (*Chelydra serpentina*), Reeve’s turtle (*Mauremys reevesii*), Chinese stripe-necked turtle (*Mauremys sinensis*), and a mud turtle of the genus *Kinosternon*. These are presumed to have been pets that either accidentally escaped or were intentionally released (Leberer 2003); their status is unknown, and additional surveys are needed to determine if breeding populations exist on the island. A few other freshwater turtles are established or have been reported on other Pacific islands. For example, the wattle-necked softshell turtle (*Palea steindachneri*) is established on the Hawaiian islands of Kauai and Oahu (Yamamoto and Tagawa 2000; Ernst and Lovich 2009).

Possible negative ecological or economic consequences resulting from the presence of nonindigenous populations of freshwater turtles on Micronesian islands have not been fully assessed. However, based on what is known about the natural diets of the taxa involved, their presence in island inland waters could pose threats to native freshwater fishes and invertebrates (Lever 2003).

Table 12. Nonindigenous aquatic and semi-aquatic anurans (frogs and toads) introduced to Guam and other islands of Micronesia. [CNMI, Commonwealth of the Northern Mariana Islands; FSM, Federated States of Micronesia]

Family	Species	Common name ^a	Location	Status	Notes	Reference(s)
Bufonidae	<i>Rhinella marina</i> (Linnaeus 1758)	cane toad	FSM (Chuuk, Kosrae, Pohnpei, Yap)	Established		Buden (2007)
			Palau	Established		Crombie and Pregill (1999)
			Guam	Established		Rodda et al. (1991); Christy et al. (2007a,b)
			CNMI	Established		Rodda et al. (1991)
Dicroglossidae	<i>Fejervarya cancrivora</i> (Gravenhorst 1829)	crab-eating frog	Guam	Unknown		Christy et al. (2007a,b)
	<i>Fejervarya limnocharis</i> (Gravenhorst 1829)	alpine cricket frog	Guam	Established		Christy et al. (2007a,b)
Eleutherodactylidae	<i>Eleutherodactylus coqui</i> Thomas 1966	Coqui	Guam	Not established	Direct development (no aquatic larval stage)	Christy et al. (2007a,b)
	<i>Eleutherodactylus planirostris</i> (Cope 1862)	greenhouse frog	Guam	Established	Direct development (no aquatic larval stage)	Christy et al. (2007a,b)
Hylidae	<i>Litoria fallax</i> (Peters 1880)	eastern dwarf treefrog	Guam	Established		Rodda et al. (1991); Eldredge (2000); Christy et al. (2007a,b);
			Saipan	Unknown	No voucher; call heard by wildlife biologist	Rodda et al. (1991)
	<i>Pseudacris regilla</i> (Baird & Girard 1852)	Pacific treefrog	Guam	Not established		Christy et al. (2007a,b)
Microhylidae	<i>Kaloula picta</i> (Duméril & Bibron 1841)	slender-digit chorus frog	Guam	Not established		Christy et al. (2007a,b)
	<i>Kaloula pulchra</i> Gray 1831	Asian painted frog	Guam	Not Established		Christy et al. (2007a,b)

Table 12. Nonindigenous aquatic and semi-aquatic anurans (frogs and toads) introduced to Guam and other islands of Micronesia. [CNMI, Commonwealth of the Northern Mariana Islands; FSM, Federated States of Micronesia]

Family	Species	Common name ^a	Location	Status	Notes	Reference(s)
	<i>Microhyla pulchra</i> (Hallowell 1861)	beautiful pygmy frog	Guam	Unknown		Christy et al. (2007a,b)
Ranidae	<i>Rana guentheri</i> Boulenger 1882	Günther's amoy frog	Guam	Established		Christy et al. (2007a,b)
Rhacophoridae	<i>Polypedates leucomystax</i> (Gravenhorst 1829)	Asian brown tree frog	Guam	Not established		Christy et al. (2007a,b)
	<i>Polypedates megacephalus</i> Hallowell 1861	Hong Kong whipping frog	Guam	Established		Christy et al. (2007a,b)

^a Many different common names are in use; see APHIS (2010) for complete list for most species.

Table 13. Nonindigenous aquatic and semi-aquatic reptiles introduced to Micronesia.

Family	Species	Common Name	Location	Status	Notes	Reference(s)
Bataguridae	<i>Mauremys (Chinemys) reevesii</i> (Gray 1831)	Reeve's turtle; three-keeled pond turtle	Palau	Unknown	Species identification not confirmed (no voucher available)	Crombie and Pregill (1999)
			Guam	Not established	One record only, animal was in captivity in 2003	Leberer (2003)
	<i>Mauremys (Ocadia) sinensis</i> (Gray 1834)	Chinese stripe-necked turtle	FSM (Pohnpei)	Not established	One record only, specimen collected	Buden et al. (2001c)
			Guam	Unknown	Breeding status unknown	Leberer (2003)
Chelidae	Chelidae, genus and species undetermined		Palau	Unknown	No voucher specimen	Crombie and Pregill (1999)
Chelydridae	<i>Chelydra serpentina</i> (Linnaeus 1758)	common snapping turtle	Guam	Unknown	Breeding status unknown	Leberer (2003)
Emydidae	<i>Trachemys scripta elegans</i> (Wied-Neuwied 1839)	red-eared slider	FSM (Pohnpei)	Not established	One record only, animal was in captivity in 2001	Buden (2000); Buden et al. (2001c)
			Guam	Established		Leberer (2003)
			Saipan	Unknown	Breeding status unknown, but likely established	Rodda et al. (1991)
Kinosternidae	<i>Kinosternon</i> sp. Spix 1824	mud turtle	Guam	Not established	One record only in published literature (animal was in captivity in 2003); unverified specimen observed for sale in 2010 by roadside vendor (E. Wostl, USGS, oral commun., 2010)	Leberer (2003)
Trionychidae	<i>Pelodiscus sinensis</i> (Wiegmann 1834)	Chinese softshell	Guam	Established		Leberer (2003)

Fishes

A wide variety and large numbers of nonindigenous fishes have been introduced to freshwater habitats in Micronesia and other islands of Oceania. As a result, nonindigenous fishes are common on most islands in the region that have freshwater environments. In many areas nonindigenous fishes are the most abundant and visible group of introduced aquatic animals. Several publications have synthesized global or regional information on the distribution of nonindigenous fishes and other nonindigenous aquatic organisms. Most include annotated listings or accounts of species introduced to Micronesia or to specific island groups (Welcomme 1981; Maciolek 1984; Welcomme 1988; Nelson and Eldredge 1991; Munro 1993; Eldredge 1994, 2000). Additionally, databases exist that track distributional records of introduced species as reported in the literature or from other sources (Casal 2006; Froese and Pauly 2011). Hawaii has also had numerous introductions and establishment of freshwater fishes (Maciolek 1984; Devick 1991; Eldredge 1994; Yamamoto and Tagawa 2000; Mundy 2005). Some fishes were intentionally transported among many different Pacific islands, island groups, and mainland areas (e.g., Southeast Asia) and for many different reasons. For example, Nelson and Eldredge (1991) and Eldredge (1994) summarized intentional tilapia introductions to Pacific islands with putative sources and reasons for introduction, where known.

At least 25 nonindigenous freshwater or catadromous fish species or taxa have been introduced into the waters of Guam. Of these, 13 are known to be established (Tables 14-15). The source of these introductions is varied. Some species were intentionally stocked on Guam, especially in the Fena Reservoir and the Talofofu River, for sport fishing, as biological control agents, or both (e.g., *Oreochromis mossambicus*, *Micropterus salmoides*, *Cichla ocellaris*, *Ictalurus punctatus*, *Gambusia affinis*) (Brock and Takata 1956). Some species were initially held in aquaculture facilities and dispersed to inland waters and/or their spread was augmented by humans (e.g., *Clarias batrachus*, *Oreochromis mossambicus*, *Tilapia zillii*, and *Channa striata*). Other species may have been releases of aquarium fishes (e.g., *Betta pugnax*, *Astronotus ocellatus*, and *Poecilia reticulata*). Agana Springs and the adjacent marsh and swamp habitats are sites where aquatic pets and other nonindigenous species have been released or spread to (Randall et al. 1974; B. Tibbatts, DAWR, pers. comm.).

A recent survey for nonindigenous species on Saipan resulted in documentation of at least four different taxa of introduced fishes (McKagan et al. 2009) (Fig. 12; Tables 16, 17). Overall fish species richness at sites on Saipan was low, with most sites having two species or less. Moreover, native species appeared to have been displaced by nonindigenous species at disturbed sites.

In comparison to other island groups of the western and central Pacific (e.g., Hawaii and Fiji), there have been relatively few freshwater fish species introduced to Micronesian islands with the exception of Guam. Certain species or taxonomic groups (e.g., tilapiine cichlids and mosquitofishes) have been broadly introduced and in some areas have spread locally. In general there may have been fewer fish

introductions from west to east in the Carolines. At least five different nonindigenous fish species have been reported from inland waters of Palau (Table 10) (Bright and June 1981; Eldredge 2000; our own surveys). The most recent fish introduced to Palau was the Mozambique tilapia (*Oreochromis mossambicus*), to which the government responded by attempting to eradicate several localized populations that were discovered, in an effort that was partially successful (Nico and Walsh, in press). To date only two nonindigenous freshwater fish species (*O. mossambicus*, *Gambusia affinis*) are known from Pohnpei (B. Lynch and D. Buden, oral commun., 2010). A single species (*O. mossambicus*) has thus far been reported from Yap (Nelson and Hopper 1989).

Table 14. Nonindigenous freshwater fish species introduced to Guam. [Status codes: E = established in inland waters of Guam; NE = not established or insufficient information available. Known or presumed pathway of introduction: A = aquaculture (escapement or intentional release); S = stocked for sport fishing, biocontrol, and/or as forage; O = ornamental. Sources of data include Maciolek (1984), Eldredge (2000), and B. Tibbatts (DAWR, written commun., 2010)]

Status	Family	Scientific name	Common name	Source
NE	Anguillidae	<i>Anguilla bicolor pacifica</i> Schmidt 1928	Japanese eel	A
NE		<i>Anguilla rostrata</i> (Lesueur 1817)	American eel	A
NE	Ariidae	<i>Arius</i> sp. Valenciennes 1840	sea catfish	A?
NE	Centrarchidae	<i>Micropterus dolomieu</i> Lacepède 1802	smallmouth bass	S
NE		<i>Micropterus salmoides</i> (Lacepède 1802)	largemouth bass	S
NE	Centropomidae	<i>Lates calcarifer</i> (Bloch 1790)	barramundi	A
E	Channidae	<i>Channa striata</i> (Bloch 1793)	chevron snakehead	A
E	Cichlidae	<i>Astronotus ocellatus</i> (Agassiz 1831)	oscar	O
E		<i>Cichla ocellaris</i> ? Bloch & Schneider 1801 ^a	peacock cichlid	S
E		<i>Oreochromis mossambicus</i> (Peters 1852)	Mozambique tilapia	S
NE?		<i>Tilapia rendalli</i> (Boulenger 1897) ^b	redbreast tilapia	S
E		<i>Tilapia zillii</i> (Gervais 1848)	redbelly tilapia	S
E	Clariidae	<i>Clarias batrachus</i> (Linnaeus 1758)	walking catfish	A
E		<i>Clarias macrocephalus</i> Günther 1864	bighead catfish	A
NE	Cyprinidae	<i>Ctenopharyngodon idella</i> (Valenciennes 1844)	grass carp	A
E		<i>Cyprinus carpio</i> Linnaeus 1758	common carp, koi	O,S
NE		<i>Hypophthalmichthys nobilis</i> (Richardson 1845)	bighead carp	S
NE		<i>Puntius lateristriga</i> (Valenciennes 1842)	spanner barb	O
NE	Ictaluridae	<i>Ictalurus punctatus</i> (Rafinesque 1818)	channel catfish	S
E	Osphronemidae	<i>Betta pugnax</i> (Cantor 1849)	Penang betta	O
NE	Pangasiidae	<i>Pangasianodon hypophthalmus</i> (Sauvage 1878)	iridescent shark-catfish	A?
E	Poeciliidae	<i>Gambusia affinis</i> (Baird & Girard 1853)	eastern mosquitofish	S
E		<i>Poecilia latipinna</i> (Lesueur 1821)	sailfin molly	O
E		<i>Poecilia reticulata</i> Peters 1859	guppy	O,S
E		<i>Xiphophorus hellerii</i> Heckel 1848	green swordtail	O
NE		<i>Xiphophorus maculatus</i> (Günther 1866)	southern platyfish	O

^a In early reports the *Cichla* species introduced to Guam was identified as *C. ocellaris*; however, over recent years the genus *Cichla* has been extensively revised, calling into question the identity of introduced populations.

^b Nomenclature/taxonomy in question; some authors place in synonymy with *T. melanopleura*. Eldredge (2000) listed this taxon as established in Guam, but Maciolek (1984) did not.

Table 15. Distribution of established (reproducing) nonindigenous freshwater fishes on Guam by drainage (DAWR data courtesy of B. Tibbatts).

Drainage	<i>Channa striata</i>	<i>Cichla ocellaris</i>	<i>Clarias batrachus</i>	<i>Cyprinus carpio</i>	<i>Gambusia affinis</i>	<i>Oreochromis mossambicus</i>	<i>Poecilia reticulata</i>	<i>Tilapia zillii</i>	<i>Xiphophorus hellerii</i>	Total Species
Agana			X	X	X	X	X	X		6
Agfayan					X	X				2
Ajayan	X				X	X				3
Almagosa		X			X	X		X		4
Aplacho							X			1
Asalonso						X				1
Asan						X				1
Atantano					X		X			2
Big Guatali						X				1
Chaligan						X				1
Chaot			X	X	X	X	X	X		6
Finile							X			1
Fonte						X	X			2
Geus					X	X				2
Guatali							X			1
Imong		X			X	X	X	X		5
Inarajan					X	X				2
Laguas							X			1
Lonfit						X		X		2
Maagas		X	X			X		X		4
Manenggon						X		X		2
Masso			X		X	X	X			4
Maulap		X				X		X		3
Namo						X	X			2
Pago					X	X		X		3
Sadog		X			X	X	X	X		5
Salinas							X			1
Sasa						X				1
Small river on Mt. Santa Rosa					X		X			2
Talofoyo		X	X		X	X				4
Tarzan							X		X	2
Tinechong			X				X			2
Togcha (E)						X	X			2
Tolaeyuus			X							1
Ugum					X	X				2
Unnamed stream - tributary to Ugum			X			X				2
Ylig						X		X		2
Total drainages	1	6	8	2	15	27	17	11	1	

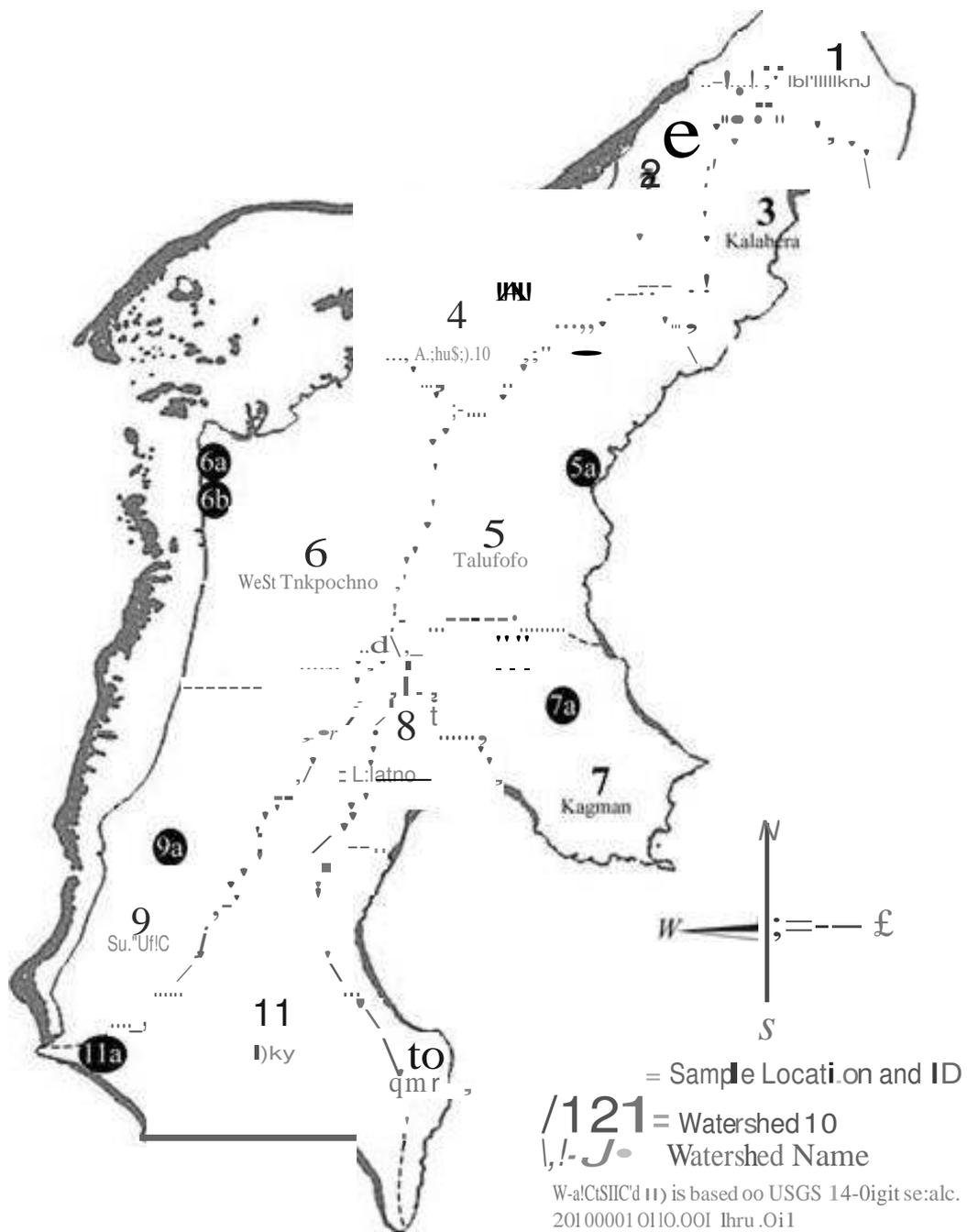


Figure 12. Watersheds of Saipan and sampling sites of species surveyed by Commonwealth of the Northern Mariana Islands (CNMI) Division of Fish and Wildlife (McKagan et al. 2009). See Table 16 for site geocoordinates.

Table 16. Freshwater sites on Saipan sampled for aquatic organisms by CNMI Division of Fish and Wildlife, with station numbers, names, and geocoordinate of each site (McKagan et al. 2009). [See Fig. 12 for location of sites; CNMI, Commonwealth of the Northern Mariana Islands]

Site no.	Site	Geocoordinates
2a	MCC Golf Course, Pond at Hole #6	15°15.75'N 145°47.69' E
3a	DPS Gun Range, Marsh	15°14.27'N 145°47.373' E
4a	Tanapeg, Bobo Achugao Stream	15°14.183'N 145°45.798' E
5a	Jeffry's Beach Stream	15°12.97'N 145°46.772' E
5b	Tegata's Upper Stream	15°13.811'N 145°46.35' E
6a	Garapan Slough at Fiesta Hotel	15°12.785'N 145°42.992' E
6b	Garapan Slough at Hafa Adai Hotel	15°12.493'N 145°42.983' E
7a	Kagman Mitigation Ditch	15°10.426'N 145°46.069' E
7b	Kagman Shrine, Upper Stream	15°10.915'N 145°45.828' E
9a	Lake Susupe	15°9.171'N 145°42.609' E
9b	Costco Marsh	15°10.227'N 145°42.833' E
11a	COP Golf Course, Pond at Hole #5	15°7.181'N 145°41.785' E

Table 17. Aquatic and semiaquatic animal species collected at freshwater sites on Saipan (McKagan et al. 2009). [See Table 16 and Fig. 12 for station information. Nonindigenous taxa indicated by shaded cells. A, anecdotal; S, surveyed; O, observed]

Class or Order	Taxon	Station											
		2a	3a	4a	5a	5b	6a	6b	7a	7b	9a	9b	11a
Gastropoda	Planorbidae		S								S	S	
	Ampullariidae										S	S	
	Thiaridae						S	S		S		S	
Decapoda	<i>Caridina typus</i>				S	S				S			
	<i>Macrobrachium lar</i>			S	S	S				S			
	<i>Palaemon concinnus</i>										S		
Osteichthyes	<i>Anguilla</i> sp.			A					A	A			
	<i>Chanos chanos</i>						S	S					
	<i>Eleotris acanthopoma</i>							S					
	<i>Gambusia affinis</i>										S		
	<i>Kuhlia rupestris</i>				S								
	<i>Megalops cyprinoides</i>							S					
	<i>Oreochromis</i> spp.	S					S	O			S	O	S
	<i>Poecilia latipinna</i>						S	S			S		
	<i>Poecilia reticulata</i> ^a												
	<i>Stiphodon elegans</i>				S	O							
Amphibia	<i>Rhinella marina</i>		S						S ^b			S ^b	
Reptilia	<i>Trachemys scripta elegans</i>								A		A		

^aLumped with *P. latipinna* by McKagan et al. (2009).

^bAll tadpoles collected were presumed to be *R. marina*, since no other amphibians have been reported from Saipan.

Pathways of Introduction

Increased rates of international trade, travel, and transport over recent decades have led to widespread introductions and frequent mixing of biotas from across the world (Pyšek et al. 2010). Introductions of nonindigenous species to new locations typically occur by means of three main mechanisms: importation of a commodity, arrival of a transport vector, or dispersal of previously introduced populations (Hulme et al. 2008). Pathways are defined here as the general route or activity by which a species can be introduced into a new locale whereas vectors are considered to be the specific mechanism, mode, or activity associated with that introduction. Often, individual species are introduced through multiple combinations of vectors and pathways.

The following types of pathways are the most common means by which freshwater animals (and plants) are introduced to inland areas outside of their natural ranges (Fuller et al. 1999; Nico and Fuller 1999; Kolar and Lodge 2002; Helfman 2007; Leung and Dudgeon 2008; Kolar et al. 2011):

- Releases of live animals previously maintained in aquaria, water gardens, and so forth (i.e., the ornamental pet trade)
- Escape from aquaculture or holding facilities
- Transport and release associated with the live-food industry
- Legal stocking, typically by government agencies (purposes may be varied; for example, to establish game or forage species, for biocontrol, for conservation of rare species, or for research or experimental purposes)
- Illegal or unauthorized stocking
- Bait-bucket release
- Transport and release through vessel ballast water, as hull-fouling organisms, or unintentional contaminants associated with other vectors
- Habitat modification (e.g., canals or artificial waterways that connect previously unconnected water bodies)
- Natural causes that aid in the dispersal of already existing nonindigenous populations (e.g., typhoons, transport by animals other than humans)

Regional patterns of invasion are complex, and shaped by a wide range of factors that vary over space and time (Pyšek et al. 2010). Over the years there has been an increasing number of studies published on pathways and the relative role that each has played in the establishment of nonindigenous aquatic species. Given the extensive and growing amount of literature on the subject, the list just presented should not be considered all-inclusive. Additional information about the role of

selected pathways in the establishment of freshwater species in Micronesia is

provided in the *Existing Conditions* sections of the *Management Alternatives* of this document.

Based on existing evidence, pathways that have contributed greatly to the introduction of nonindigenous freshwater fishes into inland waters of Micronesia—and that will likely remain a threat in the near future—include (1) intentional or unintentional releases associated with the ornamental species trade, (2) escape from aquaculture facilities, and (3) releases associated with the live food industry. Certain other pathways (e.g., ballast water, bait-bucket releases) appear to have posed little threat historically and presumably will present low relative risk in the future. However, other pathways (e.g., contaminants in other stocks) may currently and/or in the future pose relatively high risk, yet are inadequately documented and difficult to evaluate. Most threats are not mutually exclusive, and may act synergistically to increase risk.

Mechanisms of Spread

When a nonindigenous species becomes introduced into a novel environment, there are many factors that contribute to whether or not it will become established and the degree to which it will spread if established. An exhaustive review of these factors is beyond the scope of this study. However, a few generalizations provide insight into characteristics of aquatic species that contribute to their success at becoming established, and to some extent, the degree to which they spread or become invasive.

Ehrlich (1986; 1989) listed the following characteristics that are common to many species that successfully become established when introduced to places where they are not native:

- Large native range
- Abundant in native range
- Vagile
- Short generation time
- High genetic variability
- Gregarious
- Female able to colonize alone
- Larger than most relatives
- Broad diet
- Able to function in a wide range of physical conditions
- Associated with humans

As noted by Eldredge (2000), many of the nonindigenous freshwater species established on Pacific islands exhibit combinations of these characteristics, although one exception is body size, because most species introduced to these insular areas are relatively small.

Helfman (2007) examined these factors in more detail for fishes, and, drawing on selected literature sources, summarized the characteristics that favored successful invaders, characterized invulnerable habitats, and contrasted the first with opposing characteristics of vulnerable native species (Tables 18-19). Notably, many of the traits listed by Helfman (2007) are identical to those listed by Ehrlich (1986; 1989), thus indicating certain common factors across taxonomic groups and ecosystems. Many authors have invoked such species characteristics to analyze and attempt to better understand establishment and invasion success. Moreover, different factors may operate and affect success differentially and in unique combinations of ways during different stages of the invasion process (Kolar and Lodge 2001; Kolar and Lodge 2002). Some of these factors are addressed in greater detail in our risk analysis of establishment success for freshwater fishes introduced to Hawaii and Guam (see *Risk Assessment and Analysis*).

Table 18. General characteristics of successful fish invaders; see Helfman (2007) and references therein. [Different traits may affect success at different stages of invasion. Vulnerable native species were considered by the author to have characteristics contrasting to those indicated by asterisks]

Characteristic(s)
High reproductive rate; including high fecundity, short interbreeding interval*
Short generation time with rapid maturation*
Long-lived with rapid maturation
High dispersal rate*
"Pioneer" species; good colonists (with r-selected life-history traits)*
Biparental care unnecessary
Broad native range*
Abundant in native range*
High genetic variability and phenotypic plasticity*
Tolerant of wide range of water-quality criteria*
Ecological generalist with respect to habitat and trophic requirements (piscivores, detritivores, herbivores, some planktivores most successful)*
Previous history of successful invasions by the species or close relatives
Gregarious
Ability to breathe air
Medium body size; large size advantageous for predators
Human commensal

Table 19. General characteristics of highly invasible habitats and communities, after Helfman (2007).

Characteristic(s)
Human-modified habitat; such as with altered flow regime, impoundment, channelization, sedimentation, deforestation of riparian and uplands, urbanization, pollution
Decreased natural variability in hydrology or geomorphology
Relatively benign and physicochemically stable habitats, as opposed to those with extreme fluctuations (however, exceptions exist in which certain invaders may be more likely to become extirpated under such extremes)
Assemblages with vacant trophic representation, such as few or no predators or zooplanktivores
Low-diversity assemblages
Insular streams and lakes
Highland lakes
Tropical rivers

Existing Legislative and Regulatory Framework

Regulations governing the importation, stocking, and possession of nonindigenous species vary widely among different nations, states, and government agencies. Within the United States, more than 20 Federal agencies, as well as many State and local agencies are involved in the management of undesirable or invasive aquatic organisms (Kolar et al. 2011). The U.S. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 provided a strategic framework, through the establishment of an interagency committee, to coordinate and prioritize efforts and programs designed to control and manage aquatic nuisance species in U.S. waters. Federal efforts in the United States are coordinated by the National Invasive Species Council (NISC), established in 1999. A National Invasive Species Management Plan (NISC 2001, 2008) provides the guidelines for Federal agencies to engage authorities and coordinate existing programs to prevent introductions and spread of invasive species, apply rapid detection and response actions, mitigate for impacts, and restore native species and habitats. In practice, however, most fisheries management efforts for nuisance species in inland waters of the United States and its possessions are jointly administered across administrative levels, and for some activities done primarily at the local or state level. This general topic was reviewed by Kolar et al. (2011), who summarized some of the basic measures that management agencies invoke to prevent or reduce consequences of introductions (Table 20). There are also several international instruments that are available to Micronesian governments. These include binding international agreements (e.g., 1992 Convention on Biological Diversity) and guidelines to minimize the spread of non-native freshwater species (e.g., EIFAC Code of Practice for recreational Fisheries [EIFAC, 2008]).

Table 20. Common vectors by which nuisance fishes and other aquatic species are commonly introduced to inland waters, and methods used to minimize risks associated with intentional introductions (stocking by government agencies) or to minimize introduction events (all other vectors) within the United States (from Kolar et al. 2011). [Asterisk represents more common level of regulation.]

Vector of introduction	Prevention measures		
	Regulation	Management Options	Education and outreach
Ballast water	Federal*, State	X	
Aquaculture industry	Federal, State*	X	
Live food fish industry	Federal, State*	X	X
Stocking by government agencies	Federal, State*	X	X
Water garden and aquarium pets	Federal, State*		X
Unauthorized stocking	Federal, State*		X
Bait-bucket releases	State		X
Recreational activities	State	X	X
Research activities	State	X	X
Diffusion from neighboring waters			X

Initially, we attempted to review the legislative authorities and the existing regulatory framework governing management for nuisance freshwater species in Micronesia. However, the information obtained is incomplete because of the large number of different states and island nations, the complex nature of the subject, apparent or likely changes in regulations over time, and difficulty in obtaining verifiable data. Nevertheless, a brief summary of some of the relevant information obtained during the course of this study provides a basis for understanding how regional governments apply and administer rules and regulations designed to manage for invasive species. Most of this information is directly applicable to the primary pathways of interest in this document; that is, the pet trade, aquaculture, intentional stocking programs, and live-food animal trade.

Hawaii

The legislative and administrative policies for Hawaii have direct relevance to Micronesia due to the extensive trade of live animal and plant commodities across the Pacific. The Hawaiian Department of Agriculture (HDOA) maintains a web site (<http://hawaii.gov/hdoa>) that provides extensive information about regulations of the State of Hawaii governing the import and export of organisms by means of the live animal and plant trade. Most of the regulations, practices, and other management factors are similar for the individual types of trade involving aquatic species (i.e., common to the pet, live or fresh food, ornamental, bait, and aquaculture trades). HDOA requirements that pertain to the importation of live animals for food generally

emphasize nonaquatic organisms, specifically, domesticated livestock and other species. Hawaii's Administrative Rules establish the guidelines, limitations and parameters for specific types of actions within the context of the Hawaii Revised Statutes (<http://hawaii.gov/hdoa/admin-rules>). Certain types of animals, insects, microorganisms and plants are not allowed entry to Hawaii. For those that are allowed, import permits, letters of authorization, quarantine and/or health certificates may be required. A few examples of animals that are prohibited from importation or possession by private individuals in Hawaii include the following: alligators, bearded dragon lizards, coconut crabs, electric catfishes, hermit crabs, land snails, lionfishes, piranhas, snakes, and snapping turtles. All freight companies transporting agricultural items to Hawaii must notify a Plant Quarantine Inspector of these items and insure that all items, including cargo and mail, are available until the inspection is completed. The HDOA's Plant Quarantine Branch conducts pre-entry, entry, and post-entry inspections of regulated materials entering the State. All microorganisms and nondomestic animals and certain microorganisms and plants require permits prior to their importation.

Guam

Codified laws of Guam regulating the importation, care, conservation, and use of fish and wildlife are provided by the Guam Administrative Rules and Regulations, Title 9 (as of April 2004), available online at:

<http://www.justice.gov.gu/compileroflaws/GAR/09gar.html>. Most of these laws apply to domesticated livestock and feral animals. Rules governing aquatic organisms are generally listed under Title 9, Division 2 (Conservation, Hunting & Fishing Regulations), Chapter 12, Fishing Regulations. The General Guam Administrative Rules and Regulations home page is:

<http://www.justice.gov.gu/compileroflaws/gar.html>. The Guam Division of Aquatic and Wildlife Resources (DAWR) maintains a white list of permitted plants and animals; any animals or plants not present on the white list are prohibited from importation, but there is no existing legislation to prohibit possession of species not on the white list. The DAWR issues permits for the importation of any aquatic organism and requires scientific name, common name, number requested, point of origin, shipper, and receiving party. U.S. Customs maintains documents showing the number of organisms actually received. The DAWR does not allow the importation of any reptiles or amphibians. Freshwater fishes are permitted for the pet trade and for aquaculture. No fishes are currently allowed to be imported for biocontrol, bait, or sport purposes.

In Guam, the U.S. Department of the Interior, Law Enforcement Division, Fish and Wildlife Services (USFWS), has responsibility pertaining to the importation of reptiles, fish, and endangered species. A license is required for commercial imports or exports of fish and wildlife and/or their parts and products into or out of the United States and importers are also required to file a Declaration for Importation or Exportation of Fish or Wildlife (Form 3-177) at an authorized port of entry to receive clearance before U.S. Customs releases the shipment. Live aquatic animals and other wildlife are monitored through a system of national ports designated and managed by

the USFWS Office of Law Enforcement, U.S. Customs Service (USCS), and the U.S. Department of Agriculture (USDA).

The most detailed records pertaining to imports of live aquatic animals are those in the USFWS Law and Enforcement Management Information System (LEMIS). The USFWS compiles much of the information from U.S. Customs shipment declaration forms. Shipment records in LEMIS include information on number or weight of animals per container, scientific name, intended purpose, source, and country of origin; records are discarded every six years. Some data do not distinguish freshwater from marine species, and not all import declaration forms indicate source. Moreover, the country of origin is not always known with certainty because transshipments are common. Inadequate record keeping at ports makes it difficult to fully assess the diversity of live fishes imported, thereby hindering risk analysis and prevention programs.

Commonwealth of the Northern Mariana Islands

Codified laws of the CNMI are maintained by the Commonwealth Law Revision Commission (<http://www.cnmilaw.org/welcome.php>). The complete CNMI Administrative Code was not available to the authors. Regulations governing the importation of wildlife, permitting, law enforcement, and other management issues are under the jurisdiction of the CNMI Division of Fish and Wildlife (DFW): <http://www.dfw.gov.mp/Enforcement/Fishing%20Regulations.html>. The DFW enforcement section reviews all live imports, and often, dead, frozen imports. The DFW currently uses an Australian Quarantine and Inspection Service list to determine which species of fish to automatically admit and which to send for a more formal review by DFW biologists (S. McKagan, National Marine Fisheries Service, oral commun., 2010).

Federated States of Micronesia

The FSM National Government laws are summarized in the FSM Legal Information System: <http://www.fsmlaw.org/fsm/index.htm>. The FSM maintains official Plant & Animal Quarantine Regulations, which were not obtained during the course of this project. According to FSM law (Title 19, Chapter 4, Section 19.414), "No person shall export or import any live fish or viable fish eggs without the Director's prior written permission."

Republic of Palau and Other Micronesian Islands

Codified laws for Palau regarding importation, transport, distribution, or possession of nonindigenous aquatic species were not obtained. Likewise, no effort was made to obtain administrative rules and policies for those Micronesian islands or island groups with no significant freshwater resources.

Risk Assessment and Analysis

Introduction

Risk assessments are useful for estimating the risks associated with introductions of nonindigenous species. For instance, a risk assessment can be used to predict the likelihood that a particular nonindigenous species, if introduced, may become established and to what degree it may be invasive or cause ecological or economic harm (Pheloung et al. 1999; Bomford 2003; Daehler et al. 2004; Kolar 2004; Nico et al. 2005; Bomford 2008; Fujisaki et al. 2009). A variety of risk assessment techniques exist. Some of these methods are largely qualitative in nature; for example, relying on scoring relative values for species traits such as 0 or 1 (absent or present), or 'low/medium/high' (Pheloung et al. 1999; Orr 2003; Alfaro et al. 2009). Some authors have argued for use of more quantitative approaches to reduce subjectivity, more precisely, to identify gaps in knowledge and provide ways to statistically express uncertainty and variability (NRC 2002; Hayes 2003; Lockwood et al. 2007). Both qualitative and quantitative estimations of species-specific risk of establishment success may aid in screening species by identifying species that could be excluded or removed from permitted (white) lists, as well as species that could be considered for addition to prohibited (black) lists (Kolar and Lodge 2001, 2002; Marchetti et al. 2004a, b; Fujisaki et al. 2009; Bomford et al. 2010).

Among the many oceanic islands and archipelagos of the tropical Pacific, Guam is second only to the Hawaiian Islands in the numbers of nonindigenous fish introductions and establishments (Maciolek 1984). Our initial objective was to develop a purely quantitative model of establishment success of freshwater fishes in Guam. However, the number of nonindigenous fishes documented in Guam ($n = 25$), although large for an island of Oceania, was inadequate to develop a model useful for predictive purposes. To improve the power of the modeling approach to assessing establishment probability, we included data on fishes introduced and established in Hawaii. At least 46 nonindigenous freshwater fish species or taxa are documented as being established in inland waters of the Hawaiian Islands; additional nonindigenous fishes have been introduced, but apparently never formed permanent reproducing populations (Maciolek 1984; Eldredge 1994; Fuller et al. 1999; Yamamoto and Tagawa 2000; Mundy 2005; Nico et al. 2005).

A wide array of life-history traits have been correlated with the establishment and invasiveness of nonindigenous species (Kolar and Lodge 2001, 2002; Marchetti et al. 2004a, b; Bomford 2008; Bomford et al. 2009; Bomford et al. 2010). Blackburn (2009) summarized species traits into three categories related to persistence of small populations. Those authors argued that establishment success should be positively correlated with propagule pressure and with traits related to the ability to cope with novel environments, and correlated in some way with traits related to population growth rate and Allee effects (i.e., the positive correlation between population density and per capita population growth rate). We developed a model of establishment success of nonindigenous fishes in Guam and Hawaii using a set of variables related to propagule pressure, prior establishment success on tropical islands, and species traits. This model may be useful in screening freshwater fishes imported into Guam, Hawaii and other Pacific islands, thereby reducing the probability of additional invasive species becoming established on individual islands and in this region.

Nonindigenous Fish Taxa Included in Estimation of Establishment Success

For this analysis, nonindigenous fish data for the island of Guam and the Hawaiian islands are combined. Both share similar physiographic and climatic features and are subjected to fish introductions through similar pathways.

A total of 80 different nonindigenous fish taxa representing 33 fish families have been introduced to Guam and the Hawaiian Islands; this total includes species or taxa that are established as well as others that were reported as having been introduced but are not known to have formed permanent reproducing populations (Table 21) (Maciolek 1984; Eldredge 1994; Nico and Fuller 1999; Eldredge 2000; Yamamoto and Tagawa 2000; Mundy 2005). The list is composed mostly of fish recognized as distinct species. In addition, the list also treats as single taxa certain groups of closely related fish (e.g., *Channa striata* and *C. maculatus*; pacus of the genus *Colossoma* and *Piaractus*). This conservative approach was taken because members within these particular groups are very similar in appearance and records of their occurrence in Hawaii or Guam may have been based on incorrect identifications (e.g., recognizing two or more species, when only one species was actually introduced). Of the 80 total nonindigenous fish taxa

reported, 70 are recorded from Hawaii and 25 from Guam; 15 nonindigenous fish species are common to both regions.

An established species was defined as any taxon known to have a self-sustaining wild population in either Hawaii or Guam. Included in this analysis are species that are restricted to fresh water, species found in brackish and fresh water (e.g., mangrove goby, *Mugilogobius cavifrons*), and species that occur in marine, brackish, and fresh water (e.g., Gulf killifish, *Fundulus grandis*). Thirteen species identifications were not known with certainty; for these taxa, variables used in the analysis were scored based on the species most likely to have been introduced as evidenced from other introductions (e.g., Maciolek 1984; Fuller et al. 1999; Eldredge 2000; Mundy 2005) or species presumed to share similar life-history and ecophysiological attributes.

Table 21. Status of nonindigenous freshwater fishes known to have been introduced into Hawaii and Guam since the late 1800s (status: 1 = established, defined as a self-sustaining, wild population; 0 = introduced, not known to be established; blank cells indicate species not known to have been introduced into that region). [Species not identified with certainty indicated by use of “cf.,” “?”, “sp ?” or “complex.” Thirteen such species of uncertain identification were included among the 80 species used in quantitative risk analysis. Shading indicates air-breathing species; fitted values for best model (#23) of establishment success in risk analysis (see text)]

Family	Scientific name	Common name	Hawaii status	Guam status	Fitted value
Adrianichthyidae	<i>Oryzias latipes</i>	Japanese medaka	0		0.060
Anguillidae	<i>Anguilla japonica</i>	Japanese eel		0	0.031
Anguillidae	<i>Anguilla marmorata</i>	giant mottled eel	0		0.031
Anguillidae	<i>Anguilla rostrata</i>	American eel		0	0.031
Anostomidae	<i>Leporinus fasciatus</i>	banded leporinus	0		0.183
Aplocheilidae	<i>Aplocheilus lineatus</i>	striped panchax	0		0.043
Ariidae	<i>Arius</i> sp.	sea catfish		0	0.183
Belonidae	<i>Xenentodon cancila</i>	Asian needlefish	1		0.557
Blenniidae	<i>Omobranchus ferox</i>	fang-toothed blenny	1		0.780
Callichthyidae	<i>Corydoras aeneus</i> ?	green corydoras	1		0.930
Centrarchidae	<i>Lepomis cyanellus</i>	green sunfish	1		0.711
Centrarchidae	<i>Lepomis macrochirus</i>	bluegill	1		0.939
Centrarchidae	<i>Micropterus dolomieu</i>	smallmouth bass	1	0	0.953
Centrarchidae	<i>Micropterus salmoides</i>	largemouth bass	1	0	0.990
Centropomidae	<i>Lates calcarifer</i>	barramundi		0	0.060
Channidae ^a	<i>Chana striata</i>	chevron snakehead		1	---
Channidae ^a	<i>Channa maculata</i>	blotched snakehead	1	0	0.995
Characidae	<i>Colossoma macropomum</i> ?	tambaquí	0		0.037
Characidae	<i>Pygocentrus nattereri</i>	red piranha	0		0.165
Cichlidae	<i>Amatitlania nigrofasciata</i>	convict cichlid	1		0.929
Cichlidae	<i>Amphilophus citrinellus</i>	Midas cichlid	1		0.768
Cichlidae	<i>Amphilophus labiatus</i>	red devil	0		0.840

Table 21. Status of nonindigenous freshwater fishes known to have been introduced into Hawaii and Guam since the late 1800s (status: 1 = established, defined as a self-sustaining, wild population; 0 = introduced, not known to be established; blank cells indicate species not known to have been introduced into that region). [Species not identified with certainty indicated by use of “cf.”, “?”, “sp ?” or “complex.” Thirteen such species of uncertain identification were included among the 80 species used in quantitative risk analysis. Shading indicates air-breathing species; fitted values for best model (#23) of establishment success in risk analysis (see text)]

Family	Scientific name	Common name	Hawaii status	Guam status	Fitted value
Cichlidae	<i>Astronotus ocellatus</i>	oscar	1	1	0.840
Cichlidae	<i>Cichla ocellaris</i> ?	peacock cichlid	1	1	0.954
Cichlidae	<i>Cryptoheros spilurus</i>	blue-eyed cichlid	1		0.768
Cichlidae	<i>Hemichromis elongatus</i>	banded jewelfish	1		0.768
Cichlidae	<i>Hypsophrys nicaraguensis</i>	Nicaragua cichlid	1		0.768
Cichlidae	<i>Melanochromis johanni</i>	bluegray mbuna	1		0.768
Cichlidae	<i>Oreochromis macrochir</i>	longfin tilapia	1		0.929
Cichlidae	<i>Oreochromis mossambicus</i>	Mozambique tilapia	1	1	1.000
Cichlidae	<i>Parachromis managuense</i>	jaguar guapote	1		0.954
Cichlidae	<i>Pelvicachromis pulcher</i>	rainbow krib	1		0.768
Cichlidae	<i>Pterophyllum</i> sp.	freshwater angelfish	0		0.768
Cichlidae	<i>Sarotherodon melanotheron</i>	blackchin tilapia	1		0.768
Cichlidae	<i>Thorichthys meeki</i>	firemouth cichlid	1		0.840
Cichlidae	<i>Tilapia rendalli</i>	redbreast tilapia	1		0.992
Cichlidae	<i>Tilapia zillii</i>	redbelly tilapia	1	1	0.988
Clariidae	<i>Clarias batrachus</i>	walking catfish		1	0.986
Clariidae	<i>Clarias fuscus</i>	whitespotted clarias	1		0.948
Clariidae	<i>Clarias macrocephalus</i>	bighead catfish		1	0.948
Clupeidae	<i>Dorosoma petenense</i>	threadfin shad	1		0.815
Cobitidae	<i>Misgurnus anguillicaudatus</i>	Oriental weatherfish	1		0.964
Cyprinidae	<i>Carassius auratus</i>	goldfish	1		0.959
Cyprinidae	<i>Ctenopharyngodon idella</i>	grass carp	0	0	0.130
Cyprinidae	<i>Cyprinus carpio</i>	common carp	1	1	0.959
Cyprinidae	<i>Hypophthalmichthys nobilis</i>	bighead carp		0	0.130
Cyprinidae	<i>Puntius filamentosus</i>	blackspot barb	1		0.550
Cyprinidae	<i>Puntius lateristriga</i>	spanner barb		0	0.550
Cyprinidae	<i>Puntius semifasciolatus</i>	green barb	1		0.659
Fundulidae	<i>Fundulus grandis</i>	Gulf killifish	0		0.043
Gobiidae	<i>Mugilogobius cavifrons</i>	mangrove goby	1		0.780
Ictaluridae	<i>Ameiurus nebulosus</i>	brown bullhead	0		0.123
Ictaluridae	<i>Ictalurus punctatus</i>	channel catfish	1	0	0.821
Kuhliidae	<i>Kuhlia rupestris</i>	rock flagtail	0		0.183
Loricariidae	<i>Ancistrus</i> cf. <i>temmincki</i>	suckermouth catfish	1		0.928
Loricariidae	<i>Hypostomus</i> cf. <i>watwata</i>	suckermouth catfish	1		0.928

Table 21. Status of nonindigenous freshwater fishes known to have been introduced into Hawaii and Guam since the late 1800s (status: 1 = established, defined as a self-sustaining, wild population; 0 = introduced, not known to be established; blank cells indicate species not known to have been introduced into that region). [Species not identified with certainty indicated by use of “cf.”, “?”, “sp ?” or “complex.” Thirteen such species of uncertain identification were included among the 80 species used in quantitative risk analysis. Shading indicates air-breathing species; fitted values for best model (#23) of establishment success in risk analysis (see text)]

Family	Scientific name	Common name	Hawaii status	Guam status	Fitted value
Loricariidae	<i>Peckoltia</i> sp.	peckoltia	0		0.086
Loricariidae	<i>Pterygoplichthys multiradiatus</i>	Orinoco sailfin catfish	1		0.995
Lutjanidae	<i>Lutjanus fulvus</i>	blacktail snapper	1		0.780
Mochokidae	<i>Synodontis</i> sp.	squeaker catfish	0		0.043
Moronidae	<i>Morone saxatilis</i>	striped bass	0		0.183
Nothobranchiidae	<i>Nothobranchius guentheri</i>	redtail notho	0		0.043
Osphronemidae	<i>Betta pugnax</i>	Penang betta		1	0.245
Osphronemidae	<i>Osphronemus goramy</i>	giant gourami	0		0.890
Osphronemidae	<i>Trichogaster leerii</i>	pearl gourami	0		0.339
Osteoglossidae	<i>Osteoglossum bicirrhosum</i> ?	arawana	0		0.043
Pangasiidae	<i>Pangasianodon hypophthalmus</i>	iridescent shark-catfish		0	0.465
Plecoglossidae	<i>Plecoglossus altivelis</i>	ayu	0		0.183
Poeciliidae	<i>Gambusia affinis</i>	eastern mosquitofish	1	1	1.000
Poeciliidae	<i>Limia vittata</i>	Cuban limia	1		0.390
Poeciliidae	<i>Poecilia latipinna</i>	sailfin molly	1	1	0.864
Poeciliidae	<i>Poecilia mexicana/sphenops complex</i>	shortfin molly	1		0.910
Poeciliidae	<i>Poecilia reticulata</i>	guppy Poeciliidae	1	1	1.000
	<i>Xiphophorus hellerii</i>	green swordtail	1	1	0.998
Poeciliidae	<i>Xiphophorus maculatus</i>	southern platyfish	1	0	0.990
Poeciliidae	<i>Xiphophorus variatus</i>	variable platyfish	0		0.503
Salmonidae	<i>Oncorhynchus mykiss</i>	rainbow trout	1		0.630
Salmonidae	<i>Oncorhynchus tshawytscha</i>	chinook salmon	0		0.146
Salmonidae	<i>Salmo trutta</i>	brown trout	0		0.300
Salmonidae	<i>Salvelinus fontinalis</i>	brook trout	0		0.146
Synbranchidae	<i>Monopterus albus</i> ?	swamp eel	1		0.930

^a Only one taxon (*Channa* spp.) was used in risk analysis models since this is a functional guild and we were unable to verify species identifications.

Variables Used in Statistical Analysis

Many researchers have attempted to identify and describe the suite of characteristics important in determining the success and potential effects of invasive species (Moyle and Light 1996a, b; Kolar and Lodge 2001; 2002; Marchetti et al. 2004a, b; García-Berthou 2007; Hayes and Barry 2008; Bomford et al. 2009; Fujisaki et al. 2009; Bomford et al. 2010). Previous studies have suggested, for example, that many of the more successful fish invaders have the ability to reproduce rapidly, have a broad native distribution, and are habitat or diet generalists (Lodge 1993; Moyle and Light 1996a, b; Ricciardi and Rasmussen 1998). However, successful invasion also depends on the physical and biological characteristics of the receiving environment, given that some habitats appear to be more susceptible to invasion than others (Lodge 1993). Moreover, whether an introduction occurs and eventually results in establishment is heavily influenced by the types and availability of pathways and the corresponding number of individuals in the pathway that are then released into the region where they are not native; that is, propagule pressure (Lockwood et al. 2005; Wilson et al. 2009; Pyšek et al. 2010).

Based on previous studies of invasion success and our knowledge of many of the introduced fishes involved, a total of 15 different parameters (one dependent and 14 independent variables) were selected for analysis of the Hawaii and Guam nonindigenous fish dataset (Table 22). The dependent variable represented the establishment status of introduced taxa. Thirteen of the independent variables were as follows: family (taxonomic affinity); history (prior invasion success, based on the number of tropical islands or tropical island groups in which the taxon was introduced and became established); propagule pressure in the form of pathways of introduction; retail price; maximum body length; longevity; adult diet; trophic index; reproductive guild; spawning habitat; climate profile (based on the climate in a species' native range); salinity tolerance; and hypoxia tolerance). An additional independent parameter (variable 14) was developed that combined climate profile, salinity tolerance and hypoxia tolerance. These variables were scored based on (1) a survey of published literature; (2) other scientific and technical data, such as Fishbase® (Froese and Pauly 2011); (3) our own knowledge; or (4) closely related or similar species in cases where little information is available.

Certain types of biological variables are difficult to quantify precisely. Moreover, the ecology and life histories of many introduced fish species are not fully known; thus precluding assignment of exact values to some of the variables for many of the species in this analysis. Consequently, we relied primarily on categorical rather than continuous independent variables used in the predictive models. Each of the variables is summarized in Table 22 and described in greater detail in the following paragraphs.

Table 22. Variables pertaining to establishment success of nonindigenous fishes introduced to the Hawaiian Islands and Guam for use in risk analysis modeling. [Variables omitted from final model selections indicated by shading (see text)]

Parameter	Description	States
Dependent variable	Status on Hawaii and/or Guam (established versus introduced but not established)	Two (0=not established; 1=established)
Independent variable	Taxonomic affinity	
	1. Family	34 different fish families
Independent variable	Distributional attributes and history of introductions	
	2. History (prior invasion success, i.e., number of tropical islands/island groups where taxon was introduced and became established.	0-43
Independent variable	Propagule pressure	
	3. Pathways	Twelve (1=raised in aquaculture facilities/ponds; 2= in aquarium trade; 3=stocked as ornamental; 4=biological control; 5=stocked as food fish; 6=stocked as sport or game fish; 7=stocked as prey base; 8=used as bait; 9=present in live food markets; 10=ballast water; 11=contaminant with stocking of another species; 12=ceremonial release)
	4. Retail price (per individual fish in aquarium, aquaculture trade, or live food market)	Four (1=over \$50; 2=\$21-\$50; 3=\$5-\$20; 4=less than \$5)
Independent variable	Life-history attributes	
	5. Length (maximum adult size)	Four (1=small [<10 cm]; 2=medium [10-29 cm]; 3=large [30-100 cm]; 4=very large [>100 cm])
	6. Longevity	Three (1=short, less than 5 yr; 2=moderate, >5 to 10 yr; 3=long, >10 yr)
	7. Diet (trophic guild; adult diet only)	Seven (1=detrivore/algivore; 2=herbivore; 3=planktivore; 4=omnivore; 5=invertivore; 6=invertivore/piscivore; 7=piscivore/top predator)
	8. Trophic level index	2.0-4.5; values derived from FishBase

Table 22. Variables pertaining to establishment success of nonindigenous fishes introduced to the Hawaiian Islands and Guam for use in risk analysis modeling. [Variables omitted from final model selections indicated by shading (see text)]

Parameter	Description	States
	9. Reproductive guild (level of parental care, fecundity, and egg size)	Three (1=non-guarders, high fecundity, small egg; 2=guarder, medium fecundity and egg size; 3=bearer, low fecundity and large egg size ^a)
	10. Spawning habitat	Five (1=lotic; 2=lentic; 3=coastal/estuarine ^b ; 4=lotic and lentic; 5=lotic, lentic and coastal/estuarine)
Independent variable	Physiological tolerance	
	11. Climate profile (climate regions included in native geographic distribution)	Six (1=temperate; 2=subtropical; 3=tropical; 4=temperate/subtropical; 5=subtropical/tropical; 6=all)
	12. Salinity tolerance	Three (1=intolerant to salinity <1 ppm [stenohaline]; 2=moderately tolerant, >1 and <10 ppm; very tolerant, >10 ppm [euryhaline])
	13. Hypoxia tolerance	Three (1=intolerant of low O ₂ ; 2=moderately tolerant; 3=tolerant, air breathing)
	14. Environmental tolerance	3-11 (a compilation of the scores from variables 11-13 above)

^a Includes live-bearing species (e.g., *Poecilia*), species that carry eggs externally (e.g., *Oryzias*, *Ancistrus*), and species that brood eggs internally in their orobranchial cavity (e.g., *Oreochromis*, *Melanochromis*).

^b Includes species that spawn offshore or on reefs (e.g., *Anguilla marmorata*).

1. *Family (taxonomic affinity)*. This variable was included to account for effects of phylogenetic relationships among species (Kolar and Lodge 2002; Alcaraz et al. 2005; Ruesink 2005; Bomford et al. 2009; Bomford et al. 2010). Fish family designations were based on Eschmeyer (2011).

2. *History (prior invasion success)*. This variable is a measure of prior invasion success, defined in this study as the total number of tropical islands or island groups (excluding the Hawaiian Islands and Guam) where a species or taxon was introduced and became established. Prior invasion success is a parameter that has been identified as being positively correlated with the probability that a species will become established when introduced into a new area (Daehler and Strong 1993; Kolar and Lodge 2002; Marchetti et al. 2004a, b; Hayes and Barry 2008; Bomford et al. 2009; 2010). Data pertaining to the establishment of different fish taxa were based on review of published literature (important sources included Maciolek 1984; Welcomme 1988; Lever 1996; Eldredge 2000; Froese and Pauly 2000, 2011), consultation with subject-matter experts, and on original field work. Because information was limited to a taxon's history of establishment on tropical islands in the Pacific Ocean and other tropical regions of the world, this variable incorporates a form of climate matching (see Bomford et al. 2009; 2010).

3. *Pathways*. Principal pathways for introductions of freshwater fishes include aquaculture (Welcomme 1988; Fuller et al. 1999; De Silva et al. 2004), stocking of game fish (Fuller et al. 1999), releases of aquarium species (Courtenay and Stauffer 1990; Fuller et al. 1999; Rahel 2002; Padilla and Williams 2004), biocontrol of insects such as mosquitos, other fish species, or vegetation (Nelson and Eldredge 1991; Fuller et al. 1999), the live food industry (Fuller et al. 1999; Rixon et al. 2005), releases of bait fish (LoVullo and Stauffer 1993; Fuller et al. 1999), and ship ballast water (Ricciardi and MacIsaac 2000; Yamamoto and Tagawa 2000).

We distinguished 13 different pathway categories: (1) raised in aquaculture facilities or ponds; (2) used in the aquarium trade; (3) stocked for ornamental display; (4) used as biological control; (5) stocked as food fish; (6) stocked as sport or game fish; (7) stocked as forage for other fish; (8) stocked for conservation purposes to augment native populations or to establish new ones; (9) used as bait; (10) present in live food markets; (11) transported in ballast water; (12) contaminant unintentionally stocked with or instead of another species; and (13) used as part of religious or ethnic ceremonial release. It is worth noting that releases or stocking from research-related activities were not incorporated into the model but do occur.

The number and combinations of different pathways in which each taxon is known to have been introduced, either in Micronesia or any other part of the world, was determined based on the literature and other available information. Each pathway category was assigned a score of “1” and the number of pathways for each taxon was summed. Resulting values hypothetically could range anywhere from 1 to 13 and the summed value for each taxon was used for modeling. Frequency distributions by pathway for the data set of species included is depicted in Fig. 13.

We predicted that taxa with a higher pathway score would have a higher probability of establishment based on an *a priori* assumption that such taxa are more likely to have been introduced on multiple occasions or in large numbers over an extended time, reflecting high propagule pressure (Kolar and Lodge 2001; Lockwood et al. 2005; Ruesink 2005; Colautti et al. 2006; Duggan et al. 2006; Gertzen et al. 2008).

4. *Retail price*. This variable is the U.S. dollar value per individual fish in the aquarium fish trade, the aquaculture trade, or the live food market. We initially selected retail prices as a measure of propagule pressure, with the assumption that lower-priced animals would result in greater numbers of individuals in one or more pathways. However, it was not possible to obtain complete, accurate, or consistent retail pricing information for many of the fish species and the variable was later omitted from further consideration.

5. *Length (maximum adult size)*. This variable is a measure of the approximate maximum length that adult individuals achieve under good growth and survival conditions in the wild (Marchetti et al. 2004a). We elected to use only four different categories (mutually exclusive length size ranges), because (1) published and unpublished information on the size of fish in wild are often poorly documented, (2) some size data are probably associated with fish reared in captivity, and (3) methods of measurement vary (e.g., total length as opposed to standard length or fork length) and in some cases, are not reported. Information on maximum body length was obtained primarily from the online database FishBase® (Froese and Pauly 2011), Page and Burr (1991), and Fuller et al. (1999). Frequency distributions of the number of taxa in each size class are presented in Fig. 14.

According to Crawley (1986), species with a higher intrinsic rate of increase, r , are more likely to become established. Ruesink (2005) suggested that large species of fish may have a relatively low probability of establishment success based on the r - K continuum. However,

Crawley (1986) also suggested the effect of body size on establishment success might depend on the type of competition faced by an introduced species. Additionally, species held as pets that attain a large size may be more likely to be released by owners once the animals outgrow their aquaria (Gertzen et al. 2008), thereby resulting in higher propagule pressure and likelihood of establishment in the wild. Maximum length was not included in the best model of establishment success reported by Kolar and Lodge (2001) or by Marchetti et al. (2004b). However, maximum length was included in the best model of establishment success reported by Marchetti et al. (2004a), although slopes for maximum length were not reported in that study.

6. *Longevity*. Initially we categorically scored species for longevity. This variable was eventually omitted for three reasons: (1) maximum lifespans reported in the literature are highly variable and some values are suspect (e.g., for many species maximum age is derived from information on live fish maintained in captivity although it is widely known that captive individuals often live much longer than those in the wild); (2) for many species, this information is simply unavailable; and (3) general maximum adult length (variable 5) and longevity are assumed to be closely correlated. Frequency distributions of number of taxa in each lifespan category are presented in Fig. 14.

7. *Diet (trophic guild)*. This variable was a descriptor of the diets of adult fish. We recognized seven different diet categories or trophic guilds, ranging from detritivore/algivore (category 1) to top carnivore (category 7). The classification was based heavily on qualitative and quantitative information available in FishBase® (Froese and Pauly 2011), Goldstein and Simon (1999), and personal knowledge of the authors. For species for which there was little or nothing published, classification was based on information published for closely related or similar species. Frequency distributions showing the number of taxa in each trophic category are presented in Fig. 15.

Based on an analysis of terrestrial animals (mainly insects) in Europe, Crawley (1986) stated that herbivores are more likely to become established than carnivores or detritivores because herbivores experience less competition. In assessing fish invasions in California, Moyle and Light (1996a) also suggested that trophic status is an important predictor of establishment success, but they argued that piscivores and detritivores/omnivores appeared to have greater establishment success, with the caveat that such an outcome was most likely in aquatic habitats where there were low levels of human disturbance. Ruesink (2005) found that establishment success was higher for omnivorous fishes, which is consistent with the hypothesis that generalists are particularly well suited to invading new areas (Blackburn et al. 2009). However, Moyle and Marchetti (2006) reported finding no evidence of such relationships. Kolar and Lodge (2002) created a complex index of diet by combining diet breadth and foraging habitat, and found their resulting index to be correlated with establishment success.

8. *Trophic level index*. Trophic levels among fishes generally range from 2 for herbivores and detritivores to 4.5 or higher for certain top predators (Froese and Pauly 2000, 2011). We initially considered using a continuous trophic variable based on a quantitative index from FishBase® that combines diet composition with the trophic level of food items consumed (see http://www.fishbase.org/manual/English/fishbasethe_ecology_table.htm). We subsequently determined that the Fishbase® trophic level index values trended positively with our categorical classification (Fig. 16). Based on that comparison, we decided to omit the trophic level index from our models and, for fish trophic information, only the diet or trophic guild categorical variable (variable 7) was used in model analyses and to estimate separate slopes for each taxon.

9. *Reproductive guild (level of parental care, fecundity, and egg size)*. We recognized three general reproductive guilds for introduced fish, with each of the categories representing important life-history characteristics that tend to be negatively correlated; for example, the level of parental care compared to the number and size of eggs. Reproductive guild or parental care was examined as a factor of invasive success in fishes by Kolar and Lodge (2002) and Marchetti et al. (2004a, b). Annual fecundity and egg size were also included in the variable pool used by Kolar and Lodge (2002). We considered these variables to be closely related, and combined them into a single categorical variable based in part on Goldstein and Simon (1999) and on personal knowledge. Ruesink (2005) suggested that species with high fecundity may have higher establishment success. Moyle and Marchetti (2006) noted that species with intermediate or mixed life history characteristics are most likely to be successful invaders. We predicted that species with an intermediate score of our categorical variable would have highest establishment success. Frequency distributions of number of taxa in each reproductive guild are presented in Fig. 15.

10. *Spawning habitat*. We recognized five categories to distinguish the range of habitats used by island fishes for spawning. The ecological variable provides information on habitat type and distinguishes between species requiring a certain type of environment (e.g., lentic versus lotic) versus those species that are more flexible in their spawning requirements (e.g., lentic and lotic). Among the different types of habitats used by fish, it was assumed that spawning habitat would likely be the most important in determining establishment success. In the absence of appropriate spawning habitat, an introduced species might briefly survive and grow, but ultimately would fail to reproduce or persist. Marchetti and Moyle (2001) found that flow regime affected population persistence of nonindigenous fishes. Frequency distributions based on number of taxa in each spawning habitat category are presented in Fig. 17.

11. *Climate profile*. This variable is an indication of the types and numbers of different climate regions included in the species' native geographic range. We recognized six categories that provided information on the type of climate and also distinguished between species whose native range encompassed one or a few climate regions from those whose native range was much more widespread in terms of latitude and climate. Assignment of the different fish species to particular categories was based on information provided in the scientific literature, other sources (Froese and Pauly 2011), and our own observations and research. Climate profiles have been used in various species distribution models, including some (e.g., climate matching) intended for predicting the potential range of a nonindigenous species based on similarity to climates found in the species' native range (Peterson 2003; Franklin 2009). Frequency distributions of number of taxa in each size climate category are presented in Fig. 17.

The presence, absence, and relative abundance of a species in a climatic region are affected by their tolerance of, or preference for, ambient temperature. A general assumption is that climate is closely correlated with particular temperature ranges, and therefore, approximates a species' relative temperature tolerance. Those species that have broad thermal tolerance are generally considered to have a greater probability of establishment success (Kolar and Lodge 2002; Moyle and Marchetti 2006; Blackburn et al. 2009). Rather than attempt to estimate the range of temperatures suitable for survival and reproduction based on limited or nonexistent data for many species, we used a categorical classification of climate in the species' native range as a surrogate (i.e., distribution in temperate, subtropical, and/or tropical regions). This represents a qualitative form of climate matching used in some studies of establishment success (Bomford et

al. 2009; Fujisaki et al. 2009; Bomford et al. 2010). We predicted that tropical and subtropical species were most likely to establish successfully in Guam and Hawaii.

12. *Salinity tolerance*. As with temperature, a wide zone of salinity tolerance may increase probability of establishment success (Kolar and Lodge 2002; Moyle and Marchetti 2006; Blackburn et al. 2009). We used a categorical variable with three levels and predicted *a priori* that species tolerant to high salinities (euryhaline) would have highest establishment success. The classification scheme and assignment of the different fish species to particular categories was based on the scientific literature, other sources (e.g., FishBase®; Froese and Pauly 2011), personal knowledge, or inference from what is known about similar species. Species identified as intolerant to salinity (stenohaline) were predicted to have lowest establishment success. Frequency distributions of number of taxa in each salinity tolerance category are presented in Fig. 18.

13. *Hypoxia tolerance*. Hypoxia tolerance refers to the ability of a species to inhabit water with low dissolved oxygen levels. As with temperature and salinity, we created a categorical variable having three levels. The classification scheme and assignment of the different fish species to particular categories was based on the scientific literature, other sources (e.g., FishBase®; Froese and Pauly 2011), personal knowledge, or inference from what is known about similar species. Species that are very tolerant of low dissolved oxygen levels (i.e., air breathers and those capable of aquatic surface respiration) were predicted *a priori* to have the highest establishment success. Frequency distributions of the number of taxa in each hypoxia tolerance category are presented in Fig. 18.

14. *Environmental tolerance (climate profile + salinity tolerance + hypoxia tolerance)*. As an alternative to using three independent environmental tolerance variables, we combined climate profile (an approximation of temperature tolerance), salinity tolerance, and hypoxia tolerance. Their composite scores produced a new single variable that we referred to as “environmental tolerance.” For example, a temperate species that cannot tolerate salinity or low dissolved oxygen levels received an environmental tolerance score of 3 (equaling 1+1+1 for each factor) whereas a tropical species tolerant of high salinities and low dissolved oxygen levels received a physiological tolerance score of 9 (equaling 3+3+3). This variable was treated as an ordinal number to reduce the number of parameters in the most general model and to facilitate model convergence.

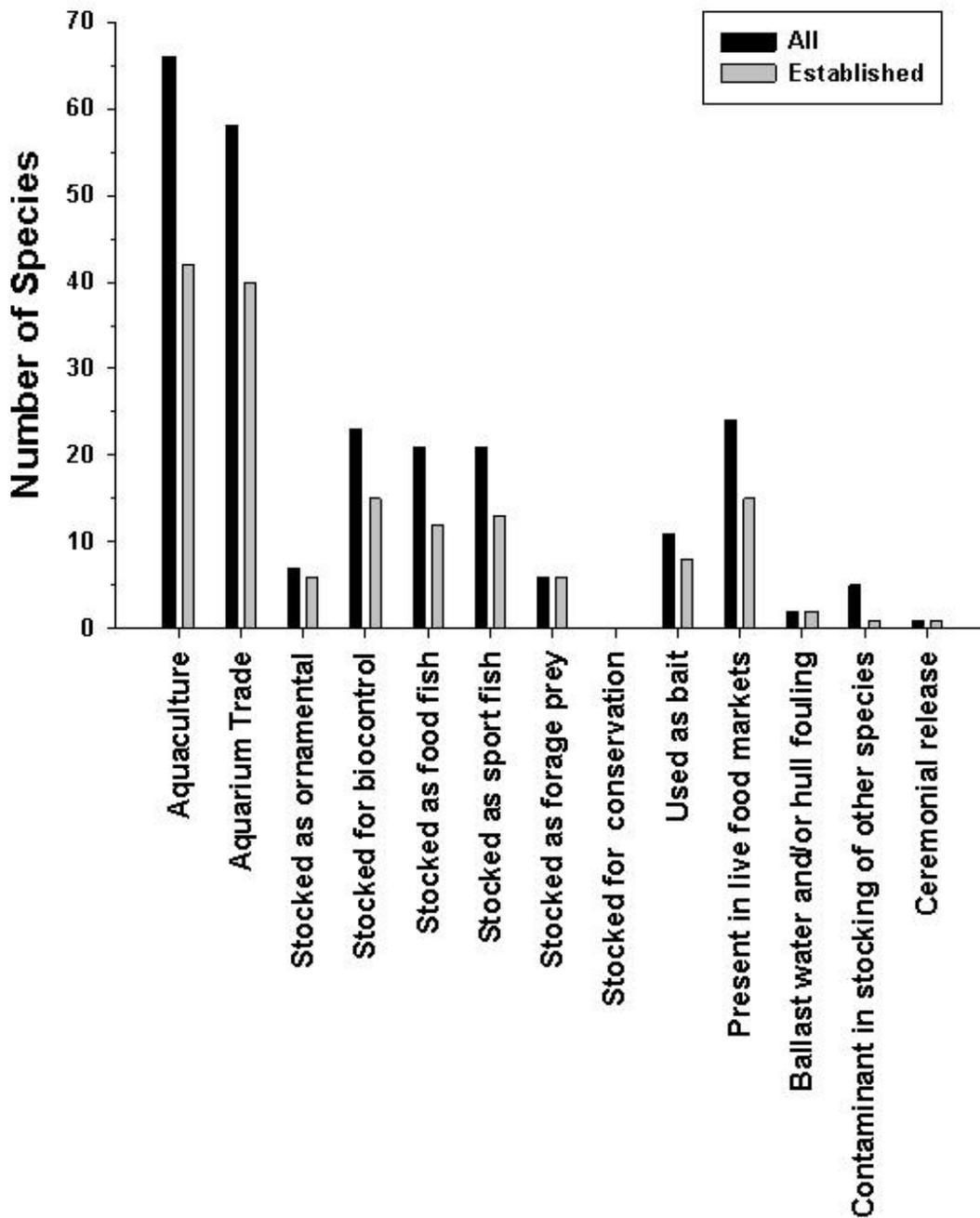


Figure 13. Number of nonindigenous freshwater fish species or taxa by known or presumed pathway of introduction in Hawaii and Guam. All = failed plus successful introductions (i.e., includes both established and non-established, nonindigenous fish species or taxa); established = only those known to have reproducing populations (graph based on data matrix used in model analyses and sources of data indicated in text).

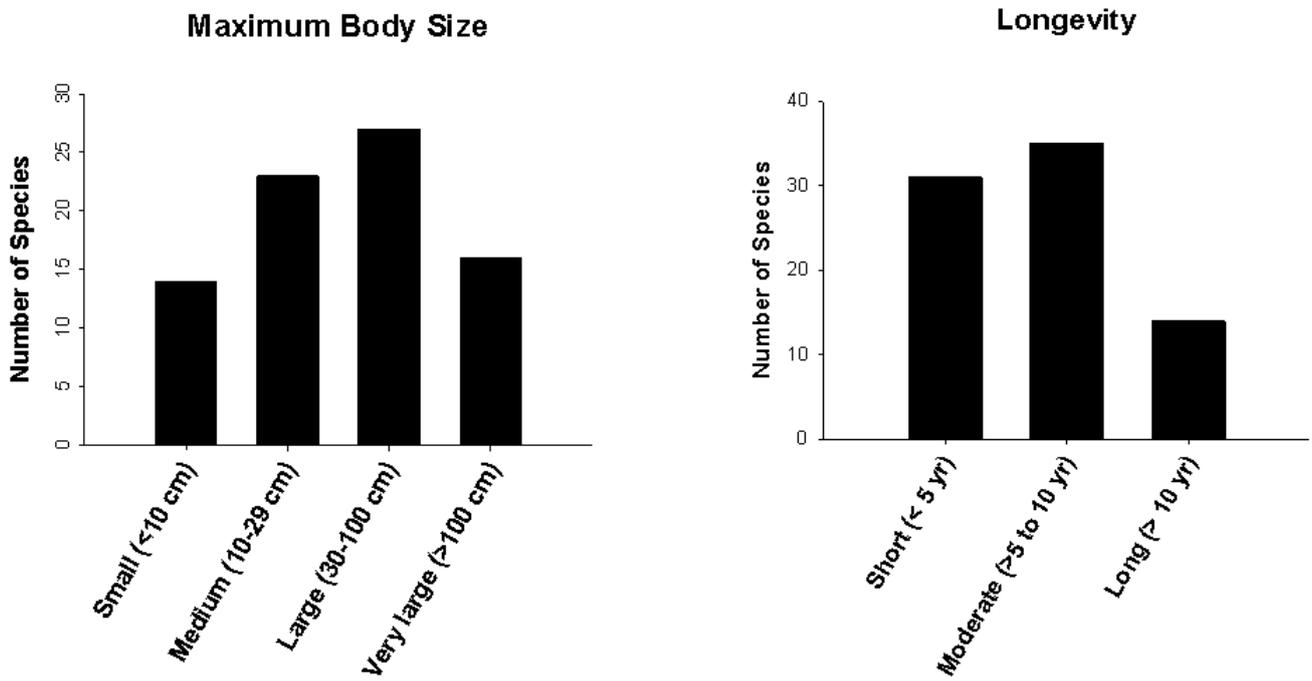


Figure 14. Frequency distribution by body size category and longevity of fishes scored for risk analysis (longevity was omitted from modeling; see text).

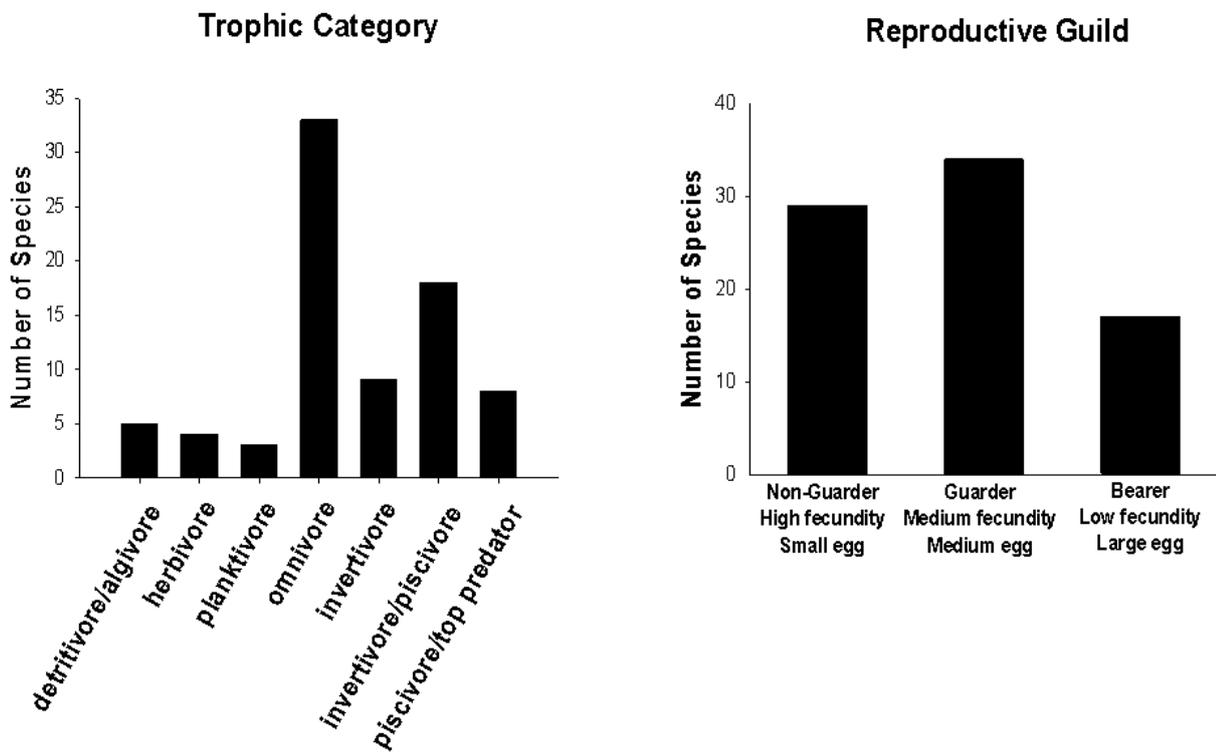


Figure 15. Frequency distribution by trophic category and reproductive guild of fishes scored for risk analysis.

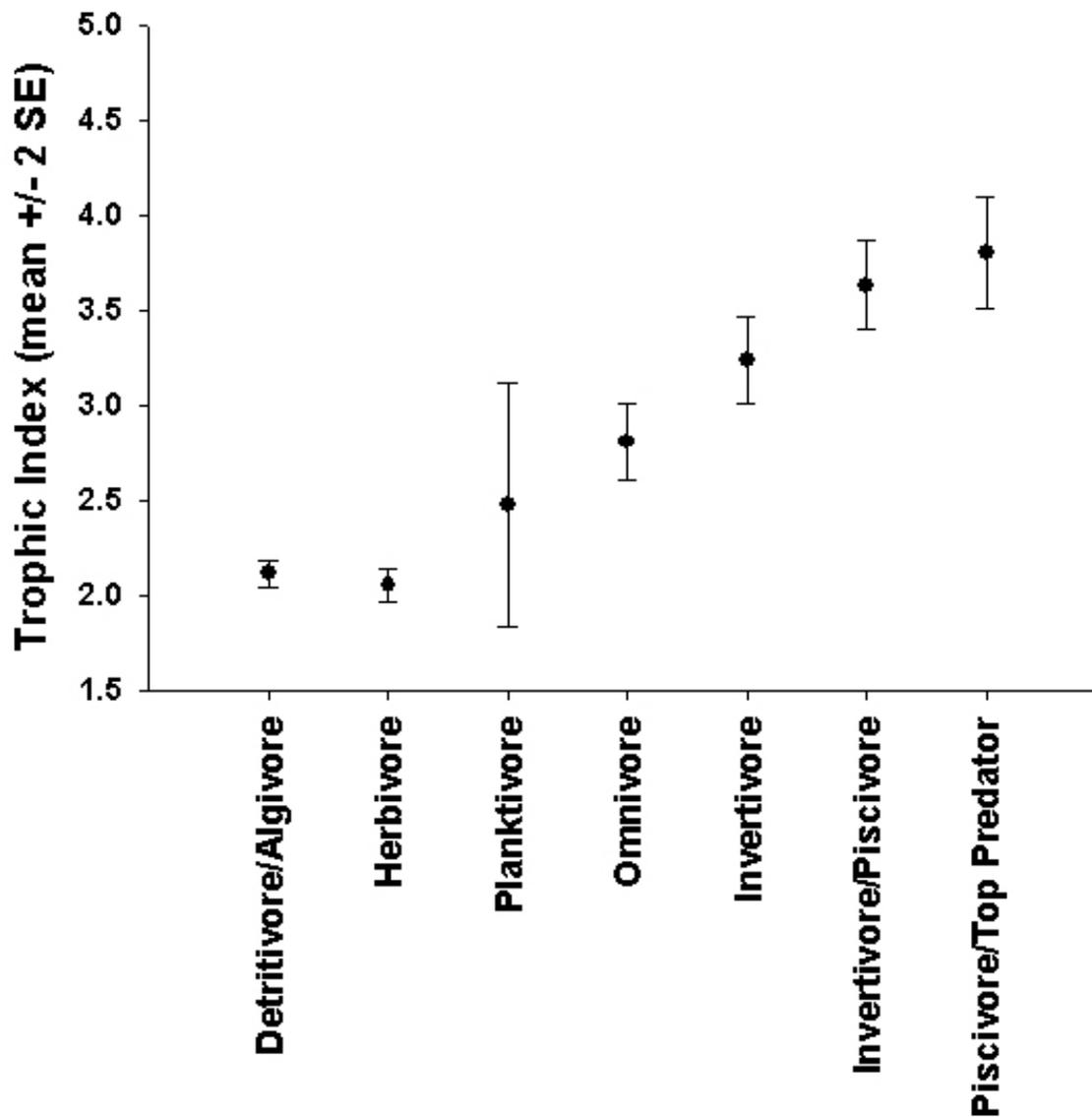


Figure 16. Relationship between trophic categories used in risk analysis versus trophic level index values appearing in species accounts of FishBase® (Froese and Pauly 2011). Mean +/-2Standard Error (SE) of species used in risk analysis matrix (for a few taxa not identified to species, mean trophic index from FishBase® was calculated as mean from congeners or family for available values).

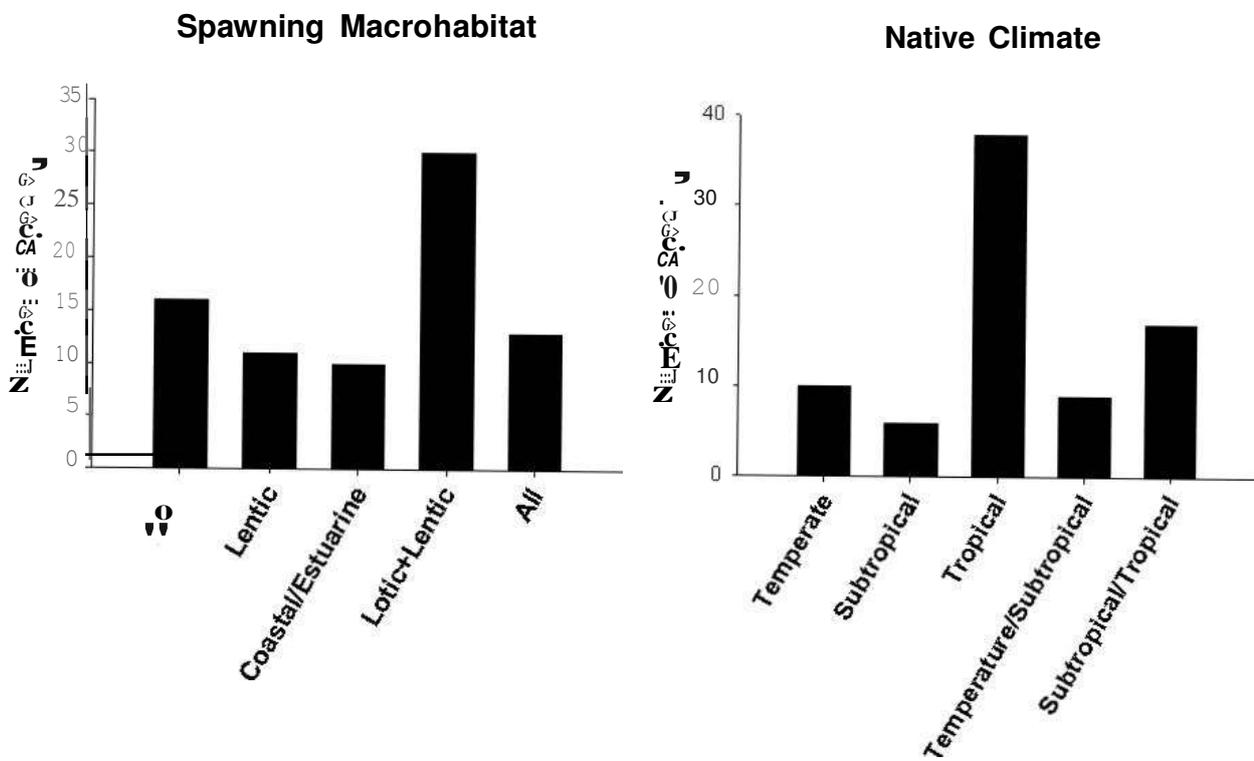


Figure 17. Frequency distribution by spawning habitat and thermal requirement (climate in native range) of fishes scored for risk analysis.

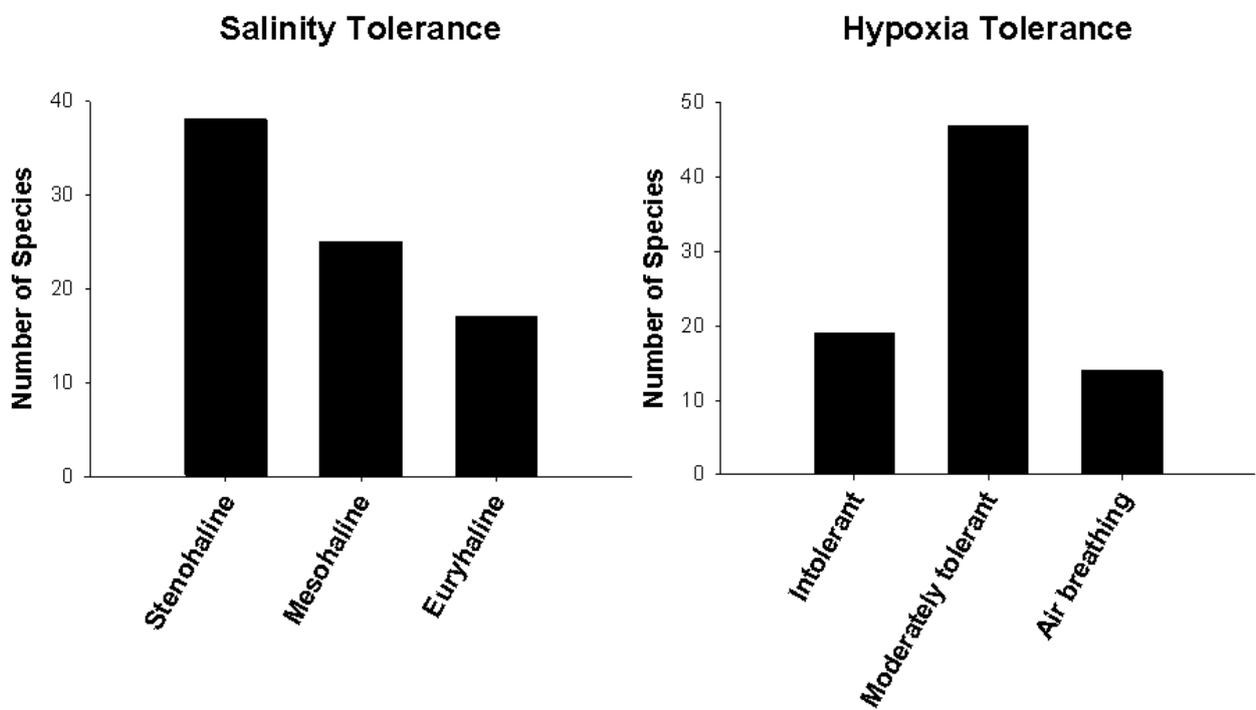


Figure 18. Frequency distribution by physiological tolerance categories of fishes scored for risk analysis.

Model Set

Establishment success was a binary response variable defined as equaling 1 for nonindigenous fish species with a self-sustaining reproducing population in the wild in Hawaii or Guam, and equaling 0 for nonindigenous fish species introduced but not known to be established in the wild in those two areas. We used logistic regression for our analysis because of the binary nature of our response variable (Agresti 2002). Our use of logistic regression followed methods of several previous authors who have predicted establishment success of nonindigenous species (Marchetti et al. 2004a, b; Ruesink 2005; Ribeiro et al. 2008; Bomford et al. 2009; Fujisaki et al. 2009; Bomford et al. 2010). The data matrix used in our analysis of establishment success is provided in Appendix 2.

We created a set of 21 competing *a priori* logistic regression models each representing a different hypothesis regarding establishment success (Table 23). This model set included our most general model, which contained eight independent variables. We included the composite variable (“environmental tolerance”) created by combining climate profile, salinity tolerance, and hypoxia tolerance, to achieve convergence of the most general model. The remaining 20 models in the set each included a unique subset of the independent variables in the most general model. Most of the competing models were created by reviewing the literature. Not all models from the literature could be reproduced exactly using our variable set. In such cases, we approximated published models as closely as possible with the variables in our set. A few additional competing models were added based on our hypotheses of possible combinations of variables that might have predictive power.

Each of the 21 *a priori* models in our model set were ranked using Akaike’s Information Criterion, AIC_c , adjusted for small sample size (Burnham and Anderson 2002). The best model has the lowest AIC_c . We calculated Akaike weights, w_i , to evaluate support for each model and for individual variables. These Akaike weights sum to 1.0, and indicate relative support for a given model. Climate, salinity and hypoxia were added to the best model in an exploratory *post-hoc* fashion by creating seven additional models to represent every possible combination of these three physiological variables. Summary output for all of the models and associated R code is available from the authors upon request.

Table 23. Set of competing models of establishment success for nonindigenous fishes introduced into Hawaii and Guam since the late 1800s and the hypotheses that each model represents. [The first 21 models were created *a priori*. Models 22-28 were *a posteriori* variations of the *a priori* model with the most support. Model 29 was an *a posteriori* version of the best model among models 1 – 28 in which the number of hypoxia tolerance scores were reduced from 3 to 2]

Model No.	Model name	Hypothesis	Reference
1	Family + history + pathways + length + diet + reproductive guild + spawning habitat + environmental tolerance	Our most general model	Present study
2	Family + history + pathways + length + diet + reproductive guild + environmental tolerance	Best model of Marchetti et al. (2004a)	Marchetti et al. (2004a)
3	Family + pathways + length + diet + reproductive guild + environmental tolerance	Invasive species characteristics	Kolar and Lodge (2001)
4	Family + history + pathways + length + reproductive guild + environmental tolerance	Expert opinion model	Marchetti et al. (2004a)
5	Family + history + pathways + diet + spawning habitat + environmental tolerance	Human interest and habitat generalist	Present study
6	Family + history + pathways + reproductive guild + environmental tolerance	Best model in a different study	Marchetti et al. (2004b)
7	Family + length + diet + reproductive guild + spawning habitat	Life history	Present study
8	Family + pathways + diet + environmental tolerance	Invasive species characteristics	Moyle and Light (1996a, b)
9	Family + diet + reproductive guild + environmental tolerance	Kolar and Lodge (2002) best model 1	Kolar and Lodge (2002)
10	Family + history + reproductive guild + environmental tolerance	Kolar and Lodge (2002) best model 2	Kolar and Lodge (2002)
11	Family + pathways + reproductive guild + spawning habitat + environmental tolerance	Propagule pressure, population growth and habitat	Williamson and Fitter (1996)
12	Family + diet + spawning habitat + environmental tolerance	Habitat generalist	Present study
13	Family + diet + environmental tolerance	Ecological characteristics or novel environments	Marchetti et al. (2004a)

Table 23. Set of competing models of establishment success for nonindigenous fishes introduced into Hawaii and Guam since the late 1800s and the hypotheses that each model represents. [The first 21 models were created *a priori*. Models 22-28 were *a posteriori* variations of the *a priori* model with the most support. Model 29 was an *a posteriori* version of the best model among models 1 – 28 in which the number of hypoxia tolerance scores were reduced from 3 to 2]

Model No.	Model name	Hypothesis	Reference
14	Family + length + reproductive guild	Life history or high population growth	Marchetti et al. (2004a)
15	Family + history + pathways	Human interest	Marchetti et al. (2004a)
16	Family + pathways + diet	Best model in a different study	Ruesink (2005)
17	Family + history + spawning habitat	Prior establishment success and spawning habitat	Present study
18	Family + history + length	Best model in a different study	Ribeiro et al. (2008)
19	Family + history	Taxonomic affinity + Prior establishment success	Bomford et al. (2010)
20	Family + pathways	Propagule pressure	Blackburn et al. (2009)
21	Family	Taxonomic effect only	Present study
22	Family + history + climate profile	Best <i>a priori</i> model + climate profile	Bomford et al. (2010)
23	Family + history + hypoxia tolerance	Best <i>a priori</i> model + hypoxia tolerance	Present study
24	Family + history + salinity tolerance	Best <i>a priori</i> model + salinity tolerance	Present study
25	Family + history + climate profile + hypoxia tolerance	Best <i>a priori</i> model + climate profile + hypoxia tolerance	Present study
26	Family + history + climate profile + salinity tolerance	Best <i>a priori</i> model + climate profile + salinity tolerance	Present study
27	Family + history + hypoxia tolerance+ salinity tolerance	Best <i>a priori</i> model + hypoxia tolerance + salinity tolerance	Present study
28	Family + history + climate profile + hypoxia tolerance + salinity tolerance	Best <i>a priori</i> model + climate profile + hypoxia tolerance + salinity tolerance	Present study
29	Family + history + hypoxia tolerance	Best <i>a priori</i> model + hypoxia with number of hypoxia scores reduced from 3 to 2 (hypoxia scores of 1 and 2 lumped vs. 3)	Present study

Model of Observations

To specify differences in establishment among species, we formulated the probability of establishment (on the logit scale) as a linear combination of Random and fixed covariates:

$$\text{logit}(p_{it}) = \beta' x_{sp} + \beta_3 \text{var}2_{sp} + \beta_4 \text{var}3_{sp} + \beta_5 \text{var}5_{sp} + \dots \dots + \beta_{20} \text{var}8_{sp}$$

where β' is a Random family effect and x_{sp} is the family for a given species, sp , (Bomford et al. 2009). Two parameters are estimated for this Random effect: a mean and a standard deviation. All other variables in the model are species-level fixed effects. The variable var2 represents number of tropical islands or island groups for a given species (sp), β_3 is the slope for that variable, var3 represents human-use score, β_4 is the slope for that variable, var5 is a binary, dummy variable used to codify one level of our maximum length variable, β_5 is the slope for that variable, var8 represents the composite environmental tolerance, and β_{20} is the slope for that variable. Model parameters were estimated using the “lmer” function for linear mixed models (Gelman and Hill 2007) in Program R (R Development Core Team 2004). Each of the 21 *a priori* competing models included a Random family effect. When no Random effect is supported by the data the lmer function estimates a constant intercept with a variance of zero, essentially removing the Random family effect from the model.

After identification of the best model, we assessed fit of that model by estimating its error rate (Gelman and Hill 2007). The error rate is the proportion of observations in the data set for which the fitted value > 0.5 and species status in the study area = 0, or fitted value < 0.5 and status = 1. We compared the error rate of the best model to the error rate of the null model. The null model is simply the proportion of observations in the data set for which species status is one. The error rate of the null model is 1; that is, the proportion of observations in the data set with a species status of one. Ideally, the error rate of the best model is low and substantially lower than the error rate of the null model.

We also assessed fit of the most general model by creating 1,000 simulated data sets based on that model (Gelman and Hill 2007). We used the proportion of observations in the data set with a species status of 0 as our test statistic and compared the value of that test statistic to the same proportion for each of the 1,000 simulated data sets. A two-sided p -value was used to estimate whether the actual test statistic differed significantly from values obtained by means of simulation.

Results

Table 24 includes summary information on the numbers of introduced and established nonindigenous fishes on Guam and the Hawaiian Islands, as well as selected information on the variable “history,” a measure of their invasion success (establishment) on other tropical islands. The 80 nonindigenous fish taxa included in this analysis include only those species and taxa known to have been introduced into inland waters of Guam, Hawaii, or both, regardless of whether their introduction resulted in establishment (i.e., 49 taxa established and 31 not established).

Many of the nonindigenous fish taxa introduced to Guam or Hawaii (42 of the 80 taxa; 52.5%) are considered established on other tropical islands or island groups. However, most (72 taxa, 90%) of the 80 Guam/Hawaii nonindigenous taxa are either not established on other tropical islands or are established on relatively few islands (eight or fewer) (Fig. 19). A few species are widely established among different tropical islands or island groups. The most extreme examples include (1) Mozambique tilapia, *Oreochromis mossambicus*, recorded as established in as many as 43 other tropical islands or island groups; and (2) three different members of the family Poeciliidae: the guppy *Poecilia reticulata*, established in 30 other tropical islands or island groups; the mosquitofish *Gambusia affinis/holbrooki*, established in 23 other tropical islands or island groups; and the swordtail *Xiphophorus hellerii*, established in 15 other tropical islands or island groups. All four of these taxa are also established in Guam and Hawaii.

Of the 80 nonindigenous fish taxa, 26 are established both in Hawaii or Guam and on at least one other tropical island. Among those 38 species not established on any other tropical islands, 20 (51%) are documented as established in Hawaii or Guam. Twenty-two of the 23 species (96%) introduced into Hawaii or Guam and established on at least three other islands or island groups also are established in Hawaii or Guam. *Osphronemus goramy* was established in seven other tropical islands or island groups, but did not become established after being introduced into Hawaii.

The 80 nonindigenous fish taxa (including grouped forms) in our analysis represented 30 families (Table 21). Family Cichlidae was represented by the most species (18), followed by Poeciliidae (8), Cyprinidae (7), Centrarchidae (4), Loricariidae (4), and Salmonidae (4). Of the 30 total families, 22 (73%) were represented by only one species. Inclusion of families with only one species does not present a problem when using a Random family effect (Gelman and Hill 2007). Overall, 50 of 81 (62%) introduced species were considered established. For the purpose of model simulation, the two species of *Channa* were treated as one taxon (i.e., *Channa maculata* on Hawaii, *C. striata* on Guam, neither identification of which was verified). Because of continued taxonomic confusion and problems in positive identification, all members of certain other genera (e.g., *Hypostomus*) were also treated as one taxon even though records could actually have been based on more than one member of that group.

The number of species introduced through means of each of the 12 pathways described earlier (and the percentage that became established) was as follows: raised in aquaculture facilities/ponds, 64 (63%); used in the aquarium trade, 58 (68%); stocked as ornamental, 7 (86%); biological control, 22 (64%); stocked or transported as food fish, 20 (55%); stocked as sport or game fish, 20 (60%); stocked as prey base (forage), 6 (20%); used as bait, 11 (73%); present in live food markets, 23 (61%); transported in ballast water, 2 (100%); contaminant with other stocking, 5 (20%); and used for ceremonial release, 1 (100%) (Fig. 13). We did not score any species as having been introduced for conservation purposes; although *Kuhlia rupestris* has been stocked in Australia to restore populations (Hutchison et al. 2002); we did not score it as such because its introduction to Hawaii would not have been for this reason.

The best model (#23) of establishment probability included a Random family effect with a nonzero standard deviation ($SD = 2.61$), an effect of history (i.e., prior invasion success on tropical islands or island groups), and an effect of hypoxia tolerance (Table 25). This model had substantial support (Akaike weight = 0.59, evidence ratio = $w_{25}/w_{27} = 6.4$). No other model had an Akaike weight > 0.09. The second, third, and fourth best models were the only other models with an Akaike weight > 0.05, and these three models were minor variations of our best model.

Effect of history variable in our best model had a positive slope, as expected ($\hat{\beta}_{\text{history}} = 0.45$, $\hat{SE} = 0.19$), suggesting establishment probability in Hawaii and Guam was higher for species established on a large number of islands or islands groups other than Hawaii and Guam. According to our best model, air-breathing fishes (hypoxia score = 3) were most likely to become established ($\hat{\beta}_{\text{hypoxia } 3} = 2.36$, $\hat{SE} = 1.71$). Fourteen air-breathing species were included in our study, and 11 of these species (79%) are established (Table 21).

Point estimates for the Random family effect in our best model ranged from -3.48 to 3.76 (Table 26). Of the nine families represented by ≥ 2 species, Cichlidae (3.76), Centrarchidae (2.54), and Poeciliidae (2.11) had the highest point estimates, representing high establishment probability. The families Osphronemidae (-3.48), Salmonidae (-1.76), and Anguillidae (-0.88) had the lowest point estimates, indicating low establishment probability.

We plotted probability of establishment based on our best model using a fixed intercept that incorporated the history variable as the x-axis (Fig. 20). Equations for each of the lines in Fig. 20 are as follows:

Species with hypoxia tolerance score of 1:

$$-0.2399136 + 0.4597635 * (\text{number of islands})$$

Species with hypoxia tolerance score of 2:

$$-0.2399136 + 0.4597635 * (\text{number of islands}) + (-2.562265)$$

Species with hypoxia tolerance score of 3:

$$-0.2399136 + 0.4597635 * (\text{number of islands}) + (2.355279)$$

Species that are intolerant of low dissolved-oxygen levels (hypoxia tolerance score of 1) had a 0.44 probability of becoming established if they were not established on any other tropical islands or island groups. The probability of establishment increased to 0.66 if these species were established on two other tropical islands or island groups. Species with a hypoxia tolerance score of 2 had only a 0.06 probability of becoming established if they were not established on any other tropical islands or island groups. Their probability of becoming established increased to 0.38 if they were established on 5 other tropical islands or island groups, and increased to 0.49 if they were established on 6 other tropical islands or island groups. Air-breathing species (hypoxia tolerance score of 3) had a 0.89 probability of becoming established if they were not established on any other tropical islands or island groups. Probability of establishment increased to 1.00 for all species as the number of tropical islands or island groups on which they were established elsewhere increased. We created one more *a posteriori* variant of our best model in which species with a hypoxia tolerance score of 1 or 2 were grouped and given a new hypoxia tolerance score of 1, while the hypoxia tolerance score for air-breathing species was changed from 3 to 2. However, that new model had only half as much support as the best model reported in Tables 25-26.

We also plotted estimated probability of establishment for individual fish families represented by more than 3 species based on our best model (Fig. 21). Species in the family Cichlidae had a 0.77 probability of establishment when not established elsewhere. All species in

that family had a hypoxia tolerance score of 2. Species in the family Salmonidae had only a 0.15 probability of establishment when not established elsewhere. All salmonids had a hypoxia tolerance score of 1. Species in the family Poeciliidae had a 0.40 probability of establishment when not established elsewhere. Snakeheads (Family Channidae) had an estimated establishment probability of 0.90 when not established elsewhere; as previously noted, the two species of snakeheads recorded for Hawaii and Guam were treated as a single taxon in our model. Species of Channidae are established on at least seven other tropical islands or island groups, and the fitted value of establishment probability for that taxon was 1.0.

Using our best-fit model we scored parameters for a set of nine taxa representing eight families not known to be currently established in Hawaii or Guam to predict probability of future establishment. These taxa were selected based on their known or presumed likelihood of presence in pathways under consideration, primarily popularity or novelty in the aquarium trade and species used for aquaculture, food, bait, or as biocontrol agents. The establishment probability for four of these taxa was greater than 70% and two were greater than 90% (Table 27). The remaining three taxa had an establishment probability of 25% or less. There was considerable imprecision in some of these estimations, given the relatively high standard deviations of predicted probability of establishment. This was due in large part to greater relative importance of hypoxia tolerance scores and low numbers of tropical islands/island groups on which they are established (0 for six taxa, 1 for two taxa, and 2 for one taxon). Nevertheless, this procedure illustrates how the modeling method can be applied to provide a general estimate of establishment likelihood for taxa of potential concern.

Table 24. Summary of the numbers of introduced and established nonindigenous fishes on Guam and the Hawaiian Islands.

Island or island group	Number of nonindigenous fish introduced ^a	Number of nonindigenous fish established (percentage of total introduced) ^b	Number established on "other tropical Pacific islands" ^c	Number established on "other tropical islands" ^d
Guam	25	13 (52%)	15	18
Hawaii	70	46 (66%)	31	37
Guam and Hawaii ^e	80 ^f	49 ^g (61%)	35	42

^aTotal number of nonindigenous fish species or taxa reported as introduced into inland waters, including those that are considered established combined with those that have been documented as introduced or occurring in the wild, but not known to have established (reproducing) populations.

^bThese values represent total number of nonindigenous fish species or taxa that have one or more populations in inland waters that are considered established (reproducing).

^cThese values represent total number of nonindigenous fish species or taxa that are known to have been introduced (established and not established) to the location identified in column #1 (i.e., either Guam, Hawaii, or both) that are also documented as having been introduced and currently considered established on one or more other tropical Pacific islands. (Note: additional nonindigenous fish species, never introduced to Guam or Hawaii, are established on other tropical Pacific islands, but these additional taxa are not considered in this tabulation).

^dThese values represent total number of nonindigenous fish species or taxa that are known to have been introduced (established and not established) to the location identified in column #1 (i.e., either Guam, Hawaii, or both) that are also documented as having been introduced and currently considered established on one or more other tropical islands throughout the globe. (Note: additional nonindigenous fish species, not known to have been introduced to Guam or Hawaii, are established on other tropical islands, but these additional taxa are not considered in the tabulation).

^eTreating Guam and the Hawaiian Islands as a single geographic unit; the values in this row relate to the total number of nonindigenous fish species or taxa documented from either Guam, Hawaii or both (e.g., a species that may have been introduced to Guam, but not to Hawaii, would be treated as introduced to Guam and Hawaii)

^fIt was determined that 15 of the 80 introduced nonindigenous fish species/taxa tallied have been introduced to both Guam and Hawaii.

^gIt was determined that 10 of the 49 total number of established species/taxa are established on both Guam and Hawaii.

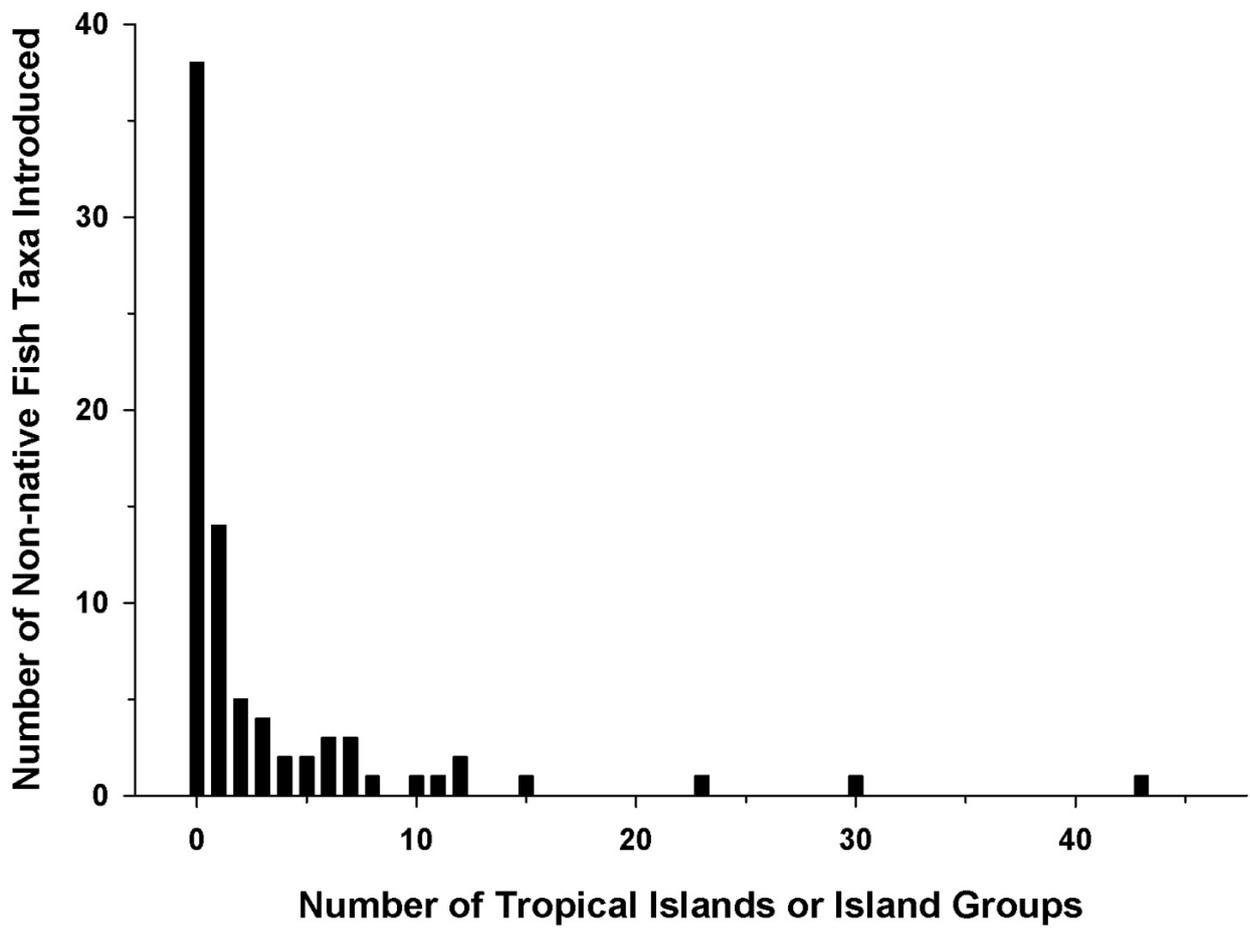


Figure 19. Frequency distribution of nonindigenous freshwater fish species introduced to Guam, Hawaii, or both, and the number of other tropical islands where they are established globally. This graph relates to the history variable used in risk analysis, i.e., prior establishment success.

Table 25. Models of establishment success of nonindigenous inland fish species introduced into Hawaii and Guam since the late 1800's were compared using an information-theoretic approach. [The model with the lowest AIC_c and highest Akaike weight had the most support. AIC_c balances model precision and bias. Akaike weights indicate relative support for each model and sum to one. Only models with an Akaike weight ≥ 0.01 are shown. The best *a priori* model included an effect of taxonomic affinity (family) and prior establishment success on tropical islands or island groups other than Hawaii and Guam (history). Seven *a posteriori* models were created, each containing a unique combination of the variables climate profile, hypoxia tolerance, and salinity tolerance added to our best *a priori* model. The new best model included effects of taxonomic affinity (family), prior establishment success on tropical islands or island groups other than Hawaii and Guam (history), and hypoxia tolerance. The second, third and fourth best models were minor variations of our best model. The third best model overall was our best *a priori* model. We did not include Model 29 from Table 23 in this model comparison since that model was two steps removed from being *a priori*.]

Model number	Model	Number of parameters in model	Log-likelihood	AIC_c	ΔAIC_c	Akaike weight
23	Family + history + hypoxia tolerance	5	-39.2382	89.28725	0	0.587
27	Family + history + hypoxia tolerance + salinity tolerance	7	-38.7221	92.9998	3.712554	0.092
19	Family + history	3	-43.4619	93.23956	3.952312	0.081
25	Family + history + climate profile + hypoxia tolerance	7	-38.9803	93.51617	4.228921	0.071
10	Family + history + reproductive guild + environmental tolerance	6	-40.7468	94.64419	5.356942	0.040
15	Family+ history + pathways	4	-43.1532	94.83976	5.552514	0.037
18	Family + history + length	6	-40.8552	94.86112	5.573872	0.036
24	Family + history + salinity	5	-42.7962	96.40313	7.115879	0.017
6	Family + history + pathways + reproductive guild + environmental tolerance	7	-40.6548	96.86508	7.577831	0.013
22	family + history + climate profile	5	-43.2218	97.25438	7.967138	0.011
28	family + history + climate profile + hypoxia tolerance + salinity tolerance	9	-38.6093	97.79007	8.502822	0.008

Table 26. Parameter estimates from the best model of establishment success of nonindigenous inland fishes in Hawaii and Guam. [Included is the estimate for the fixed intercept (no family effect) as well as estimates for each family (random intercept)]

Variable	Level	Parameter estimate	Standard error
Intercept	Fixed	-0.24	0.90
Islands (history)	Continuous	0.45	0.19
Hypoxia tolerance	2	-2.56	1.18
Hypoxia holerance	3	2.36	1.71
Adrianichthyidae	Random	-0.65	
Anguillidae	Random	-0.88	
Anostomidae	Random	-1.49	
Aplocheilidae	Random	-0.54	
Ariidae	Random	-1.49	
Belonidae	Random	2.79	
Blenniidae	Random	1.26	
Callichthyidae	Random	0.24	
Centrarchidae	Random	2.54	
Centropomidae	Random	-0.65	
Channidae	Random	-0.21	
Characidae	Random	-1.62	
Cichlidae	Random	3.76	
Clariidae	Random	0.56	
Clupeidae	Random	1.02	
Cobitidae	Random	0.01	
Cyprinidae	Random	0.20	
Fundulidae	Random	-0.54	
Gobiidae	Random	1.26	
Ictaluridae	Random	0.14	
Kuhliidae	Random	-1.49	
Loricariidae	Random	0.20	
Lutjanidae	Random	1.26	
Mochokidae	Random	-0.54	
Moronidae	Random	-1.49	
Nothobranchiidae	Random	-0.54	
Osphronemidae	Random	-3.48	
Osteoglossidae	Random	-0.54	
Pangasiidae	Random	-3.42	
Plecoglossidae	Random	-1.49	
Poeciliidae	Random	2.11	
Salmonidae	Random	-1.76	
Synbranchidae	Random	0.24	

Table 27. Predicted establishment probability using best-fit model of selected fish taxa not known to be currently established in Hawaii or Guam. [Taxa on Guam Division of Aquatic and Wildlife Resources (DAWR) white list (permitted for importation) indicated by shading]

Family	Scientific name	Common name	Tropical island groups on which established	Hypoxia tolerance score	Predicted establishment probability	Standard deviation
Callichthyidae	<i>Hoplosternum littorale</i>	brown hoplo	0	3	0.92	0.17
Mastacembelidae	<i>Mastacembelus/Macrognathus</i> spp.	spiny eels	1	2	0.25	0.36
Cyprinidae	<i>Mylopharyngodon piceus</i>	black carp	0	2	0.07	0.11
Cyprinidae	<i>Pimephales promelas</i>	fathead minnow	0	2	0.07	0.11
Polypteridae	<i>Polypterus</i> spp.	bichirs	0	3	0.75	0.37
Lepisosteidae	<i>Lepisosteus/Atractosteus</i> spp.	gars	0	3	0.75	0.37
Osteoglossidae/Arapaimidae	<i>Scleropages/Heterotis</i> spp.	Australasian/African bonytongues	2	3	0.74	0.36
Notopteridae	<i>Notopterus/Chitala</i> spp.	featherbacks	1	3	0.77	0.35
Clariidae	<i>Heteropneustes</i> spp.	stinging or air-sac catfishes	0	3	0.95	0.11

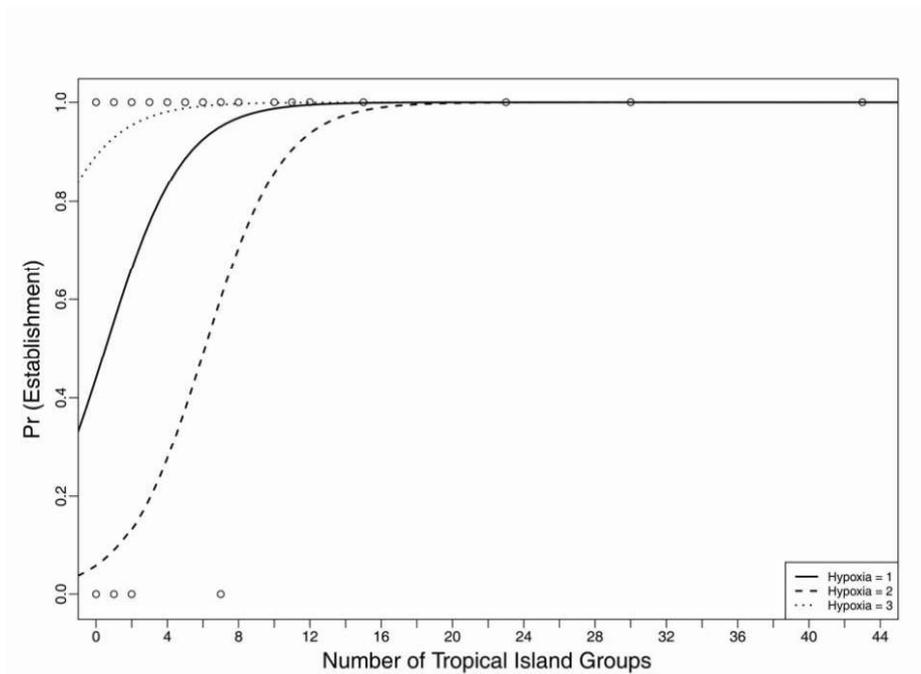


Figure 20. Probability of establishment of nonindigenous inland fishes introduced into Hawaii and Guam as a function of (1) number of tropical islands or island groups, excluding Hawaii and Guam, on which a species is established and (2) hypoxia tolerance. A fixed intercept is used to remove family effect. Species or taxa with a hypoxia tolerance score of 1 (solid line) are intolerant of low oxygen levels; species with a score of 2 (dashed line) are moderately tolerant, and species with a score of 3 (dotted line) are air-breathers. Open circles represent the number of tropical islands or island groups on which a species is known to be established. Number of islands or island groups on which a species was established, excluding Guam and Hawaii, ranged from 0 to 43. Of the 80 nonindigenous fish species or taxa introduced into Guam and Hawaii, 38 were not established on any other tropical islands, 14 were established on one other tropical island or island group, five were established on two, four were established on three, and 19 were established on > 3 other tropical islands or island groups.

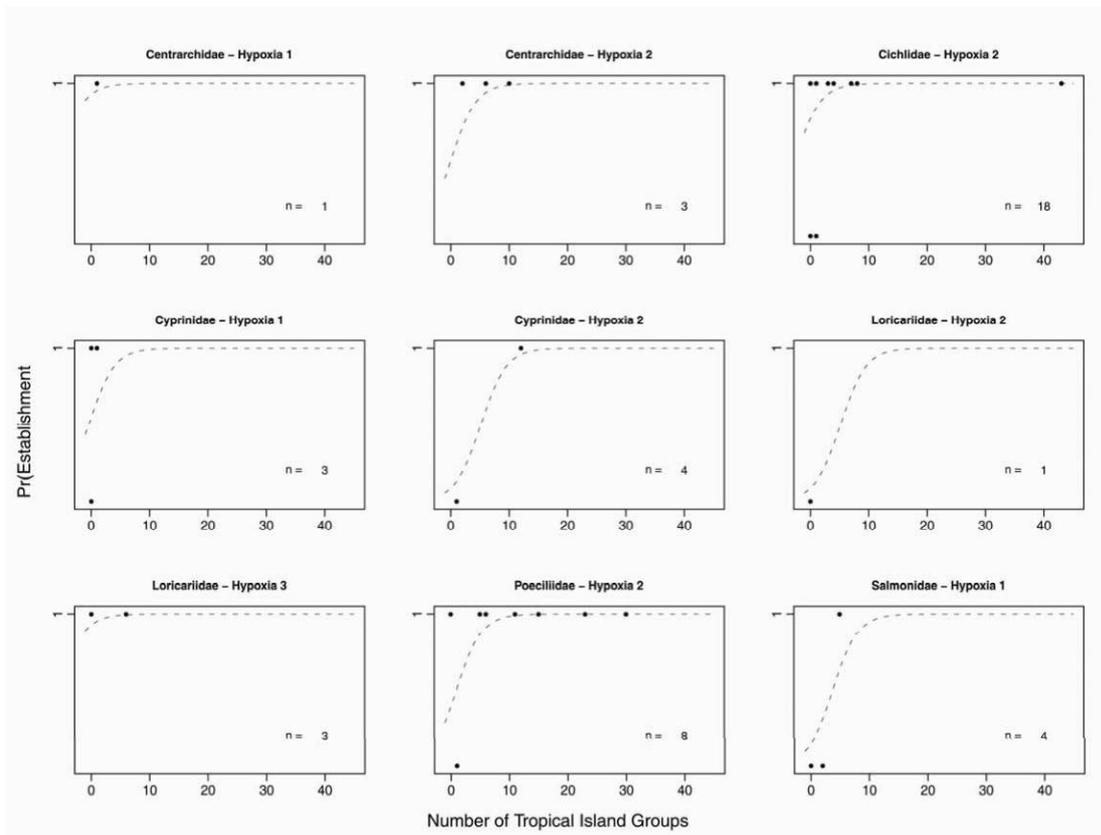


Figure 21. Probability of establishment of nonindigenous inland fishes introduced into Hawaii and Guam as a function of (1) number of tropical islands or island groups, excluding Hawaii and Guam, on which a species is established and (2) hypoxia tolerance, with family effect used as intercept. Only families represented by > 3 species are shown (n = the number of species for a given family:hypoxia tolerance combination).

Discussion

Our best model of establishment success can be used to predict establishment probability of nonindigenous fish species or taxa introduced or likely to be introduced into Hawaii or Guam in the future. Such an application of the model would require that data be gathered for each particular taxon to be tested. This would include data necessary to reliably assign a score for each of the variables in our best model: (1) history (number of tropical islands or island groups on which the species is established excluding Hawaii and Guam), (2) hypoxia tolerance score, and (3) family (taxonomic affinity).

Ultimately, authorities (e.g., resource managers, legislators) must define an acceptable level of risk that considers the benefits of importing or using a nonindigenous fish against the likelihood that it may become invasive and the potential magnitude of its unintended environmental, economic, and social costs. Once an acceptable level of risk is determined and the necessary data gathered to reliably score model variables, the model could be used to estimate whether the predicted probability of establishment was above, below, or equal to the accepted level of risk. Species above an accepted level of risk might be considered for removal from a permitted (white) list or added to a prohibited (black) list. For example, if the accepted level of risk was an establishment probability of 0.44, perhaps all air-breathing fish species would be prohibited (based on Fig. 20); species intolerant to low dissolved oxygen levels (hypoxia tolerance score of 1) might only be permitted if they were not established on any other tropical island or island group; and species with a hypoxia tolerance score of 2 might only be permitted if they were established on fewer than 6 other tropical islands or island groups.

Our results, which estimated a higher establishment probability for species with a hypoxia tolerance score of 1 than for species with a score of 2, were counterintuitive. We expected species with a score of 1 to have the lowest establishment probability. Perhaps the reason species with a score of 1 had a higher estimated establishment probability is that most stream habitats in Hawaii and Guam may have high dissolved oxygen levels because of swift currents. Restated, an abundance of habitats with high dissolved oxygen levels may provide plentiful opportunities for establishment of species that require high dissolved oxygen levels.

Nevertheless, the counterintuitive results related to hypoxia tolerance might also reflect a shortcoming of the model or the data. Some of the assigned variable scores used in the model were heavily based on expert opinion, perhaps influenced by knowledge of similar species rather than rigorous published research about a particular target species. Modeling efforts historically have (and perhaps always will) serve to highlight gaps in existing knowledge of systems and the ecology and precise life-history attributes of various organisms. Our model was no different in that regard. Available information on many fish species makes it difficult to clearly distinguish between a species' physiological tolerance limits compared to environmental preferences and requirements, much less their ecological optima. Consequently, the ecological or physiological variables incorporated into a model may reflect absence of knowledge about species-specific values for certain life-history and ecological variables rather than absence of a relationship between these variables and establishment success. A history of being established on other tropical islands or island groups did appear to be strongly correlated with establishment success and similar relationships have been reported by other authors for various taxa. The relationship we detected here is likely real, albeit not as revealing or enlightening about the biology of the species and the system studied as we might prefer. That air-breathing species have a high

estimated establishment probability was also expected, and lends additional support to our model.

An additional problem in attempting to model and predict establishment is the fact that there is a fair amount of uncertainty with regard to basic knowledge about fish introductions and the status of nonindigenous fish populations. For example, it is likely that some nonindigenous fish species have been introduced to Hawaii and Guam that were never documented. In addition, such unrecorded nonindigenous species could be established in Hawaii and/or Guam, but as yet remain undetected. Relative to the many hundreds to thousands of fish species in the ornamental fish trade, few have been documented as introduced into the wild in Hawaii and Guam, and even fewer of these have become established. That only two fish species in our analysis (both estuarine) that were documented to have been introduced into Hawaii by means of ballast may seem somewhat unexpected given the volume of ship traffic to these islands. Perhaps other fish species have been introduced by means of this vector but failed to establish and were never detected (or if established remain undetected or at least unreported). However, because most ballast water transported to these insular areas is of high salinity, relatively stenohaline freshwater or brackish water species would likely have low levels of survivorship during long periods of transport in this medium. Historical records of fish species introduced intentionally along other pathways, such as stocking for sport fishing, are presumed to be known with a greater degree of certainty than introductions by means of accidental pathways (e.g., ballast water and contaminants).

Propagule pressure has been reported as an important variable in estimating establishment success (Marchetti et al. 2004a, b; Lockwood et al. 2005; Rixon et al. 2005; Colautti et al. 2006; Duggan et al. 2006; Moyle and Marchetti 2006; Copp et al. 2007; Gertzen et al. 2008). Propagule pressure may be generally defined as the number of individual fish of a given species introduced into an area (although life-history attributes such as fecundity or parental care can also be correlates). Probability of establishment is expected to increase as the number of individuals that are released increases. Unfortunately, in most cases for freshwater fishes in Hawaii and Guam, few data exist on the number of individuals of a given species that have been released into the wild for some of the most likely pathways of introductions that lead to establishment (e.g., the aquarium trade). To better assess risk of species and pathways, a suggested approach for future analyses would be to gain greater knowledge about propagule pressure, especially for areas where important information gaps exist (e.g., prohibited importations that are undetected, contaminants in legal shipments, etc.).

Screening of nonindigenous species imported into Hawaii and Guam using a predictive model such as ours may reduce the likelihood of additional invasive species becoming established in either locale. Aquaculture and the aquarium trade are the primary pathways of introduction for nonindigenous fishes in Hawaii and Guam. These pathways reflect the intentional importation of fish. As such, they may be under greater management control than some other pathways and more conducive to regulation by means of a white list guided by a predictive model.

Management Alternatives, with Preexisting Conditions, Potential Actions, and Mitigation Measures for Micronesia

Background

In the U.S., the term “best management practice” (BMP), as applied to environmental management (specifically, pollution control), originated in the Clean Water Act of 1972, although it was not explicitly defined in that legislative document. BMPs have been widely applied to complex environmental problems, generally in a context-specific manner and often lacking imperfect knowledge about the outcome of management actions under different settings. By definition, BMPs are transitory; although in principle there can only be one “best” practice, many are likely to be “better” than a range of others, and incremental improvements may occur over time as new knowledge is attained and protocols, procedures, or practices change (Clay 2008). Increasingly, the term BMP refers to “better management practices.” Conceptually, for complex problems (such as prevention or mitigation for invasive species), BMPs are best regarded as an adaptive learning process rather than an exclusively prescriptive approach (Measham et al. 2007).

As an objective, policy-neutral, science-based agency, the USGS has no management or regulatory authority. Therefore, the USGS refrains from making recommendations that target

specific management or policy actions, and terminology such as “best management practice” or “BMP” is not used. Herein, management alternatives are provided with an implicit understanding that all options have not been thoroughly vetted and strategic actions may be warranted and modified over time as new information becomes available. Many existing sources provide baseline information on strategies for mitigating deleterious ecological or socioeconomic effects of invasive species; the information provided in this report is based on sources considered reliable (e.g., Wittenberg and Cock 2001; Tucker and Hargreaves 2008; Henderson and Bomford 2011).

This document provides management alternatives intended to help prevent, limit, or mitigate impacts of invasive freshwater animal species in the region of Micronesia, with emphasis on fishes, turtles, frogs, and macroinvertebrates. New practices or modifications of existing ones are intended to compliment other management options provided by Federal agencies to address additional organisms representing different taxonomic groups, their habitats, and associated pathways (e.g., terrestrial and marine plants and animals, pathogens, and diseases).

Summary of Management Alternatives

Management can best focus on the following aspects of the sequential invasion process: (1) preventing introductions from occurring; (2) detecting incursions at an early stage; and (3) rapidly eradicating newly found nonindigenous organisms and/or mitigating the worst effects of established or reproducing invasive populations (Kraus and Duffy 2010).

(1) Prevention requires the identification of all pathways and then screening major pathways so as to exclude importation of species most likely to become invasive. This is typically accomplished by screening for animals at the port of origin, and also port-of-entry screening of pathways or products thought or known to be at high risk for harboring nonindigenous aquatic animals.

(2) Rapid-response programs typically involve systematic attempts to detect new incursions followed by programs to eradicate (or at least contain) the worst species so detected.

(3) Long-term mitigation is usually focused on areas of high value or importance that need protection, such as national parks, undisturbed natural streams, or other unique ecosystems. For Guam and other Pacific islands, areas needing protection may best be identified through “ecosystem prioritization” (Jenkins et al. 2009). Long-term mitigation may also involve attempts to control particularly harmful species over much of their invaded ranges.

The following list (Table 28) provides management alternatives that are intended to assist in the prevention, limitation, or mitigation for possible impacts of invasive and other nonindigenous freshwater animals, with specific emphasis on Guam (although many of the items might equally apply to other governments of Micronesia, as well as other commercially linked regions). The subsequent discussion addresses the following main strategies and topics: (1) prevention/pathway disruption; (2) early detection; (3) contingency plans/rapid response; (4) long-term management; and (5) research needs. Action-specific recommendations and priority levels are not implied in keeping with the aforementioned policy and management-neutral position of the USGS. The list is followed by more detailed information and the rationale for each of the strategies. These management options are provisional in the sense that the science of invasive species is a growing and rapidly changing field. Moreover, local conditions are

dynamic. For example, relevant information may become available in the future, or events and field conditions may change that necessitate adjustments of how to best manage certain nonindigenous species or groups of species and particular pathways of introduction. Globally, bioinvasions are highly complex and management strategies require sophisticated levels of coordination (Ruiz and Carlton 2003; Henderson and Bomford 2011). As such, management alternatives as outlined here are considered to be only general guiding principles, and implementation of precautionary as well as post-invasion approaches will require a substantial degree of cooperation among all sectors involved in commerce throughout Micronesia.

Table 28. Summary of management alternatives for nonindigenous freshwater animals. [DoD, Department of Defense; Non-DoD, local, territorial, and other civilian regulatory and/or management agencies in Guam); Foreign, other sovereign governments of Micronesia]

No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
1	Inspection program: Development of an international inspection and monitoring program in which nations coordinate monitoring for invasive species and attempts to prevent their export as well as import.	Prevention/pathway disruption	X	X	X
2	Inspection program: Improvement and expansion of existing documentation and record keeping on the types and numbers of imported aquatic species, including imports from both domestic and foreign sources. Such documentation requires complete and accurate identification of animals to species level, numbers of specimens, purposes, sources, and pathways.	Prevention/pathway disruption	X	X	
3	Inspection program: Assurance that border agents and wildlife inspectors have necessary training and knowledge to identify all or most aquatic animal families, genera, and species, including those prohibited by Federal laws and also taxa permitted under Guam's White List.	Prevention/pathway disruption	X	X	
4	Inspection program: Additional personnel and training of wildlife inspectors and/or implementation of a quarantine system so that most shipments of live wildlife can be inspected.	Prevention/pathway disruption	X	X	
5	Inspection program: Augmentation, expansion, and/or replacement of existing radiographic equipment used to screen imports for live aquatic animals.	Prevention/pathway disruption		X	
6	Inspection program: Inspection of all international packages and increased efforts to inspect a greater percentage of domestic mail.	Prevention/pathway disruption	X	X	

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No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
7	Survey questionnaires: Survey(s) of incoming military and construction workforce to learn about aquatic animal pets. Questions might include the types and numbers of aquatic animal pets currently owned; which pets, if any, are intend to be transported to Guam; and, regarding unwanted pets, if owners would be likely to release animals into the wild or would they be willing to relinquish pets to pet shops or other authorities.	Prevention/pathway disruption	X	X	
8	Education/outreach—international conferences: Such venues provide a means to maintain open communication and improve diffusion of knowledge of new advances in invasive species biosecurity, covering such themes as prevention/pathway disruption, early detection, management, eradication and control. To increase participation, various Pacific island governments and institutions could be engaged by encouraging different venues among the major islands.	Long-term management	X	X	X
9	Education/outreach: Development and distribution of brochures, posters, bumper stickers, and other forms of print and mass media that provides information on invasive aquatic animals, their identification, the harm that these animals can cause, warnings against releasing pets into the wild, and warnings against transporting illegal or potentially harmful aquatic species. Target groups might include military and civilian families intending to move to Guam, as well as current Guam residents, private businesses, public organizations, schools, and others.	Prevention/pathway disruption & early detection	X	X	X

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No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
10	Education/outreach: Development of a short video describing potential harm caused by nonindigenous invasive species and warning against their transport or release. Such a video could be shown on incoming commercial and military passenger flights and passenger ships.	Prevention/pathway disruption	X	X	
11	Education/outreach: Development of education programs that target children by providing interactive school presentations that illustrate the impacts that nonindigenous species can have and discouraging release of pets.	Prevention/pathway disruption		X	
12	Education/outreach: Encouragement to pet stores and garden retail outlets to participate in the Habitattitude program (http://www.habitattitude.net/), a partnership between commercial industry and the Aquatic Nuisance Species Task Force that increases consumer awareness and engages businesses and the public to prevent the release of invasive species.	Prevention/pathway disruption	X	X	
13	Education/outreach: Assistance and encouragement for pet stores to identify captive stocks with valid scientific names, including provisioning vendors with printed material on the subject and consultation with qualified experts.	Prevention/pathway disruption		X	
14	Survey questionnaires: Surveys of pet store customers that include questions about the types and numbers of pet aquatic animals currently owned, whether any unwanted pets have ever been released into the wild; and, regarding future unwanted pets, would owners be likely to release animals into the wild or be willing to turn pets over to pet shops or other authorities.	Prevention/pathway disruption	X	X	
15	Education/outreach: Website development to disseminate information about native and invasive species.	Prevention/pathway disruption	X	X	

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No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
16	Education/outreach: Establishment of programs that provide information on alternatives to releasing unwanted pets, possibly including arrangements for pet stores to accept unwanted pets and/or establishing periodic “Amnesty Days” for the public to surrender unwanted or illegal pets.	Prevention/pathway disruption	X	X	
17	Expert panel(s): Panel(s) of experts to periodically assess operations at borders that involve screening of imported aquatic animals, identification of any existing or potential needs and problem areas in the screening process, assessment of inspector training issues and needs, and review of permitted species.	Prevention/pathway disruption	X	X	X
18	Management/regulation of aquaculture industry: Establishment and maintenance of a database of active and former aquaculture facilities that can be used by management resource agencies and invasive species researchers. Database to include location and contact information of all facilities, types and numbers of aquatic species held, and how and where live animals are distributed.	Prevention/pathway disruption		X	X
19	Management/regulation of aquaculture industry: Routine inspections of aquaculture facilities and farms to assess biosecurity features, focusing on escape risk and type(s) of stock being cultured. This may include evaluation of design and condition of facilities and ponds (e.g., pond location, status of perimeter berms and fences, inlets and outlets); assessment of live aquatic animals cultured, health and status of breeding stocks, and whether any are contaminated by unwanted or harmful species; assessment of equipment; and evaluation of personnel training and determination if additional training is needed.	Prevention/pathway disruption		X	X

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No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
20	Management/regulation of aquaculture industry: Promotion of the use of triploid, sterile, male fish or only native species in aquaculture. Higher priority for any stock that is distributed live to less secure facilities.	Prevention/pathway disruption		X	X
21	Management/regulation of live food markets: Enforcement of existing regulations and/or establishment of new procedures to minimize allowing retail live food markets on Guam and other Pacific islands to supply customers with live, potentially invasive non-native aquatic animals; encouragement to have vendors provide food fish or other aquatic animals fresh, on ice, at time of sale.	Prevention/pathway disruption	X	X	
22	Establish or strengthen existing programs for monitoring and sampling inland water bodies on Guam and other Pacific islands for the purpose of detecting new or expanding populations of invasive and other nonindigenous aquatic animals. Form and support teams to regularly visit markets and seafood restaurants to document presence of live nonindigenous aquatic animals, including any illegal species. Samples of nonindigenous aquatic species collected, preserved, and voucher specimens deposited in repositories of major scientific museums (e.g., the University of Guam in Mangilao; Bishop Museum in Honolulu). Discoveries of new nonindigenous populations reported to a rapid response team and, if appropriate, information provided to news outlets to inform and advise the public.	Early detection	X	X	X
23	Development and advertisement of a reporting process for military personnel and private citizens who suspect that they have captured or detected a new or uncommon nonindigenous aquatic species.	Rapid response	X	X	X

Table 28. Summary of management alternatives for nonindigenous freshwater animals. [DoD, Department of Defense; Non-DoD, local, territorial, and other civilian regulatory and/or management agencies in Guam]; Foreign, other sovereign governments of Micronesia]

No.	Management Alternative	Category	Applies to		
			DoD	Non-DoD	Foreign
24	Establishment of team(s) led by qualified experts who can rapidly respond and attempt to eradicate any newly discovered wild populations of invasive aquatic species. This requires training, adequate equipment, and development of appropriate protocols for control or eradication.	Rapid response	X	X	X
25	Ecosystem prioritization: Assessment of drainages and water bodies within and outside military reserves so as to prioritize aquatic and wetland ecosystems in terms of their biological significance. Such information is useful for determining areas to focus monitoring, control, and/or eradication efforts.	Long-term management	X	X	

Pathways Assessment with Existing Management Practices

In this section we provide an assessment by pathway of the current status of conditions on Guam and elsewhere in Micronesia, relevant practices currently in place, and the prognosis for future change that may be directly or indirectly associated with the military buildup.

In the following pathway assessment, the prognosis for each pathway includes a qualitative rating or estimation of the overall risk, including the level of uncertainty using criteria

established by the Risk Assessment and Management Committee of the Aquatic Nuisance Species Task Force (RAM-ANSTF 1996). Estimated level of risk of each element or pathway is rated as “low,” “medium,” or “high,” and levels of uncertainty are “very certain,” “reasonably certain,” “moderately certain,” “reasonably uncertain,” and “very uncertain.” The analysis relies on the current state of available information, and resulting risk assessments are intended only as general guidelines for what to expect for future conditions pertaining to each pathway, and how the implementation of alternative management actions may help to mitigate by preventing further establishment or spread of nuisance aquatic species.

Aquarium Trade and Related Commerce in Ornamental Aquatic Animals

Ornamental commerce involves the aquarium trade industry, which includes retail merchants, regional wholesalers, import and export wholesalers, and related businesses that raise or sell aquatic animals for captivity as pets or “ornamentals” (e.g., koi for private and public water-garden ponds.), and consumers, mainly pet hobbyists, who buy and maintain live aquatic animals in captivity. A large number and wide diversity of freshwater fishes and other aquatic organisms (e.g., crustaceans and mollusks) are distributed and marketed worldwide as ornamentals. As a result, this pathway is one of the primary means by which aquatic nonindigenous species have become introduced and established in both freshwater and marine environments throughout the world (Courtenay and Stauffer 1990; Courtenay 1999; Fuller et al. 1999; Eldredge 2000; Fuller 2003; Padilla and Williams 2004; Rixon et al. 2005; Calado and Chapman 2006; Duggan et al. 2006; Gertzen et al. 2008). Padilla and Williams (2004) estimated that perhaps one-third of the world’s worst aquatic invasive species are aquarium or ornamental species.

The aquarium pet trade is the pathway by which a large number and variety of different nonindigenous fishes and other aquatic animals are imported to Guam (Table 14) and to other Pacific islands. Over the last several decades, this pathway has also (and will likely continue to) lead to the introduction of certain fishes into the wild in Guam and other Pacific islands, and was the primary pathway of introduction for many aquatic animals now established in Hawaii (Maciolek 1984; Eldredge 2000; Yamamoto and Tagawa 2000). The aquarium trade is complex and is closely tied to other major pathways, such as aquaculture and stocking contaminants. For example, some fishes, crustaceans, and mollusks, especially snails, may be transported and enter new areas accidentally as contaminants or stowaways in shipments of other aquatic ornamental animal and plant species that are being purposely imported (Lin et al. 2006).

With the aquarium trade considered as the general pathway, there are different sub-pathways or vectors by which aquatic animals and plants become introduced to new places. One of the more common modes by which ornamental species become established is direct release of animals by pet owners. Reasons for the disposal of pet fish are varied and include the following (Gertzen et al. 2008):

- Aggressive behavior
- Large size
- Frequent illness
- Rapid reproduction
- Other reasons, such as owner(s) that are moving, bored with pets, or tired of maintenance

Other pathways and vectors that are either a subset or closely linked to the aquarium pet trade include escapement from holding facilities, especially outdoor ponds, raceways, or other structures used for holding or captive breeding. Sites where such escapements of fish commonly occur are commercial ornamental fish farms. For example, in Florida and other warmer parts of the United States, a number of species are known to have become established or probably became established in this manner (Courtenay and Stauffer 1990; Courtenay 1994; Courtenay 1999; Fuller et al. 1999).

Present Condition: Aquarium Pet Owners

Aquarium pet owners and other pet hobbyists are consumers, private citizens that commonly play important and varied roles in the aquarium trade pathway. Functioning as vectors, pet owners are known or reputed to hand carry or otherwise transport a small number of live freshwater fish or other aquatic animals to Guam and other Pacific islands. Citizens may be residents or nonresidents. This pathway may include any live aquatic animals considered to be personal pets or gifts provided to friends or family members. Animals are typically transported in this pathway by one of the following methods: (1) hand-carried or with checked-in luggage on airlines or by maritime vessel; or (2) packaged and shipped by means of private-sector couriers or the U.S. Postal Service. This pathway is distinguished from the commercial retail industry because it is small-scale, relatively sporadic, and typically not-for-profit.

The current number of private citizens that carry or send pet aquatic animals to Guam is unknown, as is information pertaining to the degree to which non-commercial shipments containing live animals arrive through this pathway. It is assumed to represent a small proportion, relative to the aquarium industry, of the total number of aquarium fishes and other aquatic pets that enter Guam or other Pacific islands. The extent to which any nonindigenous freshwater fishes and other aquatic animals established in the wild on Guam that may have been introduced by means of this pathway is unknown.

Present Condition: Retail Sales

A few nonindigenous freshwater fishes and other aquatic animals established in the wild on Guam—because of their wide distribution and popularity as pets—are presumed to have originated by means of the aquarium or ornamental pet trade. These particular species may have escaped from holding facilities or, more likely, were intentionally released.

Many freshwater fishes and other aquatic animals imported and sold in the aquarium trade are misidentified, partly because many taxa are difficult even for experts to positively identify to species level. In addition, some species that are legal to import are similar in appearance to species that are illegal. Consequently, lists of imported species maintained by government agencies and businesses associated with the aquarium industry likely contain incorrect species identifications. This situation increases the risk that certain harmful or illegal aquatic animals will be imported, unintentionally and without the knowledge of regulators. According to Gertzen et al. (2008) there is little regulation of the aquarium trade in terms of restricting potentially nuisance nonindigenous aquatic species. Molecular tools may be useful for identification and may also serve to recognize taxa in the live animal or plant trade that are mislabeled (Thum et al. 2011).

Guam currently has two retail pet stores that import and sell live freshwater and marine fishes, invertebrates, plants, and locally caught turtles: Little Wangz Petlife in Harmon, and

Feathers 'n Fins (<http://www.feathersnfins.com/>) in Hagåtña. Additionally, a vendor who does not have a physical retail shop occasionally sells live aquarium fish, plants, snails, and turtles at the flea market in Dededo. The garden center at the U.S. Naval Base was also visited and, at the time of our visit, had live freshwater plants for sale; a few fish (*Poecilia reticulata*) and snails were observed in some of the containers, but appeared to be contaminants of the water and plant stock. Most freshwater ornamental fishes for sale in the stores are imported. The primary sources of aquarium fish shipped to Guam are in Malaysia, but fish are apparently also shipped directly from both Florida and Japan (Christy et al. 2007b). Additionally, a clerk at one shop told us that they obtain a few locally-reared fishes (guppies and platyfish) from one or a few individuals who culture the fish in outdoor ponds, but this information is unverified.

Customs records and statistics maintained by the U.S. Fish and Wildlife Service indicate that the volume of imports to Guam is moderate. However, due to a variety of reasons, we were unable to obtain detailed information on types and numbers of ornamental freshwater fishes imported into Guam annually or volume of sales. Augmenting the available information, our visits to both of the “brick-and-mortar” pet stores on the island confirmed that a wide variety of species were for sale. Based on visits to the stores in 2010, we compiled a partial list of the types of live fish available for sale (Table 29). This list includes approximately 80 to 90 species or strains representing about 18 families. We suspect that the number of different species imported varies among years and certain seasons, depending on availability of stock and changing consumer demand. The typical method for commercial shipment of live ornamental fish is by means of airplane flights, with fish confined within polyethylene bags containing oxygen-saturated water; multiple bags with fish are then densely packed into insulated boxes or shipping containers (Cole et al. 1999).

In early 2010, a USGS biologist residing in Guam observed a street vendor selling live freshwater turtles, presumably intended as pets rather than for food (E. Wostl, U.S. Geological Survey, oral commun., 2010). We presume that the nonindigenous turtles were taken from an established wild population. In fact, freshwater turtles, typically red-eared sliders, are offered for sale by street vendors on a semi-regular basis in at least one village on Guam. How many turtles and the variety of species which are sold is unclear. It is assumed that these turtles are being harvested locally. This type of unauthorized pet trade increases the risk that the range of already established populations will more rapidly expand with the aid of humans.

The senior author of this report visited a pet shop in Saipan; the owners had converted part of their dwelling to a retail sales shop, plumbed it with aquaria, and were selling a small assortment of tropical freshwater aquarium fish. We are unaware if there are additional pet shops in Micronesia.

We are unaware of any outdoor facilities used for the propagation of aquarium or other ornamental species on Guam or elsewhere in Micronesia. However, there are various types of ornamental ponds and other outdoor holding facilities, some of which may have the potential to allow for escape or dispersal. For instance, some hotels on Guam and Saipan maintain water gardens with live ornamental fish (mostly koi, *Cyprinus carpio*, and milkfish, *Chanos chanos*). The senior author observed swordtails (*Xiphophorus helleri*) in an aquarium in the gift shop of the Etpison Museum in Koror, Palau; when asked about the source of fish, an employee responded that the fish had been brought to the museum by the director, who had maintained (and presumably bred) the fish in a pond on her private property.

Table 29. List of nonindigenous freshwater fishes observed for sale or display during a survey of retail pet stores on Guam, April 2010. [Common names in quotation marks as indicated on store aquaria. Most of the common names are the same as those displayed on the tanks containing the particular fish. Some of the scientific names provided are considered tentative because vouchers were not available for examination, combined with the difficulty in positively identifying live fish]

Family	Common name	Scientific name
?	"peacock ram"	
?	"flying phoenix"	
?	"catfish"	
Anostomidae	Leporinus	<i>Leporinus</i> sp.
Apterontidae	"ghost knifefish," "ghost fish"	<i>Apterontus albifrons</i>
Belontiidae/Helostomatidae	"assorted gouramis"	
Callichthyidae	"panda cory"	<i>Corydoras panda</i>
Characidae	"spotted tetra"	<i>Copella ? nattereri</i>
Characidae	"rednose tetra"	<i>Hemigrammus bleheri</i>
Characidae	"glowlight tetra"	<i>Hemigrammus erythrozonus</i>
Characidae	"rummy nose tetra"	<i>Hemigrammus rhodostomus</i>
Characidae	"black phantom tetra"	<i>Hyphessobrycon megalopterus</i>
		<i>Hyphessobrycon</i> sp. (perhaps <i>colombianus</i>)
Characidae	"red tail tetra"	
Characidae	silver dollar	<i>Metynnis</i> sp.
Characidae	"congo tetra"	<i>Phenacogrammus interruptus</i>
Characidae	"cherry tetra"	<i>Puntius titteya</i>
Characidae	"neon glass tetra"	
Characidae	"red tag tetra"	
Cichlidae	"agassi bluetail cichlid"	
Cichlidae	"red zebra"	<i>Maylandia or Metriaclina ? estherae</i>
Cichlidae	"green terror"	<i>Aequidens rivulatus</i>
Cichlidae	"oscar"	<i>Astronotus</i>
Cichlidae	"frontosa" or "red frontosa"	<i>Cyphotilapia frontosa</i>
Cichlidae	"blue frontosa"	<i>Cyphotilapia frontosa</i>
Cichlidae	"blue lumphead cichlid"	<i>Cyrtocara moori</i>
Cichlidae	severum	<i>Heros severus</i>
Cichlidae	"golden severum"	<i>Heros severus</i>
Cichlidae	"parrot cichlid"	<i>Hoplarchus psittacus</i>
Cichlidae	"flowerhorn"	hybrid
Cichlidae	"yellow labidochromis"	<i>Labidochromis caeruleus</i>
Cichlidae	"zebra cichlid"	<i>Maylandia (Pseudotropheus) zebra</i>
Cichlidae	angelfish	<i>Pteryophyllum</i> sp.
Cichlidae	"discus"	<i>Symphysodon</i> sp.
Cichlidae	"firemouth"	<i>Thorichthys meeki</i>
Cichlidae	"golden goddess" [flowerhorn?]	

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Family	Common name	Scientific name
Cichlidae	"jewel cichlid"	
Cichlidae	"blue cichlid"	
Cichlidae	"white cichlid"	
Cichlidae	"yellow cichlid"	
Cichlidae	"orange cichlid"	
Cobitidae	"pakistani loach"	<i>Botia lohachata/almorhae</i>
Cobitidae	"weather loach"	<i>Misgurnus anguillicaudatus</i>
Cyprinidae	"bala shark"	<i>Balantiocheilos melanopterus</i>
Cyprinidae	"tin foil barb"	<i>Barbonymus schwanenfeldii</i>
Cyprinidae	goldfish	<i>Carassius auratus</i>
Cyprinidae	"shubukin"	<i>Carassius auratus</i>
Cyprinidae	"pearl scale"	<i>Carassius auratus</i>
Cyprinidae	"assorted oranda" [goldfish variety?]	<i>Carassius auratus</i>
Cyprinidae	"black moor"	<i>Carassius auratus</i>
Cyprinidae	"ryukin"	<i>Carassius auratus</i>
Cyprinidae	"ranchu"	<i>Carassius auratus</i>
Cyprinidae	carp/koi	<i>Cyprinus carpio</i>
Cyprinidae	"koi"	<i>Cyprinus carpio</i>
Cyprinidae	"pearl danio"	<i>Danio albolineatus</i>
Cyprinidae	"glowlight danio"	<i>Danio choprai</i>
Cyprinidae	"zebra danio"	<i>Danio rerio</i>
Cyprinidae	"danio"	<i>Danio sp.</i>
Cyprinidae	"red danio"	<i>Danio sp.</i>
Cyprinidae	"pink danio"	<i>Danio sp.</i>
Cyprinidae	"rainbow shark"	<i>Epalzeorhynchus frenatum</i>
Cyprinidae	"flying fox algae eater"	<i>Epalzeorhynchus kalopterus</i>
Cyprinidae	"buenos aires tetra"	<i>Hyphessobrycon anisitsi</i>
Cyprinidae	"apollo shark"	<i>Luciosoma pellegrini/setigerum/spilopleura</i>
Cyprinidae	"silver dollars"	<i>Metynnis sp.</i>
Cyprinidae	"neon tetra"	<i>Paracheirodon innesi</i>
Cyprinidae	"tiger barb"	<i>Puntius anchisporus</i>
Cyprinidae	"assorted tiger barbs"	<i>Puntius anchisporus</i>
Cyprinidae	"rosy barb"	<i>Puntius conchoniis</i>
Cyprinidae	"red barb"	<i>Puntius conchoniis</i>

Table 29. List of nonindigenous freshwater fishes observed for sale or display during a survey of retail pet stores on Guam, April 2010. [Common names in quotation marks as indicated on store aquaria. Most of the common names are the same as those displayed on the tanks containing the particular fish. Some of the scientific names provided are considered tentative because vouchers were not available for examination, combined with the difficulty in positively identifying live fish]

Family	Common name	Scientific name
Cyprinidae	"gold barbs"	<i>Puntius semifasciolatus</i>
Cyprinidae	"cherry barb"	<i>Puntius titteya</i>
Cyprinidae	"harlequin rasbora"	<i>Trigonostigma</i> (formerly <i>Rasbora</i>) <i>heteromorpha</i>
Cyprinidae	"nine barb"	
Helostomatidae	"kissing gourami"	<i>Helostoma temminckii</i>
Loricariidae	"orange marble pleco"	<i>Ancistrus</i> ? sp.
Loricariidae		<i>Hypostomus</i> sp.
Loricariidae		<i>Pterygoplichthys</i> sp.
Monodactylidae	"sea angel"	<i>Monodactylus</i> ? <i>argenteus</i>
Notopteridae	"clown knife"	<i>Chitala chitala</i>
Osphronemidae	"betta"	<i>Betta</i> sp.
Osphronemidae	"betta"	<i>Betta</i> sp.
Osphronemidae	"dwarf gourami," "dwarf gouramy"	<i>Colisa lalia</i>
Osphronemidae	"paradise fish"	<i>Macropodus opercularis</i>
Osteoglossidae	"arowana"	<i>Scleropages formosus</i>
Pangasiidae	"siamese shark"	<i>Pangasius hypothalamus/sutchi</i>
Poeciliidae	"guppy"	<i>Poecilia reticulata</i>
Poeciliidae	"molly"	<i>Poecilia</i> ? <i>sphenops</i> ?
Poeciliidae	"swordtail"	<i>Xiphophorus</i> ? <i>hellerii</i>
Poeciliidae	"platy"	<i>Xiphophorus</i> ? <i>maculatus/variatus</i>
Poeciliidae	"platy"	<i>Xiphophorus maculatus</i>
Tetraodontidae	"green pufferfish"	<i>Tetraodon fluviatilis</i>
Toxotidae	"archer fish"	<i>Toxotes</i> sp.

Current Management Practices

Live animals brought to Guam legally must be declared. Individuals arriving in Guam from foreign ports must complete a U.S. Customs and Border Protection (CBP) Declaration Form 6059B, which is handed to the CBP inspector upon approaching the CBP area. If a traveler is transporting live animals, the cargo must be indicated on the form, which may result in additional questioning and possible inspection of the traveler's articles. Because airline passengers are not permitted to transport substantial volumes of liquids in carry-on luggage, there is a low probability that travelers typically carry live fish or other aquatic animals. Regulations pertaining to checked luggage and other transport or shipment of live aquatic animals apparently vary among the different passenger and freight air carriers.

The U.S. Department of the Interior, Law Enforcement Division, USFWS, has responsibility pertaining to the importation of reptiles, fish, and endangered species. A license is required for commercial imports or exports of fish and wildlife and/or their parts and products into or out of the United States (USFWS 2010) and importers are also required to file a Declaration for Importation or Exportation of Fish or Wildlife (Form 3-177) at an authorized port of entry to receive clearance before U.S. Customs releases the shipment. Live aquatic animals and other wildlife are monitored through a system of national ports designated and managed by the USFWS Office of Law Enforcement, USCS, and the USDA.

The Port of Guam in Agana is one of a number of United States ports designated to handle commercial traffic of live wildlife (see: <http://www.fws.gov/pacific/lawenforcement/portag.html>). The Guam office is overseen by the Pacific Islands Resident Agent in Charge subdistrict office which includes Hawaii, the CNMI, the territories of Guam and American Samoa, and other central and western Pacific islands subject to the jurisdiction of the United States (see: <http://www.fws.gov/pacific/lawenforcement/RAC%20Honolulu.html>).

The most detailed records pertaining to imports of live aquatic animals are those in the USFWS Law and Enforcement Management Information System (LEMIS) (Smith et al. 2008). The USFWS compiles much of the information from Customs shipment declaration forms (Form 3-177), which are completed for each shipment that arrives or exits a given U.S. port of entry (Chapman et al. 1997; Adams et al. 2001). LEMIS shipment records include information on number of animals (or their weight) per container, scientific name, intended purpose (e.g., commercial, personal), source (e.g., captive bred, wild caught), and country of origin; import records are discarded every six years (Smith et al. 2008). Some data do not distinguish freshwater from marine species, and not all import declaration forms indicate source. Moreover, country of origin is not always known with certainty since transshipments are common (Chapman et al. 1997; Adams et al. 2001). According to Smith et al. (2008), inadequate record keeping at ports makes it difficult to fully assess the diversity of live fishes imported, thereby hindering risk analysis and prevention programs.

Augmenting regulations and requirements of the USFWS, DAWR applies its white list of aquatic species—mostly aquarium fishes—that can be legally imported live into Guam. Importation of aquatic animals not present on the white list is prohibited; requests for exemptions to the list are reviewed on a case-by-case basis. The most recent version of the white list (provided to us in early 2010 by Brent Tibbatts, DAWR) includes a mix of 448 different genera, species, and hybrid freshwater fishes, saltwater fishes, and aquatic invertebrates. Since 1981, DAWR has not issued any permits allowing the importation of any turtle species into Guam for personal or commercial use (Leberer 2003). All reptiles and amphibians are currently prohibited from importation into Guam. Only saltwater fish species native to Guam can be legally imported.

Prognosis

The primary mechanisms by which future introductions and spread of nonindigenous aquatic species through the aquarium pet and ornamental species trade are likely to occur include: (1) unauthorized imports and subsequent (intentional) release to the environment; (2) organisms legally imported, purchased by consumers, and subsequent (intentional) release to the

environment; and (3) organisms legally or illegally imported and accidentally escaping from holding facilities into the environment:

(1) It is anticipated that an increase in the human population on Guam will result in an increase in the number of freshwater aquarium fishes and other aquatic pets carried or sent to Guam by private citizens outside of the normal retail trade vector. Thus, there will be increased probability that fish and other aquatic species may be transported and subsequently released through this pathway. Future risk potential for establishment of new species by means of this pathway is *medium/moderately certain*.

(2) The anticipated increase in human population in Guam is also expected to result in increased consumer demand, which will likely increase the volume of legal imports, sales, and ownership of freshwater aquarium fishes and other aquatic pets. This increases propagule pressure by increasing the likelihood of unwanted pets being released into natural waters. It is unknown if increased demand will result in the opening of any additional retail pet stores in Guam. Future risk potential for establishment of new species and/or spread of species currently established by means of this pathway is *medium-to-high/reasonably certain*.

(3) Given that at present there is little indication that ornamental species are commonly held in outdoor facilities on Guam and elsewhere in Micronesia, future risk potential for establishment of new species and/or spread of species by escapement by means of this pathway is *low-to-medium/reasonably uncertain*.

Freshwater Aquaculture Industry

Freshwater aquaculture is the farming of freshwater species in ponds and tanks for subsequent sale as food, either live, fresh, or frozen, for human consumption (in our assessment, it excludes aquaculture associated with the aquarium pet trade and other ornamental species). The freshwater aquaculture industry is a pathway that includes a variety of aquatic animals (principally finfish and shellfish). Included are eggs and fry of various fishes that are imported and subsequently reared to marketable size at aquaculture facilities. In addition, aquaculture facilities commonly hold fishes and other aquatic animals in captivity to replenish their stocks. Personnel at some facilities, usually intending to improve the marketability of their stock, experiment in an effort to produce new strains and hybrids. The mechanism by which nonindigenous aquatic species become introduced into natural water bodies by this pathway typically involves escapement from captive holding facilities, often through accidental, unintended, or natural events (e.g., failure of containment structures, hydrologic alterations, floods, tropical storms). In some Asian countries, freshwater fishes are raised in cages placed in open lakes and rivers, but we are unaware of this practice in freshwater habitats in Guam or other parts of Micronesia. Worldwide, large numbers of commercially important species, both freshwater and marine, have been introduced, established, and spread in association with the food aquaculture sector.

Present Condition

Aquaculture has long been an active and viable commercial enterprise in Micronesia and elsewhere in Oceania (Fitzgerald and Nelson 1979; FitzGerald 1982; Nelson 1988, 1989b), and continues to flourish (Prasad 2003; NMC-CREES 2011). A substantial amount of food-based aquaculture in the region is of marine species, more strictly referred to as mariculture. Common

marine seafood organisms that are cultivated include giant clam, trochus, milkfish, and sea cucumber. The Secretariat of the Pacific Community (SPC) promotes and coordinates much of the aquaculture activities throughout the western Pacific (<http://www.spc.int/aquaculture/>). The SPC headquarters are in Noumea, New Caledonia, with regional offices in the Fiji Islands, FSM (Pohnpei), Papua New Guinea, Solomon Islands, and Vanuatu. Increased interest in mariculture of marine species for the ornamental trade is expected as demand grows (e.g., live corals and other invertebrates, reef fishes).

Within Micronesia, freshwater aquaculture is most highly developed on Guam and in the CNMI. Aquaculture facilities and personnel associated with the University of Guam (UOG) and Northern Marianas College (NMC) support the industry through basic and applied research and extension service. The Guam Aquaculture Development and Training Center (GADTC) of the Western Pacific Tropical Research Center, also known as the Fadian Hatchery, is the largest and oldest aquaculture center in the western Pacific (<http://www.wptrc.org/section.asp?secID=7>). Originally built as a private facility to supply aquaculture products to Asia, the GADTC was transferred to the Government of Guam in 1986 and subsequently to the University of Guam in 2001. The hatchery is located on five acres in the east-central side of Guam and is equipped with indoor laboratories, office buildings and living quarters, ponds and raceways, and sources of sea water and fresh water. A recent effort to organize a Guam aquaculture development working group as a means to facilitate interactions between government agencies and commercial producers was unsuccessful, and instead an improvised process was adopted (CTSA 2010).

Aquaculture in the CNMI is based at the NMC Cooperative Research Extension and Education Service (<http://www.crees.org/sec.asp?secID=1>), which is mandated by public law 15-43 (effective 2007) to be the lead authority for aquaculture development in the CNMI. As part of that legislative directive, the NMC-CREES recently produced an aquaculture development plan based on extensive input from stakeholders throughout the region (NMC-CREES 2011). The NMC-CREES facilities currently include an inland hatchery composed of an assortment of recirculating systems equipped with both fresh and salt water. This facility is used for producing tilapia seedstock for distribution, and for commercial-scale grow-out trials of a variety of species. There are plans to build an additional hatchery. The location for that hatchery has yet to be finalized, but priority factors that are under consideration include (1) access to both fresh and salt water; (2) isolation of the hatchery for biosecurity and security against human intrusion, and; (3) ease of distribution of seed stock to other islands (NMC-CREES 2011).

Most of the current aquaculture production on Guam and in the CNMI involves tilapia (mainly Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*O. niloticus*), and hybrids) and penaeid shrimp (mostly two marine species, the Pacific white shrimp (*Litopenaeus vannamei*) and black tiger prawn (*Penaeus monodon*)). Government-sponsored aquaculture facilities typically conduct research and produce seedstock for distribution to private fish farms, where fish are then raised and eventually distributed to retail food markets.

There is evidence that tilapia fry were imported to Guam from Taiwan as *O. aureus* x *niloticus* hybrids, and permits may have been issued to import genetically pure *O. aureus* (CTSA 2010), but we were unable to independently confirm this. Historically, a number of species were investigated for their aquaculture potential (FitzGerald 1982), and there is also growing interest in experimenting with and utilizing additional species, including native species (M. Ogo and R. Manglona, oral commun., 2010). A list of commodity species for research and production at the NMC-CREES has been prioritized (Table 30). Diseases pose serious problems in aquaculture in

general, including the Pacific region, especially with shrimp. The GADTC has been a leader in research to understand and develop guidelines for managing aquaculture-related disease problems (J.W. Brown, oral commun., 2010).

Both facilities at UOG and NMC follow careful biosecurity protocols and staff members are conscientious of the risks involved in holding and culturing nonindigenous species in the vicinity of natural waters. At the GADTC research facility, for instance, all circulating water passes through a filtration system and is eventually dispensed onto dry volcanic rock and then channeled directly to the sea.

The CNMI aquaculture development plan specifically addresses biosecurity issues (Table 31). There is no evidence, to the best of our knowledge, that there have been any recent breaches or escapes from these facilities. The giant river prawn (*Macrobrachium cf. rosenbergii*), a taxon of interest in the past, escaped accidentally and may have also been intentionally released into natural waters on Guam. However, this species apparently failed to become established (Eldredge 2000), perhaps from being outcompeted by the native *M. lars* (J.W. Brown, oral commun., 2010). It is unclear to us whether *M. rosenbergii* escaped from government-managed or private aquaculture facilities, or both.

We are unaware of other major freshwater aquaculture facilities throughout the rest of Micronesia. However, mariculture is a growing economic enterprise in Palau and to a lesser extent in the FSM (Prasad 2003; Sakuma and Ueranant 2007; Lindsay 2008). The mariculture industry in Palau and the FSM involves production of species for food (e.g., giant clam, trochus, crab, grouper, rabbitfish, and milkfish), ornamental trade (e.g., live corals), and baitfish (e.g., milkfish for recreational and commercial tuna fishing). The best developed facility in those regions is the Palau Mariculture Demonstration Center (PMDC) on Malakal, originally established in the 1970s as the Micronesian Mariculture Demonstration Center (MMDC). The PMDC is the largest clam factory in the world and mass produces several species of giant clams that are supplied locally and also to many other island nations in the Pacific region, marketed for food, aquaculture, the aquarium trade, and for natural stock replenishment. There was a limited attempt to mass produce freshwater giant prawns (*Macrobrachium cf. rosenbergii*) at the PMDC (http://www.spc.int/aquaculture/index.php?option=com_countries&view=country&id=14).

Table 30. Priority list of species/groups in production or of interest for aquaculture by the Northern Marianas College Cooperative Research Extension and Education Service (NMC-CREES 2011).

High Priority	Medium priority	Low priority	Emerging
Tilapia	Marine finfish	Sea cucumbers/sea urchins	Coconut crabs
Marine shrimp	Freshwater crustaceans (e.g., <i>Macrobrachium cf. rosenbergii</i> , <i>Procambarus clarkii</i>)	Corals	Trochus (<i>Trochus</i> spp.)
	Giant clams (<i>Tridacna derasa</i>)	Marine ornamental fish	Sponges
	Milkfish (<i>Chanos chanos</i>)	Freshwater ornamental fish	Turban shells (<i>Turbo</i> spp.)
		Mangrove crabs (<i>Scylla serrata</i>)	

Table 31. Strategies identified to overcome biosecurity challenges for aquaculture in the Commonwealth of the Northern Mariana Islands (NMC-CREES 2011).

Objective	Action Strategies	Measures
Minimize risk of disease import	<ul style="list-style-type: none"> • Laws and regulations reducing potentially harmful imports such as fresh or frozen shrimp. • Increase public awareness of biosecurity issues through media such as posters or TV ads. • Establish a quarantine facility. • Improve disease diagnostic and observation capacity. 	Biosecurity threats to aquaculture from imported products are eliminated within five years.
Minimize risk of harmful invasive species	<ul style="list-style-type: none"> • Risk assessment of any exotic species importation into CNMI. • Publish and publicize a list of potentially invasive species for CNMI. 	Biosecurity threats to aquaculture from potentially invasive species are eliminated within five years.

Current Management Practices

As a territory of the United States, Guam is subject to Federal regulations that restrict the importation of certain live aquatic animals intended for aquaculture food production. For example, under the injurious wildlife provisions of the Lacey Act (P.L. 97-79 as amended), the USFWS prohibits the importation and interstate transport of certain injurious terrestrial and aquatic animals, including various species of mammals, birds, fish, amphibians, reptiles, mollusks, and crustaceans. All or most fish species and other taxa currently listed as prohibited under the Lacey Act are associated with the aquaculture industry or the live food industry and includes members of the families Salmonidae (salmon), Clariidae (walking catfishes), Channidae (snakeheads), and four Asian carp species and their hybrids: the largescale silver, silver, bighead, and black carp (Table 32).

Although government programs that support and promote finfish and shellfish aquaculture in Micronesia are generally proactive in implementing established biosecurity protocols, it is less clear how engaged the commercial and private sector is in doing so. Consequently, there are known cases of nonindigenous species becoming established or being spread into natural waters through this pathway. For instance, the chevron snakehead (*Channa striata*) population now established in the Ajayan River in southern Guam is thought to have resulted from the escape of fish from a local fish farm. A number of other nonindigenous fishes and other freshwater animals (e.g., walking catfish, *Clarias* spp., and turtles) were previously imported for use in aquaculture, and are established or reported in the wild. Similar to snakeheads, the source of some or all of these wild populations is possibly due to escapes or releases from aquaculture facilities.

Table 32. Aquatic species listed under the injurious wildlife provisions of the U.S. Lacey Act (<http://www.fws.gov/fisheries/ans/ANSInjurious.cfm>).

Scientific Name	Common Name
Family Salmonidae	salmon ^a
Family Clariidae	walking catfish (about 13 genera; ~100 species)
Genera <i>Channa</i> and <i>Parachanna</i>	snakeheads (2 genera; 28 species)
<i>Hypophthalmichthys harmandi</i>	largescale silver carp (and hybrids)
<i>Hypophthalmichthys molitrix</i>	silver carp (and hybrids)
<i>Hypophthalmichthys nobilis</i>	bighead carp (and hybrids)
<i>Mylopharyngodon piceus</i>	black carp (and hybrids)
Genus <i>Eriocheir</i>	mitten crabs (three species)
Genus <i>Dreissena polymorpha</i>	zebra mussel

^a Except those accompanied by proper health certification

Prognosis

It is anticipated that any increase in the human population in Guam will also result in increased demand for food animals produced through aquaculture. It is possible that such demand will also increase the likelihood of development of additional aquaculture facilities, as well as species of interest for aquaculture. Future risk potential for establishment of new species as well as the spread of already established species by means of this pathway is **medium/moderately certain**.

Live Food Industry

This pathway includes freshwater fishes or other aquatic animals that are imported live into Guam and other Micronesian islands to be sold as food, as well as freshwater fishes or other aquatic animals that are raised in aquaculture facilities on the islands and distributed live to local stores or markets where they are sold as food. The mechanism by which animals are introduced into natural water bodies by means of this pathway is typically through intentional release or unauthorized release with the intent of establishing populations for subsistence harvesting.

Present Condition

Except for some live marine animals (e.g., lobsters, crabs, clams), most aquatic animals imported to Guam for human consumption arrive dead as chilled, frozen, dried, or preserved products (Christy et al. 2007b). In contrast, some tilapia that are raised on aquaculture farms in Guam are distributed live to markets on the island where they are sold as food. During our visit to Guam in 2010, we visited at least three stores that were selling small-, medium- and large-sized Nile tilapia (*Oreochromis niloticus*), including both wild and red-color morphs, as well as live shrimp for consumption. Some stores and the farmer's market in Dededo also had live walking catfish for sale. Live animals, presumably supplied entirely by aquaculture facilities, were held in indoor tanks within each store. Based on our observations, consumers are allowed, if desired, to carry fish away live, although it is likely that most purchasers have vendors supply fresh fish or shellfish on ice, either whole or cleaned. It is unknown how many localized

populations of popular food species may have been introduced into natural water bodies by means of this pathway.

It is likely that tilapia were introduced to Palau and the FSM with the intent to be stocked locally, possibly illegally and presumably for food. Tilapia (provisionally identified as *O. mossambicus*) were first detected in Palau in 2003, and the Bureau of Agriculture promptly responded with a concerted effort to eradicate fish from four sites using rotenone (Nico and Walsh 2011). However, fish persisted at one site as of 2010, and we were informed that management authorities planned to continue efforts to eradicate fish from this site. Recently, in contrast to previous actions, a legislative bill was under consideration in Palau that was intended to promote tilapia farming in the islands. Senate bill 8-173, dated 9 December 2010, proposed the following:

“Encourage the development of Tilapia fish farms by providing Palauan citizens with training on developing Tilapia fish farms, and providing local Palauan citizens with seedlings to develop Tilapia fish farms; encourage Palauan citizens to raise, breed, consume, and sell Tilapia fish raised on Tilapia fish farms.”

This action prompted knowledgeable scientists and other experts to express concern, on behalf of the Secretariat of the Pacific Regional Environment Programme (SPREP), about potential impacts of tilapia introductions to Palau. Recently we were informed that this issue appears to be resolved and there are currently no further plans to promote tilapia farming in Palau (J. Miles, invasive species coordinator for Palau, written commun., 2011).

We are aware of the interdiction of at least one shipment of swamp eels (*Monopterus* sp.) in Saipan that was presumably imported illegally to be used for food (S. McKagan, oral commun., 2010).

Current Management Practices

Other than prohibitions against possession or sale of certain species, we are unaware of any management practices related to the distribution of live food fish within Guam. It is unknown to us whether retail markets selling live food fish are required to have permits, if food fish must be killed prior to sale, or if there are regulations in place for the handling and distribution of live or fresh animal products. At the market in Dededo we observed vendors selling live fish and shrimp to customers with no apparent sanitary precautions.

Prognosis

It is anticipated that any increase in human population in Guam will also result in an increase in the numbers of live fish and other freshwater species provided to food markets on the island. Increased consumer demand may also result in more markets distributing live food products. Future risk potential for establishment of new species as well as the spread of already established species by means of this pathway is **medium-to-high/moderately certain**. Greater risk may be likely depending on the demographic and ethnic composition of the workforce associated with the military buildup on Guam.

Recreational Freshwater Fishing

This pathway is associated with sport fishing or casual angling and typically involves government stocking as well as illegal or unauthorized stocking of sport and game fishes and the intentional or accidental release of bait fishes or other aquatic animals or invertebrates used as bait. In freshwater systems, bait releases are typically associated with anglers who release any unused, live bait fishes or other aquatic animals used as bait.

Present Condition

Guam and other areas of Micronesia have been sites where species have been historically stocked by government agencies, in most cases to establish game species (e.g., sport fishes), food species, and/or as biocontrol agents. For instance, various fish species were intentionally stocked in Fena Reservoir after its construction with the intent to establish them for sportfishing purposes (e.g., *Micropterus* spp., *Ictalurus punctatus*; Table 14) (Guam 1964, 1967). The following excerpt from Guam's Department of Agriculture 1969 annual report (Guam 1969) describes the introduction of Neotropical sportfish of the genus *Cichla*, a group commonly known as peacock bass or tucunare:

“A South American fresh water game fish called Tucunare, introduced into the 175-acre Fena Lake in February 1968, have spawned and appeared to be firmly established in the lake. By November 1968, at least three distinct sizes of Tucunare were seen in the lake and spillway catchment basin. To develop the fresh water game fishing potential of the island, young Tucunare were also transplanted into one of the large stream systems in the south-central part of the island.”

However, stocking of *Cichla* in Fena Reservoir may have also been motivated in part to control tilapia (*Oreochromis mossambicus*), a nonindigenous omnivorous fish that was stocked previously in an attempt to control nonindigenous plants (Brock and Takata 1956). Although the source of populations of some poeciliids currently established on Guam and on other islands in Micronesia may have been through the pet trade, there is also evidence that introductions of some of these species occurred through intentional stockings as biocontrol agents for insect pests (Eldredge 2000) or, in the case of *Poecilia reticulata*, to “balance” the aquatic fauna represented by previously stocked species (Brock and Takata 1956).

Fishing with live bait is a common practice throughout the world and the dispersal and introduction of nonindigenous aquatic species have often been attributed to the release or escape of baitfish and other biota from anglers (Ludwig and Leitch 1996; Fuller et al. 1999). The vector usually involves one or more anglers either accidentally or intentionally dumping the contents of a live-bait well into a water body. On some Pacific islands (e.g., Hawaii), tilapia are used as bait, although perhaps more commonly as cut bait rather than used live (Maciolek 1984). However, we are unaware of any nonindigenous freshwater fish species on Guam or elsewhere in Micronesia having become established by this vector.

Current Management Practices

In the past, intentional stockings were an important pathway by which nonindigenous species became established on Guam and other Micronesian islands. However, some agencies now recognize the adverse effects of previous stockings that resulted in the establishment of

injurious or harmful species. It is our impression that DAWR, and presumably other government agencies in Micronesia, currently undergo a thorough vetting process to evaluate the potential risks associated with fishes or other aquatic species that might be under consideration for intentional stocking in either natural or artificial water bodies. Except for aquaculture interests, there appears to be a prevailing attitude to utilize native species intended for consumptive purposes, at least for recreational fishing.

DAWR does not permit the importation of nonindigenous fishes for use as bait fish (B. Tibbatts, oral commun., 2010). DAWR is currently involved in restoration of the Masso reservoir by removing nonindigenous species, restocking with native species, and providing recreational fishing opportunities. Presumably, anglers will be allowed to fish with live bait, but we are unaware if there will be any regulations or policies implemented to govern the use of such animals. Our assumption is that use of live bait for any type of fishing (saltwater or freshwater) is limited to native species.

Prognosis

An increase in the human population on Guam will likely result in an increase in the numbers of individuals on the island interested in freshwater fishing, a situation that might lead to the introduction or spread of nonindigenous sport or bait fish or other animals. Given the abundant fishing opportunities for marine species, relatively limited freshwater sportfishing pressure, and regulations prohibiting importation of freshwater bait species (at least on Guam), there is relatively low probability that this pathway will lead to additional introductions of nonindigenous freshwater fishes in Micronesia for the foreseeable future. DAWR promotes use of native species for recreational angling purposes. Although the possibility exists of people moving freshwater game and/or bait species from one water body to another, the overall current low interest in angling in inland water bodies on Guam suggests that this situation is not likely to change substantially in association with the planned military buildup. Future risk potential for establishment of new species as well as the spread of already established species by means of this pathway is expected to be *low/reasonably uncertain*.

Ballast Water and Hull Fouling

Present Condition

Transport and release of organisms by means of this pathway is a widespread problem and has led to the establishment of numerous invasive and injurious aquatic species worldwide. This pathway has been cited as the leading cause of introductions of nonindigenous species to navigable coastal waters and inland waterways, and a few natural water bodies such as the Laurentian Great Lakes (Ricciardi and MacIsaac 2000; Fofonoff et al. 2003; Ruiz and Carlton 2003; Drake and Lodge 2004; Drake et al. 2005). Consequently, many practices and policies have been proposed and/or adopted to detect, monitor, and mitigate for translocations of organisms by means of this pathway and associated vectors (Wasson et al. 2002; Drake and Lodge 2004; Fernandez 2008; Hulme et al. 2008; Buck 2009; GWADF 2009). Ballast water and hull fouling differ as vectors in that the first usually involves benthic or free-swimming organisms whereas the second typically involves sessile or attached organisms.

We are unaware of any confirmed cases of established nonindigenous freshwater or diadromous species in Micronesia transported by means of this pathway. Two brackish-water

species used in the quantitative risk analysis for this study, the fang-toothed blenny (*Omobranchus ferox*) and the mangrove goby (*Mugiligobius cavifrons*), were assumed to have been introduced to Hawaii by means of ballast water (Englund 2002).

Current Management Practices

Current procedures and policies of either the DoD or the commercial and private shipping sectors was not reviewed to determine existing practices or policies intended to prevent or minimize introductions or spread of nonindigenous species by means of this pathway.

Prognosis

The volume and network of maritime traffic in and around Micronesia is likely to result in this pathway providing a much greater likelihood for nonindigenous marine organisms than freshwater ones. Future risk potential for establishment of new species as well as the spread of already established species in freshwater habitats of Micronesia by means of this pathway is expected to be **low/reasonably uncertain**.

Biological Control

Present Condition

Several freshwater fish species present on Pacific islands were introduced for the purpose of biological control (Maciolek 1984). The introduction of peacock cichlid (*Cichla* sp.) to Guam was not only for sportfishing purposes, but also to control feral tilapia (see *Recreational Freshwater Fishing—Present Condition*) (Nelson 1988). The mosquitofish (*Gambusia* sp.) and sailfin molly (*Poecilia latipinna*) were introduced into Hawaii for the biological control of mosquitoes (Van Dine 1907; Yamamoto and Tagawa 2000). It is likely that some poeciliids and certain other small nonindigenous fishes were also stocked on other Pacific islands in the past with the intention of using them to control insect pests. The cane toad *Rhinella marina* was intentionally introduced to various Pacific islands as a biological control agent. For example, it was introduced to the Micronesian island of Pohnpei (in FSM) by occupying Japanese forces during the Second World War to control mosquitoes and grasshoppers and to Fiji in the early 1930s to control beetle (coleopteran) pests of agriculture (Lever 2003). In Guam, the cane toad was first introduced to Agaña Spring in 1937 for insect and slug control (Eldredge 1994, 2000).

Current Management Practices

DAWR serves as the main agency to permit the importation of nonindigenous fishes or other aquatic animals for use in biological control. This would likely require careful review and vetting of any plans for such use of nonindigenous species and consideration of possible consequences.

Prognosis

We are unaware of any current activities or plans involving introductions of nonindigenous aquatic animals for the purpose of biological control agents. Thus, future risk potential for establishment of any new species by means of this pathway is considered to be **low/very uncertain**.

Research

Present Condition

We are unaware of any past or current activities involving the introduction of nonindigenous aquatic vertebrates or macroinvertebrates to Pacific islands for the explicit purpose of conducting scientific research, other than those species of interest for aquaculture.

Current Management Practices

DAWR serves as the main agency that issues permits for the importation of nonindigenous fishes or other aquatic animals for use in scientific research. This would likely require careful review and vetting of any plans for such use of nonindigenous species and consideration of possible consequences.

Prognosis

Future risk potential for establishment and/or spread of nonindigenous species by means of this pathway is *unknown*.

Natural Dispersal from Neighboring Waters

This pathway involves the natural dispersal or spread of nonindigenous freshwater aquatic animals. Within freshwater bodies of Pacific islands, this includes natural movement from one island to another, and within a single island, from a drainage where the species is established to an adjacent drainage where it previously did not occur.

Present Condition

We are unaware of any evidence to indicate that nonindigenous freshwater animals have naturally dispersed to Guam from neighboring islands. However, it is likely that some nonindigenous aquatic animals introduced into one or a few drainages subsequently dispersed naturally into adjacent drainages, as evidenced by their current distribution. For example, the widespread presence of tilapia among Guam drainages suggests that they may have naturally dispersed as well as been intentionally stocked. Peacock cichlids introduced to Fena Reservoir reportedly dispersed to streams downstream of the reservoir (B. Tibbatts and F. Camacho, oral commun., 2010).

Current Management Practices

We are unaware of any specific management practices on Guam or other Micronesian islands currently aimed at preventing the natural dispersal of nonindigenous aquatic animals.

Prognosis

Future risk potential for dispersal of nonindigenous species, both those already established on Guam, and/or other Micronesian islands, as well as those with significant probability of becoming established in the future, is *medium/moderately certain*. This pathway can be affected by different factors, some of which may act in synergy. For example, episodic

natural events such as floods or typhoons can create physical conditions that favor dispersal for some species. Moreover, the physiological tolerances of many species may predispose them with the ability to move through habitats (e.g., brackish or full-strength sea water) that would preclude other less-tolerant species.

Detection

The chance of eradicating a new introduced species decreases the longer one remains undetected (McNeely et al. 2001; Wittenberg and Cock 2001). Early detection of new introductions of nonindigenous fish species will require increasing public awareness plus surveys to monitor sites. Although surveys can and should be used to detect new introductions, the public should be engaged because the sheer size of the human population on Guam greatly increases the likelihood of early detections. The population of Guam was projected as 180,692 in 2010 (Guam Bureau of Statistics and Plans 2009, p. 290). The key is educating the public to recognize new invasive species.

Methods to increase public awareness are described in greater detail below, and emphasize possible use of posters and other media to illustrate native freshwater species in Guam, which may help the public to recognize nonindigenous species by default. In effect, if a member of the public buys or finds a freshwater fish in Guam and that fish is not recognized as being native, then it should not be released. Any fish (or other aquatic species) collected in the wild that is not recognized as native, or not known to be an established nonindigenous species, should be promptly reported to DAWR. Similar posters and other media products that illustrate native and nonindigenous species could be created for other taxonomic groups, such as turtles, frogs, snails, and crustaceans. Reporting could be enhanced by a telephone or text messaging hotline (such as is currently used by DAWR and publicized for reporting occurrence of coqui frogs), and by an online reporting form.

Any specimens of newly detected or introduced species should be preserved as vouchers and added to the museum collection at the University of Guam or another appropriate institution, where specimens could be examined by taxonomic experts to confirm identification. Local newspapers should be encouraged to report any new introductions, together with photographs to document new species on the island, and local biologists are encouraged to publish information about any such specimens in the peer-reviewed literature. The University of Guam publishes the scientific journal *Micronesica* that focuses on the natural sciences and is an appropriate outlet for the publication of new reports of the occurrence, establishment, or spread of introduced species.

Documenting Imports: Propagule Pressure

To thoroughly understand the potential risks to Micronesia of invasive species originating by means of the pet trade and other pathways requires that the types and numbers of each species imported into Guam and other islands be regularly documented. Currently this information is only partially available. Having this information available would allow for better estimation of propagule pressure (Kolar and Lodge 2001; Lockwood et al. 2005; Colautti et al. 2006; Duggan et al. 2006; Conover et al. 2007; Gertzen et al. 2008). Some information regarding species imported into Guam is recorded by USFWS personnel on Guam (animals from foreign sources) and some information is maintained by DAWR personnel (animals from domestic sources); we were unable to locate or obtain either of these sources of information. The LEMIS data for Guam

have been obtained from the USFWS. However, that database generally does not identify aquarium fish to species. In particular, many shipments of fish generally are lumped into a category termed “tropical fish.” The estimated number of freshwater “tropical fish” imported into Guam over the 2007-2009 period totaled 149,650 (67,213 fish in 2007, 60,263 in 2008, and 22,174 in 2009). These numbers only represent fish imported into Guam from foreign sources, not those shipped from Hawaii or the mainland United States. Tracking of imports could be improved if foreign exporters were to list the types and numbers of each species of fish in each shipment arriving in Guam, and if such information were to be recorded by border agents and retained in an electronic database. Additionally, tracking could be further improved if the types and number of each species imported into Guam from domestic sources also were monitored, recorded, and available in an electronic database.

Border agents and wildlife inspectors likely cannot be trained to identify all aquarium animals and plants that are or potentially can be imported into Guam. However, agents are encouraged to receive sufficient training to identify most of the approximately 265 freshwater fish species or species groups and 45 species of aquatic invertebrates (most of which are marine) on the island’s white list (see below), a list of permitted, nonindigenous species that are putatively safe to import insofar as not to pose serious threats of becoming invasive.

Currently the wildlife inspector on Guam apparently inspects about 30% of shipments brought to his attention. Perhaps this percentage could be increased by hiring an additional wildlife inspector or by requiring that live fish be held in quarantine for a brief period to provide inspectors more time to examine each shipment. Photographic documentation of containers and contents might speed the process. Any quarantine would likely increase costs for the government and the private sector. In a quarantine system some fish would need to be housed and fed while in quarantine, and a few of these animals might die from stress or other factors. However, such costs might be offset by preventing the importation of potentially invasive species that otherwise would not have been stopped. Also, diseased fish in quarantine might be identified and any pathogens prevented from spreading to wild populations.

Documenting Imports: Detecting Imports

Radiograph machines at A.B. Won Pat International Airport, the commercial airport in Guam, may be inadequate to thoroughly screen materials arriving by air; at the onset of this study, equipment was in disrepair as well as insufficient to pass large items (USDA-APHIS 2009). This indicates that contraband materials could enter the island relatively easily. Trained security dogs are used for luggage inspection at Guam’s airport, but we presume that dogs are not trained or are incapable of detecting live aquatic animals. Detection could be improved by repair or replacement of radiograph equipment and increased screening of commercial shipments arriving by air.

Even with increased inspection of known live-animal shipments to Guam, border agents cannot detect all incoming wildlife. The detection probability of live freshwater fishes and other potential nuisance aquatic species could be estimated by conducting controlled trials in which live fish are imported into Guam in known containers, along known pathways, following a predetermined schedule. In a hypothetical scenario, investigators would record the percentage of such packages and fish detected by agents who are unaware of the trial schedule or package characteristics. This information could then be used to estimate the actual number of fish

imported annually into Guam by means of each pathway. This would allow for the identification of porous pathways of introduction that subsequently could receive additional attention by inspectors.

Postal Service

By law (U.S. Code Title 39, Section 404[c]) domestic mail in the United States is protected and sealed against inspection except under exigent circumstances such as to protect human life or safety, as authorized for intelligence purposes, or if executed by Federal Search Warrant. The postal inspector in Guam currently does not allow domestic mail to be inspected unless the postal inspector is present, and this individual is frequently unavailable (USDA-APHIS 2009). Approximately 95% of mail arriving in Guam is considered domestic mail. Aquarium fish and other aquatic species can be transported by mail services, with some ordered by means of the Internet. As a result, even if customs inspectors documented every aquarium organism transported as ship or air cargo or transported by passengers, an undetermined and potentially large number of nonindigenous animals could be imported into Guam by means of other pathways, including the postal service and private courier services such as Federal Express or the United Parcel Service. Ideally, all mail entering Guam could be inspected by radiograph to establish probable cause for search warrants for undeclared live-animal packages. However, radiograph equipment at the main U.S. sorting facility in Guam was inoperative at the onset of this study (USDA-APHIS 2009). Moreover, it is unknown to us how much domestic mail is inspected.

Currently, most international mail destined for Guam enters the United States in Hawaii where it can be inspected relatively easily (USDA-APHIS 2009). From that point, such mail is considered domestic U.S. mail and a search warrant is required to inspect it once it reaches Guam. Perhaps in the future postal workers in Guam may have the capability to inspect a larger percentage of such mail than is done by workers in Hawaii.

Australia inspects 100% of international mail using visual inspection, dogs and radiograph machines (Pheloung 2003). As part of New Zealand's integrated biosecurity system, officials inspected 84% of approximately 51 million pieces of international mail within a year ending 30 June 2000; of those, 94,000 items were opened, of which 30.7% contained risk goods (Hayden and Whyte 2003). Increased interdiction of contraband live animals would result if similar measures were implemented for all mail arriving to Guam from both domestic and international sites of origin. Further improvements at intercepting live-animal shipments could be achieved if efforts were expended to better estimate detection probability, and the results used to help design the most efficient system of mail inspection.

Currently, mail that arrives at Andersen Air Force Base is not inspected (USDA-APHIS 2009). As with commercial shipments, increased inspection of military mail arriving in Guam from off the island would improve detection of undeclared live-animal shipments.

Permitted and Prohibited Species

White List Review

A white list (Simberloff 1998) or a clean list (Case Study 2.5 in Wittenberg and Cock 2001) is a list of nonindigenous species that are considered to be non-invasive and safe to import

(McNeely et al. 2001). This concept is considered to be stricter and safer than relying upon a black or “dirty list” list (Wittenberg and Cock 2001) of species that are prohibited from a given region. A white list follows the precautionary principle (Case Study 3.3 in Wittenberg and Cock 2001) of the idea of guilty until proven innocent (Ruesink et al. 1995; McNeely et al. 2001; Wittenberg and Cock 2001); in other words, of evaluating the tradeoffs by considering those species to be permitted as posing less potential invasive risk. Some researchers have proposed a third category, a “gray list,” to include taxa provisionally prohibited (or provisionally permitted) pending further information (the three-list approach has been called “white/black/gray” or “green/red/amber”) (Jenkins 2005).

DAWR has developed a white list of freshwater and marine plants and animals that are permitted to be legally imported for the aquarium trade, aquaculture, water gardens, and other uses. Species that are not on the white list are prohibited from being legally imported, with limited exceptions (for example, species allowed to be displayed by the commercial aquarium in Tumon). The white list is made available to those businesses that regularly import plants and animals, mainly pet shops and a small number of aquaculture facilities. A preliminary review of the freshwater fish species included on the white list revealed a few discrepancies in currently accepted nomenclature; the white list is included here with revisions to scientific names and the addition of taxonomic authorities and vernacular names commonly used in the aquarium trade (Table 33). A similar review was not completed for the permitted marine fishes, invertebrates (mostly marine), and the small number of allowable freshwater plants (Tables 34-36).

An independent review of DAWR white list may be warranted, including a process to ensure flexibility in omitting or adding species to the list based on recommendations by experts. Some immediate considerations were proposed from our preliminary review of the list and site visits to pet shops in Guam. For instance, we suggested in an earlier (2010) draft of this document that the legal importation of all armored suckermouth catfishes of the genus *Pterygoplichthys* and related species and genera (various taxa of the family Loricariidae) be reconsidered in Guam. Several species in the genus *Pterygoplichthys* are popular in the aquarium trade and are sold widely, and individuals commonly grow to become quite large. Owners of pet fish are more likely to release fish that become too large to house easily (Gertzen et al. 2008), and the suspected repeated release of aquarium specimens of *Pterygoplichthys* has resulted in their widespread establishment in Hawaii, Florida, Texas, Mexico, Southeast Asia, and elsewhere (Nico et al. 2009). Once released, colonies of fish in the genus *Pterygoplichthys* can cause extensive damage to stream banks by their excavation of numerous nesting burrows (Nico et al. 2009). Some populations that have become established out of their native range reach extraordinary densities. We were recently informed that, effective 31 December 2010, DAWR no longer permits the importation of armored catfishes of the family Loricariidae into Guam (B. Tibbatts, written commun., 2011). Another example of a species that likely should be removed from the list is the bighead carp, *Hypophthalmichthys nobilis*, which was recently listed as injurious by the U.S. Fish and Wildlife Service and is now prohibited from transport between U.S. states and any of its territories (USFWS 2011). The white list also contains other species known to be invasive on Pacific islands (including Guam) and elsewhere, including various cichlids and poeciliids. Some species reach relatively large body size and/or are predatory and thus likely to pose threats to native species, others may be suspected or known superior competitors, and for yet others possible ecological or interspecific impacts remain unknown. A regular review of this list, perhaps on a 5-year basis, would allow incorporation of new

information as it becomes available to assess the potential risks associated with the importation of permitted fish.

Table 33. Freshwater fishes on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. Taxonomic authorities from the “Catalog of Fishes” (Eschmeyer 2011). Common names from various sources, including Robins et al. (1991), FishBase® (Froese and Pauly 2011), and popular names in the aquarium trade.

Family	Name on original list	Current accepted name	Authority	Common name
Polypteridae	<i>Erpetoichthys calabaricus</i>	<i>Erpetoichthys calabaricus</i>	Smith 1865	reedfish
Polypteridae	<i>Polypterus</i> spp. (all)	<i>Polypterus</i> spp. (all)	Lacepède 1803	bichirs (various names)
Osteoglossidae	<i>Osteoglossum bicirrhosum</i>	<i>Osteoglossum bicirrhosum</i>	(Cuvier 1829)	arawana
Osteoglossidae	<i>Osteoglossum ferreirai</i>	<i>Osteoglossum ferreirai</i>	Kanazawa 1966	black arawana
Pantodontidae	<i>Pantodon buchholzi</i>	<i>Pantodon buchholzi</i>	Peters 1876	freshwater butterflyfish
Notopteridae	<i>Chitala</i> spp. (all)	<i>Chitala</i> spp. (all)	Fowler 1934	Asian knifefishes or featherbacks
Notopteridae	<i>Notopterus</i> spp. (all)	<i>Notopterus</i> spp. (all)	Lacepède 1800	featherbacks (various names)
Notopteridae	<i>Papyrocranus afer</i>	<i>Papyrocranus afer</i>	(Günther 1868)	reticulate knifefish
Notopteridae	<i>Papyrocranus congoensis</i>	<i>Papyrocranus congoensis</i>	(Nichols & La Monte 1932)	Congo marble knifefish
Notopteridae	<i>Xenomystus nigri</i>	<i>Xenomystus nigri</i>	(Günther 1868)	African knifefish
Mormyridae	<i>Gnathonemus petersi</i>	<i>Gnathonemus petersii</i>	Günther 1862	elephantnose fish
Mormyridae	<i>Mormyrus kannume</i>	<i>Mormyrus kannume</i>	Forsskål 1775	elephant-snout fish
Gymnarchidae	<i>Gymnarchus niloticus</i>	<i>Gymnarchus niloticus</i>	Cuvier 1829	aba
Cyprinidae	<i>Balantiocheilus melanopterus</i>	<i>Balantiocheilus melanopterus</i>	(Bleeker 1851)	bala shark; tricolor sharkminnow
Cyprinidae	<i>Barbodes</i> spp. (all)	<i>Barbodes</i> spp. (all)	Bleeker 1859	barbs (various names)
Cyprinidae	<i>Barbus</i> spp. (all)	<i>Barbus</i> spp. (all)	Cuvier & Cloquet 1816	barbs (various names)
Cyprinidae	<i>Boraras</i> spp. (all)	<i>Boraras</i> spp. (all)	Kottelat & Vidthayanon 1993	rasboras (various names)
Cyprinidae	<i>Capoeta</i> spp. (all)	<i>Capoeta</i> spp. (all)	barbs (various names)	barbs (various names)
Cyprinidae	<i>Carrasius auratus- not from Asia</i>	<i>Carassius auratus</i>	(Linnaeus 1758)	goldfish, koi
Cyprinidae	<i>Chela</i> spp. (all)	<i>Chela</i> spp. (all)	Hamilton 1822	danionin barbs (various names)
Cyprinidae	<i>Crossocheilus siamensis</i>	<i>Crossocheilus oblongus</i>	Kuhl & van Hasselt 1823	Siamese flying fox
Cyprinidae	<i>Cyprinus carpio- not from Asia</i>	<i>Cyprinus carpio</i>	Linnaeus 1758	common carp

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Family	Name on original list	Current accepted name	Authority	Common name
Cyprinidae	<i>Brachydanio</i> spp. (all)	<i>Danio</i> spp. (all)	Hamilton 1822	danios (various names)
Cyprinidae	<i>Danio</i> spp. (all)	<i>Danio</i> spp. (all)	Hamilton 1822	danios
Cyprinidae	<i>Eirmotus octozona</i>	<i>Eirmotus octozona</i>	Schultz 1959	false eight-banded barb
Cyprinidae	<i>Epalzeorhynchus</i> spp. (all)	<i>Epalzeorhynchus</i> spp. (all)	Bleeker 1855	sharkminnows (various names)
Cyprinidae	<i>Esomus danricus</i>	<i>Esomus danricus</i>	(Hamilton 1822)	flying barb
Cyprinidae	<i>Aristichthys nobilis</i>	<i>Hypophthalmichthys nobilis</i>	(Richardson 1845)	bighead carp
Cyprinidae	<i>Morulius chrysophekadion</i>	<i>Labeo chrysophekadion</i>	(Bleeker 1850)	black sharkminnow
Cyprinidae	<i>Labeo</i> spp. (all)	<i>Labeo</i> spp. (all)	Cuvier 1816	barbs, labeos (various names)
Cyprinidae	<i>Luciosoma setigerum</i>	<i>Luciosoma setigerum</i>	(Valenciennes 1842)	Apollo sharkminnow
Cyprinidae	<i>Microrasbora</i> spp. (all)	<i>Microrasbora</i> spp. (all)	Annandale 1918	dwarf rasboras (various names)
Cyprinidae	<i>Puntius</i> spp. (all)	<i>Puntius</i> spp. (all)	Hamilton 1822	barbs (various names)
Cyprinidae	<i>Rasbora</i> spp. (all)	<i>Rasbora</i> spp. (all)	Bleeker 1859	rasboras (various names)
Cyprinidae	<i>Sawbwa resplendens</i>	<i>Sawbwa resplendens</i>	Annandale 1918	sawbwa barb
Cyprinidae	<i>Tanichthys albonubes</i>	<i>Tanichthys albonubes</i>	Lin 1932	White Cloud Mountain fish
Cobitidae	<i>Acanthopsis choirorhynchus</i>	<i>Acanthopsis choirorhynchus</i>	(Bleeker 1854)	horeseface loach
Cobitidae	<i>Botia</i> spp. (all)	<i>Botia</i> spp. (all)	Gray 1831	loaches (various names)
Cobitidae	<i>Cobitis taenia</i>	<i>Cobitis taenia</i>	Linnaeus 1758	spined loach
Cobitidae	<i>Lepidocephalus guntea</i>	<i>Lepidocephalus guntea</i>	(Hamilton 1822)	guntea loach
Cobitidae	<i>Leptobotia micrionoemocheilus</i>	<i>Leptobotia microphthalma</i>	Fu & Ye 1983	Chinese loach
Cobitidae	<i>Misgurnus fossilis</i>	<i>Misgurnus fossilis</i>	(Linnaeus 1758)	weatherfish
Cobitidae	<i>Acanthopthalmus kuhlii</i>	<i>Pangio kuhlii</i>	(Cuvier & Valenciennes 1846)	coolie loach
Cobitidae	<i>Pangio</i> spp. (all)	<i>Pangio</i> spp. (all)	Blyth 1860	loaches (various names)
Balitoridae	<i>Gastromyzon</i> spp. (all)	<i>Gastromyzon</i> spp. (all)	Günther 1874	hillstream loaches (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Balitoridae	<i>Homaloptera</i> spp. (all)	<i>Homaloptera</i> spp. (all)	van Hasselt 1823	loaches (various names)
Balitoridae	<i>Noemacheilus corica</i>	<i>Nemacheilus corica</i>	(Hamilton 1822)	polka dotted loach
Balitoridae	<i>Pseudogastromyzon</i> spp. (all)	<i>Pseudogastromyzon</i> spp. (all)	Nichols 1925	hillstream loaches (various names)
Balitoridae	<i>Sinogastromyzon wui</i>	<i>Sinogastromyzon wui</i>	Fang 1930	butterfly hillstream loach, Chinese butterfly loach
Gyrinocheilidae	<i>Gyrinocheilus aymonieri</i>	<i>Gyrinocheilus aymonieri</i>	(Tirant 1883)	Siamese algae eater
Distichodontidae	<i>Distichodus lussoso</i>	<i>Distichodus lusosso</i>	Schilthuis 1891	longsnout distichodus
Distichodontidae	<i>Distichodus noboli</i>	<i>Distichodus noboli</i>	Boulenger 1899	?
Distichodontidae	<i>Distichodus sexfasciatus</i>	<i>Distichodus sexfasciatus</i>	Boulenger 1897	sixbar distichodus
Distichodontidae	<i>Nannaethiops unitaeniatus</i>	<i>Nannaethiops unitaeniatus</i>	Günther 1872	online tetra
Distichodontidae	<i>Neolebias</i> spp. (all)	<i>Neolebias</i> spp. (all)	Steindachner 1894	tetras (various names)
Alestidae	<i>Hemigrammopetersius caudalis</i>	<i>Alestopetersius caudalis</i>	(Boulenger 1899)	yellowtail tetra
Alestidae	<i>Arnoldichthys spilopterus</i>	<i>Arnoldichthys spilopterus</i>	(Boulenger 1909)	African red-eyed characin
Alestidae	<i>Bathyaethiops caudomaculatus</i>	<i>Bathyaethiops caudomaculatus</i>	(Pellegrin 1925)	African moon tetra
Alestidae	<i>Bryconaethiops microstoma</i>	<i>Bryconaethiops microstoma</i>	Günther 1873	?
Alestidae	<i>Chalceus</i> spp. (all)	<i>Chalceus</i> spp. (all)	Cuvier 1818	characins (various names)
Alestidae	<i>Ladigesia roloffi</i>	<i>Ladigesia roloffi</i>	Géry 1968	Sierra Leone dwarf characin
Alestidae	<i>Lepidarchus adonis</i>	<i>Lepidarchus adonis</i>	Roberts 1966	jellybean tetra, adonis characin
Alestidae	<i>Phenacogrammus interruptus</i>	<i>Phenacogrammus interruptus</i>	(Boulenger 1899)	Congo tetra
Hemiodontidae	<i>Hemiodopsis</i> spp. (all)	<i>Hemiodopsis</i> spp. (all)	Müller 1843	hemiodus, hemiodine characins
Prochilodontidae	<i>Semaprochilodus</i> spp. (all)	<i>Semaprochilodus</i> spp. (all)	Fowler 1941	prochilodus (various names), flagtail characins
Anostomidae	<i>Abramites</i> spp. (all)	<i>Abramites</i> spp. (all)	Fowler 1906	Headstanders
Anostomidae	<i>Anostomus</i> spp. (all)	<i>Anostomus</i> spp. (all)	Scopoli 1777	Headstanders

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Family	Name on original list	Current accepted name	Authority	Common name
Anostomidae	<i>Leporinus</i> spp. (all)	<i>Leporinus</i> spp. (all)	Agassiz 1829	Leporinus characins
Chilodontidae	<i>Chilodus punctatus</i>	<i>Chilodus punctatus</i>	Müller & Troschel 1844	spotted headstander
Lebiasinidae	<i>Copella</i> spp. (all)	<i>Copella</i> spp. (all)	Myers 1956	splashing tetras
Lebiasinidae	<i>Nannobrycon</i> spp. (all)	<i>Nannostomus</i> spp. (all)	Günther 1872	pencilfishes (various names)
Lebiasinidae	<i>Nannostomus</i> spp. (all)	<i>Nannostomus</i> spp. (all)	Günther 1872	pencilfishes (various names)
Lebiasinidae	<i>Pyrrhulina</i> spp. (all)	<i>Pyrrhulina</i> spp. (all)		pyrrhulinas (various names)
Gasteropelecidae	<i>Carnegiella</i> spp. (all)	<i>Carnegiella</i> spp. (all)	Eigenmann 1909	hatchet fishes (various names)
Gasteropelecidae	<i>Gasteropelecus</i> spp. (all)	<i>Gasteropelecus</i> spp. (all)	Scopoli 1777	hatchet fishes (various names)
Gasteropelecidae	<i>Thoracocharax stellatus</i>	<i>Thoracocharax stellatus</i>	(Kner 1858)	spotfin hatchetfish
Characidae	<i>Aphyocharax</i> spp. (all)	<i>Aphyocharax</i> spp. (all)	Günther 1868	tetras (various names)
Characidae	<i>Astyanax mexicanus</i>	<i>Astyanax mexicanus</i>	(De Filippi 1853)	Mexican tetra
Characidae	<i>Boehlkea fredcochui</i>	<i>Boehlkea fredcochui</i>	Géry 1966	blue tetra
Characidae	<i>Cheirodon</i> spp. (all)	<i>Cheirodon</i> spp. (all)	Girard 1855	tetras (various names)
Characidae	<i>Corynopoma riisei</i>	<i>Corynopoma riisei</i>	Gill 1858	swordtail characin
Characidae	<i>Ctenobrycon spilurus</i>	<i>Ctenobrycon spilurus</i>	(Valenciennes 1850 in Cuvier & Valenciennes)	silver tetra
Characidae	<i>Gymnocorymbus ternetzi</i>	<i>Gymnocorymbus ternetzi</i>	(Boulenger 1895)	black tetra Characidae
	<i>Hasemania nana</i>	<i>Hasemania nana</i>	(Lütken 1875)	silvertip tetra
Characidae	<i>Hemigrammus</i> spp. (all)	<i>Hemigrammus</i> spp. (all)	Gill 1858	tetras (various names)
Characidae	<i>Hyphessobrycon</i> spp. (all)	<i>Hyphessobrycon</i> spp. (all)	Durbin 1908	tetras (various names)
Characidae	<i>Megalampodus</i> spp. (all)	<i>Hyphessobrycon</i> spp. (all)	Durbin 1908	tetras (various names)
Characidae	<i>Iguanodectes spilurus</i>	<i>Iguanodectes spilurus</i>	(Günther 1864)	slender tetra
Characidae	<i>Inpaichthys kerri</i>	<i>Inpaichthys kerri</i>	Géry & Junk 1977	royal tetra
Characidae	<i>Mimagoniates barberi</i>	<i>Mimagoniates barberi</i>	Regan 1907	croaking tetra
Characidae	<i>Coelurichthys microlepis</i>	<i>Mimagoniates microlepis</i>	(Steindachner 1877)	blue tetra
Characidae	<i>Moenkhausia</i> spp. (all)	<i>Moenkhausia</i> spp. (all)	Eigenmann 1903	tetras (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Characidae	<i>Nematobrycon</i> spp. (all)	<i>Nematobrycon</i> spp. (all)	Eigenmann 1911	emperor tetra, rainbow tetra
Characidae	<i>Paracheirodon</i> spp. (all)	<i>Paracheirodon</i> spp. (all)	Géry 1960	neon, cardinal tetras
Characidae	<i>Petitella georgia</i>	<i>Petitella georgiae</i>	Géry & Boutière 1964	false rummynose tetra
Characidae	<i>Vesicatrus tegatus</i>	<i>Phenacogaster tegatus</i>	(Eigenmann 1911)	?
Characidae	<i>Prionobrama filigera</i>	<i>Prionobrama filigera</i>	(Cope 1870)	glass bloodfin
Characidae	<i>Pristella maxillaris</i>	<i>Pristella maxillaris</i>	(Ulrey 1894)	X-ray tetra
Characidae	<i>Rachoviscus</i> spp. (all)	<i>Rachoviscus</i> spp. (all)	Myers 1926	tetras (various names)
Characidae	<i>Roeboides descavadensis</i>	<i>Roeboides descavadensis</i>	Fowler 1932	humpbacked characin
Characidae	<i>Tetragonopterus argenteus</i>	<i>Tetragonopterus argenteus</i>	Cuvier 1816	stoplight tetra
Characidae	<i>Thayeria</i> spp. (all)	<i>Thayeria</i> spp. (all)	Eigenmann 1908	penguinfishes (various names)
Crenuchidae	<i>Crenuchus spilurus</i>	<i>Crenuchus spilurus</i>	Günther 1863	sailfin tetra
Serrasalmidae	<i>Metynnis hypsauchen</i>	<i>Metynnis hypsauchen</i>	(Müller & Troschel 1844)	silver dollar
Serrasalmidae	<i>Metynnis schreitmulleri</i>	<i>Metynnis hypsauchen</i>	(Müller & Troschel 1844)	silver dollar
Serrasalmidae	<i>Myleus rubripinnis</i>	<i>Myleus rubripinnis</i>	(Müller & Troschel 1844)	redhook myleus
Serrasalmidae	<i>Mylossoma aureum</i>	<i>Mylossoma aureum</i>	(Spix & Agassiz 1829)	golden silverdollar
Crenuchidae	<i>Poecilocharax weitzmani</i>	<i>Poecilocharax weitzmani</i>	Géry 1965	black morpho tetra
Bagridae	<i>Pelteobagrus ornatus</i>	<i>Hyalobagrus ornatus</i>	(Duncker 1904)	?
Bagridae	<i>Mystus tengara</i>	<i>Mystus tengara</i>	(Hamilton 1822)	Pyjama catfish, tengara catfish
Bagridae	<i>Mystus vittatus</i>	<i>Mystus vittatus</i>	(Bloch 1794)	striped dwarf catfish
Bagridae	<i>Leiocassis siamensis</i>	<i>Pseudomystus siamensis</i>	(Regan 1913)	Asian bumblebee catfish
Bagridae	<i>Rita rita</i>	<i>Rita rita</i>	(Hamilton 1822)	rita
Siluridae	<i>Ompok sabanus</i>	<i>Kryptopterus sabanus</i>	(Inger & Chin 1959)	?
Siluridae	<i>Kryptopterus</i> spp. (all)	<i>Kryptopterus</i> spp. (all)	Bleeker 1857	glass catfishes (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Schilbeidae	<i>Parailia longifilis</i>	<i>Parailia congica</i>	Boulenger 1899	speckled or Congo glass catfish
Schilbeidae	<i>Platyropius siamensis</i>	<i>Platyropius siamensis</i>	(Sauvage 1883)	Siamese schilbeid catfish
Pangasiidae	<i>Pangasius sutchi</i>	<i>Pangasianodon hypophthalmus</i>	(Sauvage 1878)	striped catfish, iridescent shark, swai
Pangasiidae	<i>Pangasius larnaudi</i>	<i>Pangasius larnaudii</i>	Bocourt 1866	spot pangasius
Pangasiidae	<i>Pangasius polyuranodon</i>	<i>Pangasius polyuranodon</i>	Bleeker 1852	?
Erethistidae	<i>Hara jordani</i>	<i>Hara jerdoni</i>	Day 1870	Asian stone catfish, anchor catfish
Chacidae	<i>Chaca chaca</i>	<i>Chaca chaca</i>	(Hamilton 1822)	squarehead catfish
Ariidae	<i>Bagre bagre</i>	<i>Bagre bagre</i>	(Linnaeus 1766)	Coco sea catfish
Ariidae	<i>Hexanemichthys leptospis</i>	<i>Neoarius leptaspis</i>	(Bleeker 1862)	salmon catfish
Mochokidae	<i>Synodontis</i> spp. (all)	<i>Synodontis</i> spp. (all)	Cuvier 1816	squeakers (various names)
Doradidae	<i>Agamyxis pectifrons</i>	<i>Agamyxis pectifrons</i>	(Cope 1870)	spotted raphael (or talking) catfish
Doradidae	<i>Platydoras costatus</i>	<i>Platydoras costatus</i>	(Linnaeus 1758)	Raphael catfish
Auchenipteridae	<i>Asterophysus batrachus</i>	<i>Asterophysus batrachus</i>	Kner 1858	gulper catfish
Auchenipteridae	<i>Liosomadoras</i> spp. (all)	<i>Liosomadoras</i> spp. (all)	Fowler 1940	jaguar catfish (<i>L. oncinus</i>), false jaguar catfish (<i>L. morrowi</i>)
Heptapteridae	<i>Pimelodella imitator</i>	<i>Brachyrhambdia imitator</i>	Myers 1927	false cory
Pimelodidae	<i>Sciades pictus</i>	<i>Leiarius pictus</i>	(Müller & Troschel 1849)	painted catfish, sailfin pim
Pimelodidae	<i>Pimelodas pictus</i>	<i>Pimelodus pictus</i>	Steindachner 1876	pictus catfish, spotted pimelodid
Pimelodidae	<i>Sorubim lima</i>	<i>Sorubim lima</i>	(Bloch & Schneider 1801)	duckbill catfish
Callichthyidae	<i>Corydoras</i> spp. (all)	<i>Corydoras</i> spp. (all)	Lacepède 1803	cory catfishes

Table 33. Freshwater fishes on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. Taxonomic authorities from the “Catalog of Fishes” (Eschmeyer 2011). Common names from various sources, including Robins et al. (1991), FishBase® (Froese and Pauly 2011), and popular names in the aquarium trade.

Family	Name on original list	Current accepted name	Authority	Common name
Loricariidae ¹	<i>Acanthicus adonis</i>	<i>Acanthicus adonis</i>	Isbrücker and Nijssen 1988	polka dot lyre tail pleco
Loricariidae ¹	<i>Xenocara dolichopterus</i>	<i>Ancistrus dolichopterus</i>	Kner 1854	bushymouth catfish
Loricariidae ¹	<i>Farlowella acus</i>	<i>Farlowella acus</i>	(Kner 1853)	whiptail catfish
Loricariidae ¹	<i>Glyptoperichthys</i> spp. (all)	<i>Glyptoperichthys</i> spp. (all)	Weber 1991	plecos (various names)
Loricariidae ¹	<i>Hypancistrus zebra</i>	<i>Hypancistrus</i> spp. (all)	Isbrücker and Nijssen 1991	plecos (various names)
Loricariidae ¹	<i>Leporacanthias galaxias</i>	<i>Leporacanthicus galaxias</i>	Isbrücker & Nijssen 1989	vampire pleco
Loricariidae ¹	<i>Otocinclus</i> spp. (all)	<i>Otocinclus</i> spp. (all)	Cope 1871	dwarf suckermouth catfishes, otos (various names)
Loricariidae ¹	<i>Peckoltia</i> spp. (all)	<i>Peckoltia</i> spp. (all)	Miranda Ribeiro 1912	clown plecos, tiger plecos
Loricariidae ¹	<i>Pterygoplichthys gibbiceps</i>	<i>Pterygoplichthys gibbiceps</i>	(Kner 1854)	leopard pleco
Loricariidae ¹	<i>Liposarcus multiradiatus</i>	<i>Pterygoplichthys multiradiatus</i>	(Hancock 1828)	Orinoco sailfin catfish
Loricariidae ¹	<i>Sturisoma panamens</i>	<i>Sturisoma panamense</i>	(Eigenmann & Eigenmann 1889)	royal whiptail, royal twig catfish
Sternopygidae	<i>Eigenmannia virescens</i>	<i>Eigenmannia virescens</i>	(Valenciennes 1836)	glass knifefish
Apteronotidae	<i>Apteronotus albifrons</i>	<i>Apteronotus albifrons</i>	(Linnaeus 1766)	black ghost knifefish
Bedotiidae	<i>Bedotia geayi</i>	<i>Bedotia geayi</i>	Pellegrin 1922	Madagascar rainbowfish
Melanotaenidae	<i>Glossolepis</i> spp. (all)	<i>Glossolepis</i> spp. (all)	Weber 1907	rainbowfishes (various names)
Melanotaenidae	<i>Iriatherina weneri</i>	<i>Iriatherina weneri</i>	Meinken 1974	threadfin rainbowfish
Melanotaenidae	<i>Melanotaenia</i> spp. (all)	<i>Melanotaenia</i> spp. (all)	Gill 1862	rainbowfishes (various names)
Pseudomugilidae	<i>Poppodetta conmieae</i>	<i>Pseudomugil conmieae</i>	(Allen 1981)	popondetta blue-eye or popondetta rainbowfish
Pseudomugilidae	<i>Pseudomugil furcatus</i>	<i>Pseudomugil furcatus</i>	Nichols 1955	forktail rainbowfish
Telmatherinidae	<i>Telmatherina ladigesi</i>	<i>Marosatherina ladigesi</i>	(Ahl 1936)	Celebes rainbowfish
Nothobranchiidae	<i>Aphyosemion</i> spp. (all)	<i>Aphyosemion</i> spp. (all)	Myers 1924	African lyretails
Nothobranchiidae	<i>Nothobranchius</i> spp. (all)	<i>Nothobranchius</i> spp. (all)	Peters 1868	nothos (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Rivulidae	<i>Cynolebias</i> spp. (all)	<i>Cynolebias</i> spp. (all)	Steindachner 1876	neotropical killifishes (various names)
Cyprinodontidae	<i>Jordanella floridae</i>	<i>Jordanella floridae</i>	Goode & Bean 1879	flagfish
Poeciliidae	<i>Aplocheilichthys</i> spp. (all)	<i>Aplocheilichthys</i> spp. (all)	Bleeker 1863	lampeyes
Poeciliidae	<i>Lamprichthys tanganicanus</i>	<i>Lamprichthys tanganicanus</i>	(Boulenger 1898)	Tanganyika killifish
Poeciliidae	<i>Poecilia latipinna</i>	<i>Poecilia latipinna</i>	(Lesueur 1821)	sailfin molly
Poeciliidae	<i>Poecilia reticulata</i>	<i>Poecilia reticulata</i>	Peters 1859	guppy
Poeciliidae	<i>Poecilia sphenops</i>	<i>Poecilia sphenops</i>		Mexican molly
Poeciliidae	<i>Poecilia velifera</i>	<i>Poecilia velifera</i>	(Regan 1914)	Yucatan molly
Poeciliidae	<i>Xiphophorus helleri</i>	<i>Xiphophorus hellerii</i>	Heckel 1848	green swordtail
Poeciliidae	<i>Xiphophorus maculatus</i>	<i>Xiphophorus maculatus</i>	(Günther 1866)	southern platyfish
Poeciliidae	<i>Xiphophorus variatus</i>	<i>Xiphophorus variatus</i>	(Meek 1904)	variable platyfish
Hemiramphidae	<i>Dermogenys pusillus</i>	<i>Dermogenys pusilla</i>	Kuhl & van Hasselt 1823	wrestling or Malayan halfbeak
Mastacembelidae	<i>Macrogathus siamensis</i>	<i>Macrogathus siamensis</i>	(Günther 1861)	peacock eel
Mastacembelidae	<i>Mastacembelus</i> spp. (all)	<i>Mastacembelus</i> spp. (all)	Scopoli 1777	spinybacks, mastembelid eels (various names)
Ambassidae	<i>Chanda</i> spp. (all)	<i>Chanda</i> spp. (all)	Hamilton 1822	perchlets (various names)
Ambassidae	<i>Gymnochanda filamentosa</i>	<i>Gymnochanda filamentosa</i>	Fraser-Brunner 1955	filament or longfin glassfish
Datnioididae	<i>Datnoides microlepis</i>	<i>Datnoides microlepis</i>	Bleeker 1853	finescale or Siamese tigerfish
Toxotidae	<i>Toxotes jaculator</i>	<i>Toxotes jaculatrix</i>	(Pallas 1767)	banded archerfish
Monodactylidae	<i>Monodactylus argenteus</i>	<i>Monodactylus argenteus</i>	(Linnaeus 1758)	diamond moonfish, silver moony
Scatophagidae	<i>Selenotoca multifasciata</i>	<i>Selenotoca multifasciata</i>	(Richardson 1846)	spotbanded scat
Badidae	<i>Badis badis</i>	<i>Badis badis</i>	(Hamilton 1822)	blue perch
Polycentridae	<i>Monocirrhus polyacanthus</i>	<i>Monocirrhus polyacanthus</i>	Heckel 1840	Amazon leafyfish

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Family	Name on original list	Current accepted name	Authority	Common name
Cichlidae	<i>Acarichthys heckelli</i>	<i>Acarichthys heckelii</i>	(Müller & Troschel 1849 in Schomburgk)	threadfin acara
Cichlidae	<i>Aequidens</i> spp. (all)	<i>Aequidens</i> spp. (all)	Eigenmann & Bray 1894	various names
Cichlidae	<i>Altamprologus</i> spp. (all)	<i>Altamprologus</i> spp. (all)	Poll 1986	lamprologine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Archocentrus nigrofasciatus</i>	<i>Amatitlania nigrofasciata</i>	(Günther 1867)	convict cichlid
Cichlidae	<i>Amphilophus citrinellum</i>	<i>Amphilophus citrinellus</i>	(Günther 1864)	Midas cichlid
Cichlidae	<i>Apistogramma</i> spp. (all)	<i>Apistogramma</i> spp. (all)	Regan 1913	dwarf cichlids
Cichlidae	<i>Astronotus ocellatus</i>	<i>Astronotus ocellatus</i>	(Agassiz 1831)	oscar
Cichlidae	<i>Aulanocara</i> spp. (all)	<i>Aulonocara</i> spp. (all)	Regan 1922	peacock cichlids
Cichlidae	<i>Chalinochromis</i> spp. (all)	<i>Chalinochromis</i> spp. (all)	Poll 1974	lamprologine cichlids (various names)
Cichlidae	<i>Mesonauta salvini</i>	<i>Cichlasoma salvini</i>	(Günther 1862)	yellowbelly cichlid
Cichlidae	<i>Nandopsis salvini</i>	<i>Cichlasoma salvini</i>	(Günther 1862)	yellowbelly cichlid
Cichlidae	<i>Cichlasoma</i> spp. (all)	<i>Cichlasoma</i> spp. (all)	Swainson 1839	neotropical cichlids (various names)
Cichlidae	<i>Cleithracara maronii</i>	<i>Cleithracara maronii</i>	(Steindachner 1881)	keyhole cichlid
Cichlidae	<i>Copadichromis</i> spp. (all)	<i>Copadichromis</i> spp. (all)	Eccles & Trewavas 1989	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Archocentrus sajica</i>	<i>Cryptoheros sajica</i>	(Bussing 1974)	T-bar cichlid
Cichlidae	<i>Cyathopharynx furcifer</i>	<i>Cyathopharynx furcifer</i>	(Boulenger 1898)	featherfin cichlid
Cichlidae	<i>Cyphotilapia frontosa</i>	<i>Cyphotilapia frontosa</i>	(Boulenger 1906)	humphead cichlid
Cichlidae	<i>Cyprochromis leptosoma</i>	<i>Cyprichromis leptosoma</i>	(Boulenger 1898)	"cyp"
Cichlidae	<i>Cyrtocara moori</i>	<i>Cyrtocara moorii</i>	Boulenger 1902	hump-head

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Family	Name on original list	Current accepted name	Authority	Common name
Cichlidae	<i>Dicrossus</i> spp. (all)	<i>Dicrossus</i> spp. (all)	Steindachner 1875	crenicarine dwarf cichlids; chessboard cichlids
Cichlidae	<i>Dimidiochromis</i> spp. (all)	<i>Dimidiochromis</i> spp. (all)	Eccles & Trewavas 1989	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Geophagus</i> spp. (all)	<i>Geophagus</i> spp. (all)	Heckel 1840	earthaters (various names)
Cichlidae	<i>Gymnogeophagus balzanii</i>	<i>Gymnogeophagus balzanii</i>	(Perugia 1891)	Argentine humphead
Cichlidae	<i>Haplochromis</i> spp. (all)	<i>Haplochromis</i> spp. (all)	Hilgendorf 1888	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Hemichromis bimaculatus</i>	<i>Hemichromis bimaculatus</i>	Gill 1862	African jewelfish
Cichlidae	<i>Hemichromis lifalli</i>	<i>Hemichromis lifalili</i>	Loiselle 1979	blood-red jewel cichlid
Cichlidae	<i>Herichthys carpinte</i>	<i>Herichthys carpintis</i>	(Jordan & Snyder 1899)	lowland cichlid
Cichlidae	<i>Herichthys cyanoguttatus</i>	<i>Herichthys cyanoguttatus</i>	Baird & Girard 1854	Rio Grande cichlid
Cichlidae	<i>Heros appendiculatus</i>	<i>Heros efasciatus</i>	Heckel 1840	severum
Cichlidae	<i>Heros severus</i>	<i>Heros severus</i>	Heckel 1840	banded cichlid
Cichlidae	<i>Hypselacara temporalis</i>	<i>Hypselecara temporalis</i>	(Günther 1862)	emerald cichlid
Cichlidae	<i>Theraps nicaraguense</i>	<i>Hypsophrys nicaraguense</i>	(Günther 1864)	moga
Cichlidae	<i>Julidochromis</i> spp. (all)	<i>Julidochromis</i> spp. (all)	Boulenger 1898	julies (various names)
Cichlidae	<i>Labeotropheus</i> spp. (all)	<i>Labeotropheus</i> spp. (all)	Ahl 1926	haplochromine (pseudocrenilabrine) cichlids (various names), Mbunas
Cichlidae	<i>Labidochromis caeruleus</i>	<i>Labidochromis caeruleus</i>	Fryer 1956	blue streak hap
Cichlidae	<i>Laetacara</i> spp. (all)	<i>Laetacara</i> spp. (all)	Kullander 1986	smiling acaras
Cichlidae	<i>Lamprologus</i> spp. (all)	<i>Lamprologus</i> spp. (all)	Schilthuis 1891	lamprologine cichlids
Cichlidae	<i>Melanochromis</i> spp. (all)	<i>Melanochromis</i> spp. (all)	Trewavas 1935	haplochromine (pseudocrenilabrine) cichlids (various names), Mbunas

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Family	Name on original list	Current accepted name	Authority	Common name
Cichlidae	<i>Mesonauta festivum</i>	<i>Mesonauta festivus</i>	(Heckel 1840)	flag cichlid
Cichlidae	<i>Microgeophagus</i> spp. (all)	<i>Mikrogeophagus</i> spp. (all)	Meulengracht-Madson in Schiötz & Christensen 1968	ram cichlids (various names)
Cichlidae	<i>Papiliochromis</i> spp. (all)	<i>Mikrogeophagus</i> spp. (all)	Meulengracht-Madson in Schiötz & Christensen 1968	ram cichlids (various names)
Cichlidae	<i>Nannacara</i> spp. (all)	<i>Nannacara</i> spp. (all)	Regan 1905	dwarf cichlids (various names)
Cichlidae	<i>Nannochromis</i> spp. (all)	<i>Nanochromis</i> spp. (all)	Pellegrin 1904	African dwarf cichlids (various names)
Cichlidae	<i>Neolamprologus</i> spp. (all)	<i>Neolamprologus</i> spp. (all)	Colombé & Allgayer 1985	lamprologine cichlids
Cichlidae	<i>Ophthalmotilapia</i> spp. (all)	<i>Ophthalmotilapia</i> spp. (all)	Pellegrin 1904	?
Cichlidae	<i>Oreochromis mossambicus</i>	<i>Oreochromis mossambicus</i>	(Peters 1852)	Mozambique tilapia
Cichlidae	<i>Otopharynx</i> spp. (all)	<i>Otopharynx</i> spp. (all)	Regan 1920	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Herichthys dovii</i>	<i>Parachromis dovii</i>	(Günther 1864)	Guapote
Cichlidae	<i>Paracyprochromis nigripinnis</i>	<i>Paracyprichromis nigripinnis</i>	(Boulenger 1901)	blue neon cichlid
Cichlidae	<i>Pelvicachromis pulcher</i>	<i>Pelvicachromis pulcher</i>	(Boulenger 1901)	rainbow crib
Cichlidae	<i>Placidochromis</i> spp. (all)	<i>Placidochromis</i> spp. (all)	Eccles & Trewavas 1989	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Protomelas</i> spp. (all)	<i>Protomelas</i> spp. (all)	Eccles & Trewavas 1989	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Pseudocrenilabrus</i> spp. (all)	<i>Pseudocrenilabrus</i> spp. (all)	Fowler 1934	haplochromine (pseudocrenilabrine) cichlids (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Cichlidae	<i>Pseudotropheus</i> spp. (all)	<i>Pseudotropheus</i> spp. (all)	Regan 1922	haplochromine (pseudocrenilabrine) cichlids (various names), Mbunas
Cichlidae	<i>Pterophyllum</i> spp. (all)	<i>Pterophyllum</i> spp. (all)	Heckel 1840	angelfishes (various names)
Cichlidae	<i>Satanoperca</i> spp. (all)	<i>Satanoperca</i> spp. (all)	Günther 1862	earthaters (various names)
Cichlidae	<i>Sciaenochromis</i> spp. (all)	<i>Sciaenochromis</i> spp. (all)	Eccles & Trewavas 1989	haplochromine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Symphysodon aequifasciatus</i>	<i>Symphysodon aequifasciatus</i>	Pellegrin 1904	blue discus
Cichlidae	<i>Symphysodon discus</i>	<i>Symphysodon discus</i>	Heckel 1840	red discus
Cichlidae	<i>Thorichthys meeki</i>	<i>Thorichthys meeki</i>	Brind 1918	firemouth cichlid
Cichlidae	<i>Tropheus</i> spp. (all)	<i>Tropheus</i> spp. (all)	Boulenger 1898	trophs, tropeine (pseudocrenilabrine) cichlids (various names)
Cichlidae	<i>Uaru amphiacanthoides</i>	<i>Uaru amphiacanthoides</i>	Heckel 1840	triangle cichlid, Uaru cichlid
Cichlidae	<i>Herichthys maculicauda</i>	<i>Vieja maculicauda</i>	(Regan 1905)	blackbelt cichlid
Cichlidae	<i>Theraps synspilus</i>	<i>Vieja synspila</i>	(Hubbs 1935)	redhead cichlid
Cichlidae				unnamed hybrid produced in captivity?
Eleotridae	<i>Mogurnda adspersa</i>	<i>Mogurnda adspersa</i>	(Castelnau 1878)	purple-spotted gudgeon
Eleotridae	<i>Tateurundina ocellicauda</i>	<i>Tateurndina ocellicauda</i>	Nichols 1955	peacock gudgeon
Gobiidae	<i>Arenigobius bifrenatus</i>	<i>Arenigobius bifrenatus</i>	(Kner 1865)	bridled goby
Gobiidae	<i>Brachygobius</i> spp. (all)	<i>Brachygobius</i> spp. (all)	Bleeker 1874	bumblebee gobies
Gobiidae	<i>Stigmatogobius sadanundio</i>	<i>Stigmatogobius sadanundio</i>	(Hamilton 1822)	knight goby
Anabantidae	<i>Coius</i> spp. (all)	<i>Anabas</i> spp. (all)	Cloquet 1816	anabantids; climbing perch or climbing bass (<i>A. testudineus</i>)
Helostomatidae	<i>Helostoma temminki</i>	<i>Helostoma temminkii</i>	Cuvier 1829	kissing gourami
Osphronemidae	<i>Betta</i> spp. (all)	<i>Betta</i> spp. (all)	Bleeker 1850	bettas (various names)

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Family	Name on original list	Current accepted name	Authority	Common name
Osphronemidae	<i>Colisa</i> spp. (all)	<i>Colisa</i> spp. (all)	Bloch & Schneider 1801	gouramis (various names)
Osphronemidae	<i>Macropodus</i> spp. (all)	<i>Macropodus</i> spp. (all)	Lacepède 1801	paradise gouramis (various names)
Osphronemidae	<i>Osphronemus goramy</i>	<i>Osphronemus goramy</i>	Lacepède 1801	giant gourami
Osphronemidae	<i>Sphaerichthys osphromenoides</i>	<i>Sphaerichthys osphromenoides</i>	Canestrini 1860	chocolate gourami
Osphronemidae	<i>Trichogaster</i> spp. (all)	<i>Trichogaster</i> spp. (all)	Bloch & Schneider 1801	gouramis (various names)
Osphronemidae	<i>Trichopsis</i> spp. (all)	<i>Trichopsis</i> spp. (all)	Canestrini 1860	gouramis (various names)
Achiridae	<i>Achirus errans</i>	<i>Catathyridium jenynsii</i>	Miranda Ribeiro 1915	Brazilian freshwater sole
Achiridae	<i>Trinectes maculatus</i>	<i>Trinectes maculatus</i>	(Bloch & Schneider 1801)	hogchoker
Tetraodontidae	<i>Monotretus travancoricus</i>	<i>Carinotetraodon travancoricus</i>	(Hora & Nair 1941)	Malabar pufferfish
Tetraodontidae	<i>Colomesus</i> spp. (all)	<i>Colomesus</i> spp. (all)	Gill 1884	South American or banded puffers
Tetraodontidae	<i>Tetraodon biocellatus</i>	<i>Tetraodon biocellatus</i>	Tirant 1885	eyespot pufferfish, figure-eight puffer
Tetraodontidae	<i>Tetraodon fluviatilis</i>	<i>Tetraodon fluviatilis</i>	Hamilton 1822	green pufferfish
Tetraodontidae	<i>Tetraodon fahaka</i>	<i>Tetraodon lineatus</i>	Linnaeus 1758	globe fish
Tetraodontidae	<i>Tetraodon miurus</i>	<i>Tetraodon miurus</i>	Boulenger 1902	Congo pufferfish
Tetraodontidae	<i>Tetraodon nigroviridis</i>	<i>Tetraodon nigroviridis</i>	Marion de Procé 1822	spotted green pufferfish

¹ Species in family no longer permitted for importation, effective 31 December 2010.

Table 34. Marine fishes on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. [UWW, Underwater World, a commercial aquarium in Tumon]

<i>Acanthurus achilles</i>	<i>Ctenochaetus strigosus</i>	<i>Novaculichthys taeniourus</i>
<i>Acanthurus olivaceus</i>	<i>Diodon holocanthus</i>	<i>Ostracion cubicus</i>
<i>Amblyeleotris fasciata</i>	<i>Echenius naucrates</i>	<i>Oxycirrhites typus</i>
<i>Amblyeleotris guttata</i>	<i>Echidna nebulosa</i>	<i>Paracanthurus hepatus</i>
<i>Amblyeleotris steinitzi</i>	<i>Ecsenius bicolor</i>	<i>Paracirrhites arcatus</i>
<i>Amphiprion clarckii</i>	<i>Epinephalis lanceolatus</i>	<i>Paracirrhites forsteri</i>
<i>Amphiprion peredarion</i>	<i>Forcipiger flavissimus</i>	<i>Paraglyphidodon oxyodon</i>
<i>Anampses meleagrides</i>	<i>Forcipiger longirostris</i>	<i>Parapeneus barberinoides</i>
<i>Antennarius hispidus</i>	<i>Genicanthus</i> spp. (all)	<i>Parapeneus cyclostomus</i>
<i>Antennarius striatus</i>	<i>Gnathanodon speciosus</i>	<i>Phyllopteryx taeniolatus</i> UWW only-captive bred only
<i>Anthias alleni</i>	<i>Gobiodon atrangulatus</i>	<i>Platax</i> spp. (all)
<i>Anthias dispar</i>	<i>Gobiodon histrix</i>	<i>Plectorhinchus</i> spp. (all)
<i>Anthias evansi</i>	<i>Gomphosus varius</i>	<i>Pogonocilius zebra</i>
<i>Anthias squamapinnis</i>	<i>Gorgasia preclara</i>	<i>Pogonoperca punctata</i>
<i>Anthias tuka</i>	<i>Halichoeres biocellatus</i>	<i>Pomacanthus imperator</i>
<i>Apogon cyanosoma</i>	<i>Halichoeres chrysus</i>	<i>Pomacentrus</i> spp. (all)
<i>Apolemichthys trimaculatus</i>	<i>Hemipteronotus taeniourus</i>	<i>Promicrops lanceolatus</i>
<i>Balistoides conspicillum</i>	<i>Heniochus acuminatus</i>	<i>Pseudanthias</i> spp. (all)
<i>Bothus mancus</i>	<i>Heteroconger hassi</i>	<i>Pseudechidna brummeri</i>
<i>Calloplelesioptis altivelis</i>	<i>Hippocampus abdominalis</i> UWW only-captive bred only	<i>Pseudocheilinus hexataenia</i>
<i>Centropyge</i> spp. (all)	<i>Histrio histrio</i>	<i>Pseudochromis diadema</i>
<i>Cephalopholis miniatus</i>	<i>Hoplolatilus chlupatyi</i>	<i>Pseudochromis paccagnelae</i>
<i>Cephalopholis sexmaculata</i>	<i>Hoplolatilus fourmanoiri</i>	<i>Pseudochromis porphyrous</i>
<i>Cephalopholis urodeta</i>	<i>Hoplolatilus starcki</i>	<i>Pteeleotris heteropterus</i>
<i>Cetoscarus bicolor</i>	<i>Labroides dimidiatus</i>	<i>Pterapogon kauderni</i> UWW only-captive bred only
<i>Chaetodon benneti</i>	<i>Labropsis micronesica</i>	<i>Ptereleotris coeruleus</i>
<i>Chaetodon melannotus</i>	<i>Labropsis xanthonota</i>	<i>Ptereleotris evides</i>
<i>Chaetodon meyeri</i>	<i>Lactoria cornuta</i>	<i>Pygoplites diacanthus</i>
<i>Chaetodon punctatofasciatus</i>	<i>Lutjanus kasmira</i>	<i>Rhinecanthus aculeatus</i>
<i>Chaetodon reticulatus</i>	<i>Macolor macularis</i>	<i>Rhinobatus hynnicephalus</i>
<i>Chaetodon rostratus</i>	<i>Macropharyngodon meleagris</i>	<i>Rhinomuraena quaesita</i>
<i>Chaetodon trifascialis</i>	<i>Malacanthus latovittatus</i>	<i>Rhinopias</i> spp. (UWW only)
<i>Chaetodon unimaculatus</i>	<i>Meiacanthus atrodorsalis</i>	<i>Salarias fasciatus</i>
<i>Chaetodon vagabundus</i>	<i>Meiacanthus grammistes</i>	<i>Salarias irroratus</i>
<i>Chiloscyllium colax</i>	<i>Mirolabrichthys imeldae</i>	<i>Sargocentron spiniferum</i>
<i>Chiloscyllium punctatum</i>	<i>Monocentrus japonicus</i>	<i>Serranocirrhites latus</i>

Table 34. Marine fishes on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. [UWW, Underwater World, a commercial aquarium in Tumon]

<i>Cirrhitichthys falco</i>	<i>Muraena pardalis</i>	<i>Solenostomus paradoxus</i>
<i>Cirrhitichthys oxycephalus</i>	<i>Myrichthys colubrinus</i>	<i>Spilotichthys pictus</i>
<i>Coris aygula</i>	<i>Myrichthys maculosus</i>	<i>Symphoricichthys spilurus</i>
<i>Coris gaimard</i>	<i>Nemateleotris decora</i>	<i>Taeniura lymma</i> (UWW only and only males)
<i>Cromileptes altivelis</i>	<i>Nemateleotris magnifica</i>	<i>Thalassoma lutescens</i>
<i>Cryptocentrus cyanotaenia</i>	<i>Neocirrhites armatus</i>	<i>Xyrichthys pavo</i>
<i>Ctenochaetus marginatus</i>	<i>Neoglyphidodon melas</i>	<i>Zebrasoma flavescens</i>
<i>Ctenochaetus strigosus</i>		<i>Zebrasoma veliferum</i>

Table 35. Invertebrates on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. [UWW, Underwater World, a commercial aquarium in Tumon]

Crabs and shrimp	<i>Acanthocephala limabat</i>
	<i>Calappa lophos</i>
	<i>Camposia retusa</i>
	<i>Hippolysmata grabhami</i>
	<i>Hymenocera elegans</i>
	<i>Hymenocera picta</i>
	<i>Limulus polyhemus</i>
	<i>Lybia tessellata</i>
	<i>Lysmata amboinensis</i>
	<i>Lysmata debelius</i>
	<i>Macrochir kaempferi</i> (UWW only)
	<i>Neopetrolisthes oshimmai</i>
	<i>Neopetrolisthes maculatus</i>
	<i>Oncinopus decapoda</i>
	<i>Rhynchocinetes durbanensis</i>
	<i>Rhynchocinetes uritai</i>
	<i>Saron marmoratus</i>
	<i>Saron rectirostris</i>
	<i>Stenopus hispidus</i>
<i>Thor amboinensis</i>	
Anemones and slugs	<i>Cerianthus ceriantharia</i>
	<i>Cerianthus filiformis</i>
	<i>Cryptodendrum adhesivum</i>

Table 35. Invertebrates on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation. [UWW, Underwater World, a commercial aquarium in Tumon]

	<i>Cribinopsis crassa</i>
	<i>Filogranella elatensis</i>
	<i>Heteractis aurora</i>
	<i>Heteractis magnifica</i>
	<i>Heterodactyla hemprichii</i>
	<i>Hexabranhus sanguinensis</i>
	<i>Phyllidia varicosa</i>
	<i>Stichodactyla mertensii</i>
	<i>Stoichactis haddoni</i>
	<i>Urticina felina</i>
Starfish and jellyfish	<i>Aurelia aurita</i>
	<i>Cassiopea frondosa</i>
	<i>Certonardoa semiregularis</i>
	<i>Clypeaster humilis</i>
	<i>Fronia monilis</i>
	<i>Linkia laevigata</i>
	<i>Mastigias papua</i>
	<i>Olindias formosa</i> (UWW only)
	<i>Pentaster obtusatus</i>
	<i>Protoreaster dodosus</i>
	<i>Phyllorhiza punctata</i>
Other invertebrates	<i>Sabillastarte indica</i>

Table 36. Freshwater plants on the Guam Division of Aquatic and Wildlife Resources white list of species permitted for legal importation.

<i>Anubias</i> spp.
<i>Cryptocoryne</i> spp.
<i>Echinodorus</i> spp. (except for <i>E. cordifolius</i> , <i>E. osiris</i> , and <i>E. uruguayensis</i>)
<i>Aponogeton</i> spp.
<i>Microsorium pteropus</i>
<i>Spathiphyllum tasson</i>
<i>Vesicularia dubyana</i>

Faunistic Surveys and Monitoring

Wittenberg and Cock (2001) describe three types of surveys designed for early detection of new introductions of nonindigenous species: general surveys, site-specific surveys and species-specific surveys. Such surveys must be repeated regularly to be effective.

As a general survey, one possibility is an occupancy survey (MacKenzie et al. 2006) similar to the North American Breeding Bird Survey (Sauer et al. 1994; <http://www.pwrc.usgs.gov/bbs/>), the Swiss Breeding Bird Monitoring Program (Kéry et al. 2005), the Swiss Butterfly Monitoring Program (Kéry et al. 2009), or the U.S. Geological Survey's North American Amphibian Research and Monitoring Initiative (<http://armi.usgs.gov/>). Details of survey design could be established through consultation with appropriate experts. For aquatic surveys of freshwater sites in Guam and elsewhere in Micronesia, sampling could utilize different methods, such as minnow seines, dip nets, passive fish traps, and visual observation (Hankin and Reeves 1988), depending on the knowledge and experience of personnel conducting surveys.

Site-Specific Surveys

These types of surveys are intended to target areas that have high conservation value (e.g., ecosystem prioritization) or are near high-risk entry points (Wittenberg and Cock 2001; Jenkins et al. 2009). Examples of the latter would include areas near human population centers, aquaculture facilities, and/or ports of entry. DAWR currently has a routine river and wetland survey and monitoring program in place that includes targeted sites as well as new ones; additional aquatic surveys are conducted by University of Guam researchers and the U.S. National Park Service. A review of these sites and consideration of additional sites to target specifically for monitoring potential new introductions requires careful consultation between agency biologists and cooperators. Perhaps 20-50 randomly-selected survey sites could be chosen in or near each area as listed above. Potential sites to be targeted in Guam could include: Apra Harbor, Guam International Airport, Andersen Air Force Base, Agana Swamp (Guam's largest natural freshwater marsh), Fena Reservoir (the main reservoir in Guam), Sasa Bay Wetland (102 hectares of estuarine and freshwater wetland), Atantano Wetland (130 hectares of estuarine and freshwater wetland), the Talofofu River Valley (the largest contiguous water body in Guam), and current and former aquaculture facilities.

Species-Specific Surveys

In Guam, these surveys would overlap substantially with site-specific surveys, but potentially could target species currently known to be present, such as snakeheads (*Channa* spp.), tilapia (*Oreochromis* spp., hybrids, and *Tilapia zillii*), peacock cichlids (*Cichla* sp.), walking catfish (*Clarias* spp.), as well as other taxa of special concern, such as swamp eels (Synbranchidae). Species-specific surveys might focus more on ponds, current and former aquaculture facilities, Guam's reservoirs, Agana Swamp, golf courses, and river mouths rather than focusing on stream reaches, at least if the aforementioned species were targeted.

Volunteer Surveyors

Conducting regular surveys likely would require more effort and resources than are currently available to DAWR and other Micronesian agencies. Elsewhere, some large-scale intensive surveys are volunteer-based; use of volunteers to survey for invasive species in Guam

could enhance early detection. Such efforts would be further enhanced with sufficient funding to support a survey coordinator and adequate training of volunteers.

A potential pool of volunteers might involve government biologists, military personnel in charge of managing natural resources, park personnel, students at the University of Guam, local naturalists, interested anglers, and high school students. Such volunteer groups could adopt one or more sites to survey on a regular basis. Guam might also benefit from the allure of ecotourism to recruit volunteers from off the island for commitments to survey or monitor selected sites.

Funding to Support Surveys

The government of Guam could benefit from implementing a fishing license, if a portion of any generated revenue were used to support surveys and management efforts for aquatic invasive species. Fees assessed to those who wish to profit from importing nonindigenous species is a demonstrated mechanism to advance management efforts (McNeely et al. 2001). Additional potential funding mechanisms are discussed below under *Management*.

Intercepting Animals Illegally Shipped for Food

Early detection of new introductions of nonindigenous species could be accomplished using the above approaches regardless of the pathway of introduction. Additionally, improved detection of species with potential to be intentionally introduced for food could be accomplished by means of periodic visits to markets and restaurants that sell live fish and other aquatic animals.

In cases of suspected illegal live or fresh animal products or species of questionable identity, DAWR personnel and other authorities are encouraged to collect whole-animal and tissue samples (for possible genetic analysis) using appropriate preservation techniques, and to have these samples examined and identified by qualified experts. If qualified experts cannot be found to accept specimens immediately, good-quality photographs of live animals will improve the chances that accurate identifications can be made. Freezing of any specimen(s) is preferable to discarding or releasing it (them).

Management

Prevention

Preventing transport or import of potentially harmful species so as to thwart their possible introduction or spread into new areas is generally considered to be the most efficient and cost effective way to manage invasive species (Simberloff 1998; Wittenberg and Cock 2001; Lodge et al. 2006).

Cooperation among nations in the western Pacific, whereby preventive measures are enacted to reduce the probability of exporting or importing invasive species, may benefit each nation by reducing the probability of additional nonindigenous taxa becoming established (McNeely et al. 2001). Such an approach has been implemented by Australia and its neighbors, as the North Australian Quarantine Strategy (Pheloung 2003), which involves surveillance and monitoring by all participating nations. A proactive, precautionary approach is preferred, requiring effective and coordinated efforts together with sufficient resources and networking (Henderson and Bomford 2011). Similar cooperation is encouraged between Guam, the

Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, the Republic of Palau, the Republic of Kiribati, the Republic of the Marshall Islands, the Republic of Nauru, Japan, Wake Island, Hawaii, and the U.S. mainland. There currently exists heightened awareness of invasive species in insular regions of the Pacific; consequently, a certain degree of networking and coordination is already in place.

Prevention requires that all pathways of introduction be identified and evaluated. For Guam and other insular areas in the western Pacific, the primary human-mediated dispersal pathways of nonindigenous aquatic animals are thought to be the ornamental pet trade and the aquaculture industry. The risks associated with different pathways vary among the various islands, depending in part on the scope and effectiveness of existing legal measures already in place.

Dispensing of Unwanted Aquarium Pets

Wittenberg and Cock (2001) describe options of what to do with aquarium fish that are no longer wanted by their owners. A few of the options include returning unwanted fish to the pet store of origin, donating to another hobbyist or a corporate or public aquarium, or giving unwanted animals to a public institution such as a school, nursing home, hospital, or prison.

If none of these options are available, fish may be euthanized by placing them in a container of water and putting the container in a freezer. Humane treatment can be accomplished by exposing fish to carbon dioxide (released by use of effervescent antacid tablets such as Alka-Seltzer®) or clove oil prior to freezing. Instructions for humane lethal treatments could be included in educational materials. Another alternative would be for DAWR to establish a program whereby the agency could accept unwanted fish or other aquatic life and humanely dispose of animals or distribute them to other owners who are capable of providing proper care. As an example, the Florida Fish and Wildlife Conservation Commission holds Non-native Amnesty Days at which time pet owners can relinquish unwanted pets (http://myfwc.com/wildlifehabitats/non-native_amnestydayevents.htm). DAWR is encouraged to consider adopting a similar program and to offer adequate numbers of sites, annual dates, and to sufficiently publicize events to ensure success.

Eradication

Eradication of an established freshwater fish population in a stream or river system is often difficult, and in many situations, impossible. Most successful eradication attempts rely heavily on the use of fish toxicants, mainly rotenone, but these chemicals must be used judiciously because they are largely non-selective and result in loss of both native and nonindigenous species (Kolar et al. 2011; Nico and Walsh 2011). In Guam, rotenone could possibly be used to eliminate nonindigenous fishes from certain closed systems; for example, abandoned aquaculture facilities or small ponds on golf courses where native species are absent. Reviews of eradication projects targeting invasive fishes, including eradication attempts on Pacific Islands, are included in the publications cited above.

Containment and Control

Containment is a means to prevent the spread of a nonindigenous species. Containment in a river system may be achieved by preventing a species from passing upstream or downstream beyond a natural or artificial physical barrier, or preventing the species from passing from one watershed to another. Salinity may naturally prevent a freshwater species from dispersing among river basins. Drainage alteration that connects two or more previously separated watersheds during land development or flood control is one way in which a contained species might spread. Consideration of this possibility should be given during the construction phase of the U.S. military build-up in Guam.

Control of nonindigenous species involves reducing the density and abundance to acceptable levels. For nonindigenous species in river habitats, control and eradication may simply be matters of degree, as the methods used will largely be the same. However, control measures can sometimes fail and result in increased abundance of a target species if density-dependent population mechanisms are present (Zipkin et al. 2009). These authors stated that “species with high per capita fecundity (over discrete breeding periods), short juvenile stages, and fairly constant survivorship rates are most likely to respond undesirably to harvest.”

Legislative Actions

DAWR white list only permits those species that are allowed to be legally imported into Guam. It is our understanding that no legislation currently exists that prohibits ownership of species that are not permitted for legal importation. It is possible that Guam authorities may wish to review existing legislation and consider possible benefits of laws that could apply to possession of live animals that are otherwise illegal to import (especially given the “leaky” pathways by which undeclared shipments can potentially bypass ordinary inspection procedures). Exclusionary precedents exist; for instance, the commercial aquarium in Tumon receives official permission to maintain certain prohibited species for display and educational purposes. Legislative actions could include incentives for disclosure of potentially invasive captive-held species, such as establishing the aforementioned “amnesty” program whereby live animals could be voluntarily surrendered.

Aquaculture Industry

Species introduced for aquaculture may escape and become established in the wild. Flooding of aquaculture facilities, in particular, may allow animals to escape (Nico et al. 2005). Nonindigenous species used for aquaculture may also carry nonindigenous disease organisms that can reduce populations of native species as well as captive animals (Funge-Smith and Briggs 2005). The following measures may help to prevent animals from escaping from aquaculture facilities (Fuller 2003; Tucker and Hargreaves 2008):

- Careful inspection to ensure that stock is not contaminated with unintended species (see also Nico et al. 2005).
- Avoid placing facilities within areas prone to flooding (e.g., 100-year floodplain).
- Install perimeter berms and fencing to secure the facility.
- Use strong and durable construction materials.

- Use appropriate mooring systems.
- Use closed circulation systems so that no water leaves the facility, or install other barriers to prevent escapement.
- Use nets or other devices to prevent birds and other predators from transporting fish away from the facility.
- Regularly inspect containment facilities.

Some species, especially those that pose the greatest threat if they escape into the wild, may be best maintained in aquaculture facilities or farm ponds as entire stocks of certified triploids or sterile hybrids. Triploid fish contain three sets of chromosomes in cell nuclei instead of the usual two sets and are considered sterile (Nico et al. 2005). Use of native species is also encouraged.

Triploid carp are commonly used for biocontrol and other purposes so that the stocked carp do not form wild reproducing populations. However, this approach may not be 100% effective at preventing carp from establishing wild breeding populations because some individuals presumed to be triploid may actually be diploid and capable of breeding (Nico et al. 2005). Possibly, triploid tilapia (Hussain et al. 1991; Byamungu et al. 2001; El-Sayed 2006) could be used in aquaculture facilities in Guam and elsewhere in Micronesia outside of government controlled, biosecure, closed-circulation breeding facilities. However, use of triploids for some species could increase production costs to the point that rearing of these species becomes economically unfeasible.

In addition to the above measures, facilities that are located at isolated sites with no connection to natural waterways reduce chances of accidental escapements of undesirable species. This may be considered a form of closed circulation. Facilities that are inspected regularly, followed with routine repairs and maintenance, provide greatest biosecurity. Data regarding the number and location of all existing and recently closed aquaculture facilities in Guam were not available to the investigators. A database containing the locations and information about the owners or former owners of these facilities would improve tracking of aquaculture activities. Facilities that are no longer in operation may remain a risk for nonindigenous species introductions if stocked animals were not previously removed and/or if perimeter barriers are no longer maintained.

There are many sources of information readily available that provide biosecurity guidance for the aquaculture sector, such as the review by Tucker and Hargreaves (2008). Local and regional regulatory authorities are encouraged to provide summaries of these resources, and recommended management alternatives, to private and commercial aquaculturists.

Intentional Introductions for Food

Freshwater fish and other aquatic species form a large part of the diet of some ethnic groups living in Guam and elsewhere throughout Micronesia. It is likely that some nonindigenous species have become established on Pacific islands after being imported and intentionally released to provide a source of live food favored by particular ethnic groups. The population of Guam currently consists of people from many different ethnic backgrounds, and that trend is likely to continue with new immigrants (Table 37).

Table 37. Projected ethnic background of human population of Guam for 2011, 2015, and 2020. Figures in parenthesis under Native Hawaiian and other Pacific Islander include Chamorro population. Those under Asian refer to Filipino population (Guam Bureau of Statistics and Plans 2009).

Ethnic Origin	2011	2015	2020
Native Hawaiian and other Pacific Islander	81,649 (67,763)	85,762 (71,176)	90,629 (75,215)
Asian	59,522 (48,168)	62,520 (50,594)	66,068 (53,466)
White	12,429	13,054	13,795
Black or African American	1,854	1,948	2,058
Other, single race or ethnic group	2,137	2,245	2,372
Other, mixed race or ethnic group	25,490	26,774	28,293
Total	203,216	192,302	183,081

The likelihood of additional nonindigenous species being illegally brought to Guam and/or elsewhere in Micronesia for live food may in part depend on the ethnic composition of the construction work force that will be involved in the military build-up. Thus, projections by the government of Guam and the DoD on the anticipated ethnic composition of the civilian workforce may be beneficial in assessing risk associated with this pathway of potential introductions.

As nonindigenous fish species are not allowed to be released in Guam, the best measures to prevent intentional introductions of nonindigenous species for live food will be enforcement efforts by border control and customs inspectors, and public education, similar to the approaches described above for aquarium species.

Baitfish

No nonindigenous freshwater fish species are sold legally as bait in Guam (B. Tibbatts, oral commun., 2010). Any future consideration of importation of baitfish should be thoroughly vetted.

Biocontrol

No nonindigenous freshwater fish species are currently used legally for biocontrol in Guam (B. Tibbatts, oral commun., 2010). In the past, some species were introduced into Fena Reservoir on the U.S. Naval Magazine for aquatic plant control. Additionally, various poeciliid fishes may have been released in the past in Guam and other Micronesian islands to aid in insect control. As with baitfish, any considerations to introduce aquatic species as biocontrol agents should be thoroughly vetted, drawing on the expertise of scientists and government agencies to fully assess all possible consequences that would ensue through such introductions.

Contingency Plan and Rapid Response

A contingency plan is a course of action to be taken when a new introduction has been detected or suspected (Wittenberg and Cock 2001). The first step in Guam likely would be for any person finding a fish or other aquatic species to contact one of the island's recognized authorities (e.g., Mr. Brent Tibbatts, Fisheries Biologist with DAWR, or Dr. Frank Camacho or Dr. Terry Donaldson, University of Guam). Any specimens that are available should be provided to DAWR or deposited into the biological collections at the University of Guam or another appropriate institution. Once a specimen has been positively identified or a report of a suspected new introduction has been received, personnel must then decide upon the most appropriate and effective management action to be taken. The four main management strategies described by Wittenberg and Cock (2001) are eradication, containment, control, and mitigation. These strategies will likely be the same regardless of the pathway of introduction except for intentional introductions for food, which might involve law enforcement. Officials of DAWR and other agencies are encouraged to develop a rapid response program for the early detection and management strategy for new introductions of aquatic species.

Liability

Individuals responsible for releasing an invasive species can bear responsibility to pay all or a portion of the resulting economic costs (McNeely et al. 2001). However, individual(s) responsible have to be identified. Also, endorsement of such punitive action requires public support. In practice, costs may be so high as to bankrupt many individuals. Businesses that import or use invasive species may need to carry liability insurance (McNeely et al. 2001). The cost of such insurance could potentially render aquaculture to be economically unfeasible. Perrings et al. (2005) suggested using tariffs to have exporters of nonindigenous species pay costs incurred by those species that become invasive. Jenkins (2002) suggested fees charged to intercontinental importers and cited California's Ballast Water Management and Control Program as a possible model (www.boe.ca.gov/sptaxprog/bllstweb12.htm).

As the population of Guam increases, the popularity of home aquaria is expected to increase proportionally. Therefore, propagule pressure in the form of greater numbers of nonindigenous organisms in the pathway, and greater numbers of people likely to release fish to the wild, will also increase proportionally. The most successful management actions to mitigate for this increased propagule pressure will likely require improved public education, refinement of permitted species, and increased inspections and monitoring of imports.

Education

The mainland U.S. chain pet store PetsMart discourages buyers of pet fish from releasing their pets by printing slogans directly on the bags in which customers transport their purchased fish home. This is done as part of a national campaign called “Habitattitude” (<http://www.habitattitude.net/>). This program is a partnership between the pet and aquarium trade (Pet Industry Joint Advisory Council), nursery and landscape trade, the U.S. Fish and Wildlife Service, and the National Sea Grant Program. Pet stores in Guam that sell aquatic animals and plants could be encouraged to participate in this program and to use similar bags. We asked personnel at two pet stores in Guam what measures they currently take, or would be willing to take, to discourage their customers from releasing pet fish, but staff at neither store responded.

Aquarium fish are often sold under non-standardized names. We suggest that pet stores consider labeling their stock with current valid scientific names in addition to whatever trade names they use. Scientific names could be placed on aquaria containing each species and could be visible to customers and potential inspectors. Qualified personnel of DAWR, inspection agents, and university faculty are encouraged to work closely with pet stores to achieve this and to ensure that names are kept up to date. Regular workshops could be conducted or on-site visits made to pet stores to educate store managers and their employees.

Pet store customers could be surveyed to estimate their likelihood or history of releasing animals that they purchase(d) and the reasons they do so (Gertzen et al. 2008). This information could be used to estimate the number of nonindigenous species released into Guam annually, another measure of propagule pressure, and directly related to the probability that a nonindigenous species will become established in Guam. Polled individuals could be provided with assurances of complete anonymity to prevent any possible fear of recrimination and to ensure that information is provided openly and honestly.

A website could be constructed with information about invasive aquatic species and the threats that they pose to native species and habitats. Through such a web site, the aforementioned posters and videos could be made freely available for downloading and printing. Such a website could be designed so that it appears at, or very near, the top of the list of links returned by casual searches conducted by means of Internet search engines by use of strategic key words.

Research Needs

Some authors have reported that little evidence exists concerning the negative effects of nonindigenous fish species on native species in their regions or countries, or that relatively little

research has been directed in this area (Luu and VanThanh 2005; Nuov et al. 2005; Win 2005). However, there are many well documented cases that illustrate how introduced freshwater fishes have negative consequences on native faunas—in some examples on a community level or large landscape scale (e.g., the Laurentian Great Lakes, the Colorado River basin, and Lake Victoria). In the case of Micronesia, we are aware of few studies that have directly examined interactions between nonindigenous and native species. McKagan et al. (2009) reported results of an extensive survey for nonindigenous aquatic species on Saipan, and included information from FishBase (<http://www.fishbase.org>) that summarized potential threats. MacKenzie and Bruland found that introduced poeciliid fishes posed threats to wetland habitats in Hawaii. Tilapias, which were intentionally introduced to many Pacific islands to provide food (Devambeze 1964), are now commonly regarded as pests in many places and may have impacts on native species broadly across aquatic habitats from fresh water to coral atolls (Gillett 1990; Nelson and Eldredge 1991; Canonico et al. 2005). We suggest that additional research into effects of nonindigenous species on native species in Micronesia would be helpful in prioritizing management efforts, albeit a precautionary approach is best in the absence of scientific evidence of effects (Bartley et al. 2005). Other authors have similarly suggested the need for additional empirical research on the general topic of how nonindigenous species affect native species in areas where they become invasive (Hager and McCoy 1998; Gurevitch and Padilla 2004; Didham et al. 2005).

Acknowledgments

Completion of this study would not have been possible without the generous assistance of many individuals (see pages *x-xi* for institutional or affiliation acronyms for the following people). We would especially like to thank Brent Tibbatts (DAWR) for providing extensive information and valuable assistance in the field. Phil Andreozzi (NISC) kept the project and the teams focused and greatly facilitated progress, always with a positive attitude and understanding of the challenges. For providing logistical support that enabled us to conduct fieldwork in Guam and other assistance, we are very grateful to Shane Siers, James Stanford, Eli Wostl, Gordon Rodda, and Howard Jelks (all USGS). Additional assistance with field work was provided by Jamie Barichivich (USGS), Jennifer Staiger (USGS), and Frank Camacho (UOG). Diane Vice (DAWR) kindly gave us a tour of DAWR facilities and assisted with meeting logistics and other matters. Earl Campbell (USFWS), Richard MacKenzie (USDA-FS), and Joel Miles (Palau) contributed valuable scientific insights. Steve McKagan (NMFS) was very helpful in arranging to meet with Mike Trianni and Mike Tenorio (both CNMI-DFW) to discuss issues pertinent to invasive species in the CNMI, and facilitating site visits in Saipan. Fred Sengebau (PBOA) issued a collecting permit for Palau, and Chipper Tellei (Palau) provided very helpful field and logistical support. Emil Edesomel (PEQPB) supplied us with information about eradication efforts for tilapia on Malakal. Don Buden and Brian Lynch (both College of Micronesia, Pohnpei campus) contributed valuable information on native and nonindigenous species in Pohnpei. Site visits to aquaculture facilities and discussions about biosecurity protocols were facilitated by John Brown (GADTC), Michael Ogo, and Ross Manglona (both NMC-CREES). Art Taimanglo (USFWS) answered questions about imports and inspections. Jill Nishimura (USGS, Pacific Islands Water Science Center) informed us of numerous sources of hydrologic data for Pacific islands. The Smithsonian team contributed important information and discussions and facilitated in other ways for which we are thankful: Gregory Ruiz, Chela Zabin (both SERC), Mark Sytsma, Rich Miller, Lynda Moore, Vanessa Howard (all PSU-ABRPI), Chad Hewitt, and Marnie Campbell (both CQUA-CEM). We especially thank the following members of the USDA-APHIS team who assisted in countless ways: Robert Ahearn, Dallas Berringer, Cheryl Berthoud, Alan Franklin, Julie Gauthier, Janet Grimes, Daniel Jimenez, Lisa Kohl, Ingrid Kotowski, Heike Meissner, Will Pitt, Joan Sills, Michael Simon, Randal Stahl, Kristyn Stone, and Dan Vice. We are grateful to Patterson Shed (CSP), Gibson Susumu, and John Wichep (both FSM-DEA) for answering questions pertinent to the FSM. John (Bart) Lawrence and Jackie Flores (both USDA-NRCS) provided useful contact information. The following people representing Naval Facilities Engineering Command Pacific (NAVFAC PAC) assisted in numerous helpful ways: Anne Brooke, Cory Campora, Patrick Chee, Lisa Fiedler, Joel Helm, Jeffrey Herod, Taylor Houston, Vanessa Pepi, and Paul Wenninger. Maps were improved from an earlier draft of the manuscript by Andrew Horan and Ann Foster (both USGS).

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Appendixes

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-1. Agana Spring, Guam, January 2010. Site of introduction of several non-native freshwater species. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-2. Inajaran River, Guam, January 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-3. USGS and DAWR biologists sampling for freshwater fishes and macroinvertebrates in the Moulap River, Guam, March 2010. Photograph by W.J. Barichivich.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-4. Fena Reservoir, Guam, March 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-5. USGS biologists sampling for freshwater fishes at Fena Reservoir spillway, Guam, March 2010. Photograph by W.J. Barichivich.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-6. L.G. Nico with non-native *Clariassp.* captured at Fena Reservoir spillway, March 2010. Photograph by W.J. Barichivich.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-7. Masso Reservoir restoration, Guam, March 2010. DAWR-sponsored project to remove non-native species and establish recreational fishing facility for native species. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-8. DAWR biologist B. Tibbatts assists USGS biologists in sampling for non-native poeciliid fishes at Lost Pond, northern Guam, March 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-9. Lake Susupe, Saipan, January 2010. Site of introduction of several non-native freshwater species. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-10. "Costco Marsh," Saipan, January 2010. Wetland site where non-native tilapia were introduced. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



throughout Micronesia. Photograph by S.J. Walsh.

Figure 1-11. Amplexing pair of cane toads (*Rhinophrynus*) found on Saipan; an abundant and widespread non-native anuran found

throughout Micronesia. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-12. Tilapia (*Oreochromis niloticus*) hybrids obtained live from food market on Guam, 4 April 2010. Photograph by L.G. Nico.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-13. Fresh tilapia for sale at Saturday morning flea market, Dededo, Guam, January 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-14. Live *Clarias batrachus* for sale at Saturday morning flea market, Dededo, Guam, January 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-15. Hybrid tilapia produced at Northern Marianas College Cooperative Research Extension and Education Service. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-16. Entrance to Northern Marianas College Cooperative Research Extension and Education Service aquaculture facility. The NMC-CREES implements strong biosecurity measures. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-17. Entrance to Guam Aquaculture Development Training Center (Fadian Hatchery), University of Guam. The GADTC implements strong biosecurity measures. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-18. Hatchery raceways at the Guam Aquaculture Development and Training Center. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-19. Tilapia in hatchery raceway of Guam Aquaculture Development and Training Center. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-20. Effluent of the Guam Aquaculture Development and Training Center; all water passing through the hatchery is discharged onto open rock and then directly to the ocean. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-21. Live aquarium fish for sale at retail pet shop in Barrigada, Guam, March 2010. Photograph by L.G. Nico.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-22. Rock quarry on Malakal Island, Palau. Site of introduced tilapia where eradication efforts were unsuccessful as of March 2010. Photograph by W.J. Barichivich.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-23. Lake Ngardok, Babeldaob Island, Palau, March 2010. Largest natural lake in Micronesia and site of introduced poeciliids (*Xiphophorus maculatus*). Photograph by R.A. Englund.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-24. Ngerimel Reservoir, Babeldaob Island, Palau. Source of municipal water supply for Koror. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-25. Water-garden pond at Belau National Museum, Koror, Palau. Site of introduced guppies (*Poecilia reticulata*) and cane toads (*Rhinophrynus marinus*), March 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-26. Giant clam culture facilities at the Palau Mariculture Demonstration Center on Malakal Island, Palau, March 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-27. USGS biologists sampling fishes and macroinvertebrates from streams of Babeldaob Island, Palau, March 2010. Photograph by W.J. Barichivich.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-28. Tributary of Nanpii-Kiepw River, Pohnpei, Federated States of Micronesia, April 2010. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-29. Native gobies (*Stiphodon caeruleus*) spawning on rocks in a stream on Pohnpei, Federated States of Micronesia, April 2010. Amphidromous gobies are the most abundant fishes in Micronesian streams and exhibit high endemism. Photograph by S.J. Walsh.

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-30. College of Micronesia biologist B. Lynch snorkeling to observe native fishes in streams on Pohnpei, Federated States of Micronesia, April 2010. Photograph by S.J. Walsh

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-31. Setting small trap to capture non-native poeciliids at Lake Ngardok, Republic of Palau, April 2010. Photograph by L.G. Nico

Appendix 1. Representative freshwater habitats and freshwater species of Micronesia.



Figure 1-32. Waterfalls are natural barriers that restrict upstream dispersal of many native and non-native fishes and other aquatic animals. Babeldaob Island, Palau, March 2010. Photograph by L. G. Nico

Appendix 2. Data matrix used in frequentist models for risk assessment of establishment success for non-native inland fishes of Hawaii and Guam. [HS, status in Hawaii; GS, status in Guam (0 = introduced, not established; 1 = established). Variable codes correspond to Table 22]

Dependent variable		Taxon	Independent variable																						
HS	GS		1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	Sum	5	7	9	10	11	12	13	14
0		<i>Osteoglossum bicirrhosum</i> ?	Osteoglossidae	0	1	1	0	0	0	0	0	0	0	0	0	0	2	3	7	3	4	3	1	2	6
	0	<i>Anguilla japonica</i>	Anguillidae	0	1	0	0	0	0	0	0	0	1	0	1	0	3	4	6	1	3	5	3	2	10
0		<i>Anguilla marmorata</i>	Anguillidae	0	1	0	0	0	0	0	0	0	1	0	1	0	3	4	7	1	3	5	3	2	10
	0	<i>Anguilla rostrata</i>	Anguillidae	0	1	0	0	0	0	0	0	0	1	0	1	0	3	4	6	1	3	5	3	2	10
1		<i>Dorosoma petenense</i>	Clupeidae	1	1	0	0	0	0	0	1	1	0	0	0	0	3	2	3	1	5	4	2	1	7
1		<i>Carassius auratus</i>	Cyprinidae	12	1	1	1	1	0	0	1	1	1	0	0	0	7	3	4	1	2	1	2	2	5
0	0	<i>Ctenopharyngodon idella</i>	Cyprinidae	1	1	0	0	1	1	1	0	0	1	0	0	0	5	4	2	1	1	1	2	2	5
1	1	<i>Cyprinus carpio</i>	Cyprinidae	12	1	1	1	1	1	1	0	1	1	0	0	0	8	4	4	1	5	1	2	2	5
	0	<i>Hypophthalmichthys nobilis</i>	Cyprinidae	1	1	0	0	1	1	1	0	1	1	0	1	0	7	4	3	1	1	4	1	2	7
1		<i>Puntius filamentosus</i>	Cyprinidae	0	1	1	0	0	0	0	0	0	0	0	0	0	2	2	5	1	1	5	2	1	8
	0	<i>Puntius lateristriga</i>	Cyprinidae	0	0	1	0	0	0	0	0	0	0	0	0	0	1	2	4	1	1	5	1	1	7
1		<i>Puntius semifasciolatus</i>	Cyprinidae	1	1	1	0	0	0	0	0	0	0	0	0	0	2	1	4	1	1	2	1	1	4
1		<i>Misgurnus anguillicaudatus</i>	Cobitidae	2	1	1	0	0	1	0	0	1	1	0	0	0	5	2	4	1	4	4	1	3	8
0		<i>Leporinus fasciatus</i>	Anostomidae	0	0	1	0	0	0	0	0	0	0	0	0	0	1	2	4	2	1	3	1	1	5
0		<i>Colossoma macropomum</i> ?	Characidae	2	1	1	0	0	1	0	0	0	1	0	0	0	4	4	2	1	4	3	1	2	6
0		<i>Pygocentrus nattereri</i>	Characidae	0	0	1	0	0	0	0	0	0	0	0	0	0	1	3	7	2	4	3	1	1	5
0		<i>Ameiurus nebulosus</i>	Ictaluridae	1	1	0	0	0	1	1	0	0	0	0	0	0	3	3	4	2	4	4	2	2	8
1	0	<i>Ictalurus punctatus</i>	Ictaluridae	3	1	1	0	0	1	1	0	0	1	0	0	0	5	4	4	2	4	4	2	1	7
	0	<i>Pangasianodon hypophthalmus</i>	Pangasiidae	2	1	1	0	0	0	0	0	0	0	0	0	0	2	4	4	1	4	5	1	3	9
	1	<i>Clarias batrachus</i>	Clariidae	3	1	1	0	0	1	0	0	0	1	0	0	0	4	3	4	2	5	5	2	3	10
1		<i>Clarias fuscus</i>	Clariidae	0	1	1	0	0	1	0	0	0	1	0	0	0	4	2	6	2	2	5	1	3	9
	1	<i>Clarias macrocephalus</i>	Clariidae	0	1	1	0	0	0	1	0	0	1	0	0	0	4	4	6	2	5	5	2	3	10
	0	<i>Arius</i> sp.	Ariidae	0	0	1	0	0	0	0	0	1	0	0	0	0	2	3	6	3	3	5	3	1	9
0		<i>Synodontis</i> sp.	Mochokidae	0	1	1	0	0	0	0	0	0	0	0	0	0	2	2	4	1	4	3	1	2	6
1		<i>Corydoras aeneus</i> ?	Callichthyidae	0	1	1	0	0	0	0	0	0	0	0	0	0	2	1	4	1	4	3	1	3	7
1		<i>Ancistrus cf. temminckii</i>	Loricariidae	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	3	1	3	1	3	7

Appendix 2. Data matrix used in frequentist models for risk assessment of establishment success for non-native inland fishes of Hawaii and Guam. [HS, status in Hawaii; GS, status in Guam (0 = introduced, not established; 1 = established). Variable codes correspond to Table 22]

1		<i>Hypostomus cf. watwata</i>	Loricariidae	0	0	1	0	0	0	0	0	0	0	0	0	1	3	1	2	4	3	2	3	8	
0		<i>Peckoltia</i> sp.	Loricariidae	0	0	1	0	0	0	0	0	0	0	0	0	1	2	1	2	4	3	1	2	6	
1		<i>Pterygoplichthys multiradiatus</i>	Loricariidae	6	1	1	1	0	0	0	0	0	0	0	0	3	3	1	2	4	3	1	3	7	
0		<i>Plecoglossus altivelis</i>	Plecoglossidae	0	1	0	0	0	1	0	0	0	0	0	0	2	3	4	1	1	4	3	1	8	
1		<i>Oncorhynchus mykiss</i>	Salmonidae	5	1	0	0	0	1	1	0	0	0	0	0	3	4	6	1	1	1	3	1	5	
0		<i>Oncorhynchus tshawytscha</i>	Salmonidae	0	1	0	0	0	1	1	0	0	0	0	0	3	4	6	1	1	1	3	1	5	
0		<i>Salmo trutta</i>	Salmonidae	2	1	0	0	0	0	1	0	0	0	0	0	2	4	6	1	1	1	3	1	5	
0		<i>Salvelinus fontinalis</i>	Salmonidae	0	1	0	0	0	1	1	0	0	0	0	0	3	3	6	1	1	1	2	1	4	
0		<i>Aplocheilichthys lineatus</i>	Aplocheilidae	0	0	1	0	1	0	0	0	0	0	0	0	2	1	5	1	5	2	2	2	6	
0		<i>Nothobranchius guentheri</i>	Nothobranchiidae	0	0	1	0	1	0	0	0	0	0	0	0	2	1	5	1	5	3	1	2	6	
0		<i>Fundulus grandis</i>	Fundulidae	0	0	1	0	1	0	0	0	1	0	0	0	3	2	4	1	3	2	3	2	7	
1	1	<i>Gambusia affinis</i>	Poeciliidae	23	1	1	0	1	0	0	0	0	0	0	0	3	1	5	3	4	1	2	2	5	
1		<i>Limia vittata</i>	Poeciliidae	0	0	1	0	1	0	0	0	0	0	0	0	2	1	4	3	4	2	2	2	6	
1	1	<i>Poecilia latipinna</i>	Poeciliidae	5	0	1	0	1	0	0	0	0	0	0	0	2	2	4	3	5	2	3	2	7	
1		<i>Poecilia mexicana/sphenops complex</i>	Poeciliidae	6	0	1	0	1	0	0	0	1	0	0	0	3	2	4	3	5	5	2	2	9	
1	1	<i>Poecilia reticulata</i>	Poeciliidae	30	1	1	1	1	0	0	0	0	0	0	0	4	1	4	3	4	3	2	2	7	
1	1	<i>Xiphophorus hellerii</i>	Poeciliidae	15	1	1	1	1	0	0	1	0	0	0	0	5	2	4	3	4	3	1	2	6	
1	0	<i>Xiphophorus maculatus</i>	Poeciliidae	11	1	1	1	1	0	0	0	0	0	0	0	4	1	4	3	4	3	1	2	6	
0		<i>Xiphophorus variatus</i>	Poeciliidae	1	1	1	1	1	0	0	0	0	0	0	0	4	1	4	3	4	3	1	2	6	
0		<i>Oryzias latipes</i>	Adrianichthyidae	1	1	1	0	1	0	0	0	0	0	0	0	3	1	5	3	5	2	2	2	6	
1		<i>Xenentodon cancila</i>	Belontiidae	0	0	1	0	0	0	0	0	0	0	0	0	1	3	6	1	5	5	3	2	10	
1		<i>Monopterus albus ?</i>	Synbranchidae	0	1	1	0	0	1	0	0	0	1	0	0	1	5	4	6	2	4	5	2	3	10
0	0	<i>Lates calcarifer</i>	Centropomidae	1	1	0	0	0	0	0	0	1	0	0	0	2	4	6	1	3	5	3	2	10	
0		<i>Morone saxatilis</i>	Moronidae	0	1	0	0	1	1	1	0	0	1	0	0	5	4	7	1	1	4	3	1	8	
0		<i>Kuhlia rupestris</i>	Kuhliidae	0	1	0	0	0	1	1	0	0	0	0	0	3	3	4	1	3	5	3	1	9	
1		<i>Lepomis cyanellus</i>	Centrarchidae	2	1	0	0	0	1	1	0	0	0	1	0	4	3	5	2	2	1	1	2	4	
1		<i>Lepomis macrochirus</i>	Centrarchidae	6	1	0	0	0	1	1	0	0	0	0	0	3	3	5	2	2	4	1	2	7	
1	0	<i>Micropterus dolomieu</i>	Centrarchidae	1	1	0	0	0	1	0	0	0	0	0	0	2	3	7	2	1	1	1	1	3	

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1	0	<i>Micropterus salmoides</i>	Centrarchidae	10	1	0	0	0	0	1	1	0	0	1	0	0	0	0	4	3	7	2	4	4	2	2	8
1		<i>Lutjanus fulvus</i>	Lutjanidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	6	1	3	5	3	1	9
1		<i>Amatitlania nigrofasciata</i>	Cichlidae	3	1	1	0	0	0	0	0	1	0	0	0	0	0	0	3	2	4	2	1	3	1	2	6
1		<i>Amphilophus citrinellus</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	2	3	1	2	6
0		<i>Amphilophus labiatus</i>	Cichlidae	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	4	3	1	2	6
1	1	<i>Astronotus ocellatus</i>	Cichlidae	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	3	3	6	2	2	3	1	2	6
1	1	<i>Cichla ocellaris ?</i>	Cichlidae	4	1	1	0	1	0	1	0	0	0	0	0	0	0	0	4	3	7	2	4	3	1	2	6
1		<i>Cryptoheros spilurus</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	4	3	1	2	6
1		<i>Hemichromis elongatus</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	2	4	3	1	2	6
1		<i>Hypsophrys nicaraguensis</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	4	3	1	2	6
1		<i>Melanochromis johannii</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	3	2	3	1	2	6
1		<i>Oreochromis macrochir</i>	Cichlidae	3	1	0	0	0	1	0	0	1	1	0	0	0	0	0	4	3	1	3	4	3	1	2	6
1	1	<i>Oreochromis mossambicus</i>	Cichlidae	43	1	1	0	1	1	1	1	1	1	0	0	0	0	0	8	3	4	3	5	3	2	2	7
1		<i>Parachromis managuensis</i>	Cichlidae	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	3	6	2	4	3	1	2	6
1		<i>Pelvicachromis pulcher</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	2	4	3	2	2	7
0		<i>Pterophyllum sp.</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	2	2	3	1	2	6
1		<i>Sarotherodon melanotheron</i>	Cichlidae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	3	5	3	2	2	7
1		<i>Thorichthys meeki</i>	Cichlidae	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	4	3	1	2	6
1		<i>Tilapia rendalli</i>	Cichlidae	8	1	1	0	1	1	1	0	0	1	0	0	0	0	0	6	3	2	2	4	3	2	2	7
1	1	<i>Tilapia zillii</i>	Cichlidae	7	1	1	0	1	0	0	0	0	1	0	0	0	0	0	4	3	2	2	5	3	2	2	7
1		<i>Omobranchius ferrox</i>	Bleenniidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	4	2	3	3	3	1	7
1		<i>Mugilogobius cavifrons</i>	Gobiidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	6	2	3	3	3	1	7
	1	<i>Betta pugnax</i>	Osphronemidae	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	3	1	5	3	1	3	1	3	7
0		<i>Osphronemus goramy</i>	Osphronemidae	7	1	1	0	0	0	0	0	0	1	0	0	0	0	0	3	3	4	2	2	3	2	3	8
0		<i>Trichopodus leerii</i>	Osphronemidae	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	2	3	1	3	7
1	1	<i>Channa maculata/striata</i>	Channidae	7	1	1	0	0	0	0	0	0	1	0	0	0	0	0	3	3	7	2	2	5	1	3	9

Freshwater Risk Assessment: Invasive Aquatic Plant Overview

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1. Introduction

The purpose of this document is to guide the Department of Defense (DoD), as well as civilian government and non-governmental organizations working within the region, in identifying risk associated with the potential introduction of freshwater invasive alien plant species (IAPS) in Hawaii and Micronesia. It is one component of a larger effort to address all invasive species issues in that region. The intent of this component of the Micronesia Biosecurity Plan or MBP is to provide guidance to countries and territories in the region on how to protect their natural resources and economies from freshwater IAPS by recommending management actions that will 1) reduce the risks for new introductions 2) provide early warning of new introductions and 3) minimize the spread of new infestations and 4) control, or if possible, eradicate infestations.

This effort is necessary due to the U.S. Military relocation to Guam and Commonwealth of the Northern Mariana Islands (CNMI) (the Buildup) and the associated Environmental Impact Statement (DoN 2010). The planned Buildup activities will increase the risk for IAPS and other invasive species through increased movement and trade within and outside the region and increased habitat disturbance (DoN 2010). The Buildup as envisioned in 2009 would involve the relocation of approximately 8,600 U. S. Marine Corps forces and their approximate 9,000 dependents from Okinawa, Japan to Guam; the development of existing and construction of new infrastructure and facilities to support these Marines; the construction of a new wharf and infrastructure in Apra Harbor (Guam) to support transient nuclear powered aircraft carriers; and the relocation of approximately 600 U.S. Army personnel and their approximately 900 dependents to establish and operate an Air Missile Defense Task Force in Guam (DoN 2010). DoD expected a total of approximately 30,000 people, including active duty members, civilian personnel, and dependents of both to relocate to Guam as a result of the Buildup. At the peak of construction, DoD projected the population of Guam would increase by as much as 80,000 people due to the associated military and construction work related to the Buildup. Since 2010 the overall size of the Buildup has been in question and it is no longer clear exactly how many troops, civilian and transitory workers will be required.

Regardless of its ultimate size, the Buildup will have an indirect impact beyond Guam and CNMI, the geographic scope also includes the Republic of Palau (Palau), the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI), and Hawai'i (hereafter referred to as the Region) (Figure 1-1).

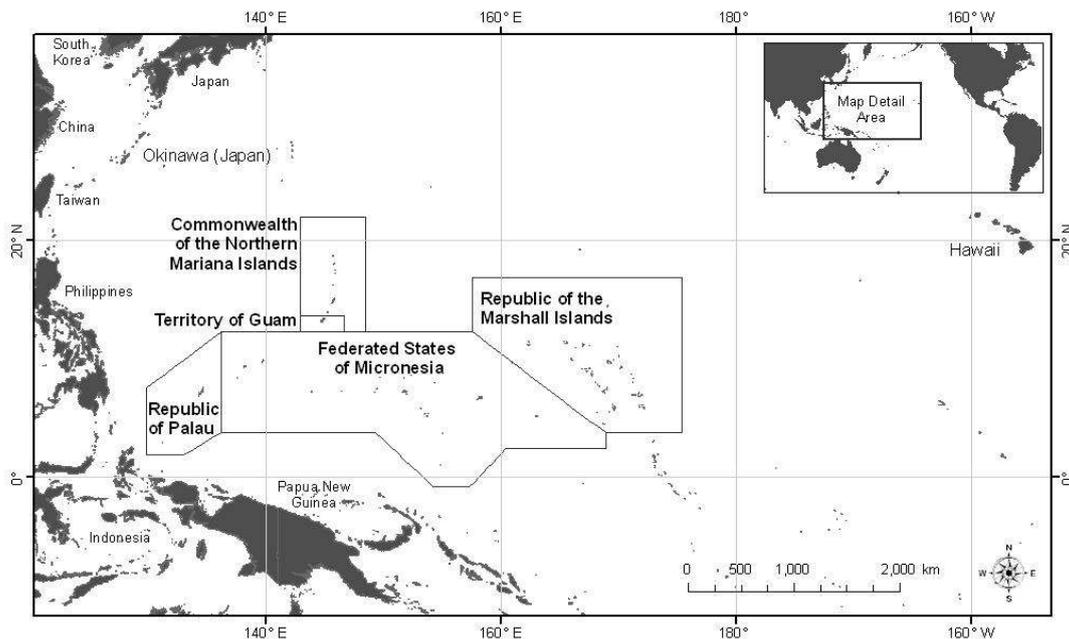


Figure 1-1: Geographic scope of the MBP Region.

1.1 Impacts of IAPS on Freshwater Habitats

Establishment and spread of IAPS in freshwater habitats often leads to considerable ecological, economical, and cultural harm. IAPS can reduce species richness and abundance of native plants (Boylen et al. 1999), affect utilization of drinking water supplies (Newroth 1985), increase water loss through evapotranspiration (Boyd 1987), retard water flow (Carpenter and Lodge 1986), and disrupt hydropower generation. IAPS can consume large amounts of oxygen during rapid senescence (Godshalk et al. 1977) creating fish kills, decrease land values (Halstead et al. 2003, Rockwell 2003), and diminish recreational opportunities such as boating, waterskiing, and fishing (Van Nes et al. 1999). Toxigenic blue-green algae associated with IAPS have been implicated in bird mortality (Wilde et al. 2005) and have the potential to affect human health. Conservative estimates of annual costs associated with IAPS in the United States (U.S.) are \$10 million in losses and damages and \$100 million in control (Pimentel et al. 2005). Flood control and recreation benefits associated with IAPS control in the U.S. are estimated to be over ten times higher (Rockwell 2003). Although IAPS can be dispersed by natural water currents, wind patterns, and animal movements; anthropogenic factors have substantially increased the rate and geographic range of invasions (Muirhead et al. 2009). In particular, increased globalization of trade has been correlated with higher rates of biological invasions (Levine and D'Antonio 2003) and establishment success is often greater in disturbed habitats (Chytrý et al. 2008).

1.2 The Freshwater IAPS Invasion Process

Although the islands in the Micronesia region are relatively isolated, they are susceptible to IAPS introduction. In fact, the low native freshwater aquatic plant species richness on the islands (there are only three native submersed species) may make the freshwater habitats on the islands particularly vulnerable to IAPS due to the available “niche space” for invaders (Kueffer

et al. 2010). This available “niche space” is just one of many factors that determines whether an IAPS will successfully invade an ecosystem after introduction. Catford et al. (2008) provides a useful framework for describing the components or factors in the invasion process (Figure 1-2). These components which are summarized below include the transport and introduction to an ecosystem followed by interactions between IAPS propagule pressure, abiotic characteristics of the ecosystem, and biotic characteristics of the IAPS and invaded community.

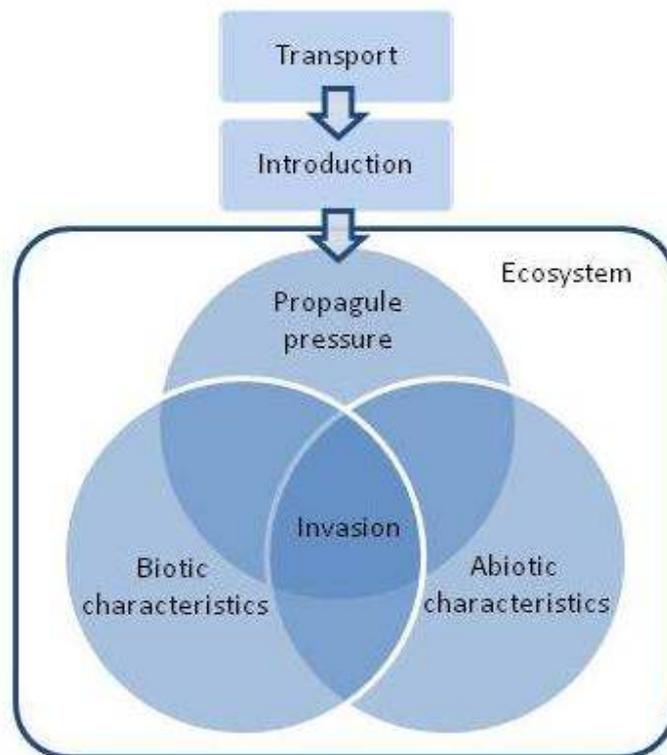


Figure 1-2: Schematic of how the transport and introduction of IAPS to an ecosystem influences propagule pressure; and how propagule pressure, abiotic characteristics, and biotic characteristics interact to determine invasion success (adapted from (Catford et al. 2008)).

IAPS are transported to new regions through natural pathways such as wind and water currents, and anthropogenic pathways such as ballast water or the pet and aquarium trade. The likely pathways of freshwater IAPS invasions to the Region are described below in Section 2. Once transported to a new region, IAPS can be released to the environment by accident or intent.

Once an IAPS is released to the environment, propagule pressure, the number of individuals released during an event and the frequency of events, are key characteristics in determining invasion success. Although a single individual can lead to successful invasion for some IAPS, higher propagule pressure is important for the continued invasion success of most IAPS.

The abiotic characteristics of an environment can also determine which IAPS successfully invade. The abiotic characteristics of freshwater aquatic environments include temperature, salinity, nutrient concentrations, light availability, soils, water flow, water depth, and the seasonality of water levels. In addition, disturbance of environments by both natural and

anthropogenic means can also promote invasion success. Characteristics of the Region's invulnerable freshwater aquatic habitats are described in Section 4.

Biotic characteristics of the IAPS and the native species also influence invasion success. Some of these biotic characteristics include a species competitive ability, dispersal modes, and reproductive capacity. The biotic characteristics of the Region's potential invaders are included in the Aquatic Weed Risk Assessment (Appendix B) and are summarized in Section 3.

2. Micronesia Region Invasion Pathways

Geographic isolation of islands is thought to limit the natural transport of viable freshwater and other IAPS via pathways such as wind patterns, water currents and animals (MacArthur and Wilson 1967). The islands of Micronesia are indeed isolated (Table 2-1); however, in a study of island plant invasions at a global scale, (Kueffer et al. 2010) found that human development (measured as gross domestic product) and habitat diversity are much more important factors than geographic isolation in determining the number of IAPS present. Kueffer et al. (2010) noted that human activity is the most important invasion pathway and that most IAPS were introduced intentionally.

Table 2-1: Approximate statute miles between locales.

	Tokyo, JP	Hagåtña, Guam	Honolulu, HI	Sydney, NSW	Los Angeles, CA
Saipan, CNMI	1460	136	3711	3393	5976
Palikir, FSM	2301	1018	3099	2842	5590
Hagåtña, Guam	1561	0	3809	3283	6099
Ngerulmud, Palau	1966	802	4592	3046	6898
Majuro, RMI	2799	1850	2285	3110	4834

2.1 Aquarium and Pet Trade

The aquarium plant trade is an important pathway for the spread and introduction of invasive species (Keller and Lodge 2007; Strecker et al. 2011) and is the primary driver of biosecurity risks associated with electronic commerce (Derraik and Phillips 2010). The aquarium trade is responsible for the introduction of several freshwater IAPS into the U.S., including Eurasian water milfoil (*Myriophyllum spicatum*), giant salvinia (*Salvinia molesta*), and Brazilian egeria (*Egeria densa*) (Reichard and White 2001). Many aquarium enthusiasts purchase fresh plant material for their aquaria online. The growing use and increasing speed and efficiency of postal/shipping delivery increases the probability that healthy invasive plants will reach appropriate climates for establishment and invasion (Reichard and White 2001).

Species misidentification, “hitchhiking” species, and disregard for regulations are major concerns with the aquarium and pet trade. Maki and Galatowitsch (2004) found that 93% of pond-plant shipments contained plant or animal species that were not ordered, and that 100% of shipments were contaminated with plants that were not ordered. Aquarium and pet trade vendors fulfilled 13 of 14 orders for species that were prohibited by either U.S. federal or state regulations, demonstrating that ignorance of or disregard for rules and regulations for the plant trade is commonplace (Maki and Galatowitsch 2004).

Nine of the first ten freshwater aquatic plant distributors returned by a U.S. internet search conducted by us during 2010 were U.S. companies. Seven of these top ten internet vendors made no mention of regulations pertaining to live plant transport. One vendor indicated that they verified the legality of shipping a plant to the customer, and two indicated that they placed the responsibility for determining the legality of the shipment on the customer.

After aquarium and water gardening species are imported, they are often discarded to ponds, ditches, streams, and lakes (Kay and Hoyle 2001; Maki and Galatowitsch 2004). Risks posed by the aquarium trade can be reduced through education regarding the dangers of improper disposal

of aquarium plants (Cohen et al. 2007). Use of scientific rather than common names of plant species (Kay and Hoyle 2001; Keller and Lodge 2007), and regulation of the intentional sale and transport of prohibited species will reduce the risk of IAPS introduction (Maki and Galatowitsch 2004).

Shipments of IAPS are likely to go undetected by both USPS and USCBP under current management practices due to U.S. Federal regulations, the large number of vendors, and discrete labeling. U.S. domestic mail is protected by being sealed against inspection (Title 39, United States Code, Section 404(c)); therefore, a U.S. Federal Search Warrant is required to open domestic mail including letters, packages, Express Mail packages and envelopes, and U.S. Priority Mail packages and envelopes. Domestic mail to Guam and the CNMI passes first through Honolulu, Hawai'i, but its inspection is not part of the Hawai'i Plant Protection and Quarantine pre-departure inspection program (D. Berringer, APHIS-PPQ, pers. comm.). All Domestic mail shipped to Guam through Honolulu is subject to an agricultural inspection in Honolulu, however, data on the number of parcels subjected to inspection was unavailable to us.

2.2 Ornamental Aquatic Plant Trade

The ornamental aquatic plant trade includes a diverse array of plants that are easy to grow, require minimal maintenance, and reproduce quickly (Bell et al. 2003, Peters et al. 2006) – all characteristics of successful invasive plants. In a global study of IAPS in island habitats, Kueffer et al. (2010) found that half of IAPS are ornamental plants. Ornamental ponds and water features are common within hotel, resort, and casino landscaping in Micronesia. Some hotels propagate and grow their own nursery stock on site for use in landscape features. Risks associated with these features include the distribution of plant propagules during flooding events or typhoons, distribution by birds, and intentional dispersal by staff, guests and other island residents.

2.3 Medicinal and Culinary Aquatic Plant Trade

Temporary and permanent workers from a diverse range of cultures, including the Philippines, China, and Korea are expected to constitute a large proportion of the work force associated with the Buildup (DoN 2010). These workers could bring along their culinary and medicinal cultures which may include freshwater IAPS. *Ipomoea aquatica* (water spinach) is a notable example of an IAPS introduced as a vegetable that is currently widespread and consumed throughout the region. Up to 80% of the populations in some Asian and African countries depend on traditional medicine for their primary health care (WHO 2003). The aquatic plant *Monochoria vaginalis* is traditionally used in the Indian State of Tamil Nadu to treat toothaches and as a dentifrice (Ganesan 2008). Alang-ilang (*Cananga odorata*) is a Tongan herbal medicine which has naturalized on numerous Pacific islands (PIER 2010). Weedy species may serve dual purposes; acapulco (*Senna alata*) is a ringworm treatment and is also occasionally planted to improve taro fields (PIER 2010).

2.4 Tourism and Business Travel

Tourism accounts for 40 to 90% of the visits to some Micronesian islands (Table 2-2Table 2-1). Risks associated with tourism include movement of passenger cargo and the unintentional introduction of plant material stuck to vessels or vehicles. Between 1984 and 2000, 62% of the 725,000 plant-pest interceptions recorded by USDA APHIS were associated with passenger

baggage. Most interceptions were at airports (73%), followed by interception during land based border crossing (13%), and finally interception at marine ports (9%). Seven percent of the interceptions were weed species (McCullough et al. 2006).

Table 2-2: Visitors that declared “tourism” as reason for visit to FSM, RMI, and Palau. No data available for CNMI.

	FSM	RMI	Palau
Year of survey	2006	2005	2006
Total visitors	19,136	9,173	87,206
Tourism	13,345	3,658	78,252
% of total	70	40	90
Country of residence of tourists (% of total)	U.S. (43) Japan (20) Europe (16)	U.S. (28) Other Pacific Islands (22) Japan (17)	Japan (35) Taiwan (17) Korea (16)

Source: Federated States of Micronesia Division of Statistics, Republic of Palau Office of Planning and Statistics, Republic of the Marshall Islands Planning and Statistics Office.

2.5 Movement of DoD Equipment and Personnel

Unintentional movement of IAPS may occur when plant propagules (vegetative fragments, seeds, capsules, roots, etc.), including those of aquatic plant species, adhere to equipment, hulls of boats, and in standing water moved from site to site. There is a risk that the relocation of equipment to Micronesia and routine deployment and training activities could increase the potential for accidental movement of plant propagules. It is worth noting that Cofrancesco et al. (2007) did reviewed some of the existing guidelines for inspecting and sterilizing military equipment from invasive species.

2.6 Movement of Cargo

Cargo is imported and exported from Guam by several methods including surface shipping containers, break-bulk (cargo packed in cases, bales, cartons, etc.), roll on-roll off (vehicles), barges, fishing vessels, private yachts and air transport. The vast majority of the cargo imported and exported from Guam (over 97% by weight) has been transported via surface shipping methods rather than via air transport (Table 2-3).

During the Buildup, the original number of commercial cargo containers handled by the Port Authority of Guam was expected to increase by about 25% between 2008 and 2018 while the number of military containers will increase to a peak of about 400% above 2008 levels (currently it is difficult to say how realistic these figures remain as the Buildup planning is under consideration and may change significantly before the efforts are completed). Following the Buildup the number of military containers could stabilize at approximately 38,000 per year until at least 2027 (DoN 2010) (again at this time more updated and realistic numbers are not known and will depend on the final true make-up of the proposed DoD Buildup). Break-bulk cargo shipments to Guam are projected to follow a similar trend to container shipments, but peak several years earlier.

Table 2-3: Guam surface and air cargo imports and exports from 2006 to 2009.

Movement type	2009	2008	2007	2006
Surface cargo (revenue tons) ^a ^b				
<i>Unloaded (Import)</i>	1,213,400	1,269,600	1,226,300	1,139,200
<i>Loaded (Export)</i>	194,700	213,700	213,500	194,900
<i>Transship</i>	447,700	576,500	629,000	579,800
<i>Total surface cargo</i>	1,855,800	2,059,800	2,068,800	1,913,900
Air cargo (metric tons) ^c				
<i>Unloaded (Import)</i>	16,539	17,528	15,380	16,904
<i>Loaded (Export)</i>	9,046	11,616	12,998	15,022
<i>Total air cargo</i>	25,585	29,144	28,378	31,926

^aRevenue tons are equal to either metric tons or cubic meters depending on cargo type. ^bSource: Port Authority of Guam and the Guam International Airport Authority, Government of Guam. ^cSource: Guam International Airport Authority, Government of Guam

All DoD air cargo is received at Andersen Air Force Base and all DoD surface cargo is received at the Naval Base Guam. Household goods associated with military personnel constitute the largest volume of cargo moving on and off of Guam (D. Vice, USDA Wildlife Services, pers. comm.). When military personnel undergo a permanent change of station their household personal goods can be shipped via air or surface. Plant propagules can lodge in tires of vehicles, in equipment, or they can adhere to hulls of boats, kayaks, personal watercraft, or other watercraft. The risk of IAPS transport is not limited to the initial re-entry into water; it persists until either the propagule becomes dislodged or dies, potentially placing multiple water bodies at risk.

In a study of the risk for transport of non-native insect species to the U.S. via foreign cargo trade, (Work et al. 2005) found that risk was highest for refrigerated maritime containers followed by non-refrigerated maritime containers, air cargo, and finally overland transport.

Approximately 2% of cargo arriving at U.S. maritime ports, border crossings, and airports has been inspected since 1972 and the number of plant pests intercepted is a linear function of the number of inspections conducted (Work et al. 2005). The volume of imported goods and inadequate funding and staffing contribute to these overall low inspection rates.

3. Freshwater IAPS of concern

IAPS of concern to the Micronesia Region include those species that:

- are already present within the region
- are likely to occur in high risk invasion pathways
- have biotic characteristics that could potentially lead to successful invasions such as ecological versatility, competitive ability, reproductive output and dispersal mechanisms, ability to colonize undisturbed habitats and similarity of climate from source to new habitat
- have known negative environmental impacts
- and have known negative impacts on economic and social uses of water and the environment

3.1 The Aquatic Weed Risk Assessment Model (AWRAM) (Champion and Clayton 2000, 2001) was used to assign risks of individual IAPS to the Region see Appendix B for details.

3.2 Field Survey Results

Field visits were conducted in January and April 2010 to survey freshwater aquatic plants established in the region (Table 4) and plants available for sale in commercial settings, such as open-air markets and aquarium stores (Table 5). Sites were visited on Guam (Figure 3-1), Saipan, CNMI (Figure 3-2), Yap, FSM (Figure 3-3), Pohnpei, FSM (Figure 3-4), and Palau (Figure 3-5). Survey sites were selected based on previous USFS vegetation surveys (Cole et al. 1987; Falanruw et al. 1987; MacLean et al. 1986) and local knowledge provided by natural resource staff and guides on the islands. Detailed survey methods and results are available in Appendix B.

Significant findings included the first record of *Monochoria vaginalis* within Micronesia in a small stream on the southern coast of Guam. *M. vaginalis* is an ornamental emergent to floating species from Indonesia (Horn 2002), Malaysia, Japan (including Okinawa), and Taiwan (Wagner et al. 1999). It has naturalized in rice fields of California (Horn 2002) and invasive populations are known in Fiji and several of the Hawai'i islands (Smith 1979, Wagner and Herbst 1995, Wagner et al. 1999). This species is considered edible, medicinal and has an attractive flower, suggesting that it was a likely intentional introduction (Yang et al. 2008). *M. vaginalis* and its congener, *M. hasata*, are listed noxious weeds by the U.S. Federal Government (7 CFR § 360.200).

Previously abundant populations of hydrilla (*Hydrilla verticillata*) and curly-leaf pondweed (*Potamogeton crispus*) in Fena Valley Reservoir, Guam were not found, apparently due to grazing by two introduced Tilapia species (*Oreochromis massambicus* and *Tilapia zillii*). *H. verticillata* was present, however, in tributaries to, and downstream of, the reservoir and was found in numerous other streams throughout southern Guam.

Eichhornia crassipes was widespread in the region. *E. crassipes* is native to the Amazon River basin in South America, but has been widely distributed as an ornamental floating leaved plant. It was found naturalized in Agana Swamp, Guam, where it was also observed in an individual's bucket; it was apparently collected there for transport. On Pohnpei, *E. crassipes* and *Pistia stratiotes* were naturalized in numerous ditches. On Yap, *E. crassipes* and *Ipomoea aquatica* were found in similar habitat. It was reported that *E. crassipes* flowers were brought to church each week on both these islands.

H. verticillata, *E. crassipes*, *P. stratiotes* and *I. aquatica* were available for sale in open-air markets in at least one location visited within Micronesia. These species, as well as *Salvinia* spp., *Nymphaea* spp., *Nelumbo* spp. were also offered for sale at numerous nurseries with ornamental pond plants. *I. aquatica*, a floating-leaved plant native to China, was widely cultivated and sold as an edible plant on all islands visited, as it is throughout many regions of the Pacific, Africa, South America, and Australia (Fang and Staples 1995).

In addition to these findings during field sampling, two websites of local flora and habitats indicated a population of *Salvinia natans* may be naturalized within the Malojloj watershed (Pauliluc River), Guam. This species was observed for sale at a nursery within this watershed.

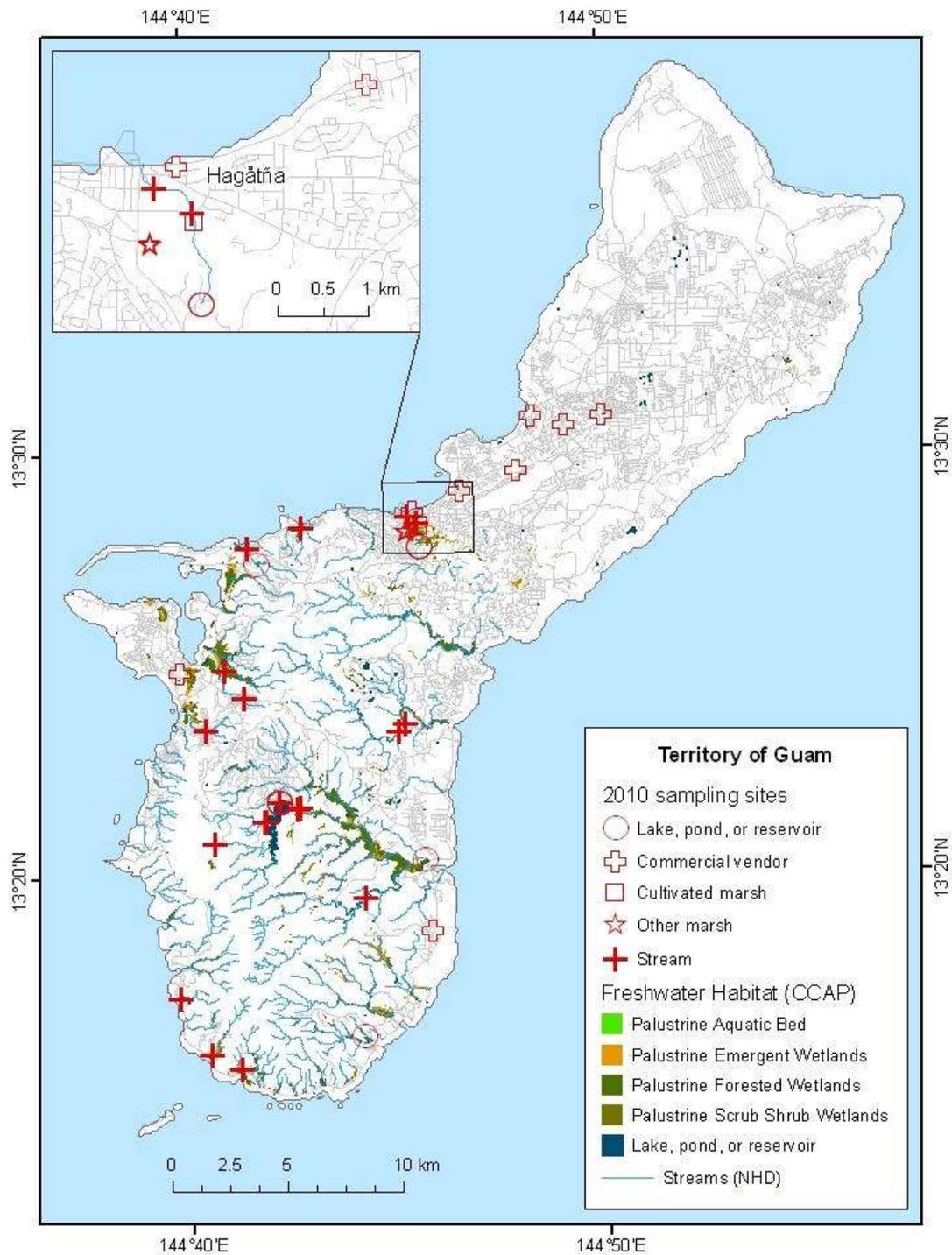


Figure 3-1: Freshwater habitats and aquatic plant survey sites in the Territory of Guam. Freshwater habitat data are from the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (NOAA-CSC 1995-present) and stream data are from the U.S. Geological Survey (USGS) National Hydrographic Dataset (NHD).

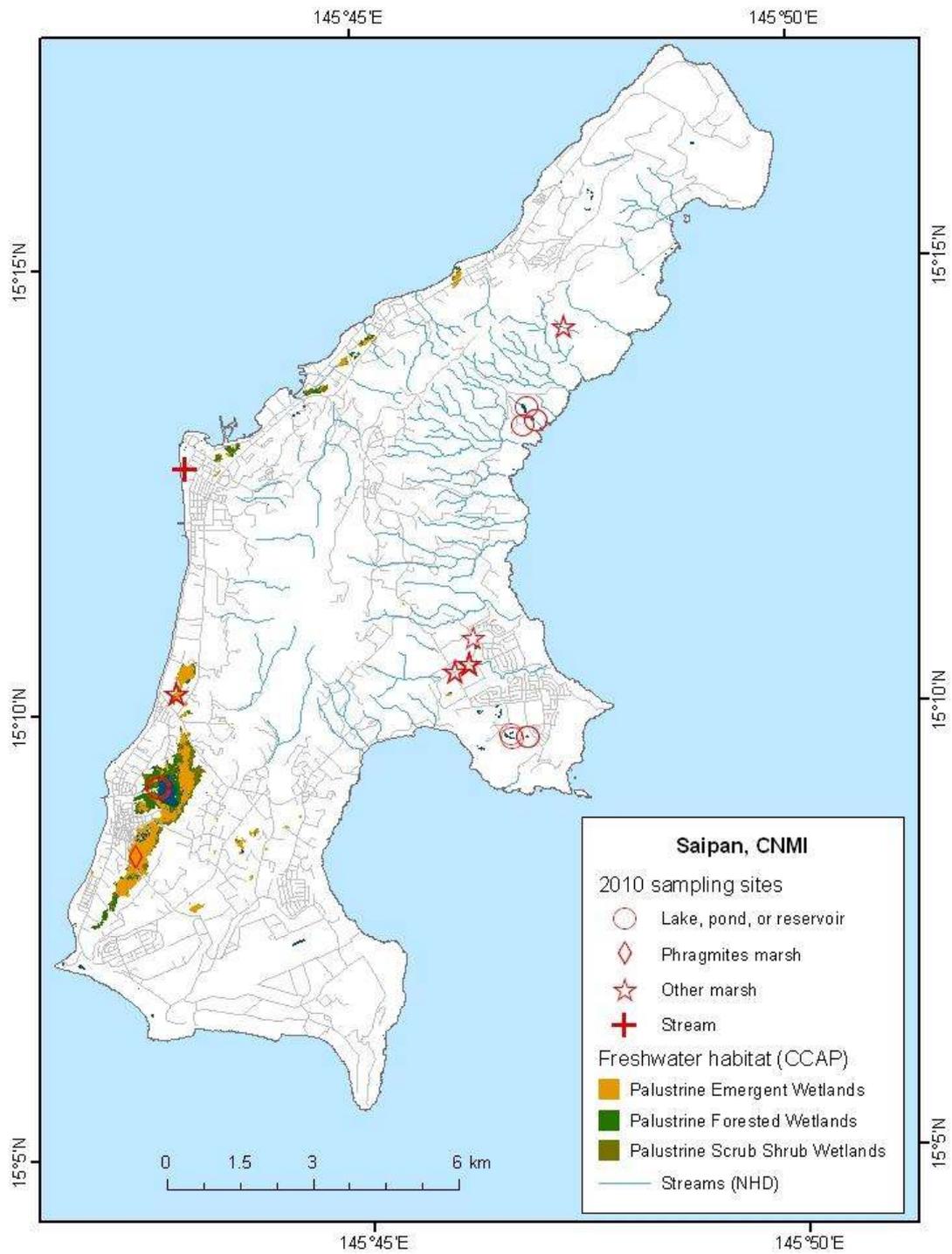


Figure 3-2: Freshwater habitats (NOAA-CSC 1995-present) and aquatic plant survey sites in Saipan, CNMI.

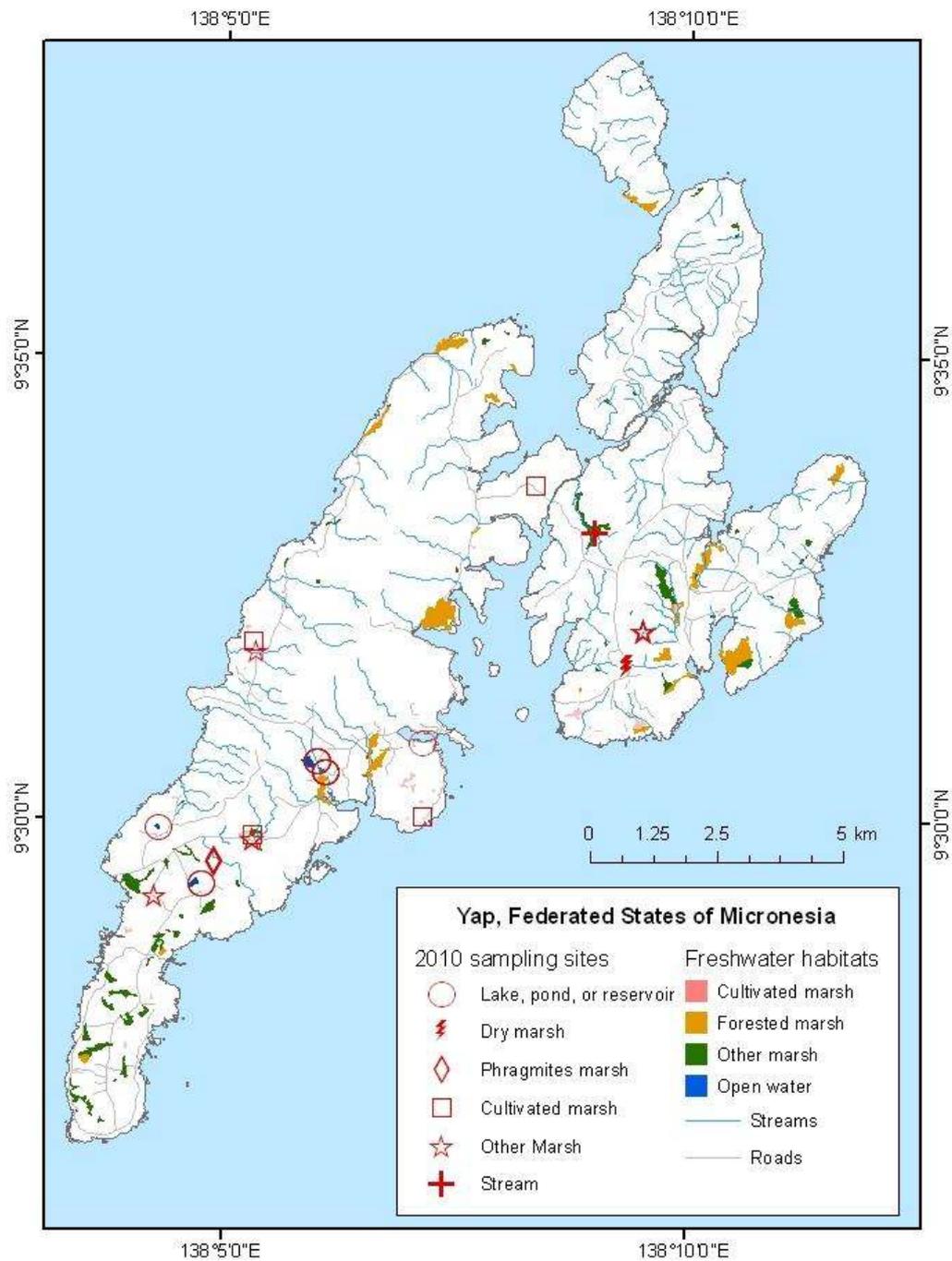


Figure 3-3: Freshwater habitats (Falanruw et al. 1987) and aquatic plant survey sites in Yap, FSM.

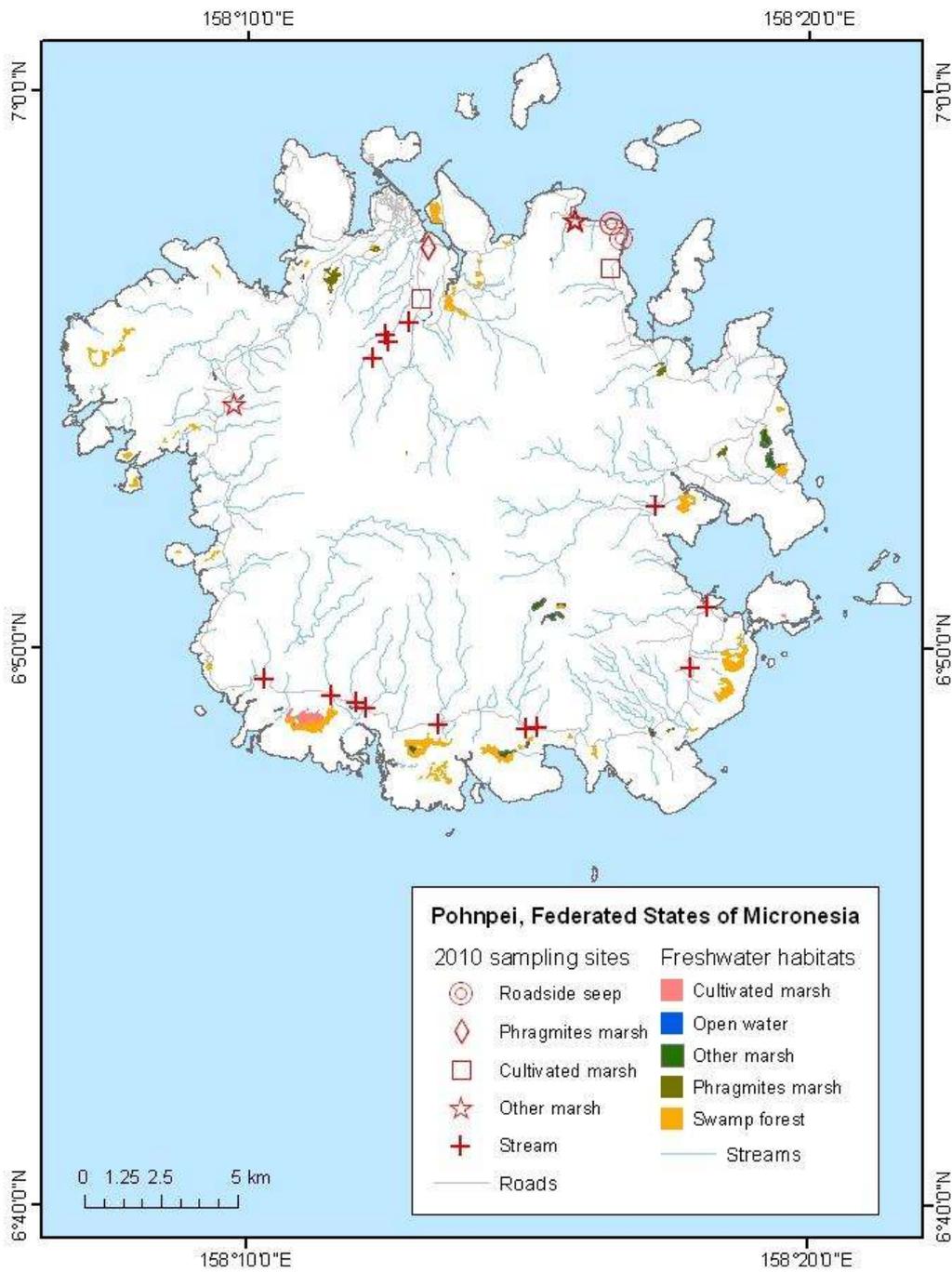


Figure 3-4: Freshwater habitats (MacLean et al. 1986) and aquatic plant survey sites in Pohnpei, FSM.

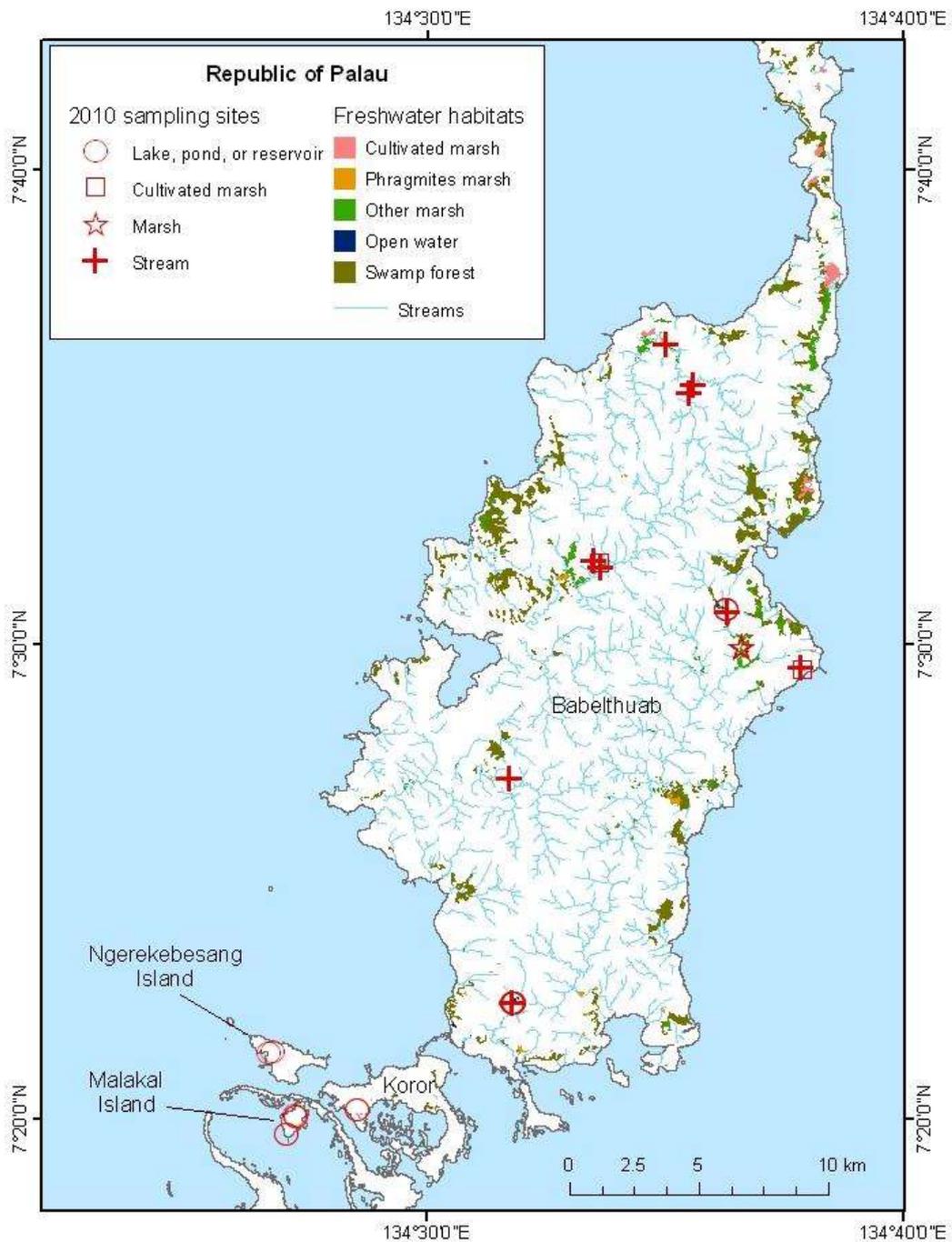


Figure 3-5: Freshwater habitats (Cole et al. 1987) and aquatic plant survey sites in the Republic of Palau.

Table 3-1: Naturalized plant populations found during field sampling, January and April 2010; ‘x’ – native, ‘I’ – introduced.

Scientific name	Common name	Guam	Saipan	Pohnpei	Yap	Palau
<i>Acacia auriculariformis</i>	earleaf acacia				I	
<i>Acrostichum aureum</i>	golden leatherfern				x	
<i>Actinoscirpus grossus</i>	giant bulrush		x			x
<i>Ageratum conyzoides</i>	tropical whiteweed					I
<i>Alternanthera sessilis</i>	sessile joyweed			x		x
<i>Bacopa monnieri</i>	water hyssop	x	x			
<i>Blyxa aubertii</i>	roundfruit blyxa			x		x
<i>Cassytha filiformis</i>	devil’s gut				x	
<i>Casuarina equisetifolia</i>	beach sheoak				x	
<i>Cayratia trifolia</i>	threeleaf cayratia				x	
<i>Centella asiatica</i>	spadeleaf			x		
<i>Ceratophyllum demersum</i>	coon’s tail	x				
<i>Ceratopteris thalictroides</i>	watersprite	x			x	x
<i>Chara sp.</i>	muskgrass, stonewort	x				
<i>Colocasia esculenta</i>	soft taro				I	I
<i>Commelina diffusa</i>	climbing dayflower			I		
<i>Cyclosorus interruptus</i>	cyclosorus fern, swamp fern			x	x	x
<i>Cyperus compressus</i>	poorland flatsedge				I	
<i>Cyperus difformis</i>	variable flatsedge	I		I		
<i>Cyperus javanicus</i>	Javanese flatsedge				x	
<i>Cyperus polystachyos</i>	manyspike flatsedge	x		x		
<i>Cyperus prolifer</i>	miniature flatsedge	x				
<i>Cyperus sp.</i>	flatsedge				x	
<i>Cyrtosperma chamissonis</i>	giant swamp taro				I	I
<i>Dicranopteris linearis</i>	Old World forked fern				x	
<i>Echinochloa crus-gallii</i>	barnyardgrass			I		
<i>Echinodorus osiris</i>	melon sword	I				
<i>Echinodorus cordifolius</i>	spade leaf sword	I				
<i>Eclipta prostrata</i>	false daisy			I		I
<i>Eichhornia crassipes</i>	water hyacinth	I	I	I	I	
<i>Eleocharis dulcis</i>	Chinese water chestnut				I	
<i>Eleocharis geniculata</i>	Canada spikesedge	x			x	x
<i>Eleocharis ochrostachys</i>	spikerush				x	x
<i>Eriocaulon sexangulare</i>					x	x
<i>Fimbristylis dichotoma</i>	forked fimbry			x	x	x
<i>Fimbristylis littoralis</i>	fimbry, grass-like fimbristylis	x		x	x	
<i>Fimbristylis sp.</i>	fimbry				x	
<i>Fuirena umbellata</i>	yefen				x	x

Table 3-1 (continued): Naturalized plant populations found during field sampling, January and April 2010. ; 'x' – native, 'I' – introduced.

Scientific name	Common name	Guam	Saipan	Pohnpei	Yap	Palau
<i>Hanguana malayana</i>					x	x
<i>Hibiscus tiliaceus</i>	sea hibiscus	x			x	x
<i>Hydrilla verticillata</i>	Hydrilla	I				
<i>Hyptis capitata</i>	false ironwort			I	I	I
<i>Ipomoea aquatica</i>	swamp morning-glory, Chinese water spinach	I	I	I	I	I
<i>Isachne confusa</i>	isachne				x	x
<i>Ischaemum polystachyum</i>				x	x	x
<i>Kyllinga brevifolia</i>	shortleaf spikesedge			x		
<i>Kyllinga sp.</i>	spikesedge					x
<i>Lemna aequinoctialis</i>	lesser duckweed	x				
<i>Lepironia articulata</i>	grey sedge				x	
<i>Limnophila aromatica</i>	rice paddy herb				x	x
<i>Lindernia antipoda</i>	sparrow false pimpernel			x		x
<i>Ludwigia hyssopifolia</i>	seedbox			x	x	x
<i>Ludwigia octovalvis</i>	Mexican primrose-willow	x		x	x	x
<i>Lycopodium cernuum</i>	staghorn clubmoss				x	
<i>Lygodium microphyllum</i>	small-leaf climbing fern				x	
<i>Mecardonia procumbens</i>	baby jump-up			x	x	
<i>Melaleuca quinquenervia</i>	punktree				I	
<i>Monochoria vaginalis</i>	heartshape false pickerelweed	I				
<i>Nepenthes mirabilis</i>	common swamp pitcherplant				x	x
<i>Nephrolepis sp.</i>	sword fern				x	
<i>Nitella sp.</i>	brittlewort				x	x
<i>Nymphaea caerulea var. zanzibarensis</i>	Cape waterlily	I				I
<i>Pandanus sp.</i>	pandanus palm				x	
<i>Persicaria minus var. procera</i>	pygmy smartweed					x
<i>Phragmites vallatoria</i>	Khagra reed, <i>P. karka</i>	x	x	x	x	x
<i>Phyla nodiflora</i>	turkey tangle, fogfruit				I	
<i>Pistia stratiotes</i>	water lettuce	I		I		
<i>Polygala paniculata</i>	milkwort, root beer plant				x	
<i>Potamogeton nodosus</i>	longleaf pondweed	x				
<i>Rhynchospora corymbosa</i>	matamat			x	x	x
<i>Sphagneticola trilobata</i>	Bay Biscayne creeping-oxeye	I	I		I	I
<i>Tradescantia sp.</i>	spiderwort			I		
<i>Urochloa mutica</i>	para grass					x
<i>Utricularia gibba</i>	humped bladderwort					x
<i>Utricularia uliginosa</i>	Asian bladderwort					x

Table 3-2: Live plants found for commercial sale during field sampling in January and April 2010 in open-air markets, plant nurseries and pet/aquarium stores on Guam.

Scientific name	Common name
<i>Anubias sp.</i>	dwarf anubias
<i>Ceratophyllum demersum</i>	common hornwort, coontail
<i>Cryptocoryne spp.</i>	water trumpet
<i>Echinodorus spp.</i>	burhead
<i>Eichhornia crassipes</i>	water hyacinth
<i>Hydrilla verticillata</i>	hydrilla
<i>Lemna minuta</i>	least duckweed
<i>Myriophyllum aquaticum</i>	parrot feather
<i>Nelumbo nucifera</i>	sacred lotus
<i>Nymphaea caerulea var. zanzibarensis</i>	Cape waterlily
<i>Nymphaea elegans</i>	tropical royalblue waterlily
<i>Nymphaea spp.</i>	waterlily
<i>Pistia stratiotes</i>	water lettuce
<i>Sagittaria latifolia</i>	broadleaf arrowhead
<i>Sagittaria sp.</i>	arrowhead
<i>Salvinia cucullata</i>	Asian watermoss
<i>Salvinia natans</i>	eared watermoss, floating watermoss
<i>Salvinia spp.</i>	watermoss
<i>Spirodela polyrrhiza</i>	greater duckweed, common duckweed

4. Susceptible Freshwater Habitats

An essential requirement for the establishment of invasive plants in any region is the availability of suitable habitat. For freshwater IAPS, suitable habitats include permanent and intermittent freshwater wetlands, lakes and other standing waters, and rivers and streams. In Micronesia these habitats are primarily limited to high volcanic, raised atoll, and raised continental shelf islands, which include Guam; most islands in CNMI; Kosrae, Pohnpei, Yap, and some of the islands of Chuuk State in FSM; and several islands in the Republic of Palau (Stemmermann and Proby 1978b). Freshwater habitats on low atoll islands in the region are restricted to cultivated wetlands, although there is one small freshwater pond in the center of Lib Island, Republic of the Marshall Islands (Dahl 1980). Land-cover data from a variety of sources were analyzed to characterize the freshwater habitats in the region (Table 4-1). Vegetation surveys conducted for the U.S. Army Corp of Engineers (USACE)¹ and the USFS² describe wetlands and their distributions throughout the Micronesian region. Wetland habitats were classified into categories including lowland swamp forests, upland wetlands, cultivated and other ruderal wetlands, riparian wetlands, lakes, reservoirs, and ponds³. Pictures of representative habitats are presented in **Error! Reference source not found.** Mangrove swamps and other habitats with salinities greater than 5‰ (parts per thousand) were not included in this assessment. Although the percentage of land area covered by freshwater is low throughout region (Table 4-2 and **Error! Reference source not found.**), freshwater areas are important for fish, wildlife, food production, recreation, and drinking water.

Forested marsh accounted for the greatest area of freshwater habitat in the region as estimated using C-CAP and USFS land cover data (Table 4-2). Palau and Guam have the most forested marsh area followed by Kosrae and Pohnpei. Non-forested marsh is the next most extensive freshwater habitat followed by lakes, ponds, and reservoirs. Although stream length data is not necessarily comparable across the different data sources with great confidence, Palau, Guam, and Pohnpei have more stream kilometers than other islands.

¹ Moore et al. 1977; Stemmermann and Proby 1978a; Stemmermann and Proby 1978b

² Cole et al. 1987; Falanruw et al. 1987a; MacLean et al. 1986; Whitesell et al. 1986

³ These classifications are similar but more detailed than classification schemes used by the NOAA Coastal Change and Analysis Program (C-CAP) and the USFWS National Wetlands Inventory (NWI) to characterize more recent conditions.

Table 4-1: Primary data sources used to summarize freshwater resources¹.

Region	Data source	Image date(s)
Territory of Guam	NOAA C-CAP (NOAA-CSC 1995-)	2005
Commonwealth of the Northern Mariana Islands	NOAA C-CAP (NOAA-CSC 1995-)	2003-2005
Federated States of Micronesia		
<i>Kosrae State</i>	USFS (Whitesell et al. 1986)	1976
<i>Pohnpei State</i>	USFS (MacLean et al. 1986)	1976
<i>Yap State</i>	USFS (Falanruw et al. 1987a)	1976
<i>Chuuk State</i>		
<i>Tol, Paata, Polle, Fanapanges, Romanum, Udot, Eot, Pwipwi, and Totiw Islands</i>	USFS (Donnegan et al. 2010)	2006
Republic of Palau	USFS (Cole et al. 1987)	1976
Republic of the Marshall Islands	Dahl 1980	No data

¹Data sources used to characterize freshwater habitats in the region included NOAA C-CAP land cover data for Guam and CNMI derived from 2000s era satellite imagery and ground verification and USFS vegetation surveys based on 1970s era aerial photographs and 1980s era ground verification. USFS Forest Inventory and Analysis Program (FIA) vegetation survey data, which is based on satellite imagery and ground verification, was used for several of the Chuuk Islands since C-CAP and USFS vegetation survey data were not available (Table 2). Although the FIA vegetation survey data is available for much of the region, and is more recent, it was only used when other data sources were unavailable because the FIA wetlands classification scheme is relatively coarse compared to the earlier USFS vegetation surveys and recent C-CAP land cover data. For example, the FIA survey data does not differentiate between fresh and brackish water.

Table 4-2: Land area of selected islands within the Micronesia, percent of land covered by freshwater habitats, and stream density.¹

Island	Land area (ha)	Percent of land covered by freshwater habitats ¹	Stream density (m/ha) ²
Guam	54376	3	8
Saipan, CNMI	11893	2	9
Rota, CNMI	8511	0	0
Tinian, CNMI	10122	< 1	0
Kosrae, FSM	11397	5	5
Pohnpei, FSM	36585	2	9
Chuuk, FSM (high islands)	8758	3	5
Republic of Palau	41229	5	15
RMI	18100	0	0

¹ NOAA C-CAP and USFS land cover. ² USGS National Hydrographic Dataset and USGS topographic maps.



Figure 4-1: Representative freshwater habitats in the Micronesia Region (clockwise from upper right): large stream on Pohnpei; upland savannah wetland with *Phragmites vallatoria* on Yap; ruderal roadside seep with *Eichhornia crassipes* on Pohnpei; cultivated taro wetland on Guam; Fena reservoir on Guam; and a small bomb crater reservoir with *Utricularia gibba* on Palau.

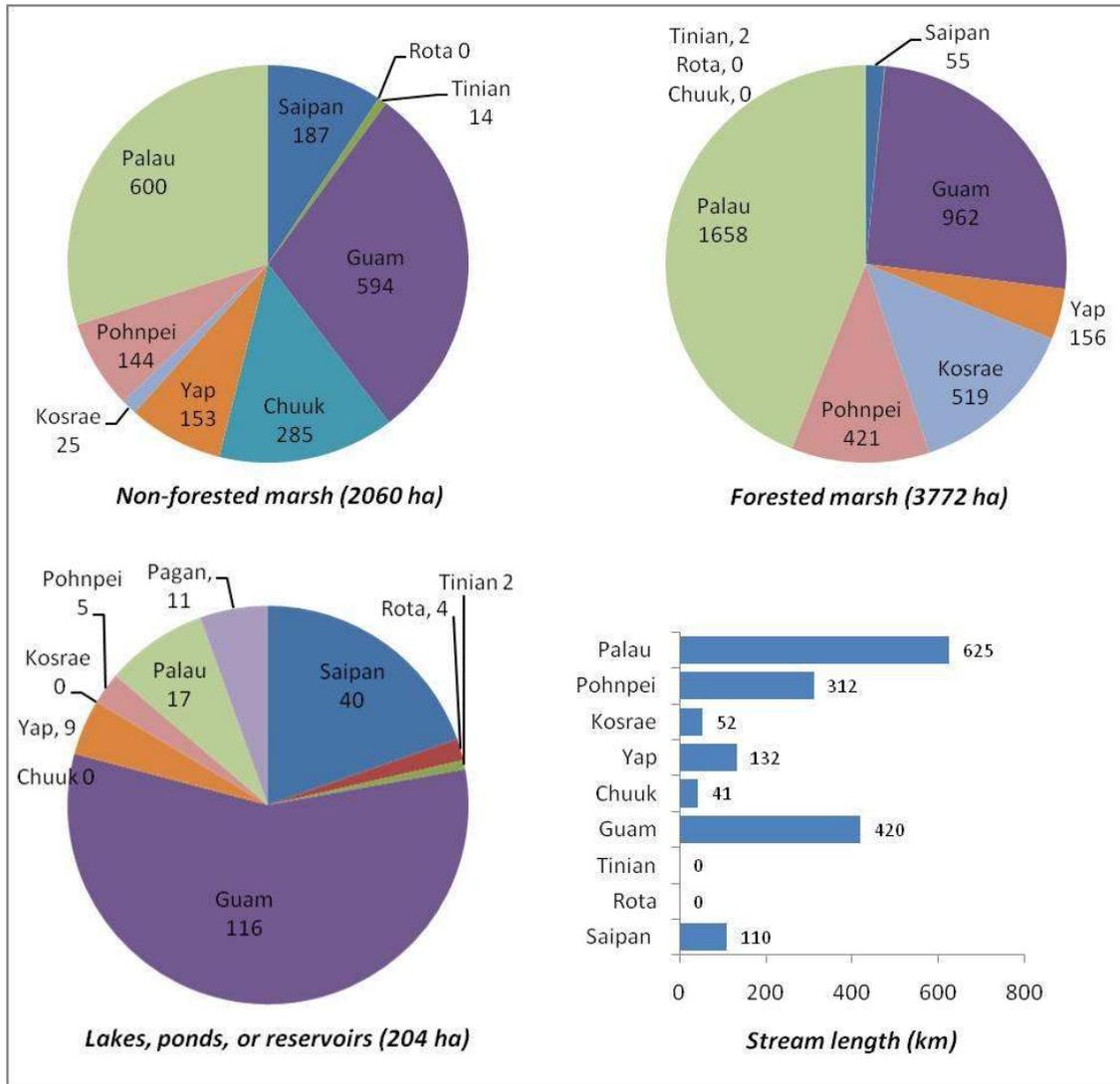


Figure 4-2: Summary of freshwater habitats in the Micronesia Region.

4.1 Freshwater wetlands

4.1.1 Lowland swamp forests

Swamp forests are by far the most extensive type of freshwater wetlands in the region and cover large areas of Palau, Kosrae, Pohnpei and Guam. Swamp forests are often to the landward side of mangrove swamps where brackish water is diluted by fresh water. Canopy cover in swamp forests ranges from high to low. Swamp forests with low canopy cover and sufficient light penetration are ideal for growing taro; consequently forest cover has been thinned or cleared in many areas for agriculture. Typical tree species present in high-canopy swamps vary across the region but include *Camposperma brevipetiolata*, *Terminalia carolinensis* (Ka tree), *Horsfieldia nunu*, and *Calophyllum cholobtaches*. Forests with low canopy cover include *Hibiscus tiliaceus*, *Barringtonia racemosa* (powder-puff tree), and *Scirpodendron ghaeri* (Stemmermann and Proby 1978a).

4.1.2 Open canopy swamps and wetlands

Several types of non-forested wetlands are common throughout the region including wetlands dominated by the tall reed *Phragmites vallatoria* (Khagra reed), wetlands with low sedge, grass, and herb species; and savannah wetlands with scattered trees such as *Pandanus spp.* (Stemmermann and Proby 1978a). Many of these wetlands are seasonally dry.

4.1.3 Cultivated and other ruderal wetlands

Wetland cultivation of the taro species *Cryptosperma camissonis* (giant or swamp taro) and *Colocasia esculenta* (soft taro) is an important component of Micronesian food production and culture (Manner 2008). In Kosrae, FSM, for example, about 97% of households cultivate taro in wetlands (Drew et al. 2005). Creation of swamp taro patches often involves clearing or thinning swamp forests, destruction of open canopy marsh, conversion of brackish mangrove swamps to freshwater, or creation of new marsh by excavating pits. Excavated taro pits are the only types of freshwater wetlands present on the numerous atolls throughout Micronesia (Stemmermann and Proby 1978b).

Swamp taro cultivation in Micronesia is declining due to increased reliance on dry-land crops such as sweet potatoes and cassava, imported foods such as rice, and the time and labor constraints associated with a more urbanized lifestyle (Manner 2008). Furthermore, human emigration from the outer islands has led to an increase in abandoned or neglected taro pits. These pits have been found to be susceptible to invasive aquatic species, such as water hyacinth. Other disturbed-area wetlands include roadside ditches, seeps, and construction areas. Although these ruderal areas are not as extensive as other wetland types (Stemmermann and Proby 1978b), their accessibility puts them at high risk for invasion.

4.2 Rivers and streams

The extent of streams and rivers in Micronesia varies considerably from island to island based on watershed size, soil permeability, rainfall amounts, and season. Because many of the islands are small and composed of permeable limestone, surface flows are typically limited to high rainfall events. Permanent rivers and streams occur on the large islands of Saipan, Kosrae, Pohnpei, Chuuk, Palau and the southern half of Guam that are composed of less permeable geological materials and where precipitation is high.

Precipitation patterns vary across the region. On a large scale, there is an east-west zone of high annual precipitation from 4-8°N across Micronesia. Precipitation drops off steadily north of this zone and the dry season becomes more prolonged. The islands of Kosrae and Pohnpei experience over 150 inches of rain annually with no appreciable dry season (Figure 4-3). Further north, annual rainfall drops to 80 inches and there is an extended dry season at Saipan, CNMI. Rainfall decreases to around 40 inches per year north and east of Saipan (Lander and Guard 2003). The result of the observed rainfall patterns is larger and more permanent streams in Kosrae, Pohnpei, and Palau than on islands to the north.

Most streams and rivers in the region are heavily shaded, which limits the potential for growth of freshwater aquatic plants. Riparian areas in urban and suburban areas are often denuded of vegetation and have more light available for the growth of aquatic plants. Riparian vegetation in upland forested areas of the wetter islands and riparian vegetation along rivers running through swamp forests is also similar to surrounding vegetation (Stemmermann and Proby 1978b). Grass

species such as *Ischaemum polystachyum* are often found along riverbanks. Where light is sufficient for aquatic plants to survive, other factors may limit establishment and growth. For instance, high stream flow can scour streambeds and remove freshwater aquatic plants such as *Hydrilla verticillata* (Brent Tibbatts, Guam DFW, pers. comm.) and the sediments necessary for rooting.

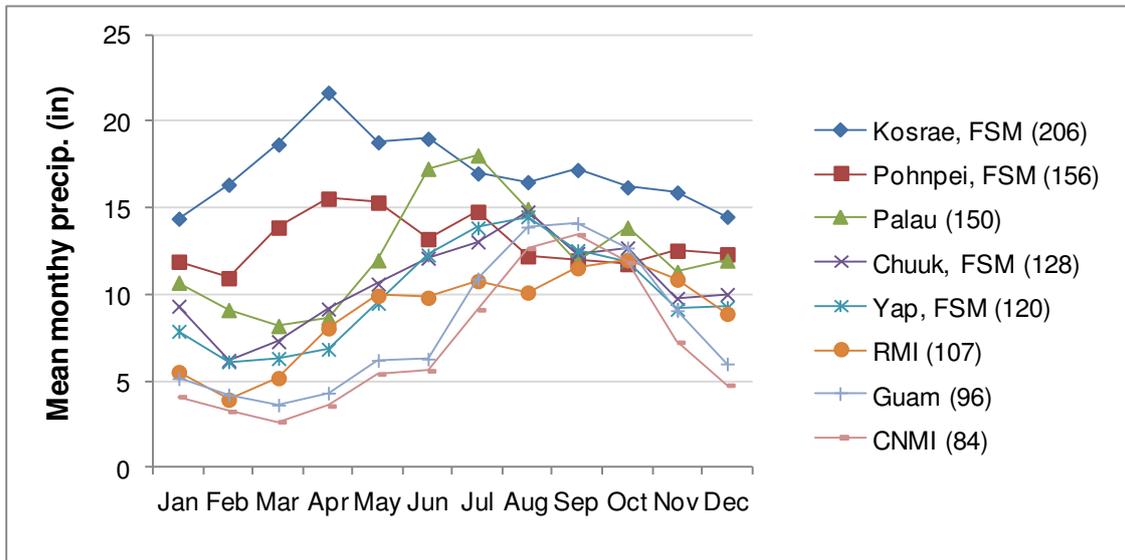


Figure 4-3. Mean monthly precipitation and annual precipitation (in parentheses) measured throughout the Micronesia region. Data are from U.S. and cooperating Government of Guam agencies (Lander and Guard 2003).

4.3 Lakes, reservoirs, and ponds

Lakes and reservoirs are not common in the region. Some notable examples include Fena Reservoir, Guam; Lake Susupe, CNMI; and Ngardok Lake, Palau. Fena Reservoir is the largest freshwater body and constitutes nearly half of the total surface area of lakes, ponds and reservoirs in the region. The non-native freshwater plant species hydrilla (*Hydrilla verticillata*) and curly leaf pondweed (*Potamogeton crispus*) were historically abundant in Fena Reservoir but are now sparse due to grazing pressure by introduced tilapia (Brock and Takata 1956; Nelson and Eldredge 1991). Lake Susupe is the second largest water body in the region, however, the lake is brackish (Wong and Hill 2000) and therefore not suitable for many species of freshwater aquatic plants. The largest natural freshwater lake in Micronesia is Lake Ngardok on the island of Babeldaob, Palau (Yeung and Wong 1999). The most numerous standing water bodies in the region include bomb crater ponds, golf course ponds, and municipal water supply reservoirs. Freshwater aquatic plant species common to many of these water bodies include *Utrichularia* spp. and *Chara* spp.

5. Aquatic Plant Treatment and Control Methods

There are numerous mechanical, physical, biological, and chemical methods available for managing emergent, floating and submersed aquatic plants. An integrated approach to aquatic plant management requires consideration of the abundance and distribution of the plants present, management goals, site-specific characteristics, legal and economic constraints, and possible impacts of management activities. Although there are limited examples of AIPS eradication and control efforts in the literature or the popular media, Simberloff (2009) argues that this is not a reflection of reality for two reasons: resource managers are more focused on management rather than publication of success stories, and unsuccessful efforts receive more interest in the media.

5.1 Mechanical Control

Mechanical techniques have been utilized for many years to control nuisance aquatic vegetation. A variety of mechanical methods exist, including hand tools; cutting, harvesting, chopping, and rotovation machines; and diver-operated suction harvesting. Mechanical methods often provide immediate results, cause little shoreline damage, are amenable to use in isolated areas, and can be used for large or small scale projects. Drawbacks to mechanical control include potentially high costs, the necessity of repeated treatments during the year, and the disposal of the collected plant material. More importantly, these methods may also promote fragmentation and, as a result, subsequent proliferation of certain species of macrophytes.

5.1.1 Hand removal

Hand removal, using cutters, rakes, or bare hands to remove plants, is the most common method of weed removal. This labor-intensive technique works best on small infestations or for small areas such as around docks. With hand cutting, plant shoots are cut below the water's surface, but roots are not removed. A simple design for a cutter uses two single-sided blades forming a "V" shape, connected to a handle with a rope. The cutter can be thrown from the shore, dock, or other floating structure. As the cutter is pulled through the water, it cuts a swath of vegetation. Raking involves tearing the plants from the sediment with a regular garden or thatch rake; the rake-head may be attached to a rope, allowing removal from deeper waters. Any type of hand removal is likely to create plant fragments, which should be removed from the water and disposed of away from the shoreline to prevent recolonization. Hand removal methods are likely to disturb sediments and increase turbidity and require repeated application during the year to maintain adequate control.

5.1.2 Harvesting

Mechanical harvesters are large specialized machines that cut and collect aquatic plants. The cut plants are removed from the water by a conveyor system and stored on the harvester or a barge following the harvester, until they can be disposed of on shore. Harvesting can target specific areas in a lake, creating boat channels for example, while leaving other areas untreated. In removing the plants from the water column, the nutrients stored within the plants are also removed. Since harvesting only removes the upper portion of the plant, some plant material remains as habitat for fish and other organisms (Gettys et al. 2009). The large size of most harvesters limits access to shallow areas or around structures such as docks. Bottom obstructions

such as logs or stumps may make harvesting difficult and shallow lakes with loose organic sediment are not suitable for harvesting.

5.1.3 Cutting

Cutter or shredder boats are specially designed to cut aquatic vegetation below the water surface. Unlike harvesting units, however, cutting equipment does not remove plant fragments from the water. Fragments generated from cutting or shredding are allowed to flow downstream on river currents or with tidal action and may spread an infestation of IAPS. Cutting is used in situations where removal of fragments is not feasible for logistical or economic reasons.

5.1.4 Rotovation

A rotovator is an aquatic rototiller, with blades that till the sediment and dislodge plants and roots. Floating booms may be placed around the treatment area to collect plant fragments created in this process; these fragments may then be removed from the water mechanically or by hand collection. This method is not species specific and since it disturbs the sediment, it may increase turbidity and negatively impact benthic organisms and fish-spawning areas.

5.2 Physical Control

Physical control methods to control existing plants involve modifying the environment to limit or eliminate conditions favorable to plant growth. Physical methods include benthic barriers, drawdown, aeration, nutrient inactivation, sediment agitation, steepening of banks, water column dyes, and others. Many physical control measures are technically simple to implement, leave little to no chemical residue, and can be very site specific. These benefits are weighed against the fact that the treatment time required to achieve the desired result can be long, often require intensive personnel resources, and are rarely species specific.

5.2.1 Benthic barriers

Benthic barriers are gas-permeable sheeting materials installed directly on the lake sediments and held in place by sandbags, pins, rocks, bricks, or other objects. Growth of rooted aquatic plants is prevented by light limitation and physical contact with the sediment. A variety of materials may be used as benthic barriers including burlap, PVC, or woven synthetics such as geotextile fabrics. The material should be gas permeable to allow for the escape of gas produced during plant decomposition beneath the barrier and sediment respiration; alternatively, the material may be strategically cut to allow venting of gases. Plants typically die within a few months, but barriers may be installed for longer periods around high-use areas such as boat launches in order to prevent recolonization. Barriers require periodic cleaning to remove sediment deposition to prevent plants from rooting on top of the barrier.

5.2.2 Drawdown

Where water control structures are in place, strategic lowering of water levels can control certain emergent or rooted aquatic plants. Siphoning or pumping can be used if gravity draining is not an option.

Effectiveness is maximized when the depth of the drawdown exceeds the maximum depth of colonization of the target species and the sediments are dried for a sufficient time to kill aquatic

plants (Nichols 1991); time required for drying varies with the local climate and substrate, but generally ranges between 4-8 weeks. Drawdown may not be effective for free-floating aquatic species, e.g., *Pistia stratiotes* or *Salvinia* spp., that retreat with diminishing water levels unless the entire water body can be dewatered. Species with desiccation-resistant propagules (seeds or resistant vegetative structures) like *Hydrilla verticillata* are adapted to seasonal drying and can persist or even increase following periods of drawdown (Gettys et al. 2009).

5.2.3 Aeration/mixing

Aeration/mixing devices that destabilize the water column and can alter nutrient concentrations in lakes and ponds. Physical disruption of water column stability can alter the phytoplankton community by increasing mixing depth and consequently the light regime that phytoplankton experience. Destabilization of the water column and increased mixing can also reduce the competitive advantage of cyanobacteria that can regulate their buoyancy. Induction of surface currents by aeration/mixing devices can reduce the cover of free-floating plants, like duckweeds; however, this method will not eliminate or effectively control rooted aquatic plants.

5.2.4 Nutrient inactivation

Applications of alum (aluminum sulfate), iron salts, or calcium (lime) reduces water column concentrations of phosphorus, which commonly limits phytoplankton abundance in lakes and ponds, resulting in reduction in phytoplankton abundance in the water column (Bellaud 2009). Nutrient inactivation may reduce growth rates of floating aquatic plant species that obtain all their nutrients from the water column, but rooted plants have access to sediment phosphorus, so the method is not effective on rooted plants (Nichols 1991). Increased light penetration due to reduction in phytoplankton abundance in the water column may actually increase growth of macrophytes (Bellaud 2009).

5.2.5 Sediment agitation

Mechanical devices like weed rollers, lake sweepers and beach groomers mechanically disturb the lake bottom within a well-defined area to remove aquatic plants and prevent regrowth. The machines sweep, roll, or drag repetitively over plants and the sediment. They must be attached to a post, dock or other structure and require a source of electricity. This method may dislodge plant fragments that could spread to new areas or re-colonize the same area when the agitation device is not in use.

5.2.6 Dredging

Dredging is usually not performed solely for aquatic plant management (Madsen 2000). It is more often used to deepen lakes subjected to sediment infill, remove high-nutrient surface sediments, increase the volume of the pelagic and hypolimnetic zones, or remove toxic substances (Peterson 1982). Lakes that are shallow due to sedimentation typically have abundant aquatic plant growth. Dredging reduces aquatic plant problems directly by removing the plants, bottom sediment, and associated nutrients.

Dredging for aquatic plant control is most effective when the depth is increased to exceed the maximum depth of colonization (Collett et al. 1981, Tobiessen et al. 1992). Shallow dredging (one meter) has been found to be effective for a few months (Engel and Nichols 1984).

Dredging is effective when nutrient-rich sediments are removed and when the increased depth decreases the light available for plant photosynthesis and growth.

Dredging has several drawbacks. It produces high turbidity due to suspended sediments and can harm benthic organisms and other wildlife that overwinter in the sediments. It also has extensive permitting issues, high costs, and sediment disposal issues.

5.2.7 Shading/Light Attenuation

Use of aquatic dyes or surface covers can effectively limit light and restrict submersed aquatic plant growth. Both dye applications and shading covers are non-selective processes and thus control growth of native and introduced plants and algae. Commercially formulated natural or synthetic aquatic dyes are considered non-toxic to aquatic animals. They are generally used in small water bodies where outflow can be controlled, such as ornamental ponds or golf-course water hazards (Gettys et al. 2009).

Surface covers made of fabric or plastic can be installed to control plant growth; these may be held above or just below the surface. Covers are typically used only on small scale control projects, like boat docks or narrow streams or canals (Nichols 1991).

5.3 Biological Control

Biological control involves the intentional release of one species in an effort to control another species. Biological control agents undergo rigorous screening on a large suite of plants including the target and its relatives. Testing includes feeding specificity (including choice/no choice and exploratory feeding) as well as the agent's ability to complete its life cycle on plants other than the target (McFadyen 1998).

Insects are commonly used in biocontrol because their coevolutionary relationship with plants has led to highly species-specific relationships, but pathogens and animals are used as well. Establishment of biocontrol agents may be complicated by source-population climate tolerances as well as by parasitism and predation by native insects, fish or other animals. Some macrophytes are also chemically or structurally resistant to herbivory. Most agents have provided insufficient control to be used as a stand-alone management tool, but they can be an important component of integrated pest management strategies.

A variety of insect control agents have been released in the U.S. for control of aquatic plants, including the salvinia weevil (*Cyrtobagous salviniae*) alligator weed flea beetle (*Agasicles hygrophila*), mottled water hyacinth weevil (*Neochetina eichhorniae*), and most recently a water hyacinth plant hopper (*Megamelus scutellaris*). Milfoil weevil (*Euhrychiopsis lecontei*) is apparently an endemic weevil to North America that has emerged as an effective control of Eurasian milfoil (*Myriophyllum spicatum*). In most cases, damage done by biological agents controls, but does not eradicate, plant populations. Insects may limit vegetative propagules and their feeding scars or entry holes can facilitate secondary damage by naturally occurring pathogens (Gettys et al. 2009).

The grass carp (*Ctenopharyngodon idella*), native to rivers of East Asia, was introduced into the U.S. in 1963 for submersed aquatic weed control (Guillory and Gasaway 1978). Although they exhibit some species preference, grass carp are typically considered a generalist herbivore that can damage native aquatic plant communities. Triploid grass carp, which have a low probability of successful reproduction and are functionally sterile (Bronson 2008), were developed to limit

natural reproduction and population size of the fish. Use of grass carp in aquatic plant control is complicated by difficulty in developing stocking plans; they often prefer native plants over IAPS and either supply inadequate control of weedy species or complete eradication of all submersed aquatic plants (Gettys et al. 2009).

5.4 Chemical Control

Aquatic herbicides are an effective and inexpensive IAPS management tool. For example, the state of Florida reduced the area of water hyacinth (*Eichhornia crassipes*) infestation from a high of 51,000 ha in the 1960s to 2000 ha primarily using the herbicide 2,4-D (Schardt 1997). The use of aquatic herbicides, however, is often controversial. In the past 20 years, the use and review of herbicides has changed significantly to accommodate human and environmental health concerns; and no herbicide can be labeled for aquatic use if it is shown to have unreasonable adverse effects on human health or the environment (Gettys et al. 2009). Because of the unique characteristics of aquatic systems and the relatively small size of the aquatic herbicide market, there are a limited number of effective, EPA-approved herbicides currently available for aquatic use (Table 5-1).

Table 5-1. Selected contact and systematic herbicides approved for aquatic use by the U.S. EPA, their mode of action, and comments on use (modified from Getty's et al. 2009).

Compound	Primary use			Mode of action
	Submersed	Floating	Emergent	
Copper	X	X		Contact, plant cell toxicant
Endothall	X	X		Contact, inhibits respiration and protein synthesis
Diquat	X	X	X	Contact, inhibits photosynthesis and destroys cell membranes
Carfentrazone		X	X	Contact, inhibits plant specific enzyme
2,4-D	X	X	X	Systematic, plant growth regulator
Triclopyr	X	X	X	Systematic, plant growth regulator
Glyphosate		X	X	Systematic, plant enzyme inhibitor
Imazapyr			X	Systematic, plant enzyme inhibitor
Fluridone	X	X		Sytematic, plant enzyme inhibitor
Penoxsulam	X	X		Sytematic, plant enzyme inhibitor
Imazamox	X	X	X	Sytematic, plant enzyme inhibitor

There are positive and negative aspects to use of herbicides for aquatic plant management. Modern application technology focuses on matching contact time and chemical concentration in the water to the target species to allow for selective control. Used appropriately, systemic herbicides can selectively remove IAPS without major, long-term impacts on native plant communities. When used inappropriately aquatic herbicides can lead to nontarget impacts on native plants, fish, and invertebrates and development of herbicide tolerance in IAPS. Effective permitting and proper training of applicators can alleviate problems with aquatic herbicides.

Acknowledgements

This project was conducted under a subcontract between Portland State University and the Smithsonian Environmental Research Center through the Portland State University/Smithsonian Environmental Research Center Aquatic Bioinvasion Research and Policy Institute. Funding for the project was provided by the U.S. Department of Defense.

John Clayton and Paul Champion conducted the AWRA weed risk assessment and provided assistance with field surveys. We would like to thank Brent Tibbatts from Guam DAWR and Paul Wenninger from DoD for guidance in the field and discussion of freshwater resources in Guam; Steve McKagan from NOAA Fisheries for guidance and Michael Trianni and Michael Tenoria from CNMI DFW, and Lisa Eller and Aric Bickel from CNMI DEQ for discussion of CNMI's freshwater resources; Dr. Rufino Mauricio, John P. Wichep, Gisbon Santos, Majoriko Victor, Rosendo Fredrick, and Konrad Englberger for guidance and discussion in Pohnpei, FSM; Pius Liyagel for guidance and Tamdad Sulog, John Runman and Margorie Falanruw for discussion of freshwater resources and aquatic plants on Yap, FSM; and Chipper Tellei for guidance and discussions in the Republic of Palau.

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Appendix A. Aquatic (Y) and other plant species currently banned from import (X) and permitted for import (W) to the Micronesia region.

Scientific Name	Common Name								Notes	
		Aquatic	US Fed	US Hawaii "	CNMI	FSM (From outside of)	FSM (From within)	RMI "		Guam "
<i>Acacia mearnsii</i> (De Wild.)	black wattle			X						
<i>Acaena novae-zelandica</i> Kirk	New Zealand bur			X						
<i>Acroptilon repens</i> (L.) D. C.	Russian knapweed			X						
<i>Aeschynomene indica</i> L.	Kat sola, Indian jointvetch			X						
<i>Ageratina adenophora</i> (Spreng.) King & H. Rob.	croftonweed, Maui pamakani creeping croftonweed,			X						
<i>Ageratina riparia</i> (Regel) King & H. Rob.	Hamakua pamakani			X						
<i>Allium vineale</i> L.	wild garlic			X						
<i>Allium vineale</i> ssp. <i>Compactum</i> L. (Thuill.) Coss. & Germ.	wild garlic			X						
<i>Alocasia macrorrhiza</i> (L.) G. Don	taro/edible aroid	Y			X					‡All except seed and tissue cultures
<i>Ananas</i> spp.	pineapple			X						"All
<i>Andropogon bicornis</i> L.	West Indian foxtail			X						
<i>Andropogon virginicus</i> L.	broomsedge			X						
<i>Anredera cordifolia</i> (Ten.) Steenis	Madeira vine			X						
<i>Anubias</i> spp.									X	"All
<i>Aponogeton</i> spp. L. f									X	"All
<i>Arachis hypogaea</i> L.	peanuts/groundnuts				X					‡All except seed
<i>Ardisia elliptica</i> Thunb.	shoebutton ardisia			X						
<i>Azolla pinnata</i> R. Brown	mosquito fern, water velvet	Y	X	X	X					
<i>Bocconia frutescens</i> L.	plume poppy			X						
<i>Brassica oleracea</i> L.	cauliflower							X		"All seeds require permit.
<i>Brassica</i> spp. L.	cabbage							X		"All seeds require permit.
<i>Cardaria pubescens</i> (C. A. Mey.) Jarmolenko	hairy whitetop			X						

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i: USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii "	CNMI	FSM (From outside of)	FSM (From within) *	RMI *	Guam *	Notes
<i>Caulerpa taxifolia</i> (Vahl) C. Agardh	Mediterranean strain, killer algae	Y	X	X	X					
<i>Cereus hildmannianus</i> K. Schum.				X						
<i>Cereus uruguayanus</i> Kiesling	spiny tree cactus, Peruvian apple				X					
<i>Chromolaena odorata</i> (L.) King & H. Rob.	siamweed, bitterbush			X						
<i>Cirsium arvense</i> (L.) Scop.	Canada thistle			X						
<i>Citropsis</i> spp. Swingle & Kellerm.	citrus				X					‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Citrus</i> spp. L.	citrus				X	X				‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs. Fruit from areas where fruit flies other than <i>Bactrocera frauenfeldi</i> (Caroline or mango fly) occur.
<i>Clidemia hirta</i> var. <i>hirta</i> (L.) D. Don	Koster's curse		X							
<i>Coccinia grandis</i> (L.) Voigt	ivy gourd		X							‡All except seeds, nuts, and pollen from areas approved by the Chief of Agriculture. Coconuts, except those from which the perianths (caps) have been removed and/or coconuts which have been dehusked and which have not sprouted. Betel nuts from areas where fruit flies other than <i>Bactrocera frauenfeldi</i> (Caroline or mango fly) occur.
<i>Cocos</i> spp. L.	palms				X	X				‡All propagating material except seeds
<i>Coffea</i> spp. L.	coffee				X					‡All except seed and tissue cultures
<i>Colocasia esculenta</i> (L.) Schott	taro/edible aroid	Y			X					
<i>Convolvulus arvensis</i> L.	field bindweed		X							
<i>Cortaderia jubata</i> (Lem.) Stapf			X							
<i>Cryptocoryne</i> spp. Fisch. ex Wydl.		Y						X		*All
<i>Cryptosperma chamissonis</i> Schott	taro/edible aroid	Y			X					‡All except seed and tissue cultures
<i>Cymbopogon refractus</i> (R. Br.) A. Camus	barbwire grass		X							

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i= USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii **	CNMI	FSM (From outside of)	FSM (From within) †	RMI †	Guam †	Notes
<i>Cyperus esculentus</i> L.	yellow nutsedge	Y	X							
<i>Cytisus monspessulanus</i> L.	French broom		X							
<i>Cytisus scoparius</i> (L.) Link	Scotch broom		X							
<i>Cytisus scoparius</i> var. <i>andreasus</i> (L.) Link (Puiss. Dippel)	Scotch broom		X							
<i>Cytisus scoparius</i> var. <i>scoparius</i> (L.) Link	Scotch broom		X							
<i>Dichrostachys cinerea</i> (L.) Wight & Am.	aroma		X							
<i>Dichrostachys nutans</i> Benth.	marabu		X							
<i>Dioscorea</i> spp. L.	yams				X					‡All except seed and tissue cultures
<i>Echinodorus</i> spp. except <i>E. cordifolius</i> Rich. ex Engelm.		Y						X		†All
<i>Eichhornia azurea</i> (Swartz) Kunth	anchored water hyacinth,	Y	X	X	X					
<i>Elephantopus mollis</i> Kunth	rooted water hyacinth				X					
<i>Elephantopus mollis</i> Kunth	elephantopus, elephant's foot				X					
<i>Elymus repens</i> (L.) Gould					X					
<i>Elytrigia repens</i> (L.) Desv. ex Nevski	quackgrass				X					
<i>Emex spinosa</i> (L.) Campd.	spiny emex				X					
<i>Eremocitrus</i> spp. Swingle	citrus				X					‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Eriocereus martinii</i> (Labour.) Riccob.	moon cactus				X					
<i>Euphorbia esula</i> L.	leafy spurge				X					
<i>Fortunella</i> spp. Swingle	citrus				X					‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Genista monspessulana</i> (L.) L. A. S. Johnson					X					
<i>Grevillea banksii</i> R. Br.	kahiliflower, Bank's grevillea				X					
<i>Halogeton glomeratus</i> (M. Bieb.) C. A. Mey.	halogeton				X					

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i: USDA, NRCs. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii "	CNMI "	FSM (From outside of) "	FSM (From within) "	RMI "	Guam "	Notes
<i>Harrisia martinii</i> (Labour.) Britton				X						
<i>Heliconia</i> spp. L.	heliconia					X	X			‡Plants, corms, and cut flowers except tissue cultures certified free from bunchy top disease, mosaic virus, Panama disease, and bacterial diseases including modo disease, black leaf streak, and Sigatoka disease
<i>Hydrilla verticillata</i> (L. f.) Royle	hydrilla	Y	X	X	X					
<i>Hygrophila polysperma</i> (Roxb.) T. Anderson	Miramar weed	Y	X	X	X					
<i>Hyptis pectinata</i> (L.) Poit.	comb hyptis					X				
<i>Hyptis suaveolens</i> (L.) Poit.	wild spikenard					X				
<i>Imperata cylindrica</i> (L.) P. Beauv.	cogon					X				
<i>Ipomoea aquatica</i> Forsskal	water-spinach, swamp morning-glory	Y	X	X	X					
<i>Ipomoea batatas</i> (L.) Lam.	sweet potato					X	X			‡All except pathogen tested tissue cultures and seed. †All planting materials except tissue cultures are prohibited entry.
<i>Lagarosiphon major</i> (Ridley) Moss	oxygen weed	Y	X	X	X					
<i>Lagascea mollis</i> Cav.	acuate					X				
<i>Lepidium latifolium</i> L.	perennial pepperweed					X				
<i>Limnophila sessiliflora</i> (Vahl) Blume	ambulia	Y	X	X	X					
<i>Lycopersicon esulentum</i> (<i>Solanum lycopersicum</i>) Miller	tomato					X		X		‡All except fruit and seed. †All seeds require permit.
<i>Malachra alceifolia</i> Jacq.	malachra			X						
<i>Manihot esculenta</i> Crantz	tapioca/cassava					X				‡All except stems and tissue cultures from pathogen tested sources. †All planting materials except tissue cultures are prohibited.
<i>Medinilla venosa</i> (Blume) Blume				X						
<i>Melaleuca quinquenervia</i> (Cav.) Blake	broadleaf paper bark tree	Y	X	X	X					
<i>Melastoma</i> L.	melastoma					X				
<i>Miconia</i> Ruiz & Pav.	miconia					X				

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i: USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii "	CNMI "	FSM (From outside of)	FSM (From within) "	RMI "	Guam "	Notes
<i>Microcitrus</i> spp. Swingle	citrus				X					† All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Microsorium pteropus</i>	java fern	Y							X	* All
<i>Mikania micrantha</i> Kunth	mile-a-minute		X							
<i>Mikania scandens</i> (L.) Willd.	climbing hempweed		X							
<i>Mimosa diplotricha</i> C. Wright	giant sensitiveplant		X							
<i>Mimosa invisa</i> Mart. ex Colla	giant sensitiveplant		X							
<i>Mimosa pellita</i> Kunth ex Willd.			X							
<i>Mimosa pigra</i> L.	thorny sensitive plant		X							
<i>Miscanthus floridulus</i> (Labill.) Warb. ex K. Schum. & Lauterb.	miscanthus, Japanese silvergrass		X							
<i>Monanthocitrus</i> spp. Tanaka	citrus				X					† All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Monochoria hastata</i> (L.) Solms-Laubach		Y	X	X	X					
<i>Monochoria vaginalis</i> (Burman f.) C. Presl. ex Kunth		Y	X	X	X					
<i>Montanoa hibiscifolia</i> (Benth.) Strandl.	tree daisy		X							
<i>Morella faya</i> (Aiton) Wilbur			X							
<i>Murraya</i> spp. J. Koenig ex L.					X					† All
<i>Myrica faya</i> Aiton	firetree, candleberry myrtle		X							
<i>Nassella trichotoma</i> (Nees) Hack.			X							
<i>Ottelia alismoides</i> (L.) Pers.		Y	X	X	X					
<i>Oxyspora paniculata</i> (D. Don) D. C.			X							
<i>Panicum repens</i> L.	torpedograss		X							
<i>Passiflora bicornis</i> Mill.			X							
<i>Passiflora mollissima</i> (Kunth) L. H. Bailey	banana passionfruit, banaba									
<i>Passiflora pulchella</i> Kunth	poka wingleaf passionfruit		X							

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i= USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii **	CNMI	FSM (From outside of)	FSM (From within) †	RMI †	Guam †	Notes
<i>Passiflora tripartita</i> var. <i>mollissima</i> (Juss.) Poir. (Kunth) Holm-Nielsen & P. M. Jørg.			X							
<i>Pennisetum setaceum</i> (Forssk.) Chiov.	fountaingrass		X							
<i>Phaseolus</i> spp.	beans				X		X			‡All parts except seeds. †All seeds require permit.
<i>Piper aduncum</i> L.	spiked pepper		X							
<i>Piper</i> spp. L.	pepper				X					‡All except seed and tissue cultures
<i>Pittosporum undulatum</i> Vent.	Victorian box		X							
<i>Pleurocitrus</i> spp. Tanaka	citrus				X					‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Poncirus</i> spp. Raf.	citrus				X					‡All except fruit and seeds. Fruit from areas where citrus canker (<i>Xanthomonas campestris</i> p.v. <i>citri</i>) occurs.
<i>Prosopis juliflora</i> (Sw.) D. C.			X							
<i>Pueraria phaseoloides</i> (Roxb.) Benth.	tropical kudzu		X							
<i>Rhodomyrtus tomentosus</i> (Aiton) Hassk.	downy rosemyrtle		X							
<i>Rubus argutus</i> Link	prickly Florida blackberry		X							
<i>Rubus ellipticus</i> var. <i>obcordatus</i> Sm. Focke	yellow Himalayan raspberry		X							
<i>Rubus niveus</i> Thunb.	hill raspberry		X							
<i>Rubus sieboldii</i> Blume	Molucca raspberry		X							
<i>Sagittaria sagittifolia</i> L.	arrowhead	Y	X	X	X					
<i>Salsola kali</i> L.	Russian thistle		X							
<i>Salvinia auriculata</i> Aubl.	giant salvinia	Y	X	X	X					
<i>Salvinia biloba</i> Raddi	giant salvinia	Y	X	X	X					
<i>Salvinia herzogii</i> de la Sota	giant salvinia	Y	X	X	X					
<i>Salvinia molesta</i> D. S. Mitchell	giant salvinia	Y	X	X	X					
<i>Senecio madagascariensis</i> Poir.	fireweed		X							
<i>Solanum carolinense</i> L.	horsenettle		X							
<i>Solanum elaeagnifolium</i> Cav.	silverleaf nightshade		X							

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i= USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawaii "	CNMI "	FSM (From outside of)	FSM (From within) "	RMI "	Guam "	Notes
<i>Solanum robustum</i> Wendl.			X							
<i>Solanum tampicense</i> Dunal	wetland nightshade	Y	X	X	X					
<i>Solanum torvum</i> Sw.	turkeyberry, terongan			X						
<i>Solanum tuberosum</i> L.	potato (Irish)				X					
<i>Sonchus arvensis</i> L.	perennial sowthistle			X						
<i>Sorghum</i> spp. Moench	sorghum									All except seed
<i>Sparganium erectum</i> L.	exotic bur-reed	Y	X	X	X					
<i>Spartium junceum</i> L.	Spanish broom			X						
<i>Spathiphyllum tasson</i>	Brazil sword	Y							X	*All
<i>Stipa trichotoma</i> Ness	nasella tussock			X						
<i>Striga</i> Lour.	witchweed			X						
<i>Themeda villosa</i> (Poir.) A. Camus	Lyon's grass			X						
<i>Theobroma cacao</i> L.	cacao				X					‡All except seeds from Asia Pacific Region
<i>Tibouchina</i> Aubl.	tibouchina			X						
<i>Triumfetta rhomboidea</i> Jacq.	parquet bur			X						
<i>Triumfetta semitriloba</i> Jacq.	Sacramento bur			X						
<i>Ulex europaeus</i> L.	gorse			X						
<i>Urena lobata</i> L.	caesarweed			X						
<i>Verbascum thapsus</i> L.	mullein			X						
<i>Vesicularia dubyana</i>	java moss	Y							X	*All
<i>Xanthosoma sagittifolium</i> (L.) Schott	taro/edible aroid	Y			X					‡All except seed and tissue cultures
<i>Zea mays</i> L.	maize/popcorn				X		X			‡All except seed. †All seed require permit.
Areaceae	palms				X	X				‡All except seeds, nuts, and pollen from areas approved by the Chief of Agriculture. †Coconuts, except those from which the perianths (caps) have been removed and/or coconuts which have been dehusked and which have not sprouted. Betel nuts from areas where fruit flies other than <i>Bactrocera frauenfeldi</i> (Caroline or mango fly) occur.

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i= USDA, NRCs. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

Scientific Name	Common Name	Aquatic	US Fed	US Hawai *	CNMI	FSM (From outside of) [‡]	FSM (From within) *	RMI *	Guam *	Notes
Brassicaceae	crucifers							X		†All seeds require permit. *Except genus <i>Ananas</i> : seeds, tissue cultured plants, and dried non-living materials require permit.
Bromeliaceae			X							
Musaceae	banana, abaca				X	X				‡Plants, corms, and cut flowers except tissue cultures certified free from bunchy top disease, mosaic virus, Panama disease, and bacterial diseases including modo disease, black leaf streak, and Sigatoka disease.
Heliconiaceae					X					

Sources: U.S. Fed: USDA, Animal Plant Health Inspection Service. 2010.; Hawai'i= USDA, NRCS. 2010. The PLANTS Database (<http://plants.usda.gov>, 11 May 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, Hawai'i Board of Agriculture, Amendments to Chapter 4-70 Hawai'i Administrative Rules. 2001.; FSM= National Government of the FSM, Plant and animal quarantine regulations. 2000.; RMI: The Government of the RMI, Ministry of Resources and Development. RMI Plants quarantine instructions and form.; Guam: Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permitted Plants List.

**Appendix B. Assessing the risk posed to
Micronesia by invasive aquatic weeds**

**Assessing the risk posed to Micronesia
by invasive aquatic weeds**

**Elements of the original document prepared
by
Paul Champion
John Clayton**

NIWA contact/Corresponding author

Paul Champion

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1. Introduction

The freshwater resources of Micronesia and Hawaii are critically important to the human populations and natural ecosystems these waters support. Introduced invasive aquatic macrophytes, algae, and cyanobacteria represent an important threat to the integrity of these aquatic systems. Understanding the potential pathways and vectors by which these taxa may be introduced is essential for creating sound management strategies to minimize their introduction and spread in Micronesia and abroad.

The New Zealand National Institute of Water and Atmospheric Research Ltd (NIWA) was contracted by Portland State University (PSU) to prepare aquatic weed risk assessments for a range of species including those locally present on Micronesia (Guam, Northern Mariana Islands, Federated States of Micronesia and the Republic of Palau) or potentially imported from Hawaii, South East Asia (Philippines, Indonesia, Malaysia, Taiwan and Japan) or from other risk sources (mainland USA and Australia), which threaten ecological, social and economic values of Micronesia.

Weed risk assessment models have been developed to predict the invasiveness of potential new weeds to a country by quantifying biological and ecological traits of the plant, their geographical origin and previous introduction history. These models then provide a decision support tool to managers as a basis for future management actions. These may include determining which cultivated freshwater plants should be banned from entry (black list), prevented from deliberate dispersal through the nursery trade, targeted for control/eradication and conversely which species are suitable for importation and pose little threat to the country to which they are imported. Examples of weed risk assessment protocols and their use to manage weed species include Esler et al., (1993), Pheloung et al., (1999), Dahler et al., (2004), Champion (2005), Parker et al., (2007), Csurhes (2008) and IFAS (2010).

NIWA has developed a risk assessment model specifically for aquatic weeds - AWRAM (Champion & Clayton 2000; 2001), based on the failure of general weed risk assessment models (e.g., Pheloung et al., 1999; Daehler et al., 2004) to adequately discriminate the level of impact caused by aquatic plant species. These general models recognise that aquatic species often become weedy, giving an assessment score of 5 to any aquatic species (generally the questions answered in the assessment only score 1 or 2). Any species exceeding a threshold score of 6 is recommended for rejection by these models, and hence the vast majority of aquatic species evaluated exceed this threshold. Although aquatic species rank highly, there is little separation between species with differing levels of impact. For example, the submerged Hydrocharitacean weeds *Elodea canadensis*, *Lagarosiphon major*, *Egeria densa* and *Hydrilla verticillata* (all invasive alien species in New Zealand) were scored 24, 23, 23 and 22

respectively using the model of Pheloung et al., (1999). AWRAM scored 46, 60, 64 and 74 respectively, out of a total possible score of 152, reflecting their relative management importance (Champion & Clayton 2000).

AWRAM has been used to determine which aquatic species are prohibited for sale and distribution and to prioritise national eradication strategies in New Zealand (Champion 2005; Champion & Hofstra 2006). AWRAM has also been modified for other countries and used to recommend weed management initiatives in Australia, The U.S. states of Indiana and Florida, and potentially in Europe (Champion et al., in press; Petroschevsky & Champion 2008; Gordon et al., 2010; Champion et al., 2010).

This report outlines the selection criteria used to select aquatic plant species prior to weed risk assessment and outlines a modified AWRAM used to score these species and identify the species of greatest concern.

2. Methods

2.1 Selection of species for assessment

Two field visits were undertaken by PSU and NIWA staff to identify aquatic plants, including introduced weeds either naturalised or in cultivation, and assess the range of freshwater aquatic habitats present on the following islands:

Guam	22-26 & 28 January; 19-20 April 2010.
Saipan, Northern Mariana Islands	26 & 27 January 2010.
Pohnpei, Federated States of Micronesia	22 & 23 April 2010.
Yap, Federated States of Micronesia	25-27 April 2010.
Palau	28 & 29 April 2010.

The jurisdictions covered by the Micronesia Biosecurity Plan but not visited as part of this initiative include Kosrae, Chuuk, Marshall Islands, and Hawaii.

Plants were identified using a variety of literature including Cook (1996), Di Tomaso et al., (2003), Hussey et al., (2007), Koo et al., (2005), Lorence & Flynn (2009), Morita (1997), Sainty & Jacobs (2003), Sharpe (1986), Stephens & Dowling (2002) and Whistler, W.A. (1995). Habitat types were taken from Fosberg (1960), Falanruw (2002) and Ellison (2008).

A review of literature and web-based data was undertaken to:

- Determine the known distribution of aquatic plants in Micronesia.
- Identify risk species traded as aquarium and pond plants that could pose a threat to Micronesia.
- Identify the weed history and distribution of other risk species with an emphasis on species known to be present in Hawaii, South East Asia (including Philippines, Indonesia, Malaysia, Taiwan and Japan), mainland USA and Australia.

Distribution data for Micronesia were sourced from Fosberg et al., (1979; 1982; 1987), Lorence & Flynn (2009), Raulerson (2006), and the Hawaii Ecosystems at Risk (HEAR, 2010) and Pacific Islands Ecosystems at Risk (PIER) website.

A list of aquarium species permitted for importation into Guam was provided by Brent Tibbatts (Government of Guam, Department of Agriculture Division of Aquatic and Wildlife Resources) and these species were also assessed. A list of species traded

internationally were collated based on Kasselmann (2003) and Champion & Clayton (2000; 2001).

Preliminary assessments of risk weeds, including aquatic species were compiled for Micronesia or various component states by Space et al., (2000a & b; 2003; 2009), Space & Falanruw (1999) and Meyer (2000). Aquatic weed species from adjacent areas were obtained from Barrett & Seaman (1980), Champion & Clayton (2000; 2001), Csurhes & Edwards (1998), Kadono (2004), Lancar & Krake (2002), Moody (1989), Pancho & Soerjan (1978), Parsons & Cuthbertson (2001), Pieterse & Murphy (1990), Staples et al., (2000) and Waterhouse (1993), with additional web-based resources HEAR (2010) Pacific Islands Ecosystems at Risk and ISSG (2010) Global Invasive Species Database, Invasive Species Specialist Group, IUCN.

A composite list of aquatic plants, mostly species, but in some cases genera or sub-specific taxa were compiled along with synonyms used in the literature, family affiliation and life-form type (Table 1). Life-form groups used were marginal (rarely growing in water), erect emergent, sprawling emergent, amphibious submerged, obligate submerged, free-floating and floating leaved - bottom rooted (water lily type). Table 2 compiles the known distribution of these taxa including additions to the flora found during the two field visits.

2.2 Aquatic weed risk assessment (AWRAM)

2.2.1 Information sources used for weed assessment

Over 100 references have been used to score the candidate weed species, ranging from specific papers on one aspect of a species ecology or management to general books on aquatic weed impacts or management. Table 3 gives the relevant information sources used for each taxon.

Two invaluable general references provide a valuable insight into the weed history of the potential aquatic weeds. Holm et al., (1979) reports the number of countries in which that weed is regarded as an economic weed. It is rather outdated and some serious weeds are either not recorded (e.g., *Cabomba caroliniana*) or underrepresented (e.g., *Mimosa pigra*) based on current information. Countries where the weed occurs are ranked (based on submissions from weed experts from each country) in 5 categories from highest to least impact:

- Serious – one of the 3 worst species.
- Principle – the next worst 10 species.
- Common.
- Present, but not widespread as a weed.

- Present in the flora but not assessed.

Randall (2002) and a web-accessible link (see Section 6) is essentially a catalogue of information on weedy species, with the number of references referring to that weed a good indication of its importance. Key words used to describe each species are:

- Agricultural weed.
- Environmental weed.
- Naturalized weed.
- Noxious weed.
- Cultivation escape (also with the term garden thug for some).
- Quarantine weed.
- Sleeper weed (or potential weed still in the lag phase of invasion).
- Unspecified weed.
- Casual alien.

Table 4 summarises information from the two references with the number of countries with each of the Holm et al., (1979) economic weed classifications, total number of Randall (2002) weed references (with tropical or sub-tropical references in parentheses), and Randall's (2002) weed classifications.

2.2.2 Weed risk assessment model

The weed risk assessment model used to score the species selected in Section 2.1, has three main component sections:

- Assessment of entry pathways to Micronesia, including the likely volume of propagules and likelihood of survival and successful establishment.
- Weed potential based on ecological versatility, competitive ability, reproductive output and dispersal mechanisms, ability to colonise undisturbed habitats and similarity of climate from source to new habitat.
- Impact based on types of impact on economic and social uses of water, environmental impacts, ease of management and weed history within indigenous and introduced ranges.

Entry Pathways

Potential weed sources and introduction routes to Micronesia are as follows:

- Present on N. Mariana Islands, FSM or Palau (internal spread).
- Present on Guam (most likely source of spread to other Micronesian islands).
- Present on Hawaii (most likely source of spread to Guam).
- Present in Philippines, Taiwan or Japan (most likely sources through military support personnel).
- Present in other SE Asian countries i.e., Indonesia, Malaysia, Thailand, Singapore, Vietnam (less likely sources of spread).
- Not in region but present in USA or Australia (even lower risk, but direct flights from Australia to Micronesia and Hawaii may alter risk profile).

Entry pathways from these sources are as follows:

- Aquarium trade of aquatic plants. Known importation to Guam is regulated, but importation of non-permitted species may occur through the mail services due to inability to inspect mail/courier from U.S. mainland. Mainland mail is likely the highest risk pathway at present due to the inability to appropriately inspect these items. Species with seeds or spores that resist desiccation and can be mailed may be particularly difficult to interdict.
- Trade in plant nurseries, markets and other sales of aquatic plants for ornamental use. This pathway is of slightly less risk because permits are required for importation and shipments are inspected.
- Food and medicinal plants introduced by various ethnicities associated with U.S. military build-up or otherwise (especially Philippines and Taiwan). It is likely that most high demand food plants (e.g., *Ipomoea aquatica*) have already been introduced into at least part of Micronesia or Hawaii but even these species may not be spread throughout the region and therefore appropriate protections both for the region and within the region should be in place to reduce the likelihood of their spread, either accidentally or on purpose.
- Deliberate introduction to 'improve' fodder etc. (e.g., recommendation to Yap to import *Azolla* (M. Falanruw pers. comm.) and apparent introduction of *Salvinia molesta* from Australia to SE Asia to improve rice cultivation). Probably a low risk especially if the production of a blacklist of prohibited species will inform responsible agencies. But for most of the jurisdictions of

Micronesia these types of blacklist either do not currently exist or are in need of updating.

- Non-commercial ornamental spp. (e.g., plants imported from Philippines) brought in by individuals for their gardens/ponds etc. Another high risk pathway, although propagule pressure would be much less than the aquarium/nursery pathways.
- Contaminants or hitchhikers with other species that are permitted for sale (e.g., duckweeds (*Lemna*, *Landoltia* and *Spirodela*), *Utricularia* and *Azolla* spp.). This pathway also includes introductions through aquacultural shipments and transport. A low risk but requiring thorough inspection of imported material for these species.
- Contamination of U.S. military equipment from wetlands and aquatic sites overseas (*S. molesta* was spread in Australia from Queensland to Victoria (>1000 km) by military vehicles (authors pers. obs.). This would be a very low risk pathway because the only marsh area the U.S. military is planning to use in Micronesia is the cleaning station by Apra Harbor. Training exercises may take place in Hagoi lake/marsh on Tinian; however, the lake is mesohaline.

If a plant is already indigenous or naturalised within Guam or elsewhere in Micronesia it is assigned the maximum score of 30.

If cultivated in Micronesia then the number of propagules and likelihood of establishing a naturalised population is assessed as relatively high (see later).

If outside of the region, then the number of likely pathways is recorded; scoring 1 for each. For each pathway, the likely number of propagules (minimum 1 to maximum 10) and the likelihood of establishing a naturalised population (minimum 1 to maximum 10) are assigned. These are multiplied and then divided by 10 to give a maximum score of 10 for each pathway. The maximum score cannot exceed 30.

Maximum Entry Pathway score = 30.

Weed potential

The scores for this section approximately follow previous AWRAM models (Champion & Clayton 2000; Champion et al., 2008) with the scores of the following parameters based on characteristics of the species and the aquatic habitats available in Micronesia:

- Habitat versatility (maximum of 13)

- Range (minimum 1 to maximum 3), maximum if able to grow from aquatic to dry land, or from margin to > 5 m deep.
- Water level fluctuation (minimum 0 to maximum 3), maximum if able to tolerate one month dewatering.
- Nutrient (minimum 1 to maximum 2), maximum if able to tolerate high or low enriched waters.
- Shade tolerant (minimum 1 to maximum 3), maximum if able to grow from full sun to deep shade.
- Salinity (minimum 0 to maximum 2), maximum if able to grow in fully saline (35 ppt) water.
- Habitat range (maximum of 9)
 - Flowing water (minimum 0 to maximum 3), maximum if dominant in this habitat.
 - Still water (minimum 0 to maximum 3), maximum if dominant in this habitat.
 - Wetland with ephemeral standing water (minimum 0 to maximum 3), maximum if dominant in this habitat.
- Competitive ability (maximum of 20)
 - Within growth form (minimum 1 to maximum 16), maximum if excludes all other species (e.g., *Eichhornia crassipes*, *Hydrilla verticillata*, *Phragmites vallisneria*).
 - Between growth form (minimum 0 to maximum 4), maximum if excludes all other life-forms (e.g., tall emergent spp.).
- Propagule dispersal (maximum of 10)
 - Natural agents (minimum 0 to maximum 5), maximum if adapted for spread by waterfowl (e.g., *Najas* spp.- Agami & Waisel 1986) or wind (e.g., *Phragmites vallisneria*).
 - Accidental human spread (minimum 0 to maximum 5), maximum if spread by 3 methods (e.g., boat trailers, machinery, fishing nets).

- Deliberate spread (minimum 0 to maximum 1), maximum if attractive to humans.
- Effective dispersal within a water body (minimum 0 to maximum 1).
- Propagule output (maximum of 10)
 - Seed quantity (minimum 0 to maximum 3), maximum if >1000 seed produced /plant or m².
 - Seed viability/persistence (minimum 0 to maximum 2), maximum if viability > 1 year.
 - Clonal spread (minimum 0 to maximum 5), maximum if spreads by fragmentation.
- Establishment (maximum of 5).
 - Existing vegetation (minimum -5 to maximum 0), maximum if able to invade unmodified vegetation.
 - Disturbance (minimum 0 to maximum 5), maximum if able to aggressively colonise following vegetation clearance, newly constructed water bodies or nutrient enrichment.
- Suitable climate (minimum 0 to maximum of 5), maximum if source and destination have same climate.

Maximum Weed Potential score = 72.

Impact

These scores follow previous AWRAM models (Champion & Clayton 2000; Champion et al., 2008) with the following parameters scored:

- Obstruction (maximum of 10)
 - Recreation (minimum 0 to maximum 1), maximum if major nuisance.
 - Access (minimum 0 to maximum 2), maximum if major nuisance.
 - Flow (minimum 0 to maximum 1), maximum if major nuisance.
 - Irrigation (minimum 0 to maximum 5), maximum if able to prevent effective irrigation.

- Aesthetics (minimum 0 to maximum 1), maximum if visual and smell problems.
- Environmental damage (maximum of 10)
 - Biodiversity (minimum 0 to maximum 5), maximum if completely displace all other species.
 - Water quality (minimum 0 to maximum 3), maximum if deoxygenation/nutrient enrichment.
 - Physical processes (minimum 0 to maximum 2), maximum if promoting flooding or siltation.
- Other undesirable traits (maximum of 10)
 - Human health (minimum 0 to maximum 2), maximum if 2 impacts such as drowning risk, mosquito habitat, thorns, etc.
 - Agricultural weed (minimum 0 to maximum 8), maximum if major impact on taro culture.
- Resistance to management (maximum of 10)
 - Ease of implementation (minimum 0 to maximum 2), maximum if dense impenetrable thickets.
 - Recognition (minimum 0 to maximum 1), maximum if cryptic (e.g., submerged spp.).
 - Control methods (minimum 0 to maximum 2), maximum if no control methods (e.g., deep water species, tolerant to available herbicides).
 - Effectiveness (minimum 0 to maximum 2), maximum if ineffective (unable to reduce impact).
 - Duration (minimum 0 to maximum 2), maximum if no control >1 month.
- Weed history (maximum of 10)
 - Indigenous range (minimum 1 to maximum 5), maximum if serious or principle weed of many tropical/sub-tropical countries.
 - Invasive alien range (minimum 0 to maximum 5), maximum if serious or principle weed of many tropical/sub-tropical countries.

Maximum Impact score = 50.

Thus the maximum and minimum theoretical scores would be:

Component	Maximum	Minimum
• Entry	30	1
• Weed potential	72	0
• Impact	50	1
• Total	152	2
• Presentation of AWRAM results		

Table 5 and 6 present the weed risk assessment scores for the 95 taxa. Table 5 presents the taxa ranked on total AWRAM score, also listing component Entry, Weed potential and Impact scores and combined Weed potential and Impact scores. Table 6 presents the taxa ranked on combined Weed potential and Impact scores and also presents the habitat types where it is likely to grow.

Habitat types discerned on the field trips can be divided into seven groups:

- Shaded ‘jungle’ streams and rivers.
- Open drains, streams and rivers.
- Reservoirs, ponds and natural lakes.
- Savannah wetlands.
- Lowland wetlands (e.g., *Phragmites vallatoria* dominated areas).
- Cultivated wetlands (e.g., taro cultivation – disturbed wetlands formerly dominated by *P. vallatoria*).
- Swamp forest.

3. Results

Table 1: List of species (or other taxa) assessed for weed potential in Micronesia, with synonyms used in recent literature, family and life-form (as - amphibious submerged;

ee - erect emergent; ff - free-floating; m – marginal, rarely growing in water; os - obligate submerged; se - sprawling emergent; wl - waterlily type).

Name	Synonyms	Family	Life-form
<i>Actinoscirpus grossus</i>	<i>Scirpus grossus</i>	Cyperaceae	ee,m
<i>Aeschynomene aspera</i>		Fabaceae	m
<i>Aeschynomene indica</i>		Fabaceae	m
<i>Alternanthera philoxeroides</i>		Amaranthaceae	se
<i>Anubias</i> spp.		Araceae	as
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)		Aponogetonaceae	os,fl
<i>Arundo donax</i>		Poaceae	m,ee
<i>Azolla filiculoides</i>		Salviniaceae	ff
<i>Azolla pinnata</i>		Salviniaceae	ff
<i>Cabomba caroliniana</i>		Cabombaceae	os
<i>Ceratophyllum demersum</i>		Ceratophyllaceae	os
<i>Ceratopteris thalictroides</i>	<i>C. gaudichaudii</i>	Parkeriaceae	m,ff
<i>Cryptocoryne</i> spp.		Araceae	as
<i>Cyperus involucratus</i>		Cyperaceae	ee
<i>Cyperus prolifer</i>		Cyperaceae	ee
<i>Echinodorus cordifolius</i>		Alismataceae	ee
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)		Alismataceae	ee,as
<i>Egeria densa</i>		Hydrocharitaceae	os
<i>Egeria najas</i>		Hydrocharitaceae	os
<i>Eichhornia azurea</i>		Pontederiaceae	ff
<i>Eichhornia crassipes</i>		Pontederiaceae	os,fl

Name	Synonyms	Family	Life-form
<i>Gymnocoronis spilanthoides</i>		Asteraceae	se
<i>Hanguana malayana</i>		Hanguanaceae	m,ff
<i>Heteranthera reniformis</i>		Pontederiaceae	se
<i>Hydrilla verticillata</i>		Hydrocharitaceae	os
<i>Hydrocleys nymphoides</i>		Limnocharitaceae ¹	fl
<i>Hydrocotyle bonariensis</i>		Araliaceae ²	se
<i>Hydrocotyle ranunculoides</i>		Araliaceae ²	se
<i>Hydrocotyle umbellata</i>		Araliaceae ²	se
<i>Hydrolea zeylanica</i>		Hydroleaceae ³	m
<i>Hygrophila difformis</i>		Acanthaceae	se,as
<i>Hygrophila polysperma</i>		Acanthaceae	as
<i>Ipomoea aquatica</i>		Convolvulaceae	m,se
<i>Ischaemum polystachyum</i>		Poaceae	m,se
<i>Landoltia punctata</i>	<i>Spirodela punctata</i>	Araceae ⁴	ff
<i>Lemna aequinoctialis</i>	<i>L. perpusilla</i>	Araceae ⁴	ff
<i>Limnobium spongia</i>		Hydrocharitaceae	ff
<i>Limnobium stoloniferum</i>		Hydrocharitaceae	ff
<i>Limnocharis flava</i>		Limnocharitaceae	ee
<i>Limnophila sessiliflora</i>		Plantaginaceae ⁵	os
<i>Ludwigia adscendens</i>		Onagraceae	se
<i>Ludwigia octovalvis</i>		Onagraceae	m
<i>Ludwigia peploides</i>		Onagraceae	se
<i>Ludwigia peruviana</i>		Onagraceae	m,ee
<i>Lysimachia fortunei</i>		Primulaceae	m
<i>Marsilea minuta*</i>		Marsileaceae	as,fl
<i>Marsilea quadrifolia</i>		Marsileaceae	fl
<i>Melaleuca quinquenervia</i>		Myrtaceae	m

Name	Synonyms	Family	Life-form
<i>Microsorium pteropus</i>		Polypodiaceae	as
<i>Mimosa pigra</i>		Fabaceae	m
<i>Monochoria hastata</i>		Pontederiaceae	ee,ff
<i>Monochoria vaginalis</i>		Pontederiaceae	ee,ff
<i>Myriophyllum aquaticum</i>		Haloragaceae	se
<i>Myriophyllum spicatum</i>		Haloragaceae	os
<i>Najas graminea</i>		Hydrocharitaceae	os
<i>Najas guadalupensis</i>		Hydrocharitaceae	os
<i>Najas indica</i>		Hydrocharitaceae	os
<i>Najas marina</i>		Hydrocharitaceae	os
<i>Nelumbo lutea</i>		Nelumbonaceae	fl
<i>Nelumbo nucifera</i>		Nelumbonaceae	fl
<i>Neptunia oleracea</i>	<i>N. prostrata, N. natans</i>	Fabaceae	se
<i>Neptunia plena</i>		Fabaceae	se
<i>Nymphaea caerulea</i>	<i>N. stellata, N. nouchali</i>	Nymphaeaceae	fl
<i>Nymphaea elegans</i>		Nymphaeaceae	fl
<i>Nymphaea lotus</i>	<i>N. pubescens</i>	Nymphaeaceae	fl
<i>Nymphaea mexicana</i>		Nymphaeaceae	fl
<i>Nymphoides indica</i>		Menyanthaceae	fl
<i>Ottelia alismoides</i>		Hydrocharitaceae	os
<i>Panicum repens</i>		Poaceae	se
<i>Persicaria minor</i> var. <i>procera</i>	<i>Polygonum minus</i>	Polygonaceae	m
<i>Phragmites vallisneria</i>	<i>P, karka</i>	Poaceae	ee,m
<i>Pistia stratiotes</i>		Araceae	ff
<i>Pontederia cordata</i> var. <i>lanceolata</i>		Pontederiaceae	ee

Name	Synonyms	Family	Life-form
<i>Potamogeton crispus</i>		Potamogetonaceae	os
<i>Rotala rotundifolia</i>		Lythraceae	as
<i>Sagittaria latifolia</i>		Alismataceae	ee
<i>Sagittaria montevidensis</i>		Alismataceae	ee
<i>Sagittaria platyphylla</i>		Alismataceae	ee,as
<i>Sagittaria sagittifolia</i>	<i>S. trifolia</i>	Alismataceae	ee,as
<i>Salvinia cucullata</i>		Salviniaceae	ff
<i>Salvinia minima</i>		Salviniaceae	ff
<i>Salvinia molesta</i>	<i>S. auriculata</i>	Salviniaceae	ff
<i>Salvinia natans</i>		Salviniaceae	ff
<i>Schinus terebinthifolius</i>		Anacardiaceae	m
<i>Spathiphyllum tasson</i>		Araceae	m
<i>Sphenoclea zeylanica</i>		Sphenocleaceae ⁶	m
<i>Spirodela polyrhiza</i>		Araceae ⁴	ff
<i>Stuckenia pectinata</i>	<i>Potamogeton pectinatus</i>	Potamogetonaceae	os
<i>Trapa</i> spp. (excluding <i>T. natans</i>)		Lythraceae ⁷	fl
<i>Typha angustifolia</i>		Typhaceae	ee
<i>Typha latifolia</i>		Typhaceae	ee
<i>Utricularia gibba</i>	<i>U. exoleta</i>	Lentibulariaceae	ff
<i>Utricularia inflata</i>		Lentibulariaceae	ff
<i>Vallisneria asiatica</i>		Hydrocharitaceae	os
<i>Vallisneria denseserratala</i>		Hydrocharitaceae	os
<i>Vallisneria natans</i>		Hydrocharitaceae	os
<i>Vesicularia dubyana</i>		Hypnaceae	as

* Formerly regarded as *M. crenata*, but now assigned to *M. minuta* (Whitten & Jacono 2009).

- 1 Previously Butomaceae.
- 2 Previously Apiaceae.
- 3 Previously Hydrophyllaceae.
- 4 Previously Lemnaceae.
- 5 Previously Scrophulariaceae.
- 6 Previously Campanulaceae.
- 7 Previously Trapaceae.

Table 2: List of species (or other taxa) assessed for weed potential in Micronesia, with their naturalised or indigenous distribution in Micronesia, or other countries where highest risk of introduction occurs. (Key to symbols used: Guam and N. Mariana Islands: G = Guam; S = Saipan; T = Tinian; R = Rota; P = Pagan. FSM and Palau: K = Kosrae; P = Pohnpei; C = Chuuk; Y = Yap; B = Palau. Southeast Asia: P = Philippines; I = Indonesia; M = Malaysia; T = Thailand; e = elsewhere).

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Actinoscirpus grossus</i>		B ¹		P,I,M,T,e	J	A	
<i>Aeschynomene aspera</i>				P,I,M,T,e			
<i>Aeschynomene indica</i>	G	P		P,I,M,T,e	J,T	A	U
<i>Alternanthera philoxeroides</i>					J	A	U
<i>Anubias</i> spp.							
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)				I,T,e		A	
<i>Arundo donax</i>	G	P,B	H	T,e	J,T	A	U
<i>Azolla filiculoides</i>			H	P,I,M,T,e			
<i>Azolla pinnata</i>			H ²	P,I,M,T,e	J	A	U2
<i>Cabomba caroliniana</i>				P,e ³	J,T	A	U
<i>Ceratophyllum demersum</i>	G ⁴		H	P,I,M,T,e	J,T	A	U

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Ceratopteris thalictroides</i>	G ⁵	Y,B	H	P,I,M,T,e	J,T	A	U
<i>Cryptocoryne</i> spp.				E			U6
<i>Cyperus involucratus</i>	G	P,C,B	H	I,e	J	A	U
<i>Cyperus prolifer</i>	G ⁶		H				U
<i>Echinodorus cordifolius</i>	G ⁶		H ²				U
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)	G ⁶			M,e			
<i>Egeria densa</i>	G ⁷		H		J	A	
<i>Egeria najas</i>							
<i>Eichhornia azurea</i>				P,e	J	A	U
<i>Eichhornia crassipes</i>	G,T,R	P,C,Y,B	H	P,I,M,T,e	J,T	A	U
<i>Gymnocoronis spilanthoides</i>			H ⁸			A	
<i>Hanguana malayana</i>		Y,B		I,M,e			
<i>Heteranthera reniformis</i>				E		A	U
<i>Hydrilla verticillata</i>	G		H	P,I,M,T,e	J,T	A	U
<i>Hydrocleys nymphoides</i>			H ⁹		J	A	U

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Hydrocotyle bonariensis</i>						A	U
<i>Hydrocotyle ranunculoides</i>						A	U
<i>Hydrocotyle umbellata</i>							U
<i>Hydrolea zeylanica</i>				P,I,M,T,e	T	A	
<i>Hygrophila difformis</i>				E		A	
<i>Hygrophila polysperma</i>				T,e		A	U
<i>Ipomoea aquatica</i>	G,S,T,R,P	K,P,C,Y,B	H	P,I,M,T,e	J,T	A	U
<i>Ischaemum polystachyum</i>	G,S,R	K,P,C,Y,B		P,M			
<i>Landoltia punctata</i>			H			A	U
<i>Lemna aequinoctialis</i>	G,S,T	C,Y		P,I,M,T,e		A	
<i>Limnobium spongia</i>							U
<i>Limnobium stoloniferum</i>					J		U
<i>Limnocharis flava</i>				I,M,T,e		A	U
<i>Limnophila sessiliflora</i>	G ¹⁰			P,M,e			U
<i>Ludwigia adscendens</i>				P,I,M,T,e	J,T	A	

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Ludwigia octovalvis</i>	G,S,T,R,P	K,P,C,Y,B	H	P,I,M,T,e	J,T	A	
<i>Ludwigia peploides</i>						A	U
<i>Ludwigia peruviana</i>				I		A	U
<i>Lysimachia fortunei</i>					J,T	A	
<i>Marsilea minuta</i>			H ¹¹	P,I,M,T,e			U
<i>Marsilea quadrifolia</i>				P,I,M,T,e	J,T	N ¹²	U
<i>Melaleuca quinquenervia</i>	G	P,Y,B				A	U
<i>Microsorium pteropus</i>				E			
<i>Mimosa pigra</i>				I,M,T,e		A	U
<i>Monochoria hastata</i>				I,M,T,e		A	
<i>Monochoria vaginalis</i>	G ¹³		H	I,M,T,e	JT	A	U
<i>Myriophyllum aquaticum</i>	G ⁶		H	P,I,e	JT	A	U
<i>Myriophyllum spicatum</i>			H	E	JT		U
<i>Najas graminea</i>				P,I,M,T,e	JT	A	U
<i>Najas guadalupensis</i>			H				U

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Najas indica</i>				P,I			
<i>Najas marina</i>			H	I,T,e	JT	A	U
<i>Nelumbo lutea</i>							U
<i>Nelumbo nucifera</i>	G ⁶		H	P,I,M,T,e	JT	A	U
<i>Neptunia oleracea</i>			H ⁸	P,I,M,T,e	J	A	U
<i>Neptunia plena</i>				I,M,e		A	U
<i>Nymphaea caerulea</i>	G	P,B	H	I,M,T,e	J	A	U
<i>Nymphaea elegans</i>	G					A	U
<i>Nymphaea lotus</i>	G		H	I,M,T,e	J	A	U
<i>Nymphaea mexicana</i>						A	U
<i>Nymphoides indica</i>		B ¹⁴		I,M,T,e		A	U
<i>Ottelia alismoides</i>				I,M,T,e	T	A	U
<i>Panicum repens</i>	S	B ¹⁵	H	I,M,T,e	J,T	A	U
<i>Persicaria minor</i> var. <i>procera</i>	G	C,Y,B				A	U
<i>Phragmites vallisneria</i> ¹⁶	G,S,T,R,P	K,P,C,Y,B		T,e		A	

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Pistia stratiotes</i>	G,R	P ¹³ ,Y ¹⁷	H	I,M,T,e	JT	A	U
<i>Pontederia cordata</i> var. <i>lanceolata</i>					J	A	U
<i>Potamogeton crispus</i>				P,I,T,e	J,T	A	U
<i>Rotala rotundifolia</i>				T,e	J,T	A	U
<i>Sagittaria latifolia</i>	G ⁶		H	N ¹⁸			U
<i>Sagittaria montevidensis</i>						A	U
<i>Sagittaria platyphylla</i>				I		A	U
<i>Sagittaria sagittifolia</i>				I,M,T,e	T		
<i>Salvinia cucullata</i>	G ⁶			M,T,e			
<i>Salvinia minima</i>							U
<i>Salvinia molesta</i>			H	P,I,M,T,e	J	A	U
<i>Salvinia natans</i>	G ¹³			I,M,e	J,T		U
<i>Schinus terebinthifolius</i>	G		H		J	A	U
<i>Spathiphyllum tasson</i>							
<i>Sphenoclea zeylandica</i>				P,I,M,T,e	T		U

Name	Guam and N Marianas	FSM and Palau	Hawaii	Southeast Asia	Japan/Taiwan	Australia	Mainland USA
<i>Spirodela polyrhiza</i>	G ⁶		H	P,I,M,T,e	J,T	A	U
<i>Stuckenia pectinata</i>			H	e	J,T	A	U
<i>Trapa</i> spp. (excluding <i>T. natans</i>)				e	J,T		
<i>Typha angustifolia</i>				P,I,M,T,e	J,T		U
<i>Typha latifolia</i>			H	P,e	J,T	A	U
<i>Utricularia gibba</i>		B	H	P,I,M,T,e	J	A	U
<i>Utricularia inflata</i>					J		U
<i>Vallisneria</i> spp			H	P,I,M,T,e	J,T	A	U
<i>Vesicularia dubyana</i>	Likely to be widespread within SE Asia and Pacific Islands				J	A	U

- 1 Possibly present at Lake Ngardok.
- 2 First identified on Hawaii as part of this project.
- 3 Only reference to this distribution Lancar & Krake (2002).
- 4 Recorded as native by Fosberg et al., (1979), found in cultivation on Guam.
- 5 Guam plants sometimes regarded as the endemic *C. gaudichaudii* (Masuyama 2008).
- 6 First identified in cultivation on Guam as part of this project.
- 7 Reported from Guam, but name misapplied to *Hydrilla verticillata* (Fosberg et al., 1987).
- 8 Reported once from Hawaii, material destroyed (HEAR 2010).
- 9 In cultivation, Manoa University Campus.
- 10 Recorded as native by Fosberg et al., (1979).
- 11 Formerly regarded as *M. crenata*, but now assigned to *M. minuta* (Whitten & Jacono 2009).
- 12 *M. quadrifolia* misapplied to *M. mutica* in Australia.
- 13 Reported as naturalized as part of this project.
- 14 *Nymphoides* sp. recorded as present on Palau by Fosberg et al., (1979).
- 15 Found on Babeldaob as part of this project; only previously reported from Koror (Fosberg et al., 1987).
- 16 This species is likely native throughout the Mariana Islands
- 17 Reported in cultivation (M. Falanrw pers. comm.) but not seen by authors.
- 18 Reported as *S. latifolia* in error from SE Asia. Plants referred to as *S. trifolia* are synonymous with *S. sagittifolia*.

Table 3: References used to carry out weed risk assessments on potential weeds of Micronesia (numbers refer to references as in Section 5).

Name	References
<i>Actinoscirpus grossus</i>	19,27,40,43,64,69,70,76,96,97,99,107
<i>Aeschynomene aspera</i>	26*,27,33,43,64,84,99
<i>Aeschynomene indica</i>	26*,27,40,42,43,46,62,64,77,99
<i>Alternanthera philoxeroides</i>	3,8,11,13,18,28,30,31,40,42,43,48,50,53,54,64,69,71,77,98,103
<i>Anubias</i> spp.	51
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)	27,43,51,62,64,69,77
<i>Arundo donax</i>	11,20,26,28,40,43,48,61,64,71,92,98
<i>Azolla filiculoides</i>	5,9,18,28,30,40,43,49,50,51,64,67,92,98
<i>Azolla pinnata</i>	4,13,33,40,42,43,48,50,51,62,64,67,69,98,99,102
<i>Cabomba caroliniana</i>	3,8,13,14,18,28,30,40,48,50,51,57,67,102,104
<i>Ceratophyllum demersum</i>	5,11,13,16,28,31,33,40,43,44,48,51,62,64,69,76,77,92,96,98
<i>Ceratopteris thalictroides</i>	44,51,59,62,64,67,69,76,97,98
<i>Cryptocoryne</i> spp.	51,67,69,98
<i>Cyperus involucratus</i>	26,40,92,98
<i>Cyperus prolifer</i>	67,92,98
<i>Echinodorus cordifolius</i>	24,43,51
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)	5,28,51,64,98
<i>Egeria densa</i>	6,7,8,9,11,12,13,16,18,28,30,31,40,43,48,50,51,67,71,75,92,98,102,109
<i>Egeria najas</i>	6,7,12,51,75,85
<i>Eichhornia azurea</i>	4,8,12,14,43,50,51,58,64,67,98
<i>Eichhornia crassipes</i>	8,9,11,13,16,18,19,27,28,30,31,40,41,43,44,48,50,51,53,61,62,64,67,69,71,76,77,84,92,96,97,98,99,102
<i>Gymnocoronis spilanthoides</i>	8,9,11,13,30,31,40,43,48,50,51,70,71,107
<i>Hanguana malayana</i>	19,64,69
<i>Heteranthera reniformis</i>	8,12,23,40,43,51,64
<i>Hydrilla verticillata</i>	3,4,9,11,13,16,18,27,28,30,31,33,40,41,42,43,48,51,53,61,62,64,67,69,76,86,92,96,97,98,99,102
Name	References

<i>Hydrocleys nymphoides</i>	11,12,31,50,51,67,92,98
<i>Hydrocotyle bonariensis</i>	40,43,46
<i>Hydrocotyle ranunculoides</i>	3,12,18,28,30,40,43,46,50,51,81
<i>Hydrocotyle umbellata</i>	28,43
<i>Hydrolea zeylanica</i>	40,43,64,69
<i>Hygrophila difformis</i>	12,27,51,64
<i>Hygrophila polysperma</i>	4,9,12,26,27,30,40,48,51,64,67,98,102
<i>Ipomoea aquatica</i>	4,27,40,42,43,48,62,67,69,76,77,92,98
<i>Ischaemum polystachyum</i>	27*,40,48,64
<i>Landoltia punctata</i>	28,43,48,50,67,92,102
<i>Lemna aequinoctialis</i>	40,43,49,53,62,64,69,92
<i>Limnobium spongia</i>	12,22,28,43,51,102
<i>Limnobium stoloniferum</i>	12,22,28,50,51,67
<i>Limnocharis flava</i>	8,19,40,43,48,64,69,70,74,76,96,97,99
<i>Limnophila sessiliflora</i>	4,9,12,27,28*,43,48,51,62,64,67,77,98,102
<i>Ludwigia adscendens</i>	27,33,40,42,43,62,64,69,77,97,99
<i>Ludwigia octovalvis</i>	40,42,43,67,69,96,97,99
<i>Ludwigia peploides</i>	3,5,11,13,18,28,30,43,67,98
<i>Ludwigia peruviana</i>	8,12,13,14,24,40,43,48,64,69,71,76,98
<i>Lysimachia fortunei</i>	26,40,43,45
<i>Marsilea minuta</i>	10,40,43,51,62,64,67,69,70,96,97,98,99,101
<i>Marsilea quadrifolia</i>	10,40,42,43,51,64,67,76,98,99,102
<i>Melaleuca quinquenervia</i>	4,26,40,48,61,66,95,98
<i>Microsorium pteropus</i>	51
<i>Mimosa pigra</i>	3,4,8,26,33,40,43,48,62,64,67,69,80,96,99,105
<i>Monochoria hastata</i>	4,19,40,43,44,64,69,76,77,97,99
<i>Monochoria vaginalis</i>	4,5,28,40,43,44,53,62,64,67,69,76,92,96,98,99
<i>Myriophyllum aquaticum</i>	9,11,12,13,18,28,30,31,40,43,48,50,51,64,67,69,71,92,98,102
<i>Myriophyllum spicatum</i>	8,12,13,14,28,40,41,42,43,48,62,64,67,69,98,108
Name	References

<i>Najas graminea</i>	5,28,40,42,43,62,64,67,69,97,98,99
<i>Najas guadalupensis</i>	5,12,14,28,40,43,51,92,98
<i>Najas indica</i>	51,64,69,96
<i>Najas marina</i>	1,14,28,40,42,43,51,67,92,98
<i>Nelumbo lutea</i>	12,43
<i>Nelumbo nucifera</i>	33,40,43,62,64,67,69,76,92,96,97,98
<i>Neptunia oleracea</i>	8,12,40,43,50,62,64,69,77
<i>Neptunia plena</i>	8,12,40
<i>Nymphaea caerulea</i>	27,40*,43,62,64,67,69,70,76,84,92,98
<i>Nymphaea elegans</i>	40*
<i>Nymphaea lotus</i>	40*,43,51,62,64,67,69,97,98,99
<i>Nymphaea mexicana</i>	11,12,28,40*,43,67,98
<i>Nymphoides indica</i>	33,43,51,62,64,67,69,76,97,98
<i>Ottelia alismoides</i>	4,5,27,40,43,51,62,64,67,69,76,77,98,102
<i>Panicum repens</i>	13,14,40,43,44,48,61,64,66,67,69,76,77,96,97,98,99
<i>Persicaria minor</i> var. <i>procera</i>	28,40,43,64,98
<i>Phragmites vallisneria</i>	8,19,43,44,62,64,76
<i>Pistia stratiotes</i>	9,12,18,26,27,28,30,31,40,41,43,44,48,50,51,53,62,64,67,69,71,76,77,92,98,99,102
<i>Pontederia cordata</i> var. <i>lanceolata</i>	12,46,50,67
<i>Potamogeton crispus</i>	5,13,28,40,42,43,48,62,64,67,98,102
<i>Rotala rotundifolia</i>	24,40,43,47,51,64,67,70,97
<i>Sagittaria latifolia</i>	12,40,43,98
<i>Sagittaria montevidensis</i>	5,11,12,13,28,43,51,67,71,98
<i>Sagittaria platyphylla</i>	11,12,13,31,43,48,71
<i>Sagittaria sagittifolia</i>	4,11,12,14,40,42,43,48,64,69,76
<i>Salvinia cucullata</i>	12,40,44,43,51,64,69,70,74,76,97,99
<i>Salvinia minima</i>	12,28,43,48,67,98
<i>Salvinia molesta</i>	3,4,8,11,12,13,16,18,28,30,31,33,40,41,43,44,48,50,51,54,60,61,62,64,67,69,71,76,80,92,96,98,99,102,106

Name	References
<i>Salvinia natans</i>	12,40,43,44,64,69,74,76,98
<i>Schinus terebinthifolius</i>	8,24,26,40,43,48,61,66,92,98
<i>Spathiphyllum tasson</i>	26*
<i>Sphenoclea zeylandica</i>	27,33,40,44,43,64,76,96,98,99
<i>Spirodela polyrhiza</i>	40,42,43,51,62,69,92
<i>Stuckenia pectinata</i>	5,28,40,42,43,51,62,64,98
<i>Trapa</i> spp. (excluding <i>T. natans</i>)	2,8,43,50,55,62,64,69,97,108
<i>Typha angustifolia</i>	5,19,28,42,43,64,67,69,98,99,102
<i>Typha latifolia</i>	8,11,12,13,14,26,28,40,42,43,48,64,71,98
<i>Utricularia gibba</i>	5,11,13,33,39,43,48,50,51,62,64,98
<i>Utricularia inflata</i>	12,39,43,50,67
<i>Vallisneria</i> spp	11,13,16,31,40,42,43,48,50,51,62,64,67,69,97
<i>Vesicularia dubyana</i>	

Table 4: Weed history for potential weeds of Micronesia, based on Holm et al., (1979), which reports the number of countries in which that weed is regarded as an economic weed (ranked in 5 categories from highest to least impact: serious, principle, common, present as a weed, present in the flora but not assessed); and Randall (2002) with the number of references referring to that weed (tropical or sub-tropical references in parentheses), and where a weed is classified g = agricultural, e = environmental, n = naturalized, x = noxious, c = cultivation escape, q = quarantine, s = sleeper weed, w = unspecified weed, c = casual alien).

Species	Holm - rankings	Randall – no. of references	Randall weed categories
<i>Actinoscirpus grossus</i>	0 4 2 3 0	12 (12)	g e w
<i>Aeschynomene aspera</i>	5 3 3 17 1	27 (21)	g e n x w
<i>Aeschynomene indica</i>	0 1 0 3 1	10 (9)	g n w
<i>Alternanthera philoxeroides</i>	2 2 2 7 0	61	g e n x c s w
<i>Anubias</i> spp.	0 0 2 5 5	28 (17)	g e n x c w a
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)	0 0 0 0 0	0	0
<i>Arundo donax</i>	0 1 0 1 0	3	e q w
<i>Azolla filiculoides</i>	0 1 2 5 0	12 (9)	g e n x c w a
<i>Azolla pinnata</i>	0 2 1 12 0	29 (15)	g e n x s w
<i>Cabomba caroliniana</i>	0 0 0 0 0	35 (6+)	g e n x c w a
<i>Ceratophyllum demersum</i>	2 5 3 26 3	30	g e n x c s w
<i>Ceratopteris thalictroides</i>	0 2 2 11 1	20 (13)	g e n c w a
<i>Cryptocoryne</i> spp.	0 0 0 0 0	4	e n
<i>Cyperus involucratus</i>	0 0 0 0 0	16 (6)	e n c w
<i>Cyperus prolifer</i>	0 0 0 0 0	12 (6)	g e n c w
<i>Echinodorus cordifolius</i>	0 0 0 1 0	8 (3)	e n c w
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)	0 0 0 0 0	3	g e n c
<i>Egeria densa</i>	0 3 0 4 0	54	g e n x c w a
<i>Egeria najas</i>	0 0 0 0 0	1	w
<i>Eichhornia azurea</i>	0 1 1 1 0	18	a e n x w
<i>Eichhornia crassipes</i>	14 8 8 20 6	89	g e n x c s w a
<i>Gymnocoronis spilanthoides</i>	0 0 0 1 0	22	e n x c s w a
<i>Hanguana malayana</i>	0 0 0 0 0	0	0
<i>Heteranthera reniformis</i>	0 0 0 1 0	7 (3)	g e n w

Species	Holm - rankings	Randall – no. of references	Randall weed categories
<i>Hydrilla verticillata</i>	3 4 4 13 1	58	g e n x c s w a
<i>Hydrocleys nymphoides</i>	0 0 0 0 0	17 (3)	e n x c w a
<i>Hydrocotyle bonariensis</i>	0 0 1 4 0	25 (9)	g e n c w
<i>Hydrocotyle ranunculoides</i>	0 0 0 1 1	13 (3+)	g e n x c s w a
<i>Hydrocotyle umbellata</i>	0 0 0 6 0	8 (2)	n x c w
<i>Hydrolea zeylanica</i>	0 0 0 1 4	9 (8)	g n w
<i>Hygrophila difformis</i>	0 0 0 0 0	4	e n c s w
<i>Hygrophila polysperma</i>	0 0 0 0 0	12 (3)	e n x c w
<i>Ipomoea aquatica</i>	3 3 3 23 2	11 (6)	a e n x c w
<i>Ischaemum polystachyum</i>	0 0 0 0 0	5 (5)	g e w
<i>Landoltia punctata</i>	0 0 0 1 1	14 (6)	g e n x c w
<i>Lemna aequinoctialis</i>	0 1 1 2 2	10 (7)	n q w
<i>Limnobium spongia</i>	0 0 0 1 0	8 (2)	g e n x w
<i>Limnobium stoloniferum</i>	0 0 0 0 0	4 (4)	n
<i>Limnocharis flava</i>	3 0 1 1 1	16 (3+)	g e n x c w
<i>Limnophila sessiliflora</i>	0 0 1 0 1	19 (12)	g e n c x
<i>Ludwigia adscendens</i>	1 1 0 28 4	15 (8)	g e w
<i>Ludwigia octovalvis</i>	0 2 0 31 1	25 (25)	g e n w
<i>Ludwigia peploides</i>	0 0 1 0 0	41 (22)	g e n w
<i>Ludwigia peruviana</i>	0 0 0 1 0	27 (8)	g e n x c w
<i>Lysimachia fortunei</i>	0 0 1 0 0	4 (3)	g e n c s w
<i>Marsilea minuta</i>	1 0 2 0 0	15 (10)	n w
<i>Marsilea quadrifolia</i>	1 5 2 14 1	19 (11)	g e n w
<i>Melaleuca quinquenervia</i>	0 0 0 0 0	30 (8+)	g e n x w
<i>Microsorium pteropus</i>	0 0 0 0 0	0	0
<i>Mimosa pigra</i>	0 2 0 5 2	41 (25)	g e n c x w
<i>Monochoria hastata</i>	2 3 1 3 0	15 (9)	g e n x w
<i>Monochoria vaginalis</i>	6 4 1 5 1	21 (8+)	g e n x w
<i>Myriophyllum aquaticum</i>	0 4 3 5 0	56	g e n x c w

Species	Holm - rankings	Randall – no. of references	Randall weed categories
<i>Myriophyllum spicatum</i>	2 3 3 22 2	52	g e n x c w
<i>Najas graminea</i>	0 4 3 14 1	18 (10)	g e n x c w
<i>Najas guadalupensis</i>	0 1 0 0 0	16 (10)	g e n w a
<i>Najas indica</i>	0 0 0 0 0	0	g e n x c w
<i>Najas marina</i>	0 0 0 21 1	18 (10)	0
<i>Nelumbo lutea</i>	0 0 1 2 0	11 (3)	g e n c w
<i>Nelumbo nucifera</i>	0 3 2 12 0	17 (8)	g e x w
<i>Neptunia oleracea</i>	0 0 0 3 3	6 (4)	e n c w a
<i>Neptunia plena</i>	0 0 0 0 0	6 (3)	g n w
<i>Nymphaea caerulea</i>	0 2 0 21 1	19 (11)	e n w
<i>Nymphaea elegans</i>	0 0 0 0 0	0	g n q w
<i>Nymphaea lotus</i>	0 3 0 21 1	19 (11)	g e n x c w
<i>Nymphaea mexicana</i>	0 0 0 1 0	23 (5)	g e n c w
<i>Nymphoides indica</i>	0 0 1 3 3	17 (15)	g e n w
<i>Ottelia alismoides</i>	1 3 12 1	18 (11)	g e n w
<i>Panicum repens</i>	8 3 5 10 3	19 (11)	g e n x w
<i>Persicaria minor</i> var. <i>procera</i>	0 0 2 0 1	10 (5)	e n x q w
<i>Phragmites vallatoria</i>	0 2 0 4 5	7 (6)	g n w
<i>Pistia stratiotes</i>	4 11 4 25 2	52	g e n w
<i>Pontederia cordata</i> var. <i>lanceolata</i>	0 0 0 0 0	21 (7)	g e n x c s w a
<i>Potamogeton crispus</i>	0 6 4 16 0	21 (9)	g e n x c w a
<i>Rotala rotundifolia</i>	0 3 0 14 0	12 (2)	e n x c s w a
<i>Sagittaria latifolia</i>	0 1 0 0 0	22 (14)	g e n c s w
<i>Sagittaria montevidensis</i>	0 0 1 6 0	21 (5)	g n x c w a
<i>Sagittaria platyphylla</i>	1 0 0 6 0	31 (11)	g e n x c s w
<i>Sagittaria sagittifolia</i>	0 0 0 1 0	20 (5)	g e n x w a
<i>Salvinia cucullata</i>	0 5 3 22 2	27 (12)	g e w
<i>Salvinia minima</i>	0 2 2 2 0	14 (8)	e n w
<i>Salvinia molesta</i>	4 5 2 4 5	44	g e n x c w a

Species	Holm - rankings	Randall – no. of references	Randall weed categories
<i>Salvinia natans</i>	0 5 4 8 1	17 (7)	g e n c w
<i>Schinus terebinthifolius</i>	0 0 1 1 2	43 (28)	g e n x c w a
<i>Spathiphyllum tasson</i>	0 0 0 0 0	0	0
<i>Sphenoclea zeylandica</i>	5 5 1 7 1	24 (20)	g e n w
<i>Spirodela polyrhiza</i>	0 4 2 28 1	27 (12)	g e n x c w
<i>Stuckenia pectinata</i>	2 3 0 27 0	21 (10)	g e n x c w a
<i>Trapa</i> spp. (excluding <i>T. natans</i>)	0 0 1 27 0	2 (1)	e n w
<i>Typha angustifolia</i>	1 7 3 42 0	19 (13)	g e n c w a
<i>Typha latifolia</i>	1 6 5 26 1	21 (9)	g e n x c w
<i>Utricularia gibba</i>	0 1 0 1 0	20 (7)	e n x s w
<i>Utricularia inflata</i>	0 0 0 1 0	8 (5)	e n x w
<i>Vallisneria</i> spp.	0 4 2 21 0	20 (6)	g e n c w a
<i>Vesicularia dubyana</i>	0 0 0 0 0	0	0

Table 5: Aquatic weed risk assessment scores generated for potential weeds of Micronesia, sorted on total score, also showing likelihood of entry into Micronesia, weed potential and likely impact scores, and combination of weed potential and impact scores.

Species	Total WRA score	Likelihood of entry score (max = 30)	Weed potential score (max = 72)	Impact score (max = 50)	WRA excluding entry score
<i>Eichhornia crassipes</i>	127	30	59	38	97
<i>Hydrilla verticillata</i>	123	30	57	36	93
<i>Pistia stratiotes</i>	117	30	50	37	87
<i>Panicum repens</i>	115	30	47	38	85
<i>Phragmites vallisneria</i>	115	30	58	27	85
<i>Ceratophyllum demersum</i>	113	30	53	30	83
<i>Schinus terebinthifolius</i>	107	30	55	22	77
<i>Melaleuca quinquenervia</i>	107	30	56	21	77
<i>Monochoria vaginalis</i>	105	30	44	31	75
<i>Ipomoea aquatica</i>	98	30	40	28	68
<i>Arundo donax</i>	96	30	32	34	66
<i>Hanguana malayana</i>	96	30	50	16	66
<i>Mimosa pigra</i>	95	2	55	38	93
<i>Azolla pinnata</i>	93	24	46	23	69
<i>Ischaemum polystachyum</i>	92	30	43	19	62
<i>Alternanthera philoxeroides</i>	90	1	49	40	89
<i>Salvinia molesta</i>	90	2	50	38	88
<i>Salvinia cucullata</i>	87	12	46	29	75
<i>Salvinia natans</i>	86	30	40	16	56
<i>Eichhornia azurea</i>	85	5	53	27	80
<i>Azolla filiculoides</i>	85	24	39	22	61
<i>Nelumbo nucifera</i>	85	30	35	20	55
<i>Utricularia gibba</i>	84	30	39	15	54
<i>Myriophyllum aquaticum</i>	83	10	44	29	73

Species	Total WRA score	Likelihood of entry score	Weed potential score	Impact score	WRA excluding entry score
<i>Myriophyllum spicatum</i>	83	1	48	34	82
<i>Typha angustifolia</i>	83	2	51	30	81
<i>Limnocharis flava</i>	83	10	46	27	73
<i>Spirodela polyrhiza</i>	83	24	39	20	59
<i>Nymphaea caerulea</i>	83	30	37	16	53
<i>Nymphaea lotus</i>	83	30	37	16	53
<i>Aeschynomene indica</i>	82	30	24	28	52
<i>Typha latifolia</i>	80	2	49	29	78
<i>Ceratopteris thalictroides</i>	80	30	35	15	50
<i>Ludwigia peruviana</i>	79	2	50	27	77
<i>Lemna aequinoctialis</i>	79	30	36	13	49
<i>Monochoria hastata</i>	78	5	44	29	73
<i>Limnophila sessiliflora</i>	77	30	28	19	47
<i>Nymphaea elegans</i>	77	30	37	10	47
<i>Ludwigia octovalvis</i>	76	30	32	14	46
<i>Gymnocoronis spilanthoides</i>	74	1	48	25	73
<i>Egeria densa</i>	73	1	40	32	72
<i>Najas graminea</i>	72	2	46	24	70
<i>Sagittaria sagittifolia</i>	71	4	43	24	67
<i>Sagittaria latifolia</i>	71	10	42	19	61
<i>Cyperus involucratus</i>	70	30	26	14	40
<i>Persicaria minus</i> var. <i>procera</i>	69	30	26	13	39
<i>Najas guadalupensis</i>	68	2	45	21	66
<i>Najas indica</i>	66	2	46	18	64
<i>Nymphaea mexicana</i>	64	1	41	22	63
<i>Sagittaria platyphylla</i>	64	1	42	21	63
<i>Najas marina</i>	64	2	44	18	62
<i>Cabomba caroliniana</i>	63	1	37	25	62

Species	Total WRA score	Likelihood of entry score	Weed potential score	Impact score	WRA excluding entry score
<i>Actinoscirpus grossus</i>	63	2	37	24	61
<i>Stuckenia pectinata</i>	63	1	44	18	62
<i>Sagittaria montevidensis</i>	62	1	40	21	61
<i>Landoltia punctata</i>	62	12	35	15	50
<i>Heteranthera reniformis</i>	61	1	39	21	60
<i>Limnobium stoloniferum</i>	60	3	39	18	57
<i>Ludwigia adscendens</i>	60	2	45	13	58
<i>Aeschynomene aspera</i>	59	1	24	34	58
<i>Neptunia oleracea</i>	59	3	37	19	56
<i>Ludwigia peploides</i>	59	2	43	14	57
<i>Nymphoides indica</i>	59	3	43	13	56
<i>Hydrocotyle ranunculoides</i>	58	4	39	15	54
<i>Neptunia plena</i>	57	1	37	19	56
<i>Vallisneria spp</i>	56	1	34	21	55
<i>Limnobium spongia</i>	55	1	39	15	54
<i>Trapa spp. (excluding T. natans)</i>	53	2	34	17	51
<i>Sphenoclea zeylandica</i>	52	1	29	22	51
<i>Vesicularia dubyana</i>	52	30	22	0	22
<i>Utricularia inflata</i>	51	1	35	15	50
<i>Hydrocleys nymphoides</i>	50	2	32	16	48
<i>Potamogeton crispus</i>	50	1	33	16	49
<i>Hygrophila polysperma</i>	49	1	32	16	48
<i>Egeria najas</i>	49	1	35	13	48
<i>Marsilea quadrifolia</i>	48	1	31	16	47
<i>Nelumbo lutea</i>	48	1	35	12	47
<i>Hydrocotyle bonariensis</i>	48	4	34	10	44
<i>Marsilea minuta</i>	47	2	32	13	45
<i>Hydrocotyle umbellata</i>	47	4	33	10	43

Species	Total WRA score	Likelihood of entry score	Weed potential score	Impact score	WRA excluding entry score
<i>Echinodorus cordifolius</i>	46	3	28	15	43
<i>Ottelia alismoides</i>	46	1	33	12	45
<i>Cyperus prolifer</i>	44	5	26	13	39
<i>Cryptocoryne</i> spp.	43	2	31	10	41
<i>Hydrolea zeylanica</i>	42	1	30	11	41
<i>Salvinia minima</i>	41	1	33	7	40
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)	40	4	29	7	36
<i>Pontederia cordata</i> var. <i>lanceolata</i>	38	1	28	9	37
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)	37	1	26	10	36
<i>Lysimachia fortunei</i>	35	5	23	7	30
<i>Rotala rotundifolia</i>	34	1	23	10	33
<i>Hygrophila difformis</i>	32	1	25	6	31
<i>Anubias</i> spp.	31	2	27	2	29
<i>Microsorium pteropus</i>	27	2	25	0	25
<i>Spathiphyllum tasson</i>	15	1	14	0	14

Table 6: Aquatic weed risk assessment scores generated for potential weeds of Micronesia, sorted on combined weed potential and impact scores, also showing likelihood of entry into Micronesia and total score, and potential habitats the species could threaten in Micronesia (1 = jungle streams; 2 = open streams; 3 = ponds; 4 = savanna wetlands; 5 = swamps; 6 = cultivated swamps; 7 = swamp forest).

Species	Combined weed potential and impact score	Likelihood of entry score	Total WRA score	Habitat threatened
<i>Eichhornia crassipes</i>	97	30	127	2 3 6
<i>Hydrilla verticillata</i>	93	30	123	1 2 3 4
<i>Mimosa pigra</i>	93	2	95	3 4 5 6 7?
<i>Alternanthera philoxeroides</i>	89	1	90	2 3 6
<i>Salvinia molesta</i>	88	2	90	2 3 6
<i>Pistia stratiotes</i>	87	30	117	5 6
<i>Panicum repens</i>	85	30	115	2 3 6
<i>Phragmites vallatoria</i>	85	30	115	6
<i>Ceratophyllum demersum</i>	83	30	113	1 2 3
<i>Myriophyllum spicatum</i>	82	1	83	2 3
<i>Typha angustifolia</i>	81	2	83	2 3 5 6
<i>Eichhornia azurea</i>	80	5	85	3
<i>Typha latifolia</i>	78	2	80	2 3 5 6
<i>Ludwigia peruviana</i>	77	2	79	2 3 6
<i>Melaleuca quinquenervia</i>	77	30	107	3 4 5 6
<i>Schinus terebinthifolius</i>	77	30	107	3 4 5 6
<i>Monochoria vaginalis</i>	75	30	105	2 3 6
<i>Salvinia cucullata</i>	75	12	87	2 3 6
<i>Gymnocoronis spilanthoides</i>	73	1	74	2 3 6
<i>Limnocharis flava</i>	73	10	83	6
<i>Monochoria hastata</i>	73	5	78	2 3 6
<i>Myriophyllum aquaticum</i>	73	30	83	2 3 6
<i>Egeria densa</i>	72	1	73	2 3
<i>Najas graminea</i>	70	2	72	2 3
<i>Azolla pinnata</i>	69	24	93	2 3 4

Species	Combined weed potential and impact score	Likelihood of entry score	Total WRA score	Habitat threatened
<i>Ipomoea aquatica</i>	68	30	98	2 3 6
<i>Sagittaria sagittifolia</i>	67	4	71	2 3 6
<i>Arundo donax</i>	66	30	96	2 5
<i>Hanguana malayana</i>	66	30	96	2 3
<i>Najas guadalupensis</i>	66	2	68	2 3
<i>Najas indica</i>	64	2	66	2 3
<i>Nymphaea mexicana</i>	63	1	64	3
<i>Sagittaria platyphylla</i>	63	1	64	2 3 6
<i>Cabomba caroliniana</i>	62	1	63	2 3
<i>Ischaemum polystachyum</i>	62	30	92	6
<i>Najas marina</i>	62	2	64	2 3
<i>Stuckenia pectinata</i>	62	1	63	1 2 3
<i>Actinoscirpus grossus</i>	61	2	63	1 6
<i>Azolla filiculoides</i>	61	24	85	2 3 4
<i>Sagittaria latifolia</i>	61	10	71	2 3 6
<i>Sagittaria montevidensis</i>	61	1	62	2 3 6
<i>Heteranthera reniformis</i>	60	1	61	2 3 6
<i>Spirodela polyrhiza</i>	59	24	83	2 3
<i>Aeschynomene aspera</i>	58	1	59	6
<i>Ludwigia adscendens</i>	58	2	60	2 3 6
<i>Limnobium stoloniferum</i>	57	3	60	3
<i>Ludwigia peploides</i>	57	2	59	2 3 6
<i>Neptunia oleracea</i>	56	3	59	2 3 6
<i>Neptunia plena</i>	56	1	57	2 3 6
<i>Nymphoides indica</i>	56	3	59	3
<i>Salvinia natans</i>	56	30	86	2 3 6
<i>Nelumbo nucifera</i>	55	30	85	3
<i>Vallisneria</i> spp.	55	1	56	1 2 3

Species	Combined weed potential and impact score	Likelihood of entry score	Total WRA score	Habitat threatened
<i>Hydrocotyle ranunculoides</i>	54	4	58	2 3 6
<i>Limnobium spongia</i>	54	1	55	3
<i>Utricularia gibba</i>	54	30	84	2 3 4
<i>Nymphaea caerulea</i>	53	30	83	3
<i>Nymphaea lotus</i>	53	30	83	3
<i>Aeschynomene indica</i>	52	30	82	6
<i>Sphenoclea zeylandica</i>	51	1	52	6
<i>Trapa</i> spp. (excluding <i>T. natans</i>)	51	2	53	3
<i>Ceratopteris thalictroides</i>	50	30	80	3 6
<i>Landoltia punctata</i>	50	12	62	2 3 6
<i>Utricularia inflata</i>	50	1	51	2 3
<i>Lemna aequinoctialis</i>	49	30	79	2 3 6
<i>Potamogeton crispus</i>	49	1	50	2 3 6
<i>Egeria najas</i>	48	1	49	2 3
<i>Hydrocleys nymphoides</i>	48	2	50	2 3
<i>Hygrophila polysperma</i>	48	1	49	2
<i>Limnophila sessiliflora</i>	47	30	77	2 3
<i>Marsilea quadrifolia</i>	47	1	48	3 6
<i>Nelumbo lutea</i>	47	1	48	3
<i>Nymphaea elegans</i>	47	30	77	3
<i>Ludwigia octovalvis</i>	46	30	76	2 3 6
<i>Marsilea minuta</i>	45	2	47	3 6
<i>Ottelia alismoides</i>	45	1	46	3
<i>Hydrocotyle bonariensis</i>	44	4	48	2 3 6
<i>Echinodorus cordifolius</i>	43	3	46	2 3 6
<i>Hydrocotyle umbellata</i>	43	4	47	2 3 6
<i>Cryptocoryne</i> spp.	41	2	43	1
<i>Hydrolea zeylanica</i>	41	1	42	6

Species	Combined weed potential and impact score	Likelihood of entry score	Total WRA score	Habitat threatened
<i>Cyperus involucratus</i>	40	30	70	2 6
<i>Salvinia minima</i>	40	1	41	2 3 6
<i>Cyperus prolifer</i>	39	5	44	2 6
<i>Persicaria minus</i> var. <i>procera</i>	39	30	69	3 6
<i>Pontederia cordata</i> var. <i>lanceolata</i>	37	1	38	2 3 6
<i>Aponogeton</i> spp. (excluding <i>A. distachyos</i>)	36	4	40	1 2 3 4
<i>Echinodorus</i> spp. (excluding <i>E. cordifolius</i>)	36	1	37	2 3 6
<i>Rotala rotundifolia</i>	33	1	34	1 2 3
<i>Hygrophila difformis</i>	31	1	32	2
<i>Lysimachia fortunei</i>	30	5	35	2 3
<i>Anubias</i> spp.	29	2	31	1
<i>Microsorium pteropus</i>	25	2	27	1
<i>Vesicularia dubyana</i>	22	30	52	1
<i>Spathiphyllum tassion</i>	14	1	15	1

4. Discussion and recommendations

4.1 Dealing with uncertainty

As with any type of prediction, there is a degree of uncertainty regarding the validity of the weed risk assessment scores. In this case there are three main issues; identity of plant taxa, quality of weed records and lack of relevant information for non-weedy species.

There are problems with the identity of some taxa, e.g., the water lilies (*Nymphaea* species especially where these are of hybrid origin), and then relating this to weed information on these species in their naturalized or indigenous ranges. Where this confusion has occurred, taxa have been grouped (e.g., *N. nouchali* and *N. stellata* records have been grouped with *N. caerulea* and *N. pubescens* grouped with *N. lotus*). In the case where genera have historically had problematic taxonomy (e.g., *Vallisneria* and *Trapa*) all species weed information has been collated under that genus.

Ideally all information used to assess potential weeds would be based on scientifically validated data (i.e., peer-reviewed journals and other publications). However, much of the information is only available as ‘grey’ literature, and several of the primary references used for this weed risk assessment either use ‘expert weed assessment’ (Holm et al., 1977; 1979; 1997) or all available information regardless of validation (Randall 2002). Both of these approaches are seen as valid, with the resulting weed risk assessment information based on a wide collection and weight of information that major weed species should generate. This is evident from Tables 3 and 4, where the world renowned weeds such as *Eichhornia crassipes*, *S. molesta*, *Pistia stratiotes* and *Hydrilla verticillata* are represented by the greatest volume of references.

Conversely, information on potential weeds yet to show weedy characteristics, or those with limited weed potential, is often lacking. Champion et al., (2008) and Petroschevsky & Champion (2008) regarded the lack of information on naturalization and weed impacts of aquarium and other ornamental species that were internationally traded in high volumes (therefore with high propagule pressure) over decades as a very good indication of lack of weed potential. Length of time and volume in the trade were scored negatively if a taxon had been traded for over 30 years without naturalising.

4.2 High ranked aquatic weeds

The top 12 AWRAM scores were assigned to species that were already naturalized, or native to at least some part of Micronesia (Table 5). Three native species were amongst the nine species with scores >100, comprising *Phragmites vallatoria*, a widespread and dominant wetland species, and also *Panicum repens* and *Ceratophyllum demersum*, both regarded as indigenous by Fosberg et al. (1979; 1987). These species were of very limited distribution, with only one site of *P. repens* seen

during the field visits. Their indigenous status could be questioned. The remaining six species were all apparently limited in distribution, with the first record of *Monochoria vaginalis* in Micronesia and the first naturalized records of the highest and third-highest ranked species *E. crassipes* and *Pistia stratiotes* from Pohnpei made during field work contributing to this report. Of the 33 species scoring ≥ 80 , ten were found or reported to be in cultivation in Micronesia, and either not naturalized or of limited distribution, including the first naturalized population of *Salvinia natans* in Guam (R. Miller pers. comm.). Clearly the greatest risk from potential weeds comes from aquatic species that have already arrived across the Micronesian border. Although such species could be regarded as no longer a border issue for the Region, they do represent a more immediate economic, social and ecological risk and their management is advocated (see later).

Of the 33 species scoring ≥ 80 , only ten have not been recorded from Micronesia. These were (in decreasing order of risk) *Mimosa pigra*, *Azolla pinnata*, *Alternanthera philoxeroides*, *Salvinia molesta*, *Eichhornia azurea*, *Azolla filiculoides*, *Myriophyllum spicatum*, *Typha angustifolia*, *Limncharis flava* and *T. latifolia*. The risk of entry of the *Azolla* species is seen as much more likely than the other species (each scoring 24/30 compared to scores of ≤ 5 for the other species).

By excluding the likelihood of entry score, a measure of weed potential and impact can be used to rank species (Table 6). Of the 12 highest ranked alien species (scores ≥ 80), six are not known to occur in Micronesia (*M. pigra*, *A. philoxeroides*, *S. molesta*, *E. azurea*, *M. spicatum*, *T. angustifolia* and *L. flava*).

The species in Table 7 are not known from Micronesia and all have combined scores higher than 50 (weed potential and impact score). These species are distributed via international aquarium and/or ornamental plant trades and are therefore recommended for inclusion of a 'black list' of imports to the jurisdictions of Micronesia (Table 7).

Additionally, there are a number of species that are sparingly naturalized or only known from cultivation in Micronesia and that rank higher or within the same range as the species in Table 7. These species are recommended for preventative measures prohibiting their sale and distribution (Table 8). Species listed in table 8 include the highest ranked species *E. crassipes*.

Management programs are advocated for a number of very high risk species (weed potential and impact score ≥ 70) that have very limited naturalized ranges in Micronesia (Table 9). These include some species previously regarded as indigenous, as discussed above. Additional to these species, the recently recognized naturalized population of *Salvinia natans* should also be assessed. Thorough surveys for their presence in cultivation and naturalized populations in each jurisdiction are recommended, with eradication programs advocated should their populations be rated as eradicable.

Table 7: High risk aquatic plant species not present in Micronesia recommended for inclusion in a ‘black-list’ of species prohibited from importation, with combined weed potential and impact score, and ranking out of 95 taxa assessed.

Species	Combined weed potential and impact score	Ranking/ 95
<i>Myriophyllum spicatum</i>	82	10
<i>Typha angustifolia</i>	81	11
<i>Eichhornia azurea</i>	80	12
<i>Typha latifolia</i>	78	13
<i>Ludwigia peruviana</i>	77	14
<i>Gymnocoronis spilanthoides</i>	73	19
<i>Limnocharis flava</i>	73	19
<i>Monochoria hastata</i>	73	19
<i>Egeria densa</i>	72	23
<i>Azolla pinnata</i>	69	24
<i>Sagittaria sagittifolia</i>	67	27
<i>Najas guadalupensis</i>	66	29
<i>Nymphaea mexicana</i>	63	32
<i>Sagittaria platyphylla</i>	63	32
<i>Cabomba caroliniana</i>	62	34
<i>Najas marina</i>	62	34
<i>Azolla filiculoides</i>	61	38
<i>Sagittaria montevidensis</i>	61	38
<i>Heteranthera reniformis</i>	60	42
<i>Spirodela polyrhiza</i>	59	43
<i>Ludwigia adscendens</i>	58	44
<i>Limnobium stoloniferum</i>	57	46
<i>Ludwigia peploides</i>	57	46
<i>Neptunia oleracea</i>	56	48
<i>Neptunia plena</i>	56	48
<i>Vallisneria</i> spp.	55	52

Species	Combined weed potential and impact score	Ranking/ 95
<i>Hydrocotyle ranunculoides</i>	54	54
<i>Limnobium spongia</i>	54	54
<i>Trapa</i> spp. (excluding <i>T. natans</i>)	51	60

Table 8: High risk aquatic plant species present in Micronesia recommended for prohibition from sale and distribution, with combined weed potential and impact score, and ranking out of 95 taxa assessed.

Species	Combined weed potential and impact score	Ranking/ 95
<i>Eichhornia crassipes</i>	97	1
<i>Hydrilla verticillata</i>	93	2
<i>Pistia stratiotes</i>	87	6
<i>Ceratophyllum demersum</i>	83	9
<i>Melaleuca quinquenervia</i>	77	=14
<i>Schinus terebinthifolius</i>	77	=14
<i>Monochoria vaginalis</i>	75	=17
<i>Salvinia cucullata</i>	75	=17
<i>Myriophyllum aquaticum</i>	73	=19
<i>Sagittaria latifolia</i>	61	=38
<i>Salvinia natans</i>	56	=48
<i>Nelumbo nucifera</i>	55	=52
<i>Utricularia gibba</i>	54	=54
<i>Nymphaea caerulea</i>	53	=57
<i>Nymphaea lotus</i>	53	=57

Table 9: Very high risk aquatic plant species present in Micronesia recommended for evaluation for possible eradication programmes, with combined weed potential and impact score, and ranking out of 95 taxa assessed.

Species	Combined weed potential and impact score	Ranking/ 95
<i>Eichhornia crassipes</i>	97	1
<i>Pistia stratiotes</i>	87	6
<i>Panicum repens</i>	85	=7
<i>Ceratophyllum demersum</i>	83	9
<i>Melaleuca quinquenervia</i>	77	=14
<i>Schinus terebinthifolius</i>	77	=14
<i>Salvinia natans</i>	56	=48

4.3 Species currently permitted for importation as aquarium plants

All the plants currently permitted as aquarium imports to Guam scored in the low range of the AWRAM, with combined weed potential and impact score < 45.

The highest ranked species (#78) was *Echinodorus cordifolius*, a native of central- and south-eastern USA, included as a quarantine weed in Western Australia (Randall 2002), but still traded in the aquarium/pond plant trade there (Champion et al., (2008). It was recently recognized in a photograph taken of a canal in Hawaii, but its status there is uncertain. It is present in cultivation in Guam, but unlikely to be a weed of much consequence.

Cryptocoryne species were the next highest group (#80), with *C. ciliata* and *C. spiralis*, both commonly traded species, reported as rice weeds (no indication of level of impact) in India (Moody 1989) and *C. beckettii*, *C. wendtii* and *C. undulata* naturalized in the San Marcos River, Texas and other U.S. localities (NAS 2010). These species are very popular in the aquarium trade and pose a minor risk to natural habitats, especially forest streams, in Micronesia.

Aponogeton species (excluding the warm temperate, water-lily like *A. distachyos*) were ranked #87. *A. crispus*, *A. natans*, *A. robinsonii* and *A. undulatus* are all reported as rice weeds (no indication of level of impact) in India and Southeast Asia (Moody 1989), with these species often occurring in seasonal pools, regrowing from tubers once these pools are flooded. Several species are included as a quarantine weed in Western Australia (Randall 2002), but they are still traded in the aquarium/pond plant trade there (Champion et al., (2008). These species are very popular in the aquarium

trade and pose a minor risk to natural habitats, especially open streams and ponds and potentially savanna wetlands in Micronesia.

Other *Echinodorus* species (excluding *E. cordifolius*) are ranked #88, with Randall (2002), reporting 14 species, including *E. osiris* recorded in pond cultivation in Guam, as weeds within their native range of South America. *E. berteroi* is a native rice weed of California (Barrett & Seaman 1980; Di Tomaso & Healy 2003), but are likely to pose minor risks to Micronesia.

The remaining taxa permitted for importation occupy the bottom four rankings (ranks #92 -95). These are *Anubias* spp. (African aroids - Kasselmann 2003), *Microsorium pteropus* (a fern native to tropical Asia and New Guinea - Kasselmann 2003), *Vesicularia duyana* (a moss native to the Philippines - Kasselmann 2003, and possibly Micronesia) and the lowest ranked South American aroid *Spathiphyllum tasson* (not included as an aquatic plant by Kasselmann 2003). All are forest stream species and are unlikely to cause any impact on habitats in Micronesia.

The inclusion of these taxa on a 'white-list' for importation as aquarium plants is supported.

5. Acknowledgements

We would like to thank Mark Sytsma and Rich Miller (PSU) for assistance in the field and also helpful discussions on approaches to weed risk assessment. Data on aquatic plant species was also provided by Linda Moore and Vanessa Howard (PSU). Rohan Wells provided a helpful critique of this report.

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3 Volume III - Marine Systems

Regional Biosecurity Plan for Micronesia and Hawaii

Volume III

Prepared by:

University of Guam and the Secretariat of the Pacific Community 2014

This plan was prepared in conjunction with representatives from various countries at various levels including federal/national, state/territory/commonwealth, industry, and non-governmental organizations and was generously funded and supported by the Commander, Navy Installations Command (CNIC) and Headquarters, Marine Corps.

**Marine Invasive Species Risk Assessment for the
Commonwealth of the Northern Mariana Islands,
Guam, Hawai'i, Palau, the Federated States of
Micronesia, and the Republic of the Marshall Islands**

Edited version of the original document

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Preface

This document presents a risk analysis for the marine systems of Micronesia, providing a framework and recommended actions to reduce the risks (probability of establishment, spread, and impacts) of invasions by non-native species in marine habitats.

The work presented in this document is primarily a synthesis and review of information available on the processes, spatial and temporal patterns, and existing management (regulations, guidelines and practices) for invasions by non-native marine species. Micronesia was the primary focus of this analysis, and information was also included from other regions, where relevant to understanding invasion dynamics and current (and emerging) management practices.

Most of the information presented in this document was obtained from extensive literature review, analysis of reports and documents, existing datasets (especially on ships and commerce), and interviews and correspondence with experts across a diverse range of topic areas. As conceived by the sponsoring agency, the project scope was constrained to what could be accomplished in one year of effort. Thus, the available time and resources were insufficient to complete any new major research effort, such as conducting field-based surveys to document existing biota in Micronesia or associated with vectors operating in the region. The resulting document indicates therefore what data and data gaps exist in this respect. An exception to this approach was an opportunistic field-based survey of a small number of supply ships in Guam, providing some preliminary data that begin to assess the extent and taxonomic diversity of marine organisms associated with the hulls (underwater surfaces).

It is important to recognize that the information presented in this report represents a snapshot in time. The work for this project began in late 2009, and most of the information collection and analyses were done in 2010. Unfortunately, due to delays in obtaining data for vessel traffic patterns (as discussed in Chapter 1), the final report was not completed until early 2012. While the authors attempted to include new information as it became available through February 2012, it also was not possible to accomplish this in a comprehensive way. Management of marine invasions is a very dynamic field that is undergoing rapid changes, and new policy changes emerged during the report drafting. For example, since this project began, new regulations have emerged for ballast water on a national level, for ballast water discharges by commercial ships operating in U.S. waters (including Guam). The U.S. Environmental Protection Agency published draft regulations (Federal Register, Volume 76, Number 236, December 8, 2011), and the U.S. Coast Guard published a final rule for ballast water treatment (Federal Register, Volume 77, Number 57, March 23, 2012). In fact, the latter rule did not become final until after this report was completed, and reference to it was added as a footnote in a revised version. Additional regulations are pending at state levels, as seen in California for management of biofouling organisms on commercial vessels operating in state waters (http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Ballast_Water_Default.html).

Finally, we are greatly indebted to the many people who generously shared their time, expertise, insights, and information concerning the invasions, management, policy, culture, and history of Micronesia and Hawai'i. This project would not have been possible without the enormous assistance and advice provided from those who shared their knowledge (at regional, national, and local scales) in resource management, customs and quarantine, commercial and military maritime transportation, port operations, fisheries, aquaculture, recreation, tourism, conservation, policy, and marine species distributions and inventories. Large numbers of people, agencies, and organizations were involved in this regard from many different parts of Micronesia and elsewhere. Rather than attempt a comprehensive list and unintentionally omit some participants, we simply acknowledge the important information contributed to this report by many people throughout Micronesia and Hawai'i.

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PART I.

Overview: Introduction to the Report and Analysis of Marine Invasion Mechanisms and Management in Micronesia

Chapter 1: Introduction to the Report and Marine Biological Invasions

By Gregory M. Ruiz, Chela J. Zabin, and Paul W. Fofonoff

1.1 Purpose of the Report

Recognizing existing concerns about biological invasions, the U.S. Department of Defense (DoD) has requested development of a Biosecurity Plan for Micronesia to minimize the risk of introduction and spread of non-native species in the region. This plan is in response to the proposed relocation of Marine Corps, Navy and Army operations from Okinawa, Japan to Guam (hereafter referred to as the Buildup), as outlined in the Draft Environmental Impact Statement (DEIS; DoD 2009) and Final Environmental Statement (FEIS; DoD 2010). Overall, the U.S. military originally anticipated the relocation to Guam of 24,713 military employees and dependents. This was expected to result in construction of ~3,000 buildings and major infrastructure improvements, including the creation of a new deep draft wharf that could accommodate a transient nuclear powered aircraft carrier. During the construction phase, the population of Guam was projected to (a) increase by 79,178 people at its peak, in order to provide the infrastructure and services in existing plans and (b) level off at 33,608 (including the military personnel and dependents). These estimates are subject to changes, and current plans are to lower the estimated size of the Buildup and extend the time of completion (U.S.-Japan Security Consultative Committee 2012). The increased demand for equipment (e.g., dredging equipment, silt curtains, etc.), vessels, construction materials, household goods, food, and other supplies regardless of the ultimate size and nature of the buildup will result in increases in commercial and military shipping and air traffic activity.

This increased flux could increase the risk of introduction and establishment of non-native species to Guam and, once established, increase their potential to spread to other parts of Micronesia. Currently there are connections between islands in the region via commercial shipping, military and private ship/boat traffic, and airline and helicopter traffic, which move goods and people. Spread within the region could be potentially further facilitated by the DoD's plans to use Tinian in the Commonwealth of the Northern Mariana Islands (CNMI) for military operations, by more frequent military ship traffic to other locations within Micronesia, and by increased tourism by military personnel and dependents within Micronesia and Hawai'i.

For this reason, the DoD has called for a Risk Assessment and Biosecurity Plan, which is required as part of the FEIS and the Record of Decision for the Buildup. The Risk Assessment and Biosecurity Plan are intended to have two phases, as specified in the Statement of Work. The first phase uses a science-based analysis and assessment to characterize potential mechanisms and associated risks of non-native species transfers. The second phase develops a biosecurity plan that identifies best management practices (BMPs) and responses needed to reduce the likelihood and potential effects of new invasions by non-native species. While this effort focuses on Guam as the center of increased military activity, the DoD has specified that the Risk Assessment and Biosecurity Plan include

analysis of the Micronesian region more broadly and also the linkages (opportunities for species transfers) between Micronesia and Hawai'i.

This document is intended to (a) outline risks of marine invasions to Guam and Micronesia, as well as those in Hawai'i associated with the Buildup, and (b) provide recommendations for practices that can reduce the likelihood of introductions, establishment, and spread of non-native marine species. Below, we provide a more detailed description of the process, structure, and content for this report.

1.2 Context, Timeline, and Limitations of the Report

The issue of biological invasions was largely absent from the DEIS , released by the DoD in November 2009, with an understanding that the current analysis (findings of the Risk Assessment and recommendations in the Biosecurity Plan) would be incorporated at a later date, as available. This project was initiated in September 2009, when funds became available to implement the analysis for coastal marine ecosystems.

In anticipation of a 2011 construction start date, especially for facilities at Apra Harbor in Guam, the DoD requested preliminary recommendations for BMPs prior to the completed Risk Assessment, focusing primarily on port facilities and operations in Guam. A set of draft BMPs were submitted to the DoD in March 2010 to serve as general guidelines while this RA and the overall MBP were completed. The recommendations contained in the current document build upon and refine those made in March 2010.

The findings and recommendations from this risk analysis support the regional biosecurity implementation plan. The U.S. Navy and University of Guam entered into a cooperative agreement in September of 2011, whereby the university has agreed to create a strategic implementation plan using this analysis, as well as those for freshwater plants, freshwater fishes, and terrestrial organisms (see above). Thus, the current report aims to highlight the current understanding about marine invasions, identify key data gaps, and recommend management strategies to include in the implementation plan, in order to reduce invasion risks to the region. However, this report does not identify the necessary resources, possible timeline, or the institutional framework and coordination required to fully implement and sustain an effective biosecurity program. These latter elements are inter- dependent upon each other, representing critical aspects of the implementation planning process.

Importantly, the time period specified by DoD in the Statement of Work limited the analysis to relying primarily on the collection and synthesis of existing data as available to us, through efforts to identify and obtain relevant information for Guam, the Commonwealth of the Northern Mariana Islands, Palau, the Federated States of Micronesia, the Republic of the Marshall Islands, and Hawai'i. It is evident that significant data gaps exist, and many of these are identified throughout the report in particular chapters, which discuss (a) the implications for risk assessment, (b) how these gaps are addressed within the analyses, and (c) approaches to address these gaps.

One of the conspicuous data gaps merits brief mention at the onset, because it is a core component to assessing invasion risk as outlined in the Statement of Work. Access to vessel movement data or hull information for U.S. Navy combatant ships was not provided,

due to concerns about the sensitive nature of these data with respect to national security and potential public release. In consultation with DoD, we sought data on both U.S. Navy combatant and supply ships, in order to assess the current connectivity among global regions and the potential opportunity for transfer of non-native species by vessels. In the summer of 2011, we received data on the supply ships, and DoD requested that analyses proceed without data for the combatant ships. Consequently, U.S. Navy combatant ships arriving to Guam or elsewhere were not included in the risk assessment (see Chapter 5). In the absence of vessel movement data, there is no reliable way to constrain the potential ports visited (and non-native species contacted) by this classification of vessel, and the potential risk of invasions associated with combatants remain undefined in this analysis.

1.3 Structure and Rationale of the Report

The report is divided into three different parts, most with multiple chapters, to address different topics associated with marine invasions and biosecurity. Part I characterizes the current status and knowledge of human-mediated transfer mechanisms (vectors) for non-native marine species into Micronesia, summarizing available information on their operation, scope, and management (including regulations and practices) in four separate chapters. Part II (one chapter) provides an assessment of risks of marine invasions for Micronesia. Part III (one chapter) outlines a biosecurity plan, providing recommendations for specific management actions, strategies, and frameworks to minimize impacts of marine invasions for the jurisdictions covered by the Micronesia Biosecurity Plan (MBP).

This first introductory chapter (Chapter 1) provides a brief overview of the report and background information regarding the patterns and mechanisms of marine invasions across multiple geographic regions. This chapter also highlights the importance of particular vectors for the introduction of marine species, including especially (a) the movement of organisms associated with vessels and (b) trade of live organisms associated with aquaculture, restocking efforts, food, bait, and home aquaria.

A focus on vectors, as described in the introductory chapter, is used as a general framework for the organization of the report. This framework serves multiple purposes; first, focusing on vectors places primary attention on understanding and preventing unwanted species transfers in order to reduce the likelihood of invasions. A pre-border (prevention) approach to biosecurity is widely considered more desirable, effective, and predictable than post-border interventions, after species have arrived or established populations (Meyerson and Reaser 2002; Wittenberg and Cock 2005). This approach is also consistent with guidance for U.S. federal agencies (see Section 2.1). Second, guidelines and management strategies to advance pre-border biosecurity are organized primarily by vector, recognizing that this is the operational unit for both (a) invasion opportunities and (b) particular segments of industry, military, commercial, and public activities. Any pre-border strategy or policy must have an explicit vector-based component, whether for particular types of organisms or habitats, addressing the transfer mechanism(s) of concern. In short, this organizational framework will underscore vector management as a critical component of the biosecurity plan, aiming to reduce the risk (probability) of future invasions.

In Chapter 2, the report reviews current regulations, guidelines, and practices used to reduce marine invasions associated with vessels. Of particular relevance are practices for

vessels arriving to Guam, other parts of Micronesia, and Hawai'i. We also consider the practices that are applied to vessels in other global regions, discussing the rapid changes that are now underway on an international scale. The analysis in Chapter 2 focuses on commercial and U.S. military vessels, including military supply vessels. Although recreational and fishing vessels also pose potential invasion risks, biosecurity guidelines and regulations are largely undeveloped for these vessels at the present time.

Chapter 3 reviews what is known about the current and projected future flux (number) of vessels arriving to Guam and Micronesia, as well as the magnitude of vessels moving between this region and Hawai'i. We focus particular attention on commercial and military vessels, evaluating what is known about the previous ports of call, since these are the potential source regions of species transfers. We also summarize available information across all types of vessels and other in-water structures and equipment which may transport organisms. In some cases, there are significant gaps in knowledge regarding vessels, in-water equipment, and various other equipment types. These information gaps are identified and discussed.

Live trade as a possible vector for non-native species introductions to Micronesia is addressed in Chapter 4, providing information available on (a) existing regulations and practices and (b) current activities, and (c) anticipated future activities.

A risk assessment for marine invasions associated with vessels is presented in Chapter 5. This uses information from several different areas, including: (a) a detailed analysis of shipping traffic for commercial and U.S. Navy vessels (specifically Navy supply ships, as data from combatant ships were not made available), indicating the connectivity to various geographic regions; and (b) a list of some of the non-native marine species known to occur in these various geographic source regions. These data are combined to assess the opportunity for transferring species with a known invasion history from areas of known occurrence, thereby posing some invasion risk to Guam, other jurisdictions of Micronesia, and Hawai'i. The analysis focuses solely on biofouling organisms, or those species that are known to occur as biofoulers on the hulls and underwater surfaces of vessels, and does not distinguish between biofoulers originating from tropical regions (which have a higher likelihood of establishment in Micronesia and Hawai'i) versus biofoulers from temperate and colder waters (which have a lower risk of establishment). Moreover, only species that have been reported thus far to be invasive were considered. A similar analysis of biofouling for other vessel types (i.e., fishing vessels, recreational vessels, and barges) was not undertaken; neither were environmental parameters accounted for in the risk assessments. Also omitted were analyses of other important vectors such as ballast water and the live trade. Such analyses were deemed to be not yet possible, due to lack of sufficient data on geographic sources and fluxes, as discussed in Chapter 3.

One of the challenges in conducting a risk assessment is to identify the potential hazards or impacts associated with invasions. As an extension of Chapter 5, a small pilot study was conducted to explore what is now known about values in Micronesia and possible implications for risk analyses. This is presented in Appendix B and begins to characterize the environment, economic, social and cultural core values that people in these locations hold and how they perceive that introduced species will affect these values.

Chapter 6 presents a biosecurity plan for Guam, Commonwealth of the Northern Mariana

Islands, Palau, the Federated States of Micronesia, the Republic of the Marshall Islands, and Hawai'i. Following a brief overview of existing regional plans and programs, this chapter outlines recommendations for management practices to (a) prevent new invasions as well as (b) detect and respond to such incursions that may occur. It is evident that there are currently many gaps in meeting these recommendations for marine biosecurity in the region. Thus, beyond the practices themselves, regional coordination and capacity are discussed and must be considered explicitly to implement various elements of the biosecurity plan.

1.4 Terminology for Non-Native Species

In general, we avoid the use of the term “invasive,” because in regards to tropical marine systems it is an imprecise term that is functionally difficult to define in a robust fashion. It is important to recognize that (a) the impacts, or potential impacts, of most non-native marine species have never been evaluated (e.g., Ruiz et al. 1999, 2011a; see also Chapter 5), and (b) such impacts can vary greatly in space and time. Thus, it is currently not possible with any confidence to divide non-native marine species into those that are “invasive” and those that are not, based on impact criteria. In the absence of data, a precautionary approach would assume that most non-native species have the potential to cause harm under some circumstances. For this report, use of the term “invasive” is restricted primarily to cases where specific negative effects are perceived or recognized, and “non-native” and “invasive” are used as synonyms.

Finally, following Carlton (1996), species that occur in a specific region are considered to fall into one of three categories: native, non-native, or cryptogenic. The latter are species of uncertain origin, reflecting a poor state of knowledge about taxonomic identity and/or biogeographic origin of an organism. A large number of species in a region may be cryptogenic, as is the case with many locations with limited historical data, such as tropical marine ecosystems (Paulay et al. 2002), but is also the case in well-studied estuaries like San Francisco Bay, California (Cohen and Carlton 1995).

1.5 Vectors as Drivers of Marine Invasions

Analyses of marine invasions have frequently been conducted to assess human-mediated transport mechanisms (vectors) responsible for marine invasions, based upon life history characteristics, the time of detection, and the operation of vectors in the relevant geographic regions and temporal context. This approach has been used to assess vector strength, or the relative contribution of different vectors to the number of observed invasions, over time in specific locations (Cohen and Carlton 1995; Ruiz and Carlton 2003; Hewitt et al. 2004).

Where available, analyses of vector strength indicate that most marine invasions are attributed to the unintentional transfer of organisms by vessels (Reise et al. 1999; Ruiz et al. 2000; Fofonoff et al. 2003; Hewitt et al. 2004). While vessels have been a dominant vector on a global scale, other transfer mechanisms can also be important sources for marine invasions in some locations. Among these, the movement of live organisms for food, bait, aquaculture, or aquaria has been a common source of invasions (Cohen and Carlton 1995; Chapman et al. 2003; Weigle et al. 2005; Hewitt et al. 2007; Ruiz et al.

2011a). This intentional movement of organisms is often referred to as “live trade.” Marine invasions and spread of non-native species are also known to result from (a) movement of in-water structures, such as docks, (b) transfer of construction or restoration materials, such as sand and rock, and (c) construction of canals that connect water bodies, such as the Suez Canal and Kiel Canal (Gollasch et al. 2006).

Below, we provide a further description about movement of organisms by vessels and live trade. We highlight these two categories because they are dominant vectors for marine invasions, contributing strongly to the total number of documented invasions on regional and global scales (as above; see also Hewitt and Campbell 2010). However, we note that invasions from other vectors may have high ecological or economic impact, even if the total number of species invasions attributed to a particular vector is not great.

1.5.1 Introductions by Vessels

There are two dominant modes of transfer for marine species by vessels, excluding organisms shipped as cargo. Organisms commonly occur in the ballast materials of vessels and on hulls (and other underwater surfaces). A significant body of literature documents the occurrence of many taxonomic groups in ballast tanks and on hulls, across a wide variety of vessel types, underscoring the enormous potential for species transfer over great distances. For both ballast tanks and vessel hulls, the transfer of organisms is an unintended consequence of normal vessel operations, as discussed below. It is also evident that both modes of ship-mediated transfer have contributed strongly to invasions observed around the globe.

1.5.1.1 Ballast Water

Ballast is used by ships to maintain stability and trim. It is generally taken on in port before a ship’s departure. Prior to the 1900s, vessels used solid ballast (rocks and sand), but this has been replaced with ballast water, which may also contain sediments (Carlton 1985). A diverse array of marine organisms, from crabs and fish to bacteria and viruses, have waterborne life stages such as larvae (often microscopic) that are taken up in ballast in one region and discharged at subsequent ports of call, creating an efficient transfer mechanism for marine organisms (National Research Council 1996; 2011). For example, a single vessel can discharge > 50,000 metric tons of ballast water upon arrival, and recent estimates indicate vessels arriving from overseas to the continental U.S. alone discharge approximately 60 million metric tons of ballast water per year (Miller et al. 2011a). While there is considerable variation among vessels in the quantity of ballast discharge and its associated biota (National Research Council 2011), the cumulative effect of global ship traffic transfers large numbers of marine organisms throughout the world in ballast water, overcoming historical barriers to natural dispersal and allowing invasions to occur.

1.5.1.2 Biofouling.

Many marine organisms colonize hard substrata during part of their life cycle, including rock, coral, wood, metal, and many other materials. Vessels and maritime structures provide such substrata, which are utilized by a wide diversity of micro- and macro-organisms (Visscher 1927; Woods Hole Oceanographic Institution 1952; Haderlie 1984).

Many of these organisms live attached to the underwater surfaces of structures; these sessile species can include algae, barnacles, protists, oysters, mussels, coral, sponges, tunicates, bryozoans, and tube-building worms. In addition, mobile fauna such as snails, crabs, and fish can occupy (a) the structure created by attached species as well as (b) “niche areas” of the vessel (such as intakes and areas around propellers, rudders, and other in-water structures) that provide protection from high flow environments on the exposed hull surfaces. Some organisms, such as shipworms and particular isopods, burrow into wooden structures when available. Throughout this document, we refer to species associated with the underwater surfaces of vessels, whether mobile or sessile (fixed to a particular location) as “biofouling organisms.”

Movement of any in-water structure creates a potential opportunity to transfer associated biofouling organisms. Attached organisms can release gametes, larvae, or various types of spores upon arrival; some organisms may be able to spread via fragmentation; and mobile animals can simply crawl or swim away.

Despite existing hull husbandry practices to reduce undesirable effects of biofouling on vessel speed and performance (as described in Chapter 2), it is evident that extensive numbers of organisms are still transferred on vessels’ hulls, resulting in new invasions (Skerman 1960; Godwin 2004; Sylvester et al. 2011). Among vessel types there is a high degree of variation in the magnitude and diversity of associated biofouling organisms (Carlton and Hodder 1995; Ferreira et al. 2006; Davidson et al. 2008; Davidson et al. 2010). However, in contrast to ballast water usage, which is restricted to particular types of vessels, biofouling organisms can occur on any type of surface vessel (commercial, fishing, military, recreational, barge; see above), submarine (Voight et al 2012), or in-water structure. Another important distinction is that vessels are exposed continuously to colonization and release of biofouling organisms at each port of call, cumulatively through time between dry-dock and thorough cleaning, whereas ballast water uptake and discharge is much more episodic and limited in space and time (Miller et al. 2011a).

1.5.2 Introductions Resulting From Live Trade

The trade in live marine organisms and their release into the environment has historically been one of the top pathways for the introduction and establishment of non-native marine species. Live organisms are often moved intentionally among biogeographic regions for use as aquaculture species, bait, food, scientific research, and pets (aquaria). Importantly, live organisms are also moved unintentionally by humans, as a type of accidental “by-catch.” Such unintentional transfers can result when biota are associated with (a) target species that are moved for commercial purpose (as above) or (b) packing materials or processes used in transfer of live species and other goods (e.g. ice chests). These unintentional transfers include a remarkably diverse range of taxonomic groups, from free-living organisms (such as macro-invertebrates and fishes) to those that occur attached or within organisms (such as microorganisms, including parasites and pathogens).

It is evident that live trade has been a potent source of invasions in some regions (e.g. Cohen and Carlton 1995), but it also has received less attention than vessels as a source of marine invasions, especially in terms of the current magnitude and geographic variation in such species transfers. Moreover, while the transfer of species poses some risk of release

and establishment, not all transfers result in release. For example, many organisms moved for consumption or for pets (aquaria) may not be released to the wild, although a subset of these are released or escape. Despite some uncertainty about various dimensions of live trade, past invasions have resulted from such species transfers, regardless of whether release is intended or not. Below, we provide further background information for selected components of live trade.

1.5.2.1 Aquaculture.

Among the unwanted consequences of importation of aquaculture species is the establishment of exotic pests, pathogens and predators (Culver and Kuris 2004; Moreno et al. 2006; McKindsey et al. 2007; Naylor et al. 2010) that become problematic for cultured and native species. Eldredge (1994) reviewed species introduced both intentionally and unintentionally to the Pacific Islands via aquaculture. From giant clam aquaculture alone, seven bacteria and bacterial diseases, four parasites, and three protozoans and protozoan diseases are known to have been introduced to various locations in Asia and the Pacific (Humphrey 1988). One of the best-known examples of an accidentally imported disease is shrimp virus IHNV (infectious hypodermal and hematopoietic necrosis virus), which was accidentally introduced to Tahiti, Guam, and Hawai'i and causes stunted growth and mortality in shrimp. Aquaculture species themselves can become problematic if they escape from pens, tanks, and marine cages, or in the case of organisms planted directly into the environment, when they reproduce or spread out of control. For example, several algal species (including *Kappaphycus striatum*, *Gracilaria salicornia*, and *Hypnea musciformis*) were introduced to Hawai'ian waters for aquaculture purposes and have since become pest species, overgrowing coral, outcompeting native algae and ruining beaches for human enjoyment by washing up in huge drift piles (Preskitt et al. 2001; Smith et al. 2004; Nelson et al. 2009; Vermeij 2009).

Although many of the species transferred for marine culture are actively managed in pens or selected areas, stocking also occurs. This has been most common with fishes in low salinity habitats (see Cohen et al. 2005). For example, tilapia (*Oreochromis mossambicus*, *Oreochromis* hybrids, and *Tilapia zilli*, native to Africa,) were brought into the Micronesia region for aquaculture and mosquito-control purposes, have become established in the region, and have been the target of eradication efforts on Palau and Nauru (Nelson and Eldredge 1991; Nico and Walsh 2011). However, there are also examples of stocking to create marine invertebrate fisheries, such as the king crab introduction in Russia; this has created a large population of the introduced crab that is spreading in Scandinavia, creating some concerns about ecological and fisheries impacts (Jørgensen and Nilssen 2011). In the Pacific, there have been introductions of hatchery-raised giant clams (tridacnids) to many overharvested and non-native localities. These seeding efforts have sometimes been associated with the introductions of some diseases, parasites, and gastropod predators, most notably the predatory snail *Cymatium muricinum* (reviewed in Eldredge 1994). Since the 1920s, *Trochus niloticus* has also been brought in to many localities outside its native range (including the Marianas, Chuuk, Kosrae, Pohnpei) in order to create new fisheries for trochus shell (Eldredge 1994). More recently, the sandfish (*Holothuria scabra*) has been introduced to Kiribati from Fiji and to New Caledonia from Wallis.

1.5.2.2 Live Food Trade.

Marine organisms imported live for food can become established if they a) accidentally escape from holding tanks or pens or b) are “planted” in the environment, either for short-term use or to establish local populations. This is perhaps best illustrated by the massive transfer of oysters to California in the late 19th and early 20th centuries, from eastern North America and Asia (Carlton 1979; Miller et al. 2007). This resulted in the unintentional transfer of many other associated organisms, including a diverse range of taxonomic groups (e.g., bacteria, protists, crustaceans, gastropods, and bryozoans) that were present in and on the oysters, and over 80 non-native species established in California may have arrived by oyster importation (Ruiz et al. 2011b). Other examples of established non-native species associated with live food trade on the U.S. West Coast include several brackish water species (that use both freshwater and marine environments): the Chinese mitten crab (*Eriocheir sinensis*), the crayfish *Procambarus clarkii*, and the clam *Corbicula fluminea* (Cohen and Carlton 1995).

Transfers of organisms for food have resulted in introductions in other parts of the U.S. and globally. This has been documented for some transfers of shellfish, including oysters, mussels, lobsters, and crabs (Wolff and Reise 2002; Chapman et al. 2003, Jørstad et al. 2007; Miller et al. 2007; Fofonoff et al. 2009). In addition, the recent arrival of the northern snakehead (*Channa argus*) to eastern North America is attributed to its importation for food and subsequent release (Orrel and Weigt 2005). It is noteworthy that snakehead fishes and mitten crabs, both attributed to live food trade as a mechanism of introduction, are now listed as “injurious wildlife” in the U.S. under the federal Lacey Act, prohibiting future importation and interstate movement (Thomas et al. 2009; Miller 2011).

1.5.2.3. Pet/Aquarium Trade.

The release of species associated with the aquarium trade represents a significant vector for introductions of non-native aquatic and marine organisms (Ruiz et al. 1997). In the mainland U.S., 150 species that have invaded natural ecosystems have been transferred via aquarium and ornamental culture trade (Padilla and Williams 2004). In some cases, release from aquaria is accidental (through public aquarium outflows, escapes from tanks/pens during storms, etc.), but in others, pets and plants are released into local waters by aquarists who no longer want them. In contrast to transfer via shipping in which organisms are released into only a few locations (mainly ports), aquarium plants and animals are widely distributed into homes and businesses, and thus potentially may be released into a wider distribution of natural habitats, including coral reef habitats (e.g., Semmens et al. 2004). Non-native species linked to the aquarium trade include intentionally traded species and species transported accidentally with these and aquarium components such as live rock (Bolton and Graham 2006; Minchin 2007; Duggan 2010). Generally speaking, organisms imported intentionally for the aquarium trade are often hardy species (i.e., able to withstand stress of transport and a relatively wide range of environmental conditions), and those that survive transport are hardy individuals, increasing the potential for survival upon release.

Two high-profile examples of marine invasions associated with the aquarium and pet trade are the alga *Caulerpa taxifolia* and the Indo-Pacific lionfish (*Pterois* spp.). The alga, which now carpets vast swaths of the Mediterranean Sea, outcompetes native algae and sea grasses, apparently causing major changes in habitat and food sources for many native

organisms (Meinesz and Hesse 1991; Bellan-Santini et al. 1996). This species was also detected in California and was the focus of an intensive and successful eradication effort (Anderson 2005). *Caulerpa taxifolia* is also invasive in New South Wales, Australia, where control and eradication efforts are ongoing (Creese et al. 2004). The lionfish, a popular aquarium fish, is now established in the Caribbean and Western Atlantic, where it appears to be altering reef fish community structure through predation (Whitfield et al. 2002; Albins and Hixon. 2009).

1.5.2.4. Bait.

Imported bait, including algal packing materials and associated organisms, is often discarded into the environment, providing another transfer mechanism for marine introductions (Weigle et al. 2005). Available studies indicate a large volume (number) of bait shipments occur in some regions, and these shipments can include a diverse assemblage of associated non-target species (Passarelli et al. 2010; Haska et al. 2011). As with live food imports, associated organisms found in bait shipments range from macrofauna to microorganisms, including parasites and pathogens (Pernet et al. 2008; Haska et al. 2011). Moreover, several recent invasions may have resulted from bait transfers, such as colonization of western North America by the knotted wrack (*Ascophyllum nodosum*), the common periwinkle (*Littorina littorea*), and the green crab (*Carcinus maenas*), which originated from the North Atlantic coast (Miller et al. 2004).

1.5.2.5. Scientific Research.

Some marine organisms are imported for research and teaching purposes, presenting a potential opportunity for release of non-native species to local environments. While this can occur, relatively few invasions have been attributed to this mechanism in existing analyses for multiple global regions (Cohen and Carlton 1995; Hewitt et al. 1999; Fofonoff et al. 2009; Minchin and Gollasch 2002; Siguan 2002).

1.6 Distribution of Marine Invasions across Habitat Types

In marine ecosystems, most known invasions are reported from within protected bays and estuaries, with relatively few non-native species documented along exposed coasts or in deep water (Carlton 1979; Ruiz et al. 1997; Wasson et al. 2005; Preisler et al. 2009). While this does not imply that offshore waters are immune to invasions, the observed pattern indicates that bays are hotspots for invasion. This is likely driven, at least in part, by (a) the relatively high concentration of shipping and other activities that deliver organisms to port systems as centers of human commerce and (b) the relatively prolonged time periods that vessels spend stationary in ports.

Within bays and estuaries, a large proportion of non-native species is associated with artificial hard substrata, such as pilings, docks, and seawalls (Cohen and Carlton 1995; Wasson et al. 2005; Glasby et al. 2007; Ruiz et al. 2009). It is not clear what factors generate this pattern. It is thought that the presence of artificial substrata may facilitate establishment of non-native populations, providing a beachhead for colonization and possible spread to surrounding areas. One implication of this is that construction in ports and harbors (which usually include use or creation of man-made structures such as pilings

and walls) may increase the probability of invasions, independent of propagule supply.

Despite this general pattern of association with artificial substrata and protected waters, marine invasions do indeed occur on natural substrata (e.g., rock, cobble, and reefs) and in outer coastal waters. This is illustrated by *Didemnum vexillum*, a colonial tunicate that has covered extensive offshore areas of seafloor in the Georges Bank of eastern North America (Bullard et al. 2007; Valentine et al. 2007). Additional examples are also documented in tropical ecosystems such as Hawai'i (see Section 1.7.1). Thus, it is not surprising to see that outer coastal waters are susceptible to invasions, even at considerable depths, given a supply of non-native organisms with suitable characteristics.

1.7 Geographical Patterns of Marine Invasions

Invasions have occurred commonly in coastal marine habitats during recent time. Hundreds of non-native marine species are known to be established in many well-studied regions throughout the world, such as Australia (Hewitt and Campbell 2010), the Mediterranean Sea (Galil 2009), the continental U.S. (Ruiz et al. 2000; 2011a), and Hawai'i (Carlton and Eldredge 2009). It is clear that some non-native marine species are having significant ecological, economic, and human-health impacts (Carlton 2001). Importantly, a comprehensive estimate of marine invasion impacts is not available for any global region, because (a) many invasions are undetected (Carlton 1996; Ruiz et al. 2000) and (b) effects of most invasions have not been studied and remain difficult to predict (Ruiz et al. 1999; 2011b).

For marine ecosystems, most of the invasions to date have been detected in temperate latitudes, compared to polar or tropical regions (Hewitt 2002; Ruiz and Hewitt 2009; Ruiz et al. 2009). A similar pattern has been reported for some taxonomic groups in terrestrial habitats, where the number of established non-native species increases from high to subtropical latitudes followed by a precipitous decline in the tropics (Sax 2001). This pattern may reflect historical differences across latitudes in (a) the amount of research on biological invasions, (b) understanding of species biogeography and (c) the level of organism transfer, or propagule supply. Although not well quantified, the level of research and economic activity (trade and transportation which transfers organisms) is concentrated at mid-latitudes. In addition, it is also possible that tropical and polar regions are relatively more resistant to invasions, due to either environmental or biological conditions.

Despite the dominance of information about temperate invasions, it is evident that marine invasions do occur in tropical marine systems. This is illustrated by the introduction and rapid spread of the lionfish in the Caribbean basin (Guerrero et al. 2008; United States Geological Survey 2011). Lionfish, native to the Indo-Pacific, have invaded the U.S. coast from Florida to Rhode Island, and several Caribbean locations. These aggressive predators have reduced the abundance of native fishes on coral reefs (Albins and Hixon 2009) and mangrove habitats (Barbour et al. 2010) and are the target of management efforts. Yet, to date, few studies have begun to explore the extent to which tropical marine invasions are occurring relative to those in mid-latitudes. Hawai'i is exceptional in this regard, and some background data also exist in Guam, as outlined below.

1.7.1 Marine Invasions in Hawai'i

Carlton and Eldredge (2009) compiled a comprehensive monograph of introduced and cryptogenic marine species from the Hawai'ian Islands, which includes species of protists, fungi, invertebrates, fish, algae, and flowering plants. They reviewed 490 species, including (a) 301 species considered to be established non-natives and (b) 117 species classified as established cryptogenic species (of uncertain biogeographic origin). The remaining 72 species were non-native but either not established or not known to be established.

Crustaceans, insects, mollusks, and ascidians were among the most speciose taxonomic groups in this analysis. Indo-Pacific species comprised the largest portion at 46%; Western Atlantic species represented 22% and species from the Eastern Pacific made up 7%. The origin of 34% was unknown, but most likely was Indo-West Pacific or Western Atlantic.

For these documented invasions in Hawai'i, 70% were classified as introductions attributable to shipping (including either ballast water or biofouling, or both), and 15% were attributed to intentional and accidental releases. Only 11 species were considered introduced prior to 1900. Over 290 species are thought to have been introduced in the early 20th century, although many may have been transported earlier. Intentional releases occurred during two phases: (a) between 1895 and 1939, when 10 species were introduced, and (b) between 1950 and 1974, when 17 species were released. Intentional introductions appear to have ceased after 1974. Overall, the greatest number of introductions was detected in the mid-20th century and more recently, through numerous harbor and shoreline surveys and collections.

Remarkably, of the 301 introduced species considered, only six have been studied for impacts at the community or ecosystem level. Some of the major studies have been carried out on the snapper *Lutjanus kasmira* (ta'ape), the sponge *Mycale grandis*, the barnacle *Chthamalus proteus*, the octocoral *Carijoa riisei* (snowflake coral), and the algae *Kappaphycus* sp. and *Acanthophora spicifera*. The Caribbean mangrove *Rhizophora mangle* has become a particularly conspicuous species that is undergoing rapid spread in Hawai'i.

Among reported impacts in Hawai'i, several non-native species of marine algae, introduced for aquaculture purposes, are now overgrowing coral reefs and crowding out native algae (e.g., Smith et al. 2004; Vermeij et al. 2009; Carlton and Eldredge 2009); the non-native octocoral *Carijoa riisei* threatens the black coral fishery down to depths of 120 m (Grigg 2003); an Australian sponge, *Mycale grandis*, overgrows and kills corals (Coles and Bolick 2007); community structure of native reef fishes is likely affected by *Cephalopholis argus*, an introduced piscivorous grouper (Dierking et al. 2009); competition for shelter with the introduced snapper *Lutjanus kasmira* may make native goatfish more vulnerable to predation (Shumacher and Parrish 2005); and non-native tilapia are considered a serious threat to native aquatic plants (K. Peyton, University of Hawai'i, personal communication 2009).

A handful of these species have become the target of management efforts, including hand removal by volunteers, a massive pier wrapping project in a Maui harbor, the use of a "super sucker" which can be used to vacuum algae off the reef (The Nature Conservancy

2012), and experimental-scale biological control, but eradication has not yet been successful. Costs for marine invasive-species management in Hawai'i exceed millions of U.S. dollars (A. Montgomery, Hawai'i Department of Land and Natural Resources, personal communication).

1.7.2 Marine Invasions in Guam and Micronesia

Humans have transported many marine organisms to Guam and other parts of Micronesia over time. Some non-native species have successfully colonized and are documented for the region, but the full extent of marine invasions is much more difficult to determine as no comprehensive study of the marine invasive species of Micronesia currently exists.

Micronesia as a whole lies within the planet's greatest region of marine biodiversity, the coral reef region of the Indo-West Pacific (Vermeij 1978; Paulay 2003; Kingsford et al. 2009). The natural marine habitats of Micronesia are extremely diverse, ranging from the rocky shores of volcanic islands to coral reefs, mangroves, estuaries of small rivers, the lagoons of atolls, and many other habitats. In addition, many new habitats have been created by human activities, especially with the addition of artificial structures to create ports and harbors.

For Micronesia, the biota associated with many of these habitats has not been well characterized, especially given the high diversity and areal extent of the region. A recent series of surveys documented 5,640 species from the Mariana Islands, including some non-indigenous species (Paulay et al. 2002; Paulay 2003). However, even where surveys exist, recognizing introduced species is a major challenge in the face of this high native diversity and the relatively recent onset of marine biological studies in relation to the long history of human activity in the region.

A variety of criteria are used for recognition of non-native species including: (1) lack of previous known occurrence in a region, (2) recent range expansion, (3) association with likely vectors of introduction, (4) association with known invaders, (5) strong association with artificial substrata or human-disturbed habitats, (6) restricted local distribution, (7) disjunctive global distribution, (8) poor adaptation for long-range natural dispersal, and (9) exotic evolutionary origin (Chapman and Carlton 1994). The high diversity of the region means that many native species remain to be discovered, so that criteria 1 and 2 are difficult to apply. Micronesia is close enough to a major region of biodiversity that Criterion 7 is more difficult to apply than in such isolated island regions as Hawai'i or New Zealand.

Many marine organisms known to occur in Guam and other islands are widely distributed in both the Atlantic and Pacific oceans, but have not previously been treated as introductions anywhere. Some of these are probably undiscovered introductions, others represent species complexes, and others may be organisms which have not diverged enough to become distinct species since the closure of the ocean basins (Vermeij 1978; Lambert 2002; Lessios 2008). Criterion 5 may be a stronger indicator of native status, but native species may also show similar traits, for example some native species with fossil records on Guam are restricted to Apra Harbor, and frequently occur on artificial substrata.

Using a combination of the above criteria, Paulay et al. (2002) identified 21 non-native marine species as established in Guam waters and an additional 21 non-native species as recorded for the area but not known to have established populations. In a review of available recent literature, using similar methods, 33 non-native marine species that are considered to be established in Micronesia as a whole can be readily identified, including nine species in Palau, 25 in Guam, five in the Commonwealth of the Northern Marianas Islands (CNMI), five in the Federated States of Micronesia (FSM), one in Kiribati, and six in the Republic of the Marshall Islands (RMI). An additional 23 non-native marine species have been reported for the region, but to date it is not known whether or not these species have established populations. A more recent and comprehensive analysis is presented in Chapter 5, reporting the occurrence of additional non-native species in Micronesia.

These documented non-native species occurrences represent gross underestimates of the number of invasions in Micronesia, for several reasons. First, many important groups of organisms, including copepods, amphipods, isopods, mysids, marine insects, and bryozoans have not been well studied in Micronesia. In the Hawai'ian Islands, where these taxa have been better-studied, these five groups alone contained 68 non-native species (Carlton and Eldredge 2009). Second, the biota for many regions of Micronesia has simply not been sampled. Third, where surveys exist for particular groups and locations, these are not comprehensive inventories of all species present but instead an analysis of a subset of the total species pool. The combination of high biodiversity and limited taxonomic effort means that much of the biota in the region is unidentified. Moreover, the difficult taxonomy and biogeography of many of the identified species means that a large fraction of the biota deserves cryptogenic status, and can neither be designated as native or introduced (Carlton 1996; Paulay et al. 2002).

The known established marine invaders in Guam and elsewhere in Micronesia are dominated by sessile organisms that occur on hard substrata (18 of 25 species for Guam and 25 of 33 for all of Micronesia). Cnidarians (six hydrozoans, one anemone) and tunicates (nine species) are the most numerous non-native taxa in Micronesia. Motile taxa are represented by the crab *Metopograpsus oceanicus*, two gastropods (*Trochus niloticus* and *Tathirella iredalei*), and five fish species. All of the fishes identified in the present review are capable of inhabiting freshwater and marine (or at least brackish) habitats (this, however, does not include three species of non-native marine fishes reported from Apra Harbor by Smith et al. 2009). The majority of non-native marine species in Micronesia (18 of 33) are species of uncertain geographic origin, but very broad ranges in multiple oceans, with cryptogenic ranges in the Atlantic, Indian, and Pacific Oceans. At least 20 of the 33 species introduced to Micronesia have also been introduced to the Hawai'ian Islands (Carlton and Eldredge 2009).

Most of the detected non-native species for Micronesia (16 of 33 species) are attributed to ship biofouling as a possible vector, but seven of these species (including hydrozoans and barnacles) have planktonic life stages and could have been transported either by fouling or ballast water. One notable fouling introduction was the hydroid *Eudendrium carneum*, native to the Western Atlantic, and introduced to Palau in July 1997 when a floating bridge was brought to Palau from Guangzhou City, China (Shine et al. 2003). Three species were introduced by fisheries activities -- the mother-of-pearl snail (*Trochus niloticus*, also referred to in the region as the topsnail) and the peacock bass (*Cichla ocellaris*) were

deliberately stocked (Maciolek 1984; Smith 1987; Eldredge 1994; Lever 1996), while the parasitic snail *Tathrella iredalei* was introduced with giant clams (*Tridacna* sp.) via aquaculture (Eldredge 1994). The western mosquitofish (*Gambusia affinis*) was widely stocked in freshwater and brackish water for mosquito control on many islands (Krumholz 1948; Maciolek 1984; Lever 1996). The tilapias *Oreochromis mossambicus* (Mozambique tilapia and hybrids) and redbelly tilapia (*Tilapia zilli*) were both stocked in Guam reservoirs for control of aquatic weeds, but *O. mossambicus* was also widely introduced to many islands for aquaculture and as bait for tuna (Maciolek 1980; Lever 1996). It is unclear how the sailfin molly (*Poecilia latipinna*) was introduced to Guam; it may have been an aquarium release, intended for insect biocontrol, or as a baitfish (Maciolek 1984; Lever 1996).

The 23 additional non-native species that are documented without established populations add to our knowledge of the vectors which are active in the region. Perhaps most instructive is analysis of a floating dry-dock, the *Machinist*, which was towed from Hawai'i to Guam, having been positioned in the Philippines prior to its existence in Hawai'i. At the start of its voyage, 113 species were identified on its hull, and at least 42 species were identified soon after arrival in Apra Harbor. At least 12 species were considered definite introductions to Guam. However, many of these organisms survived the voyage in poor condition, so their ability to colonize Guam waters is uncertain (Paulay et al. 2002). At least two species of fishes (*Neopomacentrus violascens* and *Omobranchus elongatus*), each represented by single specimens, were found associated with ship hulls in Apra Harbor (Eldredge 1994; Paulay et al. 2002). These could have been transported in ballast water, in sea-chests (openings on the outer hulls of vessels for water intake), or on slow-moving structures such as dry-docks.

At least 12 marine species have been introduced for aquaculture, of which 10 have failed to survive or reproduce, or are apparently confined to aquaculture facilities. Four species of shrimp are, or have been cultured on Guam, starting in 1978. One of these, the catadromous *Macrobrachium rosenbergii*, escaped into rivers on Guam when dams burst during a typhoon in 1992, but its establishment in the wild is unknown and does not appear to have been studied (Eldredge 1994). Three species of edible oysters (the Pacific oyster, *Crassostrea gigas*; the spiny rock oyster, *Saccostrea echinata*; and the Philippines rock oyster, *Saccostrea mordax*) have been stocked in Guam and Palau, but failed to reproduce (Eldredge 1994). In the 1930s, Japanese pearl companies stocked waters in the Marshall Islands, Palau, and Christmas Island, Kiribati, with the non-native pearl oysters *Pinctada fucata martensi* and *P. maxima*, but these operations were abandoned during World War II, and the oysters are not known to have become established (Eldredge 1994). A notable freshwater introduction, the chevron snakehead (*Channa striata*), escaped from fish farms in the 1970s, and is established in the Ajayan River drainage on Guam. Attempts at eradication are underway (Nico and Walsh 2011).

In summary, the available data demonstrate that marine invasions are occurring in Micronesia associated with the known transport mechanisms that are driving invasions throughout the world. Most invasions reported for Micronesia to date are known from Guam and have been associated with shipping. However, it is critically important to recognize that the extent of marine invasions to the region (a) has not been estimated formally or quantitatively and (b) is certain to far exceed the documented number of non-

native species to date, as with many other regions (Cohen and Carlton 1995; Carlton and Eldredge 2009). The ecological, economic, and social impacts of marine invasions are not well-known in Micronesia, in part because so few invaders have been identified, and in part because the known non-native species have not been carefully studied (for further discussion see Shine et al. 2003; Marino et al. 2008; Appendix A).

Chapter 2: Overview of Current Regulations, Guidelines, and Practices Related to Ship-Mediated Marine Bioinvasions

By Chela.J. Zabin, Gregory M. Ruiz, Gail V. Ashton, and Ian C. Davidson

2.1 Introduction

Historically, ships have played a dominant role in the transfer of non-native marine species, leading to biological invasions throughout the world, as outlined in Chapter 1. Although the issue of marine invasions has received significant attention in recent time, the rate of reported invasions has increased in the past few decades, and this increase has been driven largely by shipping (Cohen and Carlton 1998; Hewitt et al. 2004; Ruiz et al. 2000; 2011b). In response, numerous regulations, agreements, and guidelines have emerged to reduce the likelihood of species invasions at national, regional and international levels (see recent review by Hewitt et al. 2009a). It is important to also note that these existing frameworks are undergoing rapid changes, which aim to further limit the transfer of organisms.

In general, and within the specific context of the Buildup, U.S. Executive Order 13112 on Invasive Species (signed by President Clinton in 1999) directs U.S. federal agencies to: "... not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The Executive Order applies to all activities of federal agencies and also establishes the U.S. National Invasive Species Council (NISC), to coordinate actions to prevent and control non-native species throughout the U.S. federal government. Toward this end, NISC has developed a National Invasive Species Management Plan and implemented a formal framework of interagency and advisory meetings to limit the extent and impact of biological invasions.

In addition to the overarching framework outlined in Executive Order 13112 for the U.S., there are also some specific regulations and guidelines to limit species transfers by ships (including ballast water and hull biofouling) , but to date these guidelines are either not comprehensive or are not currently established (such as the IMO hull fouling guidelines). These guidelines exist primarily at national and international levels. It is also noteworthy that different requirements and practices exist for commercial versus military vessels.

This chapter provides a review of current regulations, guidelines, and practices for management of ballast water and hull biofouling. We focus on commercial and military vessels, examining differences in the way in which ballast water and biofouling are managed for these vessel types. Throughout, we consider these management practices in the explicit context of Guam, the Commonwealth of the Northern Mariana Islands, Palau, the Federated States of Micronesia, and the Republic of the Marshall Islands.

2.2 Ballast Water

2.2.1 Regulations and Guidelines

2.2.1.1 Commercial Vessels.

At a national level, U.S. federal regulations exist currently for ballast water management and discharge by commercial vessels arriving to U.S. ports. The federal regulations governing ballast discharge in the U.S. were issued by the USCG (United States Coast Guard 2004), and more recently by the EPA (United States Environmental Protection Agency 2008; see National Research Council 2011 for review). At the present time, the regulations by these two agencies are similar. Both require commercial vessels arriving to U.S. ports from beyond the exclusive economic zone (EEZ) to treat ballast water of coastal origin (i.e., taken up within 200 nautical miles (nmi) of shore) prior to discharge in U.S. waters. In general, discharging vessels arriving from overseas are required to treat their ballast water by (a) use of open ocean ballast water exchange (i.e., flushing out tanks in open ocean, > 200 nmi from shore) or (b) an alternative technology that is approved for use (of which there currently are none). In addition, the EPA regulations also apply to some coastwise (domestic) vessel traffic along the western U.S.

Under the USCG regulations, commercial vessels (whether arriving from a foreign or a domestic port) are also required to submit a detailed report to the USCG on the origin, treatment, and volume of discharges. These reports are submitted for each arrival event to evaluate compliance and changes in ballast water management over time. Vessels out of compliance with regulations are subject to criminal prosecution and financial penalty (United States Coast Guard 2004).

The aim of current U.S. federal regulations is to reduce the concentration of coastal organisms delivered in discharged ballast water that pose a risk of invasion to subsequent ports of call and coastal waters of the U.S. During ballast water exchange, coastal organisms are replaced with oceanic organisms. In general, it is considered unlikely for coastal organisms to survive in the open ocean (or to reach coastal habitats if discharged at sea), or for oceanic organisms to colonize coastal regions, due to their respective habitat requirements. While ballast water exchange provides a significant reduction of coastal organisms delivered in ballast water (Minton et al. 2005; Ruiz and Reid 2009; Bailey et al. 2011), some residual coastal organisms are still present following this treatment, and, critically, there are logistical constraints that prohibit its application for some routes and conditions (Miller et al. 2011a). For these reasons, there is significant momentum to replace ballast water exchange with treatment technologies, which (a) can be used on most vessels and routes and (b) achieve lower concentrations of organisms in ballast discharge than possible with ballast water exchange (National Research Council 2011).

New regulations are now being advanced by U.S. federal agencies for ballast water to meet specific discharge standards which are lower than organism concentrations often achieved by ballast water exchange. This is reflected in a Notice of Proposed Rulemaking (United States Coast Guard 2009) issued by USCG, which is required to regulate ballast water under the Nonindigenous Aquatic Nuisance Species Prevention and Control Act of 1990

(updated by the National Invasive Species Act of 1996). This rule has just cleared administrative review, and a Final Rule is scheduled for publication in March 2012; this is expected to result in new requirements (regulations), but the specific details and timetable are not yet available publicly. Similar regulations to require specific discharge standards are also under consideration at the EPA (United States Environmental Protection Agency 2011), which is required to regulate ballast water discharge under the Clean Water Act of 1972 (see National Research Council 2011 for review of recent requirement to regulate ballast water under this law).

Requirements for ballast water treatment are also being advanced at the international level by the International Maritime Organization (IMO). The International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted in 2004, establishing ballast water management requirements for commercial shipping on a global scale. The IMO convention will slowly phase out ballast water exchange, replacing it with treatment technologies to achieve specific discharge standards (International Maritime Organization 2004). The IMO discharge standards are the same ones that have recently¹ been proposed by USCG¹ and the EPA.

The IMO Convention is awaiting ratification and is not yet in force. The Convention requires ratification by at least 30 countries accounting for 35% of the world's merchant shipping. As of February 2012, it had been approved by 33 countries that represent 26% of the global fleet (International Maritime Organization 2012).

Although not directly relevant to Micronesia, it is also perhaps useful to note that several individual state regulations exist for ballast water discharge in the U.S. (e.g. California, Oregon, Washington and Michigan; see National Research Council 2011 for

¹ The Final Rule was issued by USCG and published in the Federal Register after completion of this report. For specific details see: Standards for living organisms in ships' ballast water discharged into U.S. waters, Federal Register, Volume 77, Number 57, March 23, 2012¹

discussion). These state regulations do not replace federal regulations, but instead impose additional requirements on commercial vessels. In some cases, the state regulations result in more stringent discharge standards and have created additional requirements for treatment of coastwise vessel traffic among U.S. ports. Some of these state requirements are also written into (included) in current, existing federal regulations from the EPA.

In considering the geographic scope of this report, USCG and EPA regulations apply to commercial vessels arriving to Guam, Commonwealth of Northern Mariana Islands (CNMI), and Hawai'i. Thus, vessels arriving to each of these jurisdictions are presently required to either (a) retain ballast water, (b) undergo open ocean ballast exchange (at 200 nmi from shore), or (c) use an alternative ballast water treatment technology that is approved by USCG. As noted above, the requirements for ballast water treatment are likely to change to concentration-based discharge standards, which are pending at both the U.S. federal and international levels.

For the rest of Micronesia, there are no other countrywide or regional regulations that specifically address ballast water management and discharge by commercial operators. On a local scale, ballast water discharge is not allowed within 12 nmi of the Port of Saipan, per port regulations (Commonwealth Ports Authority Regulations Private Use of Harbor Property and Facilities 3.26b). In Palau, although there are no regulations specifically addressing ballast water, it is thought that discharges can be regulated as non-point discharge under the Environmental Protection Act 24 PNC. In several other parts of Micronesia, officials suggested that agencies regulating water quality already may have the legal authority to control deballasting. Moreover, it was widely recognized throughout Micronesia that the pending IMO standards would apply to arriving vessels, when they come into force. Palau, the FSM and the RMI each have pending biosecurity bills that would, among many other topics, address ballast water management.

One aspect not currently being considered in the management of ballast water in the region is the proximity of the Mariana Islands to the West Mariana Ridge (WMR). While none of the volcanic peaks of the WMR quite reach sea level, 11 summits have depths of less than 500 m, of which three seamounts (including Stingray Shoal) are 16 m or less in depth (Gardner 2010). The WMR is well within the 200 nmi allowable zone for ballast water exchange. Of equally great concern are a number of shallow banks west of Guam and the Marianas that are only about ~22 nmi or less from the main island chain. These shoals are potential landing sites for invasive species flushed from ballast. As such, "open ocean" ballast water discharge is not the ideal solution for the Marianas, and alternative technologies should be explored.

2.2.1.2 U.S. Navy Vessels

Although military vessels are exempted from the above regulations, there are separate requirements that exist for the U.S. Navy. Specifically, when U.S. Navy ships take on ballast water within 3 nmi of shore (or in areas that are potentially polluted), they are instructed to exchange ballast water outside the 12 nmi zone from shore before next entry (Section 22-10.3.1, Environmental and Natural Resources Manual 2007; OPNAVINST 5090.1C, updated July 18 2011). U.S. Navy ships are instructed to pump out and twice fill tanks with clean seawater outside the 12 nmi mark, and to do this exchange even when

deballasting has happened before exiting the 3 nmi mark (or polluted waters) to remove any contaminated residual ballast water. The ships' engineers are instructed to record in ships' engineering logs such ballasting and ballast exchange, including the location and amount of water taken on (Section 22-10.3.2, Environmental and Natural Resources Manual 2007).

Based on current policy, two key differences exist in regulations for U.S. Navy vessels compared to commercial vessels. First, for U.S. Navy vessels, the required distance from shore for source of ballast water (3 nmi) or ballast water exchange (12 nmi) is much less than that for commercial ships (200 nmi). Second, we are not aware of a reporting requirement or analysis for U.S. Navy vessels, in which compliance with these requirements has been evaluated (see Section 2.2.2). In addition, we note that regulations for commercial vessels are rapidly moving toward a requirement for alternative treatment technologies with specific discharge standards, and we are not aware of similar efforts to develop such requirements for U.S. Navy vessels.

By having ballast water sources (including ballast water exchange) closer to shore, the likelihood of transfer of coastal organisms by U.S. Navy vessels to a suitable habitat is increased per unit ballast water volume relative to commercial vessels that conduct exchange in the open ocean (see Chapter 3 for comparison of traffic and ballast discharge between these vessel types). With increasing proximity to any particular shore, the concentration of coastal organisms is expected to increase, and the probability that organisms can reach coastal habitats by currents should also increase. For both attributes, the specific decay functions with distance from shore will vary geographically and temporally. Nonetheless, it is certain that coastal organisms occur in many regions at 3- 12 nmi from shore. It is partly for this reason that greater distances were required for ballast water exchange by commercial vessels (Brickman 2006; Miller et al. 2011a). Moreover, there is evidence that ballast water exchange closer to shore does entrain coastal organisms, which can be discharged at subsequent ports of call (Endresen et al. 2004; Cordell et al. 2009; Simkanin et al. 2009).

It is worth reiterating that the 12 nmi stipulated by the U.S. Navy for ballast water exchange may lead to ballast water being flushed in close proximity to shallow shoals only 22 nmi from the main island arc of the Marianas, as well as to the West Marianas Ridge approximately 100 nmi from the islands. These shoals and seamounts could become areas for alien coastal species to settle and invade.

A recent study aboard U.S. Navy supply vessels (oilers) along the eastern U.S. found a high efficacy for ballast water exchange, when conducted properly (Ruiz and Smith 2011). Experimental tests found that double ballast water exchange removed 99% of the original water and up to 99% of selected coastal organisms, compared to untreated control tanks on the same vessels. While comparable or better than similar tests on commercial vessels (Ruiz et al. 2005; Bailey et al. 2011), it also appears that concomitant entrainment of new coastal organisms occurred with this nearshore ballast water exchange, as perhaps expected (see above discussion). Thus, ships that undergo nearshore ballast water exchange can have residual coastal organisms from a previous source (albeit with severely reduced concentrations compared to pre-exchange conditions) as well as additional coastal organisms that are entrained during the nearshore exchange process.

Based on available information for both commercial and U.S. Navy vessels (Minton et al. 2005; Holm et al. 2005; Levings et al. 2004; Cordell et al. 2009; Ruiz and Smith 2011), it is apparent that the current ballast water management practices on the Navy vessels will often not allow them to meet the concentration-based discharge standards for zooplankton that are being advanced for commercial vessels by the U.S. and IMO (see above). These new standards are more stringent than ballast water exchange, at least for zooplankton concentrations (Minton et al. 2005), requiring fewer than 10 organisms (≥ 50 microns in size) per cubic meter. Importantly, this standard applies to total concentrations and does not distinguish between coastal and oceanic organisms. Thus, even if all coastal organisms could be replaced by the process of ballast water exchange (which does not occur), the entrainment of new organisms from nearshore or oceanic waters would frequently cause exchanged ballast water to exceed discharge standards.

Although the U.S. Navy is exempted from the discharge standards now being proposed for commercial vessels by the USCG, EPA, and IMO, all military vessels do fall under the jurisdiction for Section 312(n) of the Clean Water Act, which requires establishment of Uniform National Discharge Standards (UNDS). More specifically, Section 312(n) of the Clean Water Act requires the DoD and EPA to determine which discharges from military vessels require control and to set standards for environmental protection. While ballast water was identified previously as a discharge that required control by UNDS (United States Environmental Protection Agency 1999), no specific guidance or standard has been provided to date for this discharge.

Another area of concern is the risk of invasive species being transported to Micronesia and Hawai'i by foreign military vessels of partnering countries (e.g., Singapore, Philippines, Japan, Australia, etc.) that will arrive in the area to partake of training and joint exercises with the U.S. military. The routes and anticipated frequency of such foreign military vessel visits, as well as the ballast water guidelines these vessels are expected to follow, will need to be clarified.

2.2.1.3 Military Sealift Command Vessels

Supply vessels for the U.S. Navy operate under the Military Sealift Command (MSC). Some supply vessels are owned and operated by the MSC, representing a subset of U.S. Navy-owned vessels. However, additional supply vessels are privately owned or operated, under contract to the MSC. This latter group is distinctly different from other commercial vessels, which may transport cargo but are not under MSC orders.

Vessels that are owned or operated by the MSC are governed by the same environmental instruction as U.S. Navy vessels. However, ships that are operated by civilians under contract to the MSC are not subject to the Navy's regulations and are thus not obligated to carry out any of the Navy guidelines for environmental stewardship. It appears regulations for commercial vessels would apply in the latter case, but it is not clear (a) the extent to which these vessels operate with this understanding and (b) what management practices are used routinely on these vessels (see below for additional details).

2.2.1.4 Other Military Vessels

Vessels operated by the U.S. military (including Army, Navy, Marine Corps, Air Force, MSC, and USCG) are all exempt from U.S. regulations that exist for commercial vessels, as outlined above. While ballast water on all military vessels falls under the jurisdiction of UNDS, no ballast discharge standards have been advanced under UNDS to date for these vessels (United States Environmental Protection Agency 1999). Aside from the ballast management requirements in place for U.S. Navy vessels (above), we were unable to identify similar policies or requirements for other branches of the military or for military vessels of other countries when operating in U.S. waters.

2.2.2 Current Practices, Operating Procedures and Compliance

2.2.2.1 Commercial Vessels

A considerable amount of information is available on ballast water management for commercial vessels arriving to U.S. ports, because the USCG has established a reporting and analysis mechanism through the National Ballast Information Clearinghouse (NBIC). As noted above, commercial vessels are required to submit a report on ballast water management and discharge upon arrival to U.S. ports, and these data are used by NBIC to characterize status and trends in ballast water compliance and management (for more detail see <http://invasions.si.edu/nbic/>).

For the two-year period 2006-2007, NBIC received over 200,000 ballast water reporting forms that were submitted by ships' personnel or agents for arriving vessels (Miller et al. 2011b). Using an independent data set, it was estimated that 83.5% of overseas arrivals and 77.8% of coastwise arrivals (from another domestic port in the contiguous U.S.) were in compliance with the reporting requirements that exist. Most (76.9%) of these commercial arrivals reported no ballast water discharge. The remainder reported a cumulative discharge of >390 million metric tons of ballast water over the two-year period, including 111 million tons from overseas sources and 280 million tons from domestic sources. For the overseas ballast water, 81.7% of the total volume had reportedly undergone some type of treatment (ballast water exchange) prior to discharge, whereas 18.3% was not treated before release into U.S. waters. Under current USCG regulations, a similar requirement for treatment of ballast water from domestic sources (by coastwise traffic) does not exist; however, recent regulations by the EPA, and also those for a subset of States, do require ballast water treatment for some domestic sources (United States Environmental Protection Agency 2008; National Research Council 2011).

Miller et al. (2011b) estimated that ballast water reports were submitted by 62.6% of overseas arrivals to Guam and 73.7% to Hawai'i for 2006-2007. These compliance rates were below the national average (83.5%). A recent examination of NBIC reporting data, for the five-year period of 2005-2009, suggested that reporting compliance for arrivals to Guam and Hawai'i remains at approximately this level (<http://invasions.si.edu/nbic/>). For this five-year period, overseas arrivals reported discharge of 358,496 metric tons of ballast water to Guam, and an estimated 15.5% of this volume was reported to be untreated (i.e., did not undergo ballast water exchange). This represents a minimum estimate, given the low reporting compliance for Guam, which does not include roughly one third of the commercial vessel arrivals (see Chapter 3 for additional information on ballast water movement within Micronesia, and between Micronesia and Hawai'i).

Overall, Guam and Hawai'i have a relatively low number of vessel arrivals, representing 0.9% and 2.5% of the total vessel traffic reported for the entire U.S. in 2005-2006 (Miller et al. 2011b). Moreover, these regions accounted for an even lower percentage of the total reported volume of ballast discharge, reflecting the fact that these regions are net importers, with the exception of some transshipping operations. Commercial ships tend to arrive loaded with cargo and leave with less than they came with. Thus, the need for deballasting is likely to be lower in the region than in many other port locations; instead, Hawai'i and Micronesia are likely net exporters of ballast water (Godwin and Eldredge 2001). Despite the low relative volumes, ballast water discharges into these regions create opportunities for species transfer, and ballast uptake in these regions increases the probability of spread both within and outside of each region.

Much less information is available about ballast water management in other parts of Micronesia. In most locations in the region, management officials told us they depended on ships and shipping agents to be aware of existing regulations and to follow them. However, we note that few regulations exist currently. In the FSM, legal code allows for the inspection of ballast by agricultural quarantine inspectors (FSM Code, Title 22, 410); in most locations, it appears that environmental protection or environmental quality agencies also have the authority to regulate ballast water. As far as we were able to determine, none of the jurisdictions in the region check the records of arriving vessels to evaluate the extent of ballast water management and discharge.

While IMO discharge standards appear likely to come into force in the near future, requiring ballast water management throughout Micronesia, understanding the current and future ballast water practices will require increased capacity. Outside of the ballast- water reporting program described above for the U.S. jurisdictions, based on extensive interviews and correspondence with port officials throughout Micronesia, it appears there are no programs with such a focus in the region. Thus, evaluating ballast management in Micronesia would require personnel and training, which are not currently available. Further, it is noteworthy that existing programs throughout the world have primarily served to compile self-reported data from ships' personnel, with little effort to implement tests that verify whether ballast water exchange was conducted properly (but see Noble et al. 2010), which would require some additional development and training.

2.2.2.2 Military Vessels

In contrast to commercial vessels operating in Guam and other U.S. waters, relatively little information is accessible to evaluate current practices for U.S. military vessels, which are not required to submit reports to the USCG. While the U.S. Navy has a specific requirement to conduct ballast water exchange and record ballast water management in the ships' engineering logs, as noted above (Section 22-10.3.1, Environmental and Natural Resources Manual 2007; OPNAVINST 5090.1C), we are unaware of any effort to synthesize, analyze, or evaluate data on implementation of the Navy's ballast water management program. Instead, it is our understanding that existing data remain distributed across individual ships' logs and are not readily accessible. As a result, it appears there are no summary statistics available to characterize (a) the extent of compliance with OPNAVINST 5090.1C, (b) locations of ballast water sources, exchange and discharge, or

(c) volumes of ballast water discharged to Micronesia, Hawai'i, or other locations.

A small amount of information is available on supply vessels that operate under the MSC; because some of these vessels submitted ballast water data to the USCG through NBIC (see above for description). From 2005 to 2009, 77 MSC arrivals to Guam reported to NBIC, representing < 20% of the total estimated arrivals to Guam for this period (for commercial and MSC vessels combined; see Chapter 3). These MSC vessels reported

7,408 metric tons of ballast water discharged in Guam, and 15.2% of the total volume had not been treated by ballast water exchange. This accounts for 2% of the cumulative ballast water discharge reported to NBIC for Guam during this time period, and the percentage of untreated discharge is similar to that reported for commercial vessels to Guam (15.5%). However, with such a low proportion of the MSC arrivals included, it is premature to draw any conclusions about the relative contribution or nature of ballast water management by MSC vessels. Equally important, the volume of ballast discharge is not a good proxy for concentration of organisms or the probability of invasion (see National Research Council 2011 for discussion of this issue).

Beyond such records for MSC vessels, no other information was available to us to evaluate ballast water management and discharge of other Navy or other military vessels arriving to Micronesia or Hawai'i.

Some U.S. Navy vessels, such as surface combatants, have compensated fuel stowage systems, which are also subject to Navy regulation (Section 22-10.3.3, Environmental and Natural Resources Manual 2007). These regulations require vessels to record seawater intake occurring in potentially polluted areas or within 3 nmi of shore during routine internal fuel transfer for propulsion plant operation (but do not require ballast water exchange). Most fuel operations are reported to occur away from ports, possibly restricting uptake and transfer of coastal organisms. However, we have no access to information on the location of operations, volumes of water involved, or biota (types and concentrations) associated with this water arriving to Guam or any other region.

In addition, amphibious vessels are instructed to wash down any amphibious vehicles they are recovering (as well as anchors, anchor chains, and other shipboard equipment) and to dispose of wash water 12 nmi outside of the next operating area. This is outlined in Section 22-10.3.4 of the Environmental and Natural Resources Manual (2007). We have no information on the frequency or locations of this activity, or the biota that may be associated.

2.3 Biofouling

2.3.1 Regulations and Guidelines

2.3.1.1 Commercial Vessels

Biofouling is probably the most important vector of invasive species introductions. Biofoulers may account for up to 55% of marine pests globally, while in Australia over 60% of the known introduced species have most likely arrived as biofouling (Hewitt and

Campbell 2010). Despite this, the requirements surrounding biofouling on vessels are less advanced with respect to biosecurity than those for ballast water discharges. Existing requirements that apply to hull husbandry are motivated primarily by international vessel classification societies for insurance purposes (Takata et al. 2006), operational performance, and efficiency of the vessel, instead of prevention of species transfers and biological invasions. There are currently no international requirements that aim specifically to manage biofouling and associated invasion risks by commercial, military, or recreational vessels. Nor are there such requirements specific to Guam or the rest of Micronesia. However, the IMO has recently agreed to guidelines for biofouling with this goal (see below), and regulations are advancing for several specific regions around the globe.

For the U.S., existing requirements for hull husbandry focus on safety and operations. The USCG requires most large commercial vessels that operate in U.S. waters to be inspected at least 2 times every 5 years, with 3 years as the maximum interval between inspections. Newer vessels can qualify for underwater inspections under certain circumstances under the USCG regulations, and other vessel types are exempt. Although it appears that the USCG may have the authority to regulate the extent of biofouling as well (Hewitt et al. 2009a), this has not resulted in any specific regulations or requirements to date. None of the countries or states in the Micronesian region has additional regulations or guidelines for the management of biofouling.

In contrast, several regional or state regulations are emerging that seek to limit biofouling transfers and the likelihood of invasions. Strict regulations exist for vessels applying for permits to enter (as opposed to passing through) the Papahānaumokuākea National Monument, Northwestern Hawaiʻian Islands (Papahānaumokuākea Marine National Monument Best Management Practices No. 011, 2009), whereby the vessels must meet specific standards indicating clean hulls. However, these regulations do not apply to vessels transiting through the monument nor do they apply to other areas of Hawaiʻi. In addition, the State of California is in the process of enacting regulations for control of biofouling on commercial vessels arriving to ports within the state (http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Laws_Regulations.html).

On a global basis, several countries already have voluntary guidelines for management and have developed very detailed recommended management practices. For example, New Zealand has released draft regulations requiring all vessels entering territorial water to be free of biofouling (Ministry of Agriculture and Forestry 2010).² Australia has released draft antifouling and in-water cleaning guidelines for all vessels and other moveable structures in aquatic environments (Department of Agriculture, Fisheries and Forestry 2011), and was, at the time of this report, accepting public comment on whether to adopt voluntary or mandatory regulations³. Most recently, the IMO has adopted guidelines for management practices to reduce invasion risk associated with biofouling of commercial vessels (International Marine Organization 2010).

2.3.1.2 Military Vessels

For U.S. Navy vessels, there is an established schedule for inspection, and the level (both type and extent) of biofouling is used to determine the need for cleaning, dry-docking and application of coatings (Naval Ships Technical Manual (NSTM) 2006). The NSTM Chapter 081 lists criteria for frequency of hull inspection and in-water cleaning (i.e., removal of biofouling organisms), including a fouling rating system on which to base maintenance, information on tools to clean hulls underwater, a decision tree for other actions based on coating condition and rust, and limited information on underwater paint systems for U.S. Navy ships.

² New Zealand was slated to release mandatory regulations for commercial and recreational vessels in 2012, but had not done so at press time. Further information on these regulations and enforcement is available at <http://www.biosecurity.govt.nz/enter/ships>.

³ Further information on Australia's biofouling regulations is available at <http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds/marine-pests/biofouling>

As specified in NSTM 081, cleanings of ablative coatings (paints that work by slowly eroding, exposing new layers of anti-fouling compounds at the surface) are not done until 24 to 36 months after application, as the anti-fouling paint is expected to work well until then. Underwater paintings and coatings are expected to require no cleaning during the first year or two of service. Following this initial high-performing period, hulls may be cleaned as often as required to maintain fouling below acceptable levels. Acceptable is defined as: not above a one-knot speed penalty at shaft revolutions per minute (rpm) for standard sea-speed, not over a fuel usage penalty of 5% to attain standard sea-speed, or not to exceed fouling rating limits outlined in NSTM 081. Though heavy fouling and hard calcareous fouling in particular is to be avoided, full hull in-water cleanings are not expected to occur more frequently than every six months, even with tired coatings in high fouling bioregions. At present, dry-dock intervals for U.S. Navy ships range between five and twelve years, the upper limit far exceeding that for commercial vessels.

Beyond the hull itself, specific underwater fixtures require the use of specialized husbandry protocols, as outlined in NSTM 081. Vessels intended for “silence” (submarines) have specialized hull husbandry protocols intended to maintain that feature. This may include sheathing of certain features while in port. On all ships, sonar equipment, propulsion equipment in general (including bow-thrusters and emergency propulsion units), and the bow area receive priority attention, and may be cleaned much more frequently than the entire hull. Propellers, which are not painted with anti-fouling paints, foul more quickly than painted areas. In general, these are expected to be cleaned quarterly, although practices vary depending on operations. The NSTM also mentions that sea-chests commonly require hand tools for cleaning.

The UNDS, established under the Clean Water Act of 1996, has identified hull coating leachate and underwater ship (hull) husbandry as discharges requiring control for DoD vessels (United States Environmental Protection Agency 1999). Reports that characterize the nature of these discharges indicate that there is the potential for transport of non-native species associated with the hulls of vessels and also vessel cleaning, but the reports did not identify analyses that characterized the transfer of organisms on DoD vessels or the associated biosecurity risks (<http://unds.bah.com/Nod/uwshphub.pdf>).

The U.S. Navy has sustained a long-term program that records data and maintains information on the extent and type of biofouling organisms present on Navy vessels, following protocols outlined in NSTM 081. Based on interviews with U.S. Navy personnel, it is our understanding that a routine schedule of in-water inspections and associated data (for biofouling) are maintained for all Navy-owned vessels. Existing analyses of these data to examine the potential for non-native species transfers with the U.S. Navy vessels could not be found.

Vessels that are privately owned and operated under the MSC appear to not be subject to similar requirements for inspections, records, and maintenance as outlined above for U.S. Navy-owned vessels. Navy personnel indicated that most such vessels under contract to MSC do not follow the U.S. Navy protocols for biofouling and operate instead under guidelines for commercial vessels, as discussed above.

Aside from the Navy, it is not clear if any specific regulations, requirements, or policies

may exist for biofouling associated with other types of U.S. military vessels. Inquiries to DoD and associated research did not identify any existing policy in this regard.

2.3.1.3 Other Vessels and In-Water Structures

Any in-water structure or platform such as a floating dry-dock that is allowed to accumulate marine organisms has the potential to transfer non-native species when moved to another location. Although most recent efforts to evaluate and prevent marine invasion outcomes have focused on large vessels, small recreational craft and other in-water structures (such as drilling rigs and dry-docks; see below) can be potent sources of invasions. Indeed, even if these represent low frequency arrivals to a region, they can be sources of high-density inocula, especially because they may have high port residence times, slow travel speeds, and highly variable maintenance practices (see Section 2.3.2 for discussion).

For example, transportation of a decommissioned vessel (e.g., for scrap metal breaking or an artificial reef) may transfer large biofouling assemblages because the vessels have often been laid-up in port for long periods of time with little to no hull husbandry and are then towed slowly to another destination. These two attributes allow for extensive colonization of the outer hull by organisms and facilitate transfer and survival under low shear forces (Davidson et al. 2008). A similar situation exists for floating dry-docks, mobile drilling platforms, floating docks, pontoons, navigation buoys, and fish aggregating devices (FADs), which operate often with high residence times and slow transport speeds. Indeed, although the literature on stochastic and high-density biofouling transfer events is limited, there are examples of such vessels and structures arriving to Hawai'i and Guam (Doty 1961; Brock et al. 1999; deFelice 1999; Godwin and Eldredge 2001). Floating FADs have also occasionally arrived at Saipan and Tinian waters within the past decade, concomitant with the increased use of that fishing technology in the Central and Western Pacific region.

Considering this more broadly, the transfer of any in-water material has some probability of transferring associated organisms, if present. Although this section focuses attention on vessels as a transfer mechanism for biofouling organisms, the same concept applies to the transfer of other materials as well, including port infrastructure (caissons, seawalls, rip-rap materials, sand), construction equipment (dredges and barges), scuba diving gear, and other equipment. This broader range of transfer mechanisms is outside the scope of the current chapter but will be revisited in the Biosecurity Plan (Chapter 6).

To our knowledge, there are currently no regulations or guidelines in Micronesia that address biofouling and invasion risks associated with the movement of these types of vessels, structures, and platforms, however both the FSM and RMI are in the process of developing biosecurity bills that will address these issues. Inquiries to DoD and review of available documents did not identify any such regulations or guidelines.

2.3.2 Current Practices, Operating Procedures and Compliance

2.3.2.1 Commercial Vessels

There are strong incentives to reduce biofouling on vessels, as it reduces streamlining of vessels and thus increases the drag, resulting in higher fuel consumption and longer transit times. Fouling on propellers, rudders and intake pipes can also interfere with functionality. To reduce biofouling, vessels are cleaned in dry-dock, often at set time intervals, and antifouling or foul-release coatings (paints) are applied to prevent the settlement or accumulation of marine organisms on boat hulls. Painted surfaces are also cleaned in water to remove biofouling organisms that accumulate between dry-docking intervals.

Several factors are known to influence the extent and species richness of fouling communities on underwater surfaces of ships, including age and type of coatings, route, speed, and frequency of operation (including port residence times). New vessels tend to have relatively low biofouling levels, due to several attributes, such as (a) complete coating of underwater surfaces with intact paint surfaces, (b) relatively high performance of new coatings, and (c) a paint type that is selected to be appropriate for the intended function (route and tempo) of the vessel, which can change over the approximate 30-year lifespan of the vessel. In general, the performance of coatings to prevent biofouling deteriorates with age, requiring routine cleaning and reapplication (Visscher 1927; Haderlie 1984; Schultz et al. 2011).

Controlling for other factors, short residence times in port and fast traveling speeds reduce the likelihood of an extensive fouling community on the exposed hull surfaces (Coutts and Taylor 2004; Davidson et al. 2009; Floerl and Coutts 2009; Sylvester and MacIsaac 2009). Floerl and Coutts (2009) also noted the “potential ramifications on the human-mediated spread of non-native marine species from commercial vessels being moored stationary for extended period of time due to the economic crisis. Vessels which visit a diverse or extreme range of environments (e.g., freshwater of the Panama Canal, warm water tropical ports, freshwater and cold water high-latitude ports), exceeding environmental tolerances of many biofouling organisms, are likely to be less prone to biofouling accumulation than vessels which remain within a narrow environmental range (Visscher 1927; Skerman 1960; Coutts and Taylor 2004, Davidson et al 2006). In addition, “niche” areas, or those protected from laminar flow (i.e., crevices), appear to be more susceptible to hull fouling (Coutts and Taylor 2004; Davidson et al. 2009). Thus, a vessel with low surface complexity will likely be cleaner than a vessel with complex and numerous niche areas, independent of other influences on hull fouling.

Many, if not most, anti-fouling coatings (which operate to reduce settlement of organisms) and foul-release coatings (which operate to prevent permanent adhesion, and therefore accumulation of organisms, under shear forces) are engineered to work best when vessels are underway (Lewis 2002b). Thus, vessels that are seldom used, slow moving or poorly maintained are at high risk of being fouled. In general, vessels that are laid-up or spend long residence times in port can accumulate extensive biofouling, relative to vessels that are in continuous service or operate with shorter port residence times. Moreover, increased residence time in ports also causes niche areas, such as intakes and rudders (which are protected from shear forces while the vessel is underway), to be highly vulnerable to

fouling, even on otherwise well-maintained vessels.

Since most existing guidelines and practices to reduce biofouling are aimed at maintaining the operational safety and cost efficiency of vessels, and are not driven by reducing invasion risk, there has been little incentive to address biofouling for (a) niche areas that do not increase drag, (b) slow-moving vessels, and (c) vessels that remain stationary for long periods of time. Yet, from a biosecurity perspective, high biofouling levels in niche areas (even though a small overall proportion of underwater surface area of a ship) are thought to pose significant invasion risks. For similar reasons, the transfer of biofouling communities on vessels that are slow-moving or that have had long residence times, even if rare events, is of considerable concern.

These gaps in current biofouling management practices are now the focus of guidelines and requirements, which are still taking shape around the world. Some programs are including (a) requirements for in-water hull inspections and consistently maintained reports (logs) on hull biofouling, and, (b) specific standards on permissible levels of biofouling for operations (California State Lands Commission 2011; Department of Agriculture, Fisheries and Forestry 2011; Ministry of Agriculture and Forestry 2010).

At the current time, there are no specific requirements to manage or report biofouling associated with commercial vessels operating in Micronesia, beyond those discussed in Section 2.3.1.1 (however, regulations should be forthcoming for FSM and RMI, upon approval of their biosecurity bills). While there is considerable literature on biofouling on vessels operating throughout the world (as above), relatively little information applies to Micronesia specifically. However, Section 2.3.3 provides new data on biofouling surveys conducted during this project.

2.3.2.2 Military Vessels

All U.S. Navy vessels operating in Micronesia and elsewhere in the world are expected to have regular in-water inspections for extent and type of biofouling coverage, as specified in the NSTM 2006 and discussed previously (see Section 2.3.1.2). According to U.S. Navy personnel, most of the records (including data and photographs collected during inspections) are maintained by the U.S. Navy, and these can be especially useful for analysis of biofouling associated with these vessels (see Bendick et al. 2010; Schultz et al. 2011). Based on interviews with U.S. Navy personnel and literature searches, we were unable to identify such analysis to examine biosecurity issues associated with these vessels (see also Section 2.3.1.2).

We were not given access to these records and therefore were unable to assess either (a) the hull maintenance and cleaning schedules for U.S. Navy vessels arriving to the Micronesia region or Hawai'i or (b) the extent and diversity of biofouling organisms associated with such Navy vessels. There are at least three steps that would be needed to examine these records. First, we would need to know the name (or other unique identifier) of Navy vessels arriving to or visiting Micronesia or Hawai'i, in order to examine the associated inspections records. This request was denied, due to concerns about national security. Second, we would need to access the records themselves. While this can clearly be done (see Bendick et al. 2010), it is also our understanding that many records are not readily available or in

electronic format, requiring considerable effort (the third step).

In-water cleaning occurs in Apra Harbor, as outlined in NSTM 081 protocols, according to U.S. Navy personnel. A commercial dry-dock on Guam services MSC vessels, and U.S. Navy vessels are also sometimes dry-docked here for emergency repairs. Further details on the frequency or particular methods surrounding each aspect above were not available to us.

While existing protocols and schedules for hull biofouling management clearly apply to the surface combatants, there is some uncertainty about their application to supply vessels, barges, floating dry-docks, lighters, small craft or auxiliaries associated with U.S. Navy activities. We have discussed earlier this issue with respect to those MSC vessels that are privately owned and under contract. Other vessels with limited (local) operating distances also may not receive the same attention as surface combatants, with respect to biofouling inspection and maintenance, however we have no data on this to evaluate implementation or performance of existing protocols.

2.3.3 Survey of Biofouling on Commercial and MSC Vessels in Guam

We surveyed six MSC vessels and eight commercial vessels that were docked in Apra Harbor in summer and fall 2010. For each vessel, information concerning the hull maintenance history and voyage characteristics was collected using a questionnaire that was completed by a member of the crew. Questions included date of last dry-dock or delivery of the vessel, regular service route/destinations visited in the previous year, average speed of the vessel, and average in-port duration.

In-water surveys were conducted using SCUBA to access biofouling communities on hull surfaces and niche areas on one side (non-dock side) of each vessel. The following areas were targeted during the surveys: bulbous bow, bow thruster, bow hull surface areas, bilge keel, mid-ship hull surface areas, rudder, propeller, propeller-strut, and stern hull surface areas. In-water survey duration was approximately 60 minutes. This time was divided between the target areas described and other niche areas were sampled as encountered during the survey

Digital photographs were taken of all fouling communities encountered to assess the extent of fouling. Where fouling was present, the total abundance of attached macro-invertebrates was estimated to the nearest order of magnitude for each of the targeted survey areas; as only a portion of each vessel was surveyed, this represented a minimum estimate of abundance and also provided a standard measure for comparison across vessels. In addition, samples of invertebrates were collected and examined to assess the diversity (composition) of the biofouling community. Samples of the attached invertebrates were dislodged carefully and collected in zipped bags. A sample of each organism that appeared morphologically distinct was collected to provide an estimate of species diversity (richness) on the vessel. On return to the lab, each sample was inspected under a microscope and described using taxonomic characteristics (dead specimens were not included in this assessment).

As a coarse measure, morpho-taxa (or organisms that appeared to be different species based on morphology) were used as a conservative estimate of the total number of species.

Many species are cryptic and difficult to differentiate without in-depth (morphological and molecular) analyses and taxonomic expertise, which exceeded the scope of the current project. Furthermore, the analysis focused only on large (>1mm) invertebrates and did not include smaller organisms and algae that were present. Thus, pragmatically, morpho-taxa were used to provide a quick, first assessment for our analysis and data presentation here. Although algae are an important component for biofouling communities, these were excluded from this initial assessment, because none of the biologists involved had sufficient taxonomic expertise for this group.

2.3.3.1 Vessel Histories.

All vessels sampled had been either delivered new or dry-docked within the past four years (Table 2.1). Three of the MSC vessels were nearing the end of this dry-docking period, which suggests that they could go into dry-dock in the very near future; according to interviews, most were planning to maximize the five-year window before going into dry-dock again. Five of the commercial vessels sampled were also towards the end of this expected service window, however these vessels were all new builds (generally subsequent antifouling paint applications deteriorate more quickly) and were recently inspected by underwater survey.

Based on interviews, a stark contrast existed between MSC and commercial vessels in terms of both in-port duration and average speed (Table 2.1). Commercial vessels spent minimum time in port (less than one day) and moved quickly between locations (14-21 knots, with the exception of Comm 8 which is a locally-operating vessel on a slower schedule). However, MSC vessels spent up to and sometimes over four weeks in a single location, and did not move quickly between locations (<14 knots). Several of the MSC vessels spent >60% of their time in one location (Guam for these vessels) and tended to stay within the central Pacific region, with occasional trips further afield (Table 2.1). Commercial vessels operated on a regular route, either between the East-Central and West-Pacific (Comm 1-4), Central and West-Pacific (Comm 5-7) or in a very small area around Guam (Comm 8).

Table 2.1 Vessel characteristics from questionnaires of vessel crew. Characters considered indicative of potential for heavy fouling are highlighted in grey.

Vessel	Dry-dock (DD)/ New build (NB)	Duration in Port	Average Speed (knots)	MSC Program/ typical round-trip duration	Destinations in past 12 months/ regular route for commercial vessels
MSC 1	DD 2007	2 wks	8-14	NFAF	Pacific: SW-NW-Central
MSC 2	DD 2007	65%	14	NFAF	North Pacific: Central-West, 65% time in Guam
MSC 3*	DD 2008	3-4 wks	10-14	NFAF	Pacific: SW-NW-Central, 70% time stationary
MSC 4	DD 2010	3-4 wks	12-14	PP	Gulf of Mexico-Panama-California-Central Pacific [normally stay within 7 th Fleet]
MSC 5	DD 2007	1 wk	13	NFAF	Pacific: SW-NW-Central
MSC 6	DD 2009	3-4 wks	12	PP	Gulf of Mexico-Panama-California-Central Pacific [normally stay within 7 th Fleet]
Comm 1	NB 2007	6-12 hrs	21	35 days	North Pacific: East-Central-West
Comm 2	NB 2007	6-12 hrs	21	35 days	North Pacific: East-Central-West
Comm 3	NB 2007	6-12 hrs	21	35 days	North Pacific: East-Central-West
Comm 4	NB 2007	6-12 hrs	21	35 days	North Pacific: East-Central-West
Comm 5	NB 2007	6-12 hrs	14	21 days	North Pacific: Central-West
Comm 6	DD 2008	6-12 hrs	15	21 days	North Pacific: Central-West
Comm 7	DD 2009	6-12 hrs	14	28 days	North Pacific: Central-West
Comm 8	DD 2008	2-3 days	unknown	7 days	Local vessel, stays within 150 miles of Guam

NFAF- Naval Fleet Auxiliary Force

PP- Prepositioning Program

7th Fleet encompasses the Asia-Pacific region from the Kuril Islands to the north to Antarctica to the south, from the International Date Line to the 68th meridian.

*-MSC 3 was scheduled to be taken out of service in December 2010 and thus may not have been maintained to 'normal' standards.

2.3.3.2 Extent of biofouling.

Biofouling was detected on all 14 vessels sampled in Guam. Twelve of the vessels had greater than 10,000 organisms across various submerged locations, indicating dense aggregations of biofouling (Figures 2.1 and 2.2). The remaining two vessels had abundances of invertebrates on the order of 1,000s of organisms (Comm 1 and Comm 2). There was a distinction between MSC ships and commercial ships: MSC vessels tended to have biofouling that was at least one order of magnitude higher than commercial vessels.



Figure 2.1. Biofouling organisms on vessels arriving to Guam. Left: High percent cover of fouling organisms below the rudder. Right: Sessile species such as sponges, tunicates and hydroids, growing on a grate provide habitat for mobile species.

For hull surfaces, biofouling tended to be most abundant at stern areas compared to bow and mid-ship areas among all vessels, and hull biofouling was far more extensive on MSC ships compared to commercial vessels (Figure 2.2). The higher biofouling at stern areas of most ships is a general feature of vessel biofouling because stern hull surfaces tend to have greater protection from laminar water movement which allows greater retention of biofouling organisms. The higher levels of fouling on MSC vessels was probably due (at least in part) to operational differences among the two ship types, especially port durations (time spent stationary) and average speeds, which are expected to increase biofouling accumulation (see Section 2.3.2 for discussion).

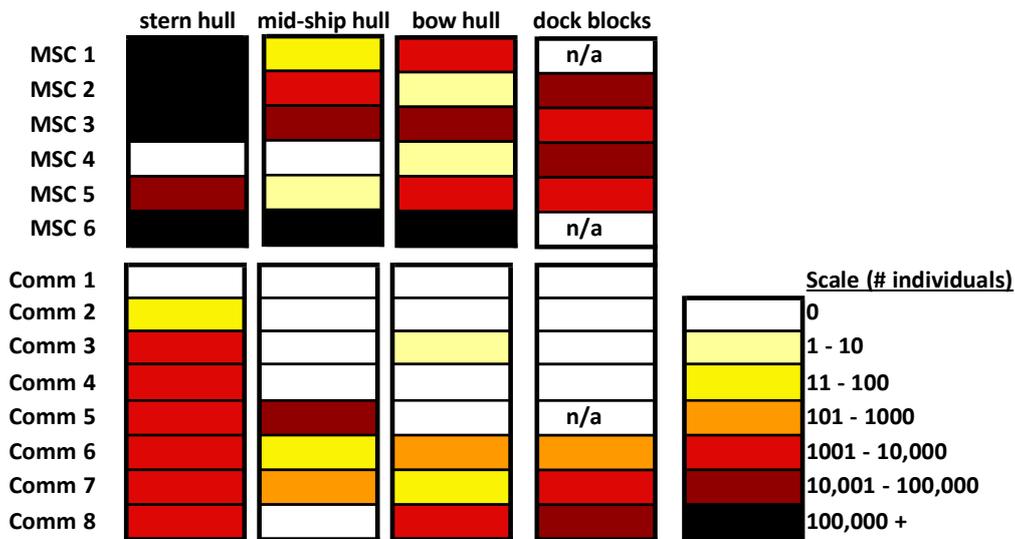


Figure 2.2. Biofouling extent on hull surfaces of 14 ships sampled in Guam. The scale of biofouling extent is color-coded to correspond with orders-of-magnitude abundances of macro-invertebrates detected for the portion of each vessel surveyed (see text). Biofouling was generally higher on stern surfaces than bow surfaces across all vessels and higher on MSC vessels (darker boxes) compared to commercial vessels.

The vessel with most fouling on hull surfaces (MSC 6) had hundreds of thousands of invertebrates at stern, midship and bow areas. This was a preposition ship, with long port residence times, but it was transient, moving among regions as distant as the Gulf of Mexico, California, and Micronesia (Table 2.1).

Four commercial vessels (Comm 1, 2, 3, and 4) had little or no biofouling on bow, midship and dock block surfaces. The major operational difference between these commercial vessels and others was that their voyage routes include trans-oceanic trips to the U.S. Pacific coast. All other commercial vessels had voyage routes within the Central- NW Pacific region.

Biofouling abundance on non-hull surfaces (vessel appendages and grates) was highly variable (Figure 2.3). The pattern of higher biofouling on MSC compared to commercial ships was most notable on propeller surfaces; most commercial vessels had zero or <10 organisms while all military ships had an order-of-magnitude higher abundance. One MSC vessel had more than 10,000 organisms on its propeller, which is unusually high for an in-service vessel. By contrast, bow thruster areas had similar high levels of fouling for both types of ship (commercial and military). Moreover, bow thrusters had the highest extent of fouling compared to other niche areas, and a majority of ships had tens to hundreds of thousands of invertebrates on thruster grates and within the thruster tube. Rudders also tended to have substantial numbers of fouling invertebrates associated with their surfaces, edges and articulations. The abundance of organisms detected on rudders was of a similar

range between commercial and military vessels.

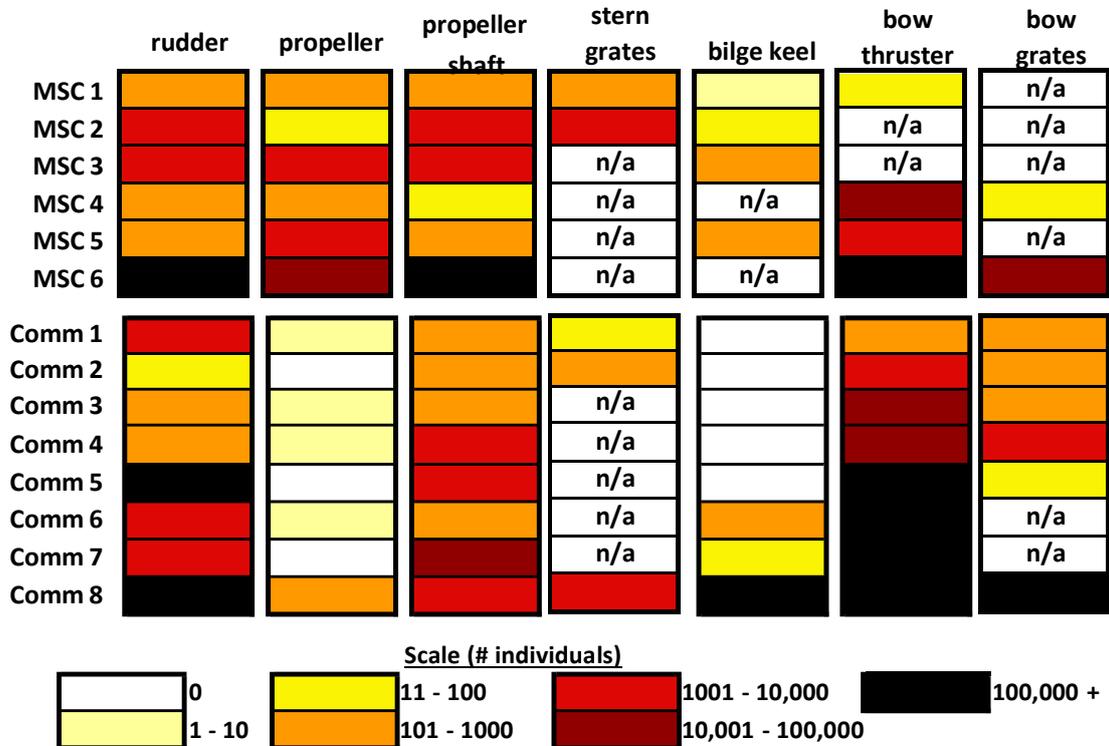


Figure 2.3. Biofouling extent on hull appendages or niche areas of 14 ships sampled in Guam. The scale of biofouling extent is the same as Figure 2.2, with white and black corresponding to zero and hundreds of thousands of organisms, respectively. Ships are listed down the side while niche area locations are listed across the top.

2.3.3.3 Biofouling composition.

The diversity of fouling organisms on both commercial and MSC vessels was high compared to previous studies (e.g., Davidson et al. 2009; Figure 2.4). Bryozoans, bivalves, tunicates and tubeworms were the most diverse groups on MSC vessels, while barnacles and bivalves were richest on commercial vessels. Various forms of algae were also encountered on all vessels, but the taxonomic diversities were not analyzed (as noted above).

The average number of morpho-taxa of invertebrates collected from MSC vessels (30) was slightly higher than for commercial vessels (27). It is noteworthy that this estimated species number was higher on both vessel types than that found in previous studies, using similar methods, on the west coast of North America (Davidson et al. 2009). MSC vessels 3, 4 and 6 each had above-average taxonomic diversities: these were the vessels which spend the most time in-port (3-4 weeks at a time). MSC vessels 4 and 6 were also both in the Prepositioning Program and generally stayed within a closer range of Guam than vessels in the Naval Fleet Auxiliary Force. Of the commercial vessels, vessels 5 and 8 had the highest numbers of morpho-taxa, which can be explained by the long duration since dry-docking for vessel 5 and narrow operating range and longer in-port duration for vessel 8.

The results also show that there was a wide variability in species diversity even when vessel histories were very similar. Commercial vessels 1-4 were operated by the same company and had very similar histories, yet the number of sessile morpho-taxa varied between 17 and 28 for these four vessels. Although not included in estimates of biofouling cover (Figures 2.2 and 2.3), which focused on sessile and sedentary invertebrates, a number of mobile species were found on the vessels, including crustaceans and mollusks (Figure 2.4), despite most of them being sampled soon after the vessel docked.

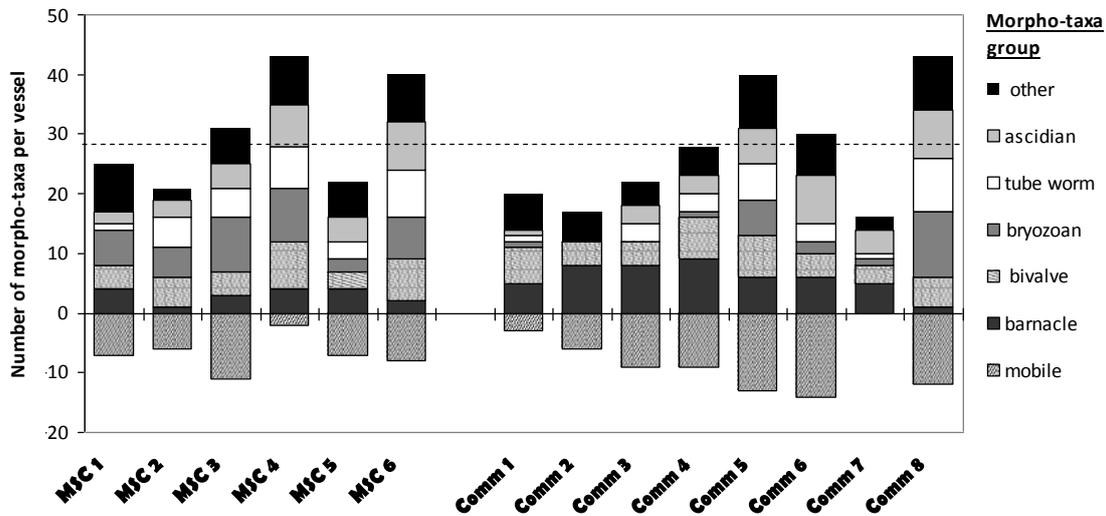


Figure 2.4. Diversity of morpho-taxa found on all surfaces of each vessel sampled during 2010. Vessels on the left are MSC and vessels on the right in the shaded portion are commercial vessels. Sessile species are accumulated above the x-axis (with the dashed line showing the mean value of 28.42 across all vessels) with mobile species shown separately below the x-axis.

2.3.3.4 Inferences for Hull-Mediated Transfers of Organisms to Guam, Hawai'i, and Micronesia.

It is evident that substantial numbers of organisms are currently associated with MSC and commercial vessels that arrive to Guam. Despite a relatively small sample size of vessels, the 2010 surveys indicated that both abundance and diversity (species number) on these Guam arrivals was often high relative to similar analyses of commercial vessels in other regions (Coutts and Taylor 2004; Davidson et al. 2009; Sylvester and MacIsaac 2009). It is also important to emphasize that these were minimum estimates for abundance and diversity, because (a) only a portion of each vessel was surveyed, (b) the analysis focused only on macro-invertebrates, excluding algae and other smaller organisms that were present, and (c) the use of morpho-taxa can only detect species with conspicuously different morphological characteristics. Further study of existing samples would certainly reveal higher taxonomic diversity (species number). Nonetheless, the current coarse-grained analysis provides a clear indication that transport of biofouling organisms to and from Guam is relatively high for these vessels on a per-capita basis.

While multiple factors may contribute to the accumulation of biofouling communities on vessels, vessel speed and port residence time probably explain (at least in part) why such dense and diverse communities occurred on many Guam arrivals (see Section 2.3.2 for discussion of mechanisms). Vessel speeds were slower for these arrivals, and port residence times longer, compared to many biofouling studies on vessels in other regions (e.g. Gollasch 2002; Davidson et al. 2009; Sylvester et al. 2011). In addition, it is also the case that most studies of vessel biofouling have occurred in temperate latitudes (Pyefinch 1950; Skerman 1960; Gollasch 2002; Sylvester et al. 2011; Godwin 2004 is an exception), and it is possible that the rates of biofouling accumulation or survival (persistence) are greater for either tropical systems or the specific routes represented. Perhaps important in this regard is that many of the surveyed vessels operate within tropical waters, and sometimes within a narrow range of ports, providing stable environmental conditions (i.e., temperatures and salinities) compared to some routes. The available data are presently insufficient to test the relative contribution of these (and other mechanisms) to the observed patterns.

While the identity and biogeography of the organisms has not yet been determined in the current analysis, it is unlikely that all fouling species encountered are native to Guam. Instead, simply based on voyage histories, the assemblages may include species that are non-native to Guam and other regions of Micronesia, and some of these species may not yet be present (established as self-sustaining populations or invasions) in the region. Further evaluation is required for these particular ship-biofouling samples, but also for the background communities in ports and harbors of Micronesia (see Chapter 6), in order to obtain robust estimates of non-native species richness on vessels and the proportion of novel species that have not yet colonized Guam or Micronesia.

2.4 Conclusions

2.4.1 Ballast Water

While ballast water management practices are advancing on a global scale to limit non-native species transfers by this vector, there are some conspicuous gaps for Micronesia and Hawai'i, including the following:

- On a broad scale, management requirements do not exist at the present time for ballast water discharged in many ports and coastal areas throughout Micronesia.
- While this will change if and when the IMO international regulations eventually come into force, most countries in Micronesia do not currently have a program or specific plan to assess compliance with these requirements.
- While the U.S. Navy has established requirements for ballast water exchange, there is uncertainty about whether these requirements apply to vessels operated under MSC; if not, and these are considered commercial vessels, a large fraction of MSC vessels that arrive to Guam appear currently to be out of compliance with USCG federal regulations.
- It is not evident whether any policies or requirements exist for DoD vessels operated by other branches of the military. Although these vessels fall under the

UNDS process, no ballast water guidelines or discharge standards have been issued under this program to date.

The U.S. Navy was quick to adopt requirements for ballast water management, which were contemporary with those implemented for commercial vessels, but there are some substantive differences between these programs. First, U.S. Navy vessels are allowed to conduct ballast water exchange much nearer to shore (3-12 nmi versus 200 nmi), which increases the likelihood of non-native coastal species transfers. Second, we are unaware of any program by the U.S. Navy to evaluate compliance with this requirement in Guam, Hawai'i, or elsewhere in the world. Third, it appears that ballast management of the commercial fleet is poised now to transition from ballast water exchange to more stringent, concentration-based discharge standards, but we are unaware of a similar transition plan for U.S. Navy vessels.

We recognize that ballast discharge volumes in Guam and Hawai'i by U.S. Navy vessels are likely to be relatively small, whether considering cumulative or per-capita volumes, but the current treatment requirements may be less protective than those for commercial vessels. As discussed above, treatment efficacy will depend on location of ballast management and other factors. Importantly, the data required for this assessment were not available to us, and it appears such an assessment has not been made.

2.4.2 Biofouling

The available data suggest that per-capita transport of biofouling organisms to Guam by commercial and MSC vessels is relatively high, creating significant opportunities to transfer species. While the current analysis has focused on arrivals to Guam, it is critical to recognize that all of these vessels have visited other regions. Thus, they may simultaneously be a source of new introductions to Guam and other ports of call, including those in Hawai'i and elsewhere in Micronesia. Moreover, native and non-native species present in Guam (a regional hub) can colonize vessels and be transferred sequentially to other ports, in a hub-and-spoke model of dispersal (see Carlton 1995). Chapter 3 further illustrates the degree of connectivity between Guam and other ports in Micronesia and Hawai'i.

It is also apparent that the management practices outlined in NSTM 081 for hull husbandry (see Section 2.3.1) are not applied to all MSC vessels, given the extent of biofouling observed on several vessels. This is perhaps not unexpected for vessels that are relatively stationary (such as preposition ships) or slow-moving supply ships, where the penalty in time and fuel are not major considerations for additional maintenance.

Obviously, the current data cannot be extrapolated to other types of U.S. Navy vessels (e.g., surface combatants), where the frequency of operations and speed differ substantially. Although the Navy conducts routine in-water surveys, as discussed previously, these data were not available for us to evaluate the extent and composition of biofouling for vessels visiting Guam. Importantly, the surveys are used primarily to sustain vessel performance, and we are unaware of an analysis of these data by the U.S. Navy to assess the opportunity for non-native species transfers to Guam or elsewhere.

Although the window of opportunity is open for hull-mediated transfers of non-native species by MSC and commercial vessels that visit Guam, it should be noted that these vessels may not be out of compliance with current regulations. It is presently unclear whether those outlined in NSTM 081 are intended to apply to all MSC vessels (i.e., privately owned or operated vessels under contract to the U.S. Navy), and husbandry requirements for commercial vessels are still largely undeveloped with respect to biosecurity (see Section 2.3.1). In addition, we are unaware of any requirements for husbandry of vessels and equipment used by DoD contractors, or for movement of decommissioned vessels by DoD; barges may be of particular concern in this regard for Micronesia, because of (a) their long residency periods and slow speeds, as discussed previously, and (b) a likely increase in barge traffic during the Buildup on Guam (see Chapter 3). Thus, the lack of a well-defined, consistent, and effective approach to hull husbandry (to limit species transfers) represents a clear gap in biosecurity, given the importance and dominant role of hull biofouling as a vector for introductions of marine species throughout the world (Chapter 1).

Chapter 3: Current and Predicted Vessel Flux and Related Activities

By Gregory M. Ruiz, Chela J. Zabin, and Mark Minton

While Chapter 2 reviewed current management practices for vessels operating in the region of interest for this report (Micronesia and Hawai'i), Chapter 3 summarizes what is known about the magnitude of vessel movements (flux) and vessel-related activities for these areas. The predominant focus is on military and commercial vessels, examining (a) the number of arrivals and (b) the direct linkage to other geographic regions. This approach provides one measure of connectivity among port systems, and the potential for movement of organisms associated with vessels. In addition to consideration of military and commercial vessels, this chapter also summarizes information for other types of vessels and vessel-related activities with relevance to species introductions.

Some of the same data presented here are used for a more detailed analysis and risk assessment for biofouling organisms, which combines vessel movement and non-native species information, in Chapter 5. The current chapter is intended to provide a broad overview of vessel movement patterns, describing both sources and constraints of available information. In this sense, Chapter 3 provides important background information and sets the stage for the subsequent analyses.

While this report attempts to consider both past activities and possible future shifts across vessel-related vectors, associated with the Buildup (construction) phase and post-Buildup phase in Guam, it is important to recognize that the latter are extrapolations as provided in previous reports. For example, projections of increased vessel traffic (arrivals) exist for Guam, both during and after Buildup. While such an increase appears inevitable for both military and commercial traffic, there is some uncertainty about the rate and magnitude of increase. Moreover, there is likely to be high uncertainty about geographic source(s) of vessel traffic for both military and commercial vessels, which will respond to dynamic strategic and financial interests respectively.

Finally, while a distinction is made throughout this chapter between military and commercial activities, it is also recognized that the magnitude of commercial activities (during and after Buildup on Guam) will be affected by the increased military activity and associated personnel. This indirect effect or feedback is inevitable, given the significant size of the military presence in Guam.

3.1 U.S. Military Vessels

There are many different types of U.S. military vessels that currently visit Guam. The following vessel types are home ported or regularly visit the DoD port in Inner Apra Harbor (Department of Defense 2009, 2010):

<u>U.S. Navy (COMNAVMARIANAS)</u>	<u>USCG</u>
SSNs/Sub Tender	225' Buoy Tender (responsible for Guam,
Logistics Prepositioned Ships	most of the Marianas, and Kwajalein)
MSC Combat Stores Ships	110' Patrol Boat
Maritime Prepositioning Ships	25' Response Boat
MSC Ammo Ships	
H60s	

Several additional U.S. Navy vessels will be home ported in Guam following the Buildup. These include: High Speed Vessels (HSVs) and a Littoral Combat Ship (LCS).

In addition to the home-ported vessels, the DoD port in Guam serves 12-14 ammunitions ships in the region, with 275 total days per year of use at its Kilo Wharf. Kilo Wharf appears to be near capacity, as Fleet and MSC vessels have been turned away due to lack of space at the wharf (Department of Defense 2009; see Volume 2).

Military vessel arrivals to Guam occur generally at the DoD port, or Naval Base Guam, which is distinct from the commercial Port of Guam. Although adjacent to each other in Apra Harbor, the military and commercial ports function largely as separate entities from the operations and record-keeping perspective.

The U.S. Navy reported 143 ship arrivals into the DoD port in 2008; 268 were reported in 2009, and 271 in the first 10 months of 2010 (Table 3.1). For 2009, the only year for which we were able to obtain data, the DoD port in Okinawa reported 175 visits of MSC traffic, and 85 days of warship traffic.

Additional vessel traffic data were provided for MSC vessels (and are presented in Section 3.3), but for the all other vessel types we have no further information on (a) the frequency with which vessels have visited Naval Base Guam, (b) their residence time in port, or (c) their specific transit histories (routes and ports of call). Although such data exist for U.S. Navy surface combatants and other vessels, these data were considered sensitive information and were not available to us.

The DoD provided lists of typical last ports of call for some of the vessel types arriving to Guam (Table 3.2). It is clear that military vessels arriving to Guam visit many ports throughout Asia and the Pacific Islands region as well as some ports in the Middle East (the latter not shown in Table 3.2). However, it is important to note that this is not a full list of vessel histories and ports visited; also excluded are any data on the frequency of port visits. Without such comprehensive data, it was not possible to evaluate the relative importance (weighting) of different ports, or the degree of connectivity to Guam for the U.S. Navy ships. Such data were only available for vessels operated under MSC, allowing for an analysis of a portion of the military ship traffic, the military supply ships.

Table 3.1 Number of ship arrivals by type reported by Naval Base Guam for Inner Apra Harbor.

Ship type	2008	2009	2010 (10 months)
CVN (aircraft carrier)	3	0	0
SSGN (nuclear-powered cruise missile submarine)	0	16	7
SSN (nuclear-powered fast attack submarine)	12	51	41
AS (submarine tender)	1	4	0
CG (guided missile cruiser)	5	3	1
DDG (guided missile destroyer)	14	23	12
FFG (guided missile frigate)	0	3	7
LCC (amphibious command ship)	0	1	7
Amphibious craft	3	5	4
Foreign	11	9	0
Research	0	7	8
NOAA	0	1	5
MSC	40	80	87
Commercial tankers	0	8	13
USCG	54	57	79
Totals	143	268	271

Military ship traffic and personnel are expected to increase as a result of the Buildup, which will also affect commercial traffic (see later sections). Based on recent interviews, the U.S. Navy projects only a modest increase in military ship traffic in Guam post- Buildup. The Navy estimates that approximately (a) 600 vessel movements per year (which includes arrivals, departures, and berth changes) are expected post-Buildup and (b) 65% of these vessel movements are expected to be transient vessels, for which Naval Base Guam is not the home port.

The U.S. Navy is proposing changes to Apra Harbor which would provide berthing capacity for an aircraft carrier. The carrier is expected to visit Guam three to four times a year, staying approximately three weeks each visit, up to a maximum of 63 cumulative days each year (Department of Defense 2010). Munitions operations that involve vessels are also projected to increase by 40 visit days to 315 per year (Department of Defense 2010).

Table 3.2 Typical last ports of call for vessels arriving to Naval Base Guam by vessel type. These are examples of ports visited but are not comprehensive, and vessels do visit additional ports.

Vessel type	Last ports of call
ACT	Philippines, Korea
ACTL (Assault troop carrier)	Kwajalein
AGOR (Oceanographic research)	Taiwan
AOR (Replenishment)	Philippines, Korea, Wake Island
ARS (salvage ship)	Saipan
AS (sub tender)	Saipan, Philippines, Hong Kong
CG (guided missile cruiser)	Japan, Philippines, Hawai'i, Korea, Malaysia
CV/CVN (aircraft carrier)	Japan, Philippines, Korea
DD/DDG (destroyers)	Australia, Japan, Philippines, Hawai'i, Korea, Thailand, Singapore
FFG (guided missile frigate)	Australia, Japan, Philippines, Hawai'i, Singapore, Palau
SSN (nuclear-powered fast attack submarine)	Saipan, Japan, Philippines

Plans for the Buildup include (a) relocation of Marine Corps assets and troops from Okinawa and (b) training exercises on the island of Tinian that involve the deployment of amphibious vehicles from Guam. Aside from what is outlined generally in the DEIS (Department of Defense 2009), we were not able to determine which, if any, specific in-water assets and vessels will be relocated from Okinawa.

With respect to training exercises on Tinian, amphibious task force visits, typically three weeks in duration, are expected to increase from two to four a year. The composition of the amphibious fleet varies with the mission, but may be up to 15 total vessels, typically including three ships carrying personnel, equipment, and the amphibious vehicles, and an escort of four surface combatant ships. Anti-submarine and strike force surface and subsurface vessels may also be included. In addition to these transient ships, the expanded harbor would house 12 AAVs (amphibious assault vehicles), two rigid hull inflatable boats and eight combat rubber raiding craft.

Of the transient ships associated with the amphibious task force, according to the FEIS (Department of Defense 2010), this fleet might travel to Guam from either Okinawa or California before deployment to Tinian, or travel directly to Tinian. More detailed information is not available for the future traffic patterns associated with the additional aircraft carrier, amphibious group, or other vessels associated with Naval Base Guam.

Aside from routine supply and training operations based in Guam and Tinian, such forecasts are undoubtedly difficult (if not impossible), given the shifting background of geopolitical and strategic interests.

3.2 Commercial Cargo Vessels

Guam and Hawai'i are major shipping hubs for commercial vessel traffic in Micronesia (Figure 3.1). Most commercial cargo entering Micronesia from the east or west goes to Guam (see also Section 3.3). Commercial cargo comes to Guam via three major trade routes: U.S. West Coast, Asia, and other foreign ports, and via transshipments within Micronesia.

Most trade routes from the U.S. Mainland to Guam also include Hawai'i. As indicated in Figure 3.1, all regular U.S. West Coast shipping lines to Micronesia stop in Hawai'i before continuing to Guam and west to Asia, returning directly back to the U.S. Mainland. In addition to these major shipping lines, Hawai'i also receives some commercial vessel traffic directly from Micronesia and the surrounding region (Godwin and Eldredge 2001).

Although most commercial vessels arriving to the region come to Guam, movement of cargo by vessels also creates connectivity throughout Micronesia, making it possible for species that occur (or colonize) in Guam to be transferred to other locations. Commercial inter-regional shipping currently follows various routes, and examples include:

1. Guam, Ebeye (RMI), Kwajalein (RMI), Majuro (RMI), Kosrae, Pohnpei (FSM), Chuuk (FSM), Guam
2. Guam, Saipan (CNMI), Yap (FSM), Koror (Palau)
3. Guam, Chuuk, Pohnpei, Kosrae, Guam
4. Guam, Saipan, Rota/Tinian (CNMI)

Although the magnitude of intra-regional transport is not great for commercial vessels, it is highly regular, as indicated here for 2009-2010. Kosrae, Pohnpei and Chuuk received usually two visits a month from Matson vessels traveling on a circuit between FSM and Guam. Port times appear to be extremely short, just a few hours in each location. Kosrae is also connected to Guam via (a) Kyowa Lines, which arrived on about a one-month interval, with some overnight stays, and (b) a fuel tanker, which arrives on a two-month interval. Regular commercial ship traffic to Chuuk also comes from Asian ports: the state received Kyowa vessels, at a rate of about two per month, from the Far East, and a fuel tanker once a month from variable locations including Guam, Majuro, Singapore, and the Solomon Islands. Yap was less directly connected to Guam, with Matson vessels coming from Palau two times a month, and one to two visits per month from Kyowa Lines coming from Hong Kong and Japan. FSM states are further connected by a government run passenger and cargo vessel based in Pohnpei (four to five times per year to Kosrae from Pohnpei) and by federal patrol boats.

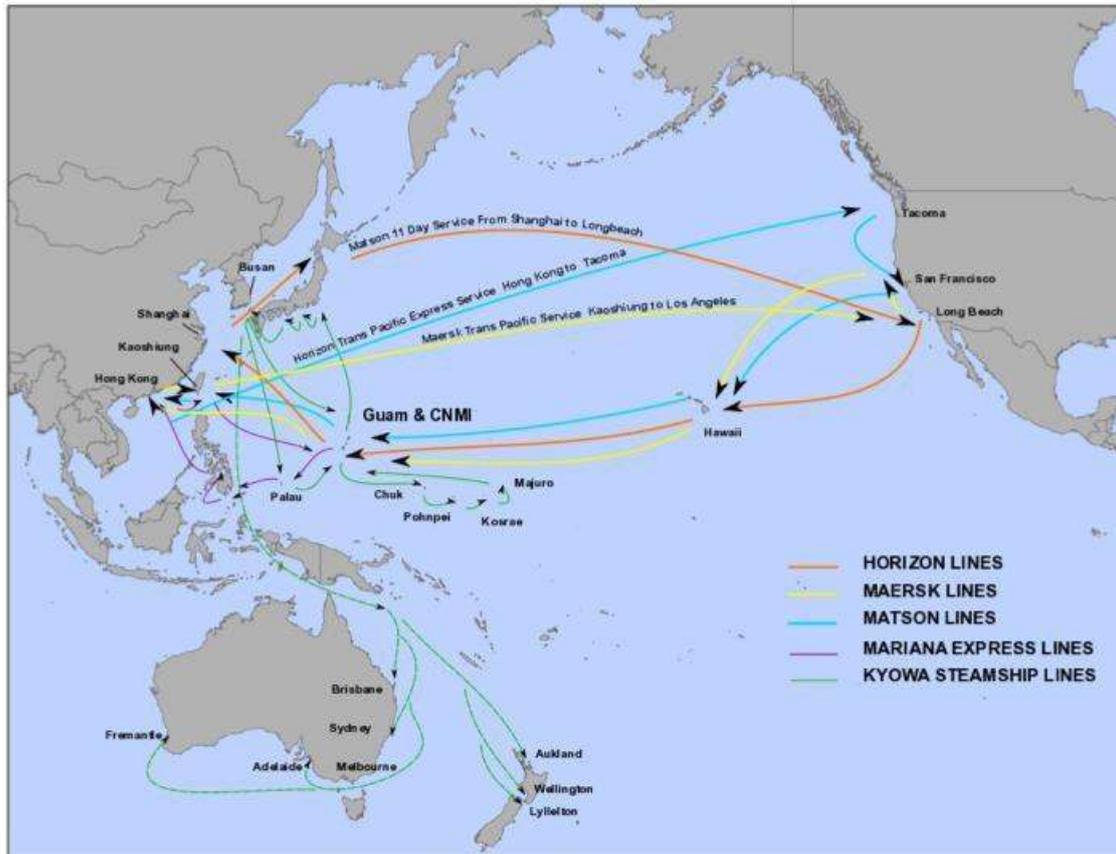


Figure 3.1. Recent commercial ship traffic routes in the region (from FEIS, Chapter 2, Figure 14.1-2; Department of Defense 2010). It is worth noting that not all jurisdictions nor ship routes appear in this image.

From a relative perspective, commercial traffic to most regions of Micronesia includes a strong linkage to Guam. For example, about 80% of the commercial ships arriving in Palau have stopped in Guam during 2009-2010. Palau also receives ships coming directly from Australia and various Asian ports, including oil tankers arriving once a month from Indonesia and the Philippines. A barge travels regularly between Palau and Yap, indicating a further level of intra-regional connectedness, independent of Guam.

The relative magnitude of commercial vessel traffic and connectivity is examined in greater detail in the next section (Section 3.3), based on past data, but future changes in traffic patterns are challenging to predict. In recent years, the number of commercial ships of all types calling at the Port of Guam has declined (PB International 2008). Commercial cargo ships (container ships and break-bulk/roll-on, roll-off (RoRo)/bulk) declined from 445 visits in FY 2003 to 353 in FY 2009 (Figure 3.2). However, the volume and nature of commercial ship traffic and perhaps routes will be affected by the Guam Buildup, and these effects are likely to differ during the Buildup and post-Buildup phases.

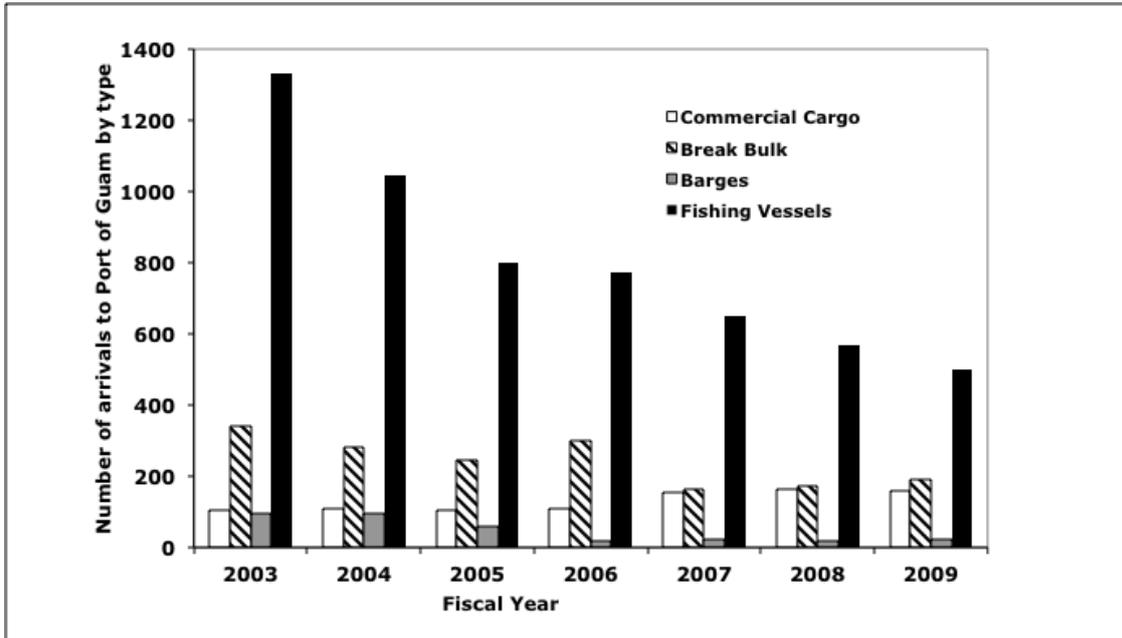


Figure 3.2. Number of commercial ship visits by vessel type to the Port of Guam per fiscal year. Data provided by the Port of Guam.

Guam cannot supply sufficient materials or labor for the construction phase. Thus, imports of construction materials, equipment, and supplies are expected to increase rapidly as the Buildup proceeds. Although information about the source of construction materials was not available, approximately 50% of the materials are expected to come from Asia (PB International 2008), but the sources are also likely to be strongly affected by market prices and other forces, which are dynamic. Thus, shipping imports associated with construction are likely to differ (both in geographic source and quantity) from historical patterns.

In addition to construction materials, the Buildup phase will require a significant and temporary increase in civilian workforce. Imports of household goods, food, and other commodities will increase to support those working on the Buildup. The source(s) of the temporary workforce will affect the geographic origin of shipped goods. While household goods may move along established shipping routes, demand for particular types of goods may shift according to geographic origins and customs of the workforce, having potential consequences for the trade of live organisms associated with food and pets (see Chapter 4 for further discussion).

Published projections for commercial shipping through 2018 predict a peak in the number of commercial container ship arrivals at 269 visits to Guam in 2015 (Table 3.3), during peak construction, slightly more than double the average number for 2003-2009 (see Department of Defense, 2009, Volume 4). An estimated 532 arrivals for break-bulk and RoRo ships are predicted during peak construction, slightly less than double the average annual number for 2003-2009. An additional 150 vessel trips by tugboats (tugs) and scows are anticipated over an eight to 18 month period during peak construction, compared to previous baseline traffic.

Across these vessel types, total additional commercial ship visits could increase by as much as 537 in a peak year, driven by the large pulse in construction materials and equipment delivered by break-bulk and RoRo vessels.

In the post-Buildup phase, following the pulse of construction and associated personnel, the number of commercial ship arrivals is expected to form a new baseline that is above recent (2009-2010) pre-Buildup levels. This overall increase in shipping reflects an increase in demand for goods, related to a projected increase in population size.

Table 3.3. Projected changes in number of commercial ship arrivals to the Port of Guam by vessel type. Data from FEIS (Department of Defense 2010; Volume 2, Tables 14.2-2 and 14.2-3-3).

Year	Container ships	Break-bulk/RoRo Ships	Total
2011	211	450	661
2012	244	532	776
2013	252	519	771
2014	258	507	765
2015	269	262	531
2016	255	199	454
2017	215	204	419
2018	207	206	413

From 2006-2009, barge traffic has been relatively infrequent at the Port of Guam, with 20 or fewer barges calling at the port each year (Figure 3.2). As recently as 2004, however, barge traffic had been significantly higher, with more than 100 such vessels arriving in port. Projections for barge traffic are not available in port documents, but it is reasonable to assume that the number of these vessels will increase along with other commercial ships during the Buildup.

Outside of Guam, with the possible exception of Saipan, it appears that other locations in Micronesia are not anticipating an increase in commercial shipping as a direct result of the Buildup, based on meetings and discussions with local management agency personnel. In Saipan, port officials have been approached by shipping concerns inquiring whether the port could accommodate vessels, should there be a back-up in unloading cargo to Guam during the Buildup. While it appears that Majuro hopes to increase its transshipping business in the near future, making better use of an underutilized container yard, we were unable to identify a specific plan for this activity in association with the Buildup.

3.3 Regional Comparison of Vessel Traffic and Geographic Connectivity

While previous documents on the Guam Buildup have focused some attention on the possible effects of shipping traffic to individual locations, and especially Guam (as above), it is of particular importance from a biosecurity perspective to also consider overall regional traffic patterns and connectivity. The first two sections (Sections 3.1 and 3.2) describe some of the linkages that exist among ports, in terms of vessels that move from one port to another, creating opportunities for species transfers to occur. Here, we expand upon this treatment and formally evaluate (a) the number of vessel arrivals to ports in Micronesia by vessel type, (b) the number of vessel visits to each country in Micronesia, (c) the last port of call (LPOC) and next port of call (NPOC) for vessels arriving to Micronesia, (d) the flux (number) of vessels that move among paired ports in Micronesia (and in both directions between Micronesia and Hawai'i) and (e) the reported ballast water discharge volumes for vessels arriving to Guam and also those moving from Guam to other regions of the U.S.

This regional analysis focuses primarily on commercial and MSC vessels, for which sufficient data could be obtained; the necessary data for similar analysis of other U.S. Navy ships (e.g., combatants) were not made available, as noted previously (see Chapter 1, Section 1.2). Throughout this section, only the direct links among ports and regions were evaluated, including LPOC and NPOC. Because vessels can often visit many ports with the potential to accumulate organisms, both on the hulls and in ballast tanks, indirect links among ports can also be important sources for invasions and are considered further in Chapter 5.

3.3.1 Sources of Data and Methods for Analyses

To characterize regional vessel traffic, data were collected and compared from multiple sources, as follows:

1. Data were obtained from Lloyds List Intelligence for commercial vessel arrivals to Micronesia over a 10-year period (1999-2009). For each unique vessel arriving to the region in Lloyds' database, an extensive synthesis of information concerning vessels and

maritime traffic on a global scale, we requested a complete history of all ports of call (globally) within this time period, including dates of arrival and departure.

2. Similar data were requested and obtained for MSC vessels arriving to Guam during the same time period.

3. For vessels that reported ballast water information to the National Ballast Information Clearinghouse (NBIC) (see Chapter 2 for description), we obtained (a) records of arrivals to Guam and CNMI, (b) records of ballast water discharge to Guam, and (c) records of ballast water discharge to U.S. ports for water aboard vessels that originated in Guam.

4. For vessels arriving to Guam and the Northern Marianas Islands, we obtained arrivals data reported to USCG National Vessel Movement Center (NVMC).

Each of these data sources provided individual vessel identification numbers, which could be used to identify unique vessels and subsequent vessel movements. These datasets were used to create a single synthetic dataset of unique vessel arrivals to Guam and other jurisdictions of Micronesia, and their voyage histories (ports of call) both before and after calling on Micronesia. This dataset provided the basis for analysis presented here for arrivals and direct linkages (LPOC and NPOC) of vessels calling on Micronesia; the scope of this analysis is expanded in Chapter 5 to also consider indirect linkages, based on these voyage histories over a multi-year time horizon.

Additional information was available for fishing vessels, which were excluded from this analysis. In particular, the Lloyds dataset contained some data on fishing vessels. This was combined with data from multiple ports throughout Micronesia, to estimate flux (number of arrivals) for fishing vessels that is presented below in Section 3.5. In many cases, LPOC and NPOC data were not available for fishing vessels, limiting the extent of analysis to flux measures (i.e., arrivals to a port) and preventing a broader consideration of geographic linkages such as the one presented for commercial and MSC vessels.

3.3.2 Unique Vessels Visiting Micronesia

Based on a synthesis of available datasets, 461 unique commercial vessels and 123 unique MSC vessels were identified with a record of arrival to Micronesia during the 11- year time period (Figure 3.3). As noted previously, the U.S. Navy would not provide unique vessel identifications (or voyage histories) for vessels other than MSC due to security restrictions, so it is not possible for us to provide a comparable estimate for the number of unique surface combatants or other U.S. military vessels visiting Micronesia.

Figure 3.3 also indicates the number of unique vessels found in each of the four respective datasets, which were compared to create a synthetic dataset for further analyses. As illustrated for commercial vessels (top panel), no single dataset had a comprehensive record of arrivals, so a combination of the four datasets provided a more complete record than any individual dataset. In contrast, the MSC dataset is thought to provide nearly a complete record of MSC vessel arrivals to Micronesia, and the other sources listed in Section 3.3.1 were used to fill in some gaps in voyage histories for these vessels.

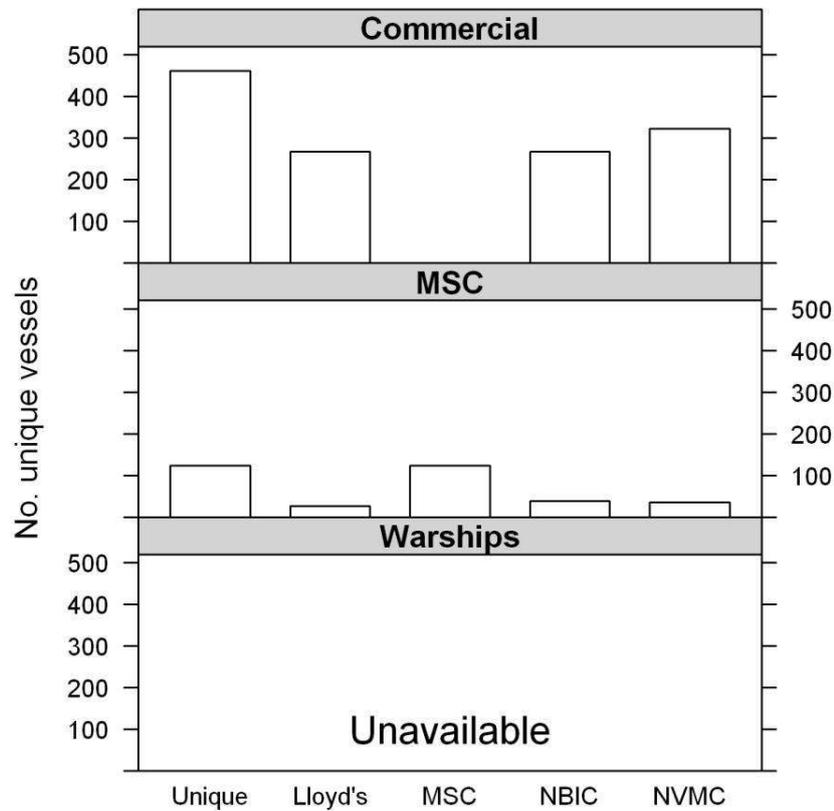


Figure 3.3. Number of unique vessels reported to have visited Micronesia from 1999-2009, according to data source. On the x-axis, “Unique” indicates the total number of unique vessels, based on synthesis and comparison across data sources (Lloyds, MSC, NBIC, NVMC; see text). Also shown for each data source is the number of unique vessels reported. Comparable data were not provided by DoD for warships (Navy vessels other than MSC).

We emphasize that neither synthetic dataset for commercial or MSC vessels is likely to be comprehensive, in terms of unique vessels, arrivals, or voyage histories. There is no clear way to verify or assess the percentage of all vessels included. Moreover, it is evident that vessel arrivals were missing from each dataset, suggesting the synthetic datasets are also likely to include omissions. For this reason, the information presented here and throughout should be considered a minimum estimate of vessel arrivals and connectivity among ports.

3.3.3 Vessel Flux for the Micronesian Region

The number of unique vessels is a useful measure to consider from a management and policy perspective, especially considering any possible future efforts to implement management actions or outreach, but the vessel arrival events are the operative measures from an invasion perspective. Each arrival event presents a potential opportunity for species transfer, and each arrival has a unique set of environmental and biological conditions that affect whether species can survive and spread. Even the same individual vessel arriving at different points in time will have a unique history of recent port visits and voyage conditions, husbandry or management conditions, and therefore a unique set of potential associated biota.

Figure 3.4 shows the mean number of arrivals per year to ports in Micronesia for each of three vessel types, based on available data (see Section 3.3.1). Commercial vessels accounted for 70% of reported arrivals to Micronesia, whereas the remaining 30% were attributed to MSC vessels (20%) and additional U.S. Navy and other military vessels (10%). This estimate includes each arrival to a port in Micronesia, regardless of LPOC; intra-regional flux (or traffic among ports within Micronesia) is addressed separately below (see Section 3.3.5).

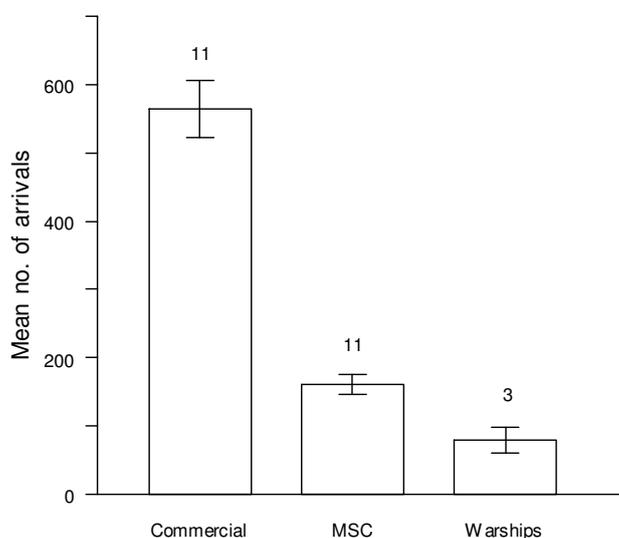


Figure 3.4. Annual mean (\pm standard error) for number of arrivals to Micronesia by vessel population. The number of years of data is indicated above each bar; commercial ships and MSC data are from 1999-2009, while the warships are from 2008-2010.

3.3.4 Vessel Flux into the Separate Countries within Micronesia

For commercial vessels, Guam had the largest number of arrivals for ports in Micronesia, with an average of 374 arrivals/year reported from 1999-2009 (Figure 3.5A), including vessels arriving from LPOCs both within and outside of Micronesia. This accounted for 66% of the commercial arrivals that we were able to document for the region during this time period. The second largest number of commercial arrivals was to CMNI (Figure 3.5A), with 26% of the average annual traffic for the region. Thus, Guam and CNMI account for > 90% of commercial vessel arrivals recorded in our dataset (see Section 3.3.1).

A similar pattern was observed for MSC vessel traffic, with over 90% of average annual arrivals in Micronesia recorded in Guam and CNMI over the same time period (Figure 3.5B). The relative contribution of arrivals to CNMI (~34% of total annual flux for MSC in the region) was slightly higher than that for commercial vessels (26%), during the same time period, as seen in comparison of Figure 3.5A and B.

A comparable analysis of vessel flux was not possible for other types of U.S. Navy vessels (or other military vessels), since we did not have access to data on arrivals or transit histories. Thus, beyond vessels operated by MSC, military vessels are excluded here and from subsequent analyses in this chapter, representing an information gap for vessel traffic associated with the Guam Buildup and Micronesia overall.

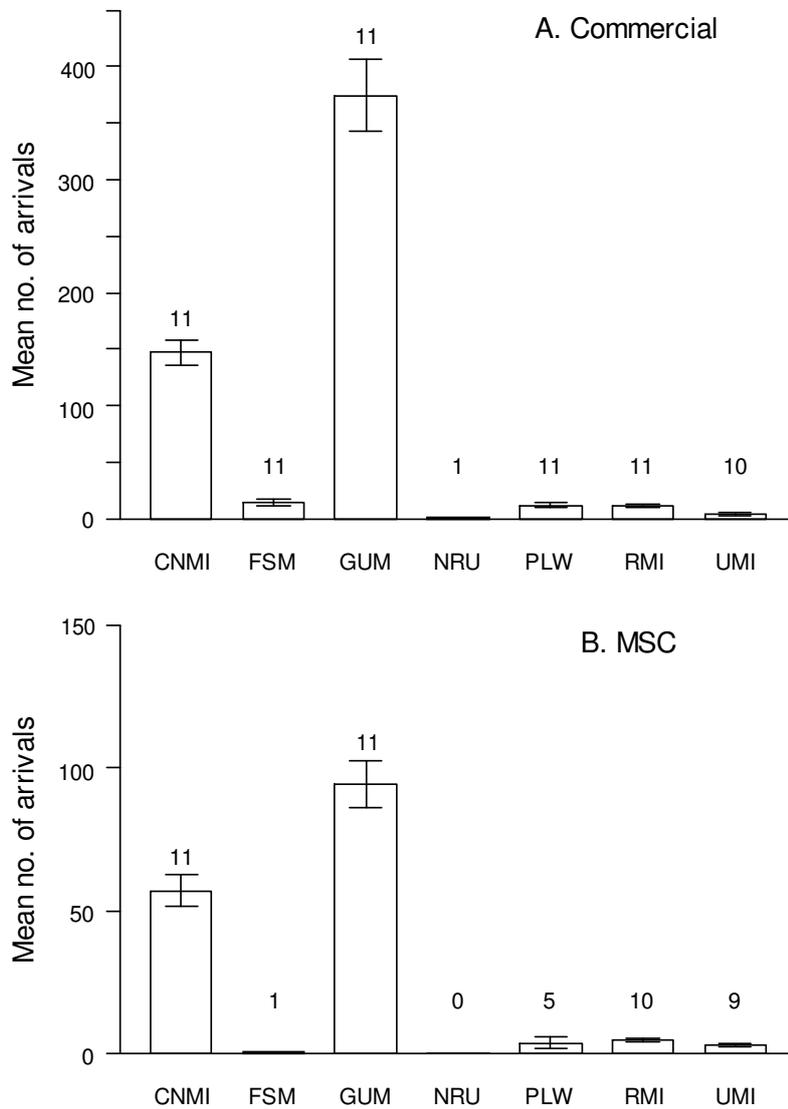


Figure 3.5. Annual mean (\pm standard error) number of arrivals for different regions of Micronesia for (A) commercial vessels and (B) MSC vessels. Shown are: Commonwealth of Northern Mariana Islands (CNMI), Federated States of Micronesia (FSM), Guam (GUM), Republic of the Marshall Islands (RMI), Nauru (NRU), Republic of Palau (PLW), and the U.S. Minor Outlying Islands (UMI). The number of years of data is indicated above each bar [Note: Only years for which arrivals were reported are included in the mean estimates for each country. Thus, overall mean arrivals for the entire 11-year period would be lower for those countries with fewer years of reported arrivals.]

3.3.5 Vessel Transit Histories

Across the entire 11-year time period, we documented 7,973 vessel arrivals to ports in Micronesia, including commercial and MSC vessels. MSC vessels represented 22% of the total arrivals. The distribution of these arrivals among countries is shown in Figure 3.6 (top panel). As expected from the previous section, the majority of arrivals for each commercial and MSC vessels occurred in Guam and CNMI.

We were able to document some portion of the previous voyage histories for most MSC and commercial vessel arrivals (see Section 3.3.1 for sources). Figure 3.6 (bottom panel) shows the percentage of arrivals to each country for which voyage history was available, according to type (extent) of historical data. Across all countries: (a) LPOC was available for $\geq 99\%$ of arrivals of each vessel type; (b) NPOC was available for a smaller subset of MSC arrivals (94%) and commercial arrivals (84%); and (c) data on additional ports of call, or transit history, were available for 74% of commercial vessels and 97% of MSC vessels.

The sections below present an analysis to examine connectivity among ports, using these data for LPOC and NPOC. Although some additional transit information was obtained for most vessel arrivals, it is difficult to evaluate its completeness. One measure of completeness may be the temporal extent of records, which is < 100 days for 10-20% of arrivals. Analysis in Chapter 5 evaluates this extended transit history information, considering indirect connections (i.e., those ports visited beyond simply LPOC and NPOC). Characterizations of connectivity presented here and in Chapter 5 should be considered minimum estimates, because data on direct and indirect linkages are not available for all vessels that arrived in Micronesia.

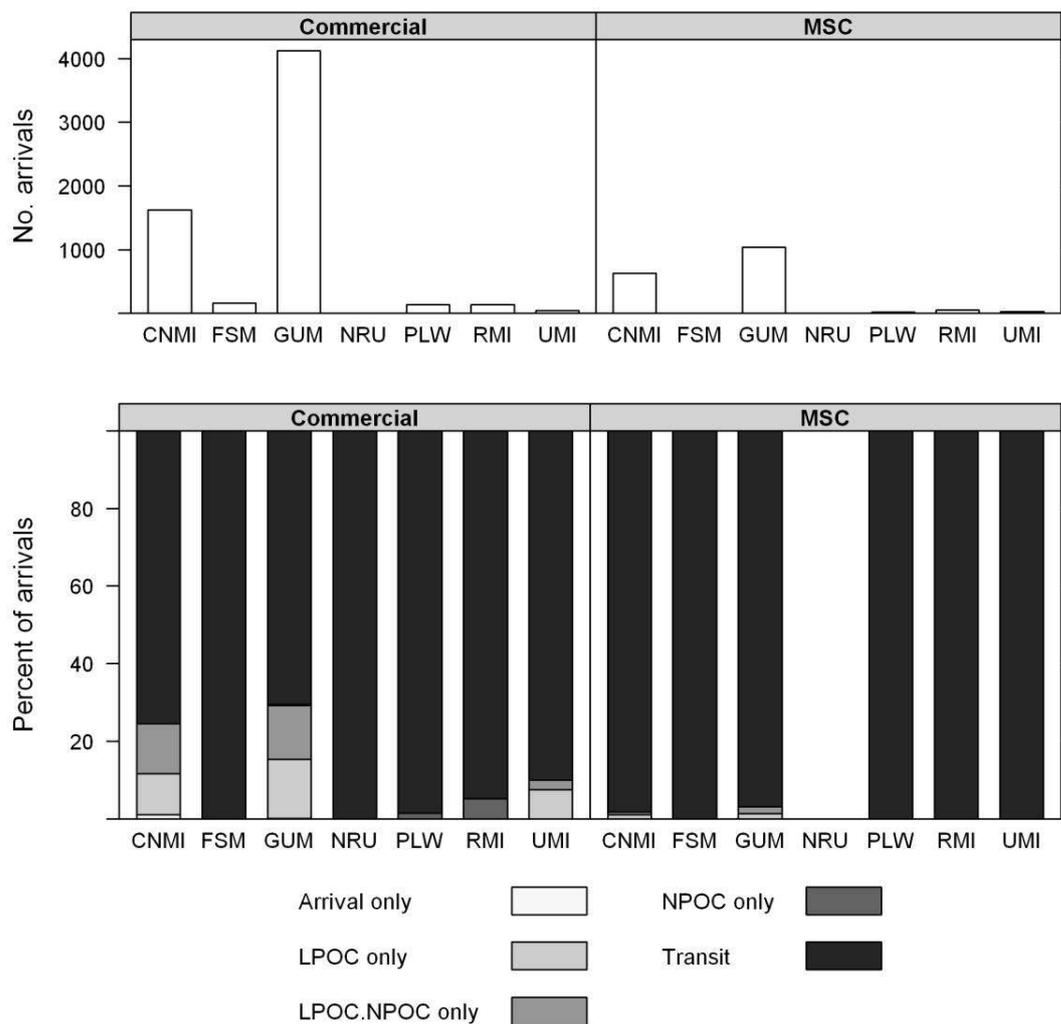


Figure 3.6. Data used in connectivity analyses of Micronesia and Hawai'i. Shown for each commercial and MSC vessel arrivals to Micronesia are (A) total number of arrivals by the country and (B) percentage of arrivals to each country with associated data on vessel transit history. Categories of vessel history types are: arrival record only; last port of call (LPOC) only; next port of call (NPOC) only; LPOC and NPOC only; extended transit history that includes additional ports beyond LPOC and NPOC.

3.3.6 Last and Next Ports of Call for Vessel Arrivals to Micronesia

Figures 3.7-3.10 show the geographic distribution of LPOC and NPOC of arrivals to Micronesia for each commercial and MSC vessel, from 1999-2009, indicating the connectivity that exists with specific geographic regions or countries around the globe. Overall, most connections for both vessel types were with Asia and the western U.S. As expected from above, Guam had the largest number of arrivals. For both MSC and commercial vessels, Guam was also connected to the largest number of ports (for both LPOC and NPOC). Finally, the extent of vessel traffic that connects Guam to other parts of Micronesia, as well as Hawai'i, is evident for both MSC and commercial vessels.

A more detailed view of connectivity for vessel traffic within Micronesia, and between Micronesia and Hawai'i, is presented in Figures 3.11 and 3.12 (for commercial and MSC vessels, respectively). As expected from previous maps, Figures 3.11 and 3.12 illustrate the strongest connections (in terms of vessel arrivals) were between Guam-Hawai'i and Guam-CNMI, for traffic moving in both directions between these locations. This pattern existed for both the commercial and MSC vessel traffic. In addition, commercial vessels exhibited relatively strong linkages between Guam-Palau, Guam-FSM, and Hawai'i-UMI (Figure 3.11).

Thus, both commercial and MSC vessels showed strong linkage between Guam-Hawai'i, with connectivity throughout Micronesia, illustrating the magnitude of vessel flux and the potential opportunity for ship-mediated species transfers to occur associated with biofouling (of hulls) or ballast water from these vessels. It should be noted that the scale differs between the two figures, and there is more commercial than MSC traffic overall.

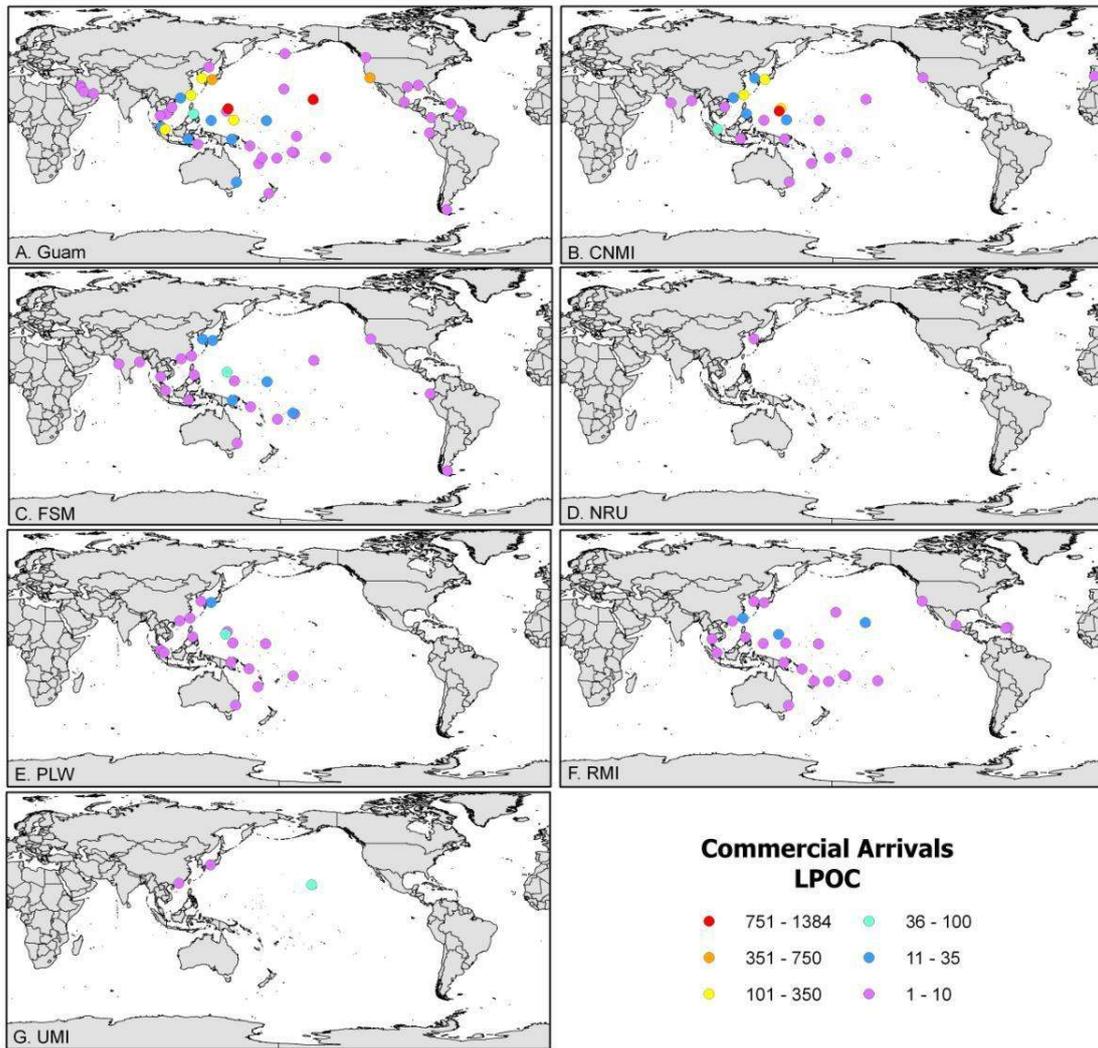


Figure 3.7. Last port of call (LPOC) of commercial vessel arrivals between 1999-2009 to different countries and states in Micronesia. Shown are: A. Guam, B. Commonwealth of Northern Mariana Islands (CNMI), C. Federated States of Micronesia (FSM), D. Nauru (NRU), E. Republic of Palau (PLW), F. Republic of the Marshall Islands (RMI), and G. U.S. Minor Outlying Islands (UMI).

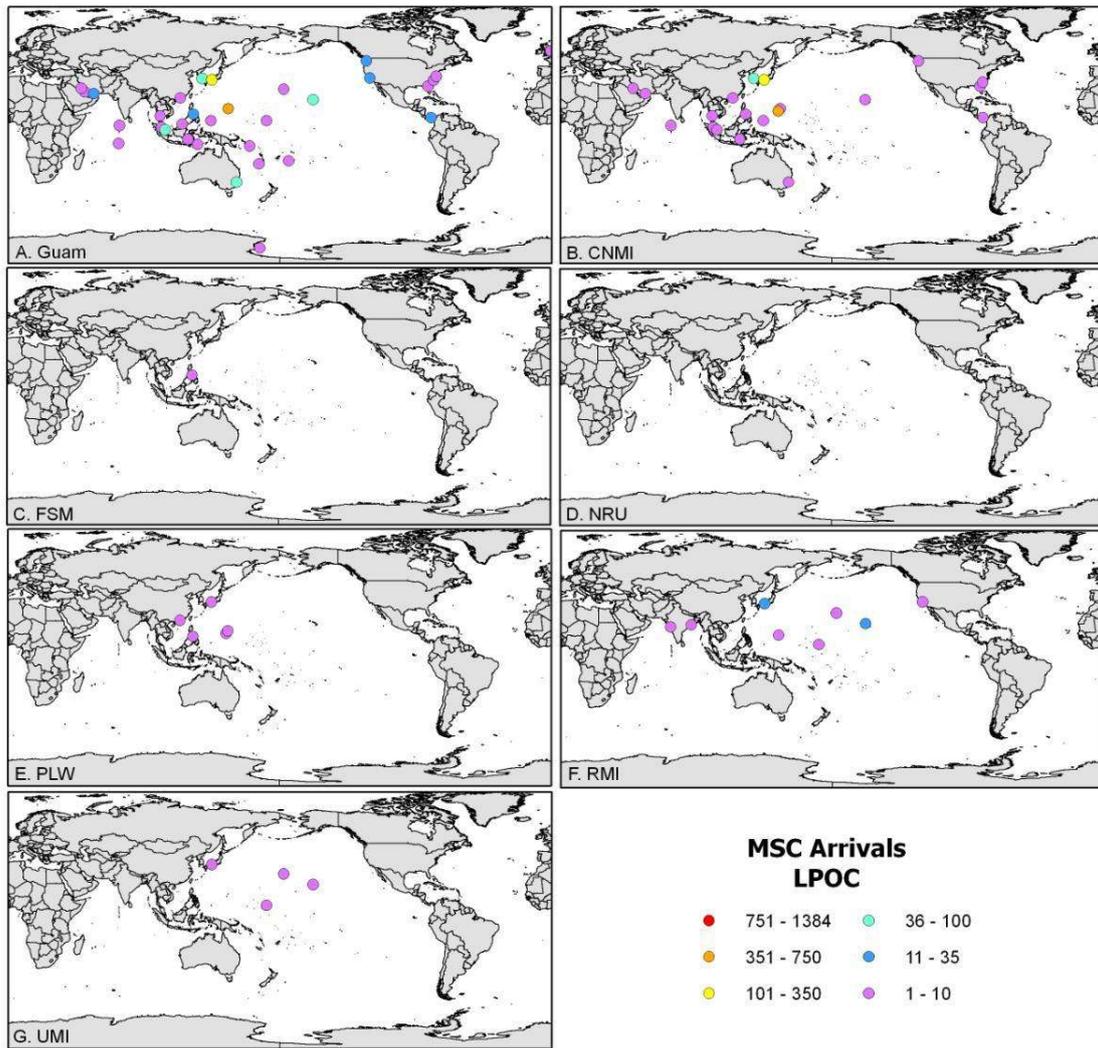


Figure 3.8. Last port of call (LPOC) of MSC vessel arrivals between 1999-2009 to different countries and states in Micronesia. Shown are: A. Guam, B. Commonwealth of Northern Mariana Islands (CNMI), C. Federated States of Micronesia (FSM), D. Nauru (NRU), E. Republic of Palau (PLW), F. Republic of the Marshall Islands (RMI), and G. U.S. Minor Outlying Islands (UMI).

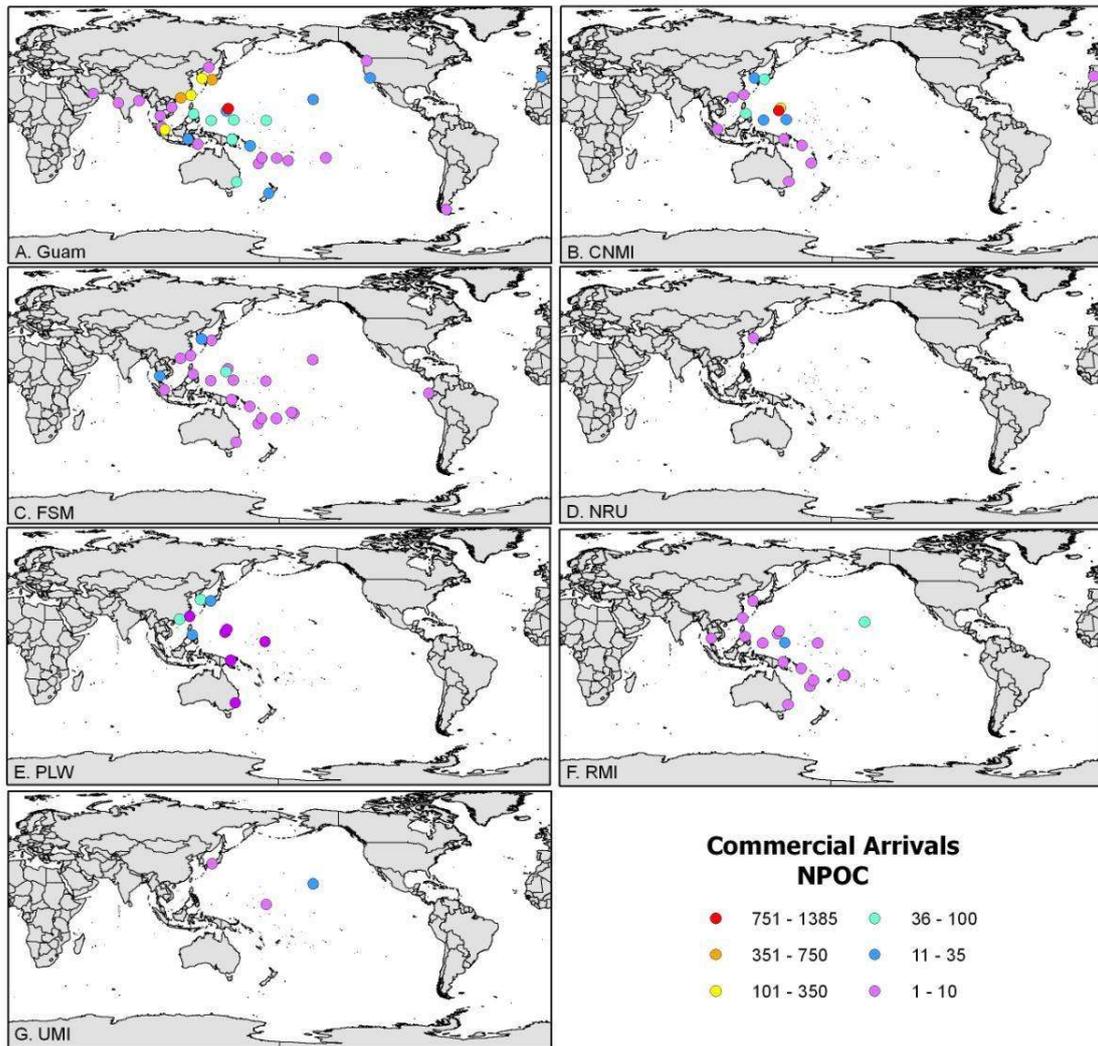


Figure 3.9. Next port of call (NPOC) of commercial vessel arrivals between 1999-2009 to different countries and states in Micronesia. Shown are: A. Guam, B. Commonwealth of Northern Mariana Islands (CNMI), C. Federated States of Micronesia (FSM), D. Nauru (NRU), E. Republic of Palau (PLW), F. Republic of the Marshall Islands (RMI), and G. U.S. Minor Outlying Islands (UMI).

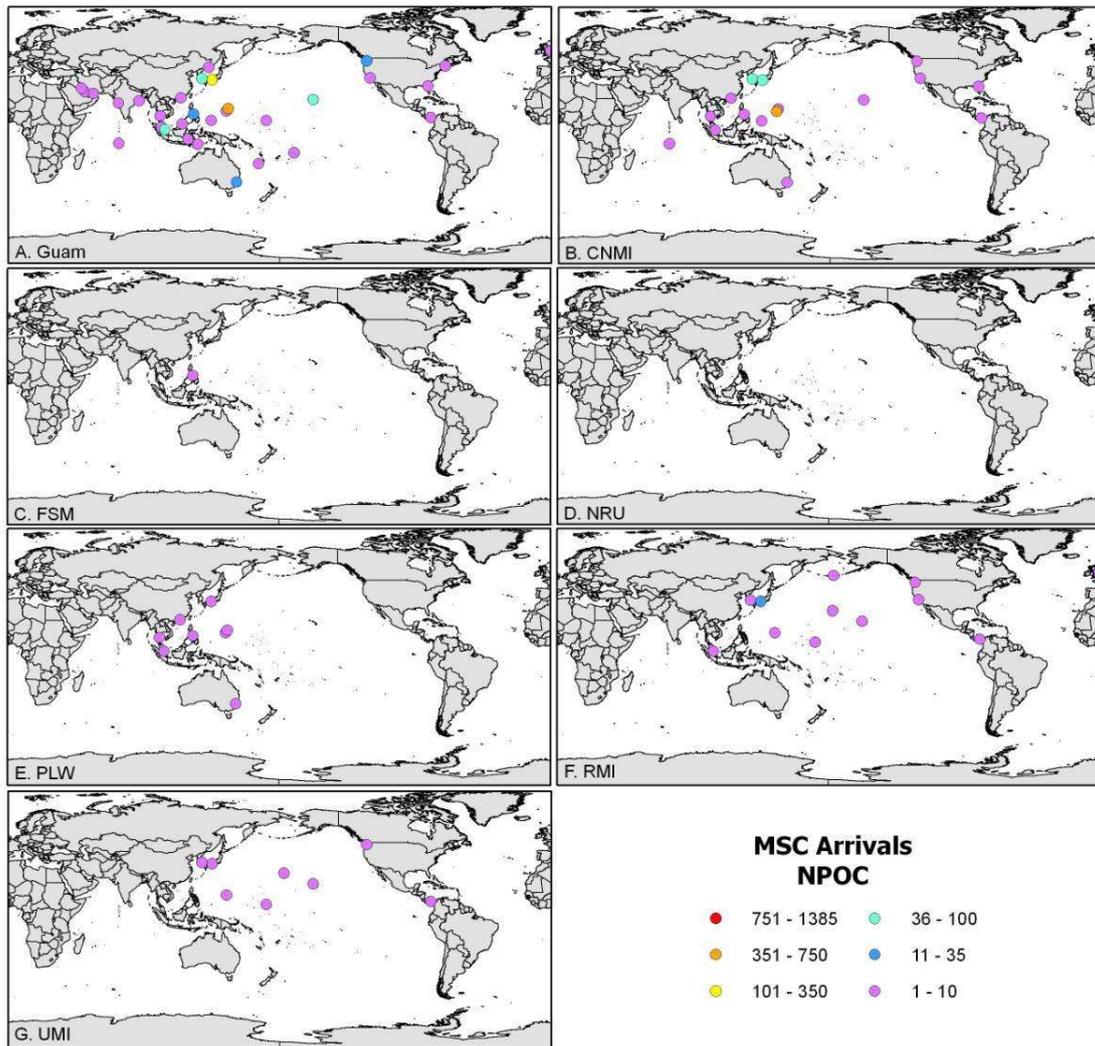


Figure 3.10. Next port of call (NPOC) of MSC vessel arrivals between 1999-2009 to different countries and states in Micronesia. Shown are: A. Guam, B. Commonwealth of Northern Mariana Islands (CNMI), C. Federated States of Micronesia (FSM), D. Nauru (NRU), E. Republic of Palau (PLW), F. Republic of the Marshall Islands (RMI), and G. U.S. Minor Outlying Islands (UMI).

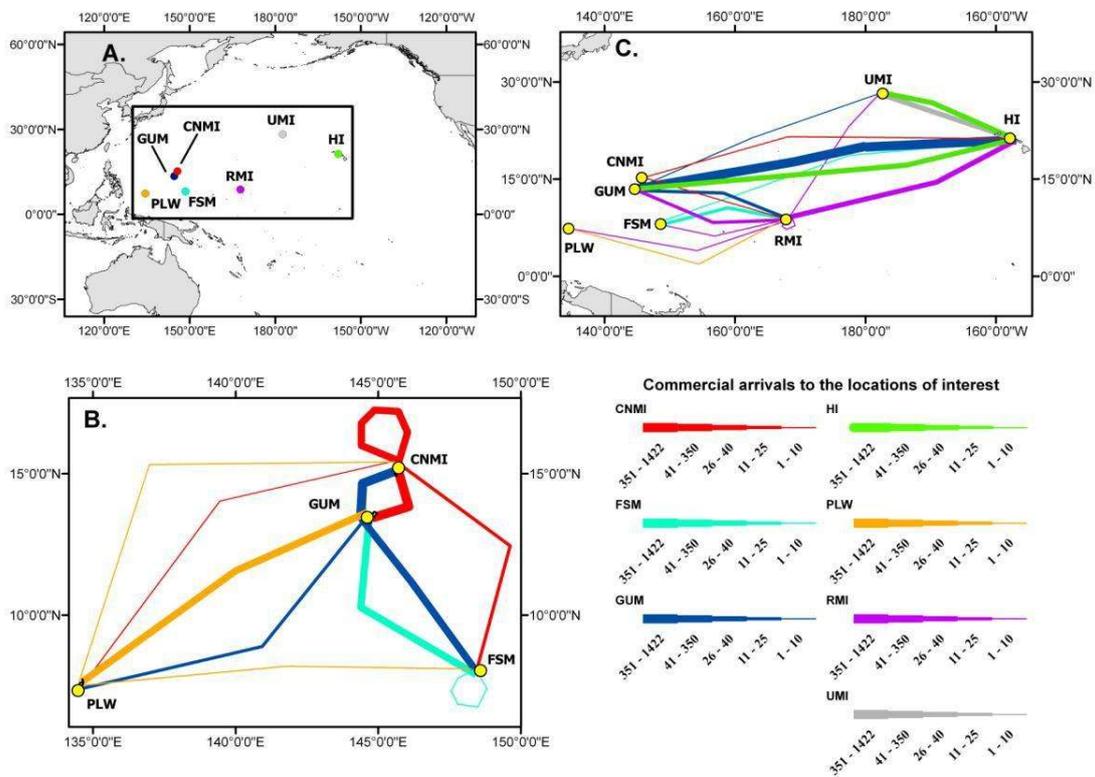


Figure 3.11. Maps showing the connectivity (number of arrivals) of Micronesia, Guam and Hawai'i resulting from commercial ship traffic. A) Color coding associated with the ports of arrival. B) Connectivity between Guam (GUM), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Island (CNMI), and Palau (PLW). C) All arrivals to and from Hawai'i (HI), the Republic of the Marshall Islands (RMI), and the U.S. Minor Outlying Islands (UMI). In these figures, color denotes the destination port (as shown in panel A), and the width of line is scaled to the number of arrivals from the connected port. For example, the dark blue line between CNMI and Guam indicates the number of vessel arrivals to Guam from the Northern Marinas Islands (as LPOC). In contrast, the red line connecting these locations indicates traffic that originates in Guam and arrives to CNMI.

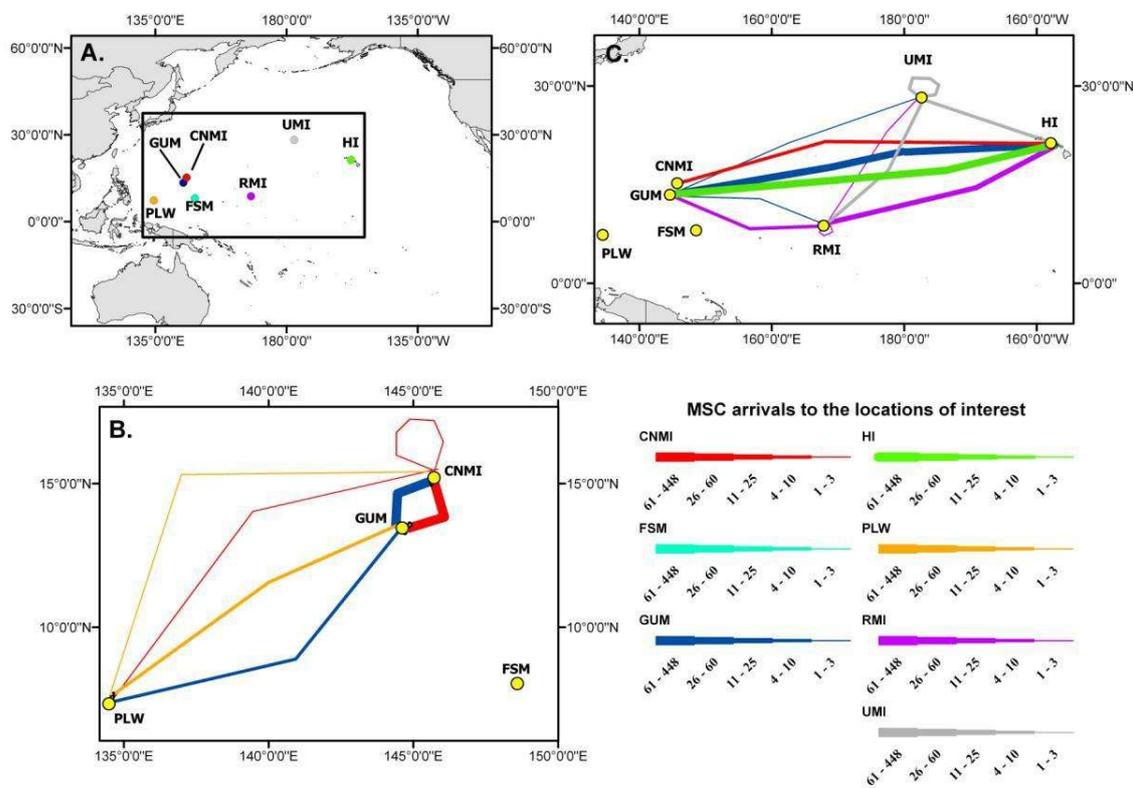


Figure 3.12. Maps showing the connectivity (number of arrivals) of Micronesia, Guam and Hawai'i resulting from MSC ship traffic. A) Color coding associated with the ports of arrival. B) Connectivity between Guam (GUM), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Island (CNMI), and Palau (PLW). C) All arrivals to and from Hawai'i (HI), the Republic of the Marshall Islands (RMI), and the U.S. Minor Outlying Islands (UMI). In these figures, color denotes the destination port (as shown in panel A), and the width of line is scaled to the number of arrivals from the connected port. For example, the dark blue line between CNMI and Guam indicates the number of vessel arrivals to Guam from the Northern Marinas Islands (as LPOC). In contrast, the red line connecting these locations indicates traffic that originates in Guam and arrives to CNMI.

3.3.7 Ballast Water Flux Associated with Guam and the Northern Mariana Islands

Records exist for the discharge of 365,904 metric tons of ballast water to Guam between 2005-2009 for commercial and MSC vessels. Figure 3.13 shows the volume of this ballast water as a function of vessel type, geographic source region, and whether it was reportedly managed (treated by ballast water exchange) prior to discharge. As discussed in Chapter 2, most vessels do not discharge ballast water upon arrival, and information is available for only a subset of arrivals. The available data provide a minimum estimate for ballast volume discharged to Guam from various source regions and illustrate that some of this water was reported to be untreated.

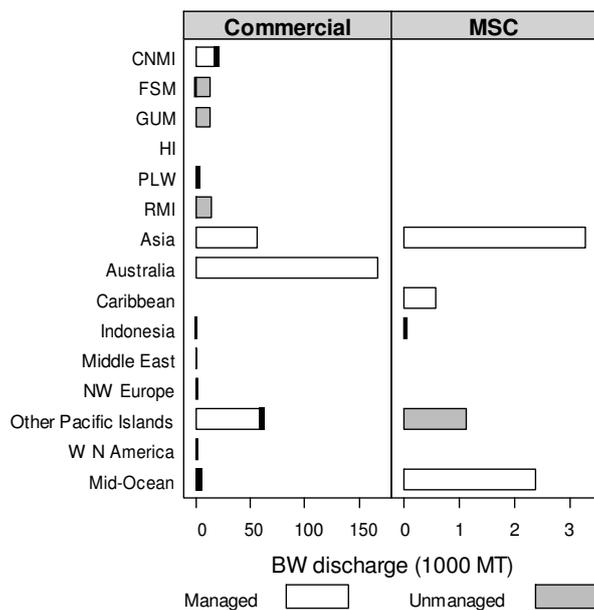


Figure 3.13. Source regions and volume of ballast water reported to USCG as discharged in Guam by commercial and MSC vessels, 2005-2009. Total volumes are shown in thousands of metric tons (MT) as a function of source and management (i.e., whether water was reported to be treated with ballast water exchange or not). The specific source regions of interest include the Commonwealth of Northern Mariana Islands (CNMI), Federated States of Micronesia (FSM), Guam (GUM), Hawai'i (HI), Republic of the Marshall Islands (RMI), and the Republic of Palau (PLW).

In similar fashion, Figure 3.14 shows data available for ballast water discharge to CNMI. Although many ships did not report information, the available data suggest a relatively small volume is discharged in this country. It is noteworthy that the small volume of ballast that originated in Guam was untreated, indicating that an occasional transfer of coastal organisms entrained in ballast tanks from Guam to CNMI may occur without any management to reduce concentrations (see Chapter 2 for discussion).

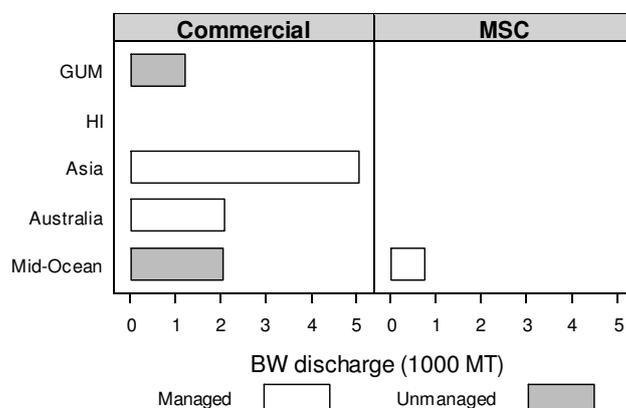


Figure 3.14. Source regions and volume of ballast water reported to USCG as discharged in the Commonwealth of the Northern Mariana Islands by commercial and MSC vessels, 2005-2009. Total volumes are shown in thousands of metric tons (MT) as a function of source and management (i.e., whether water was reported to be treated with ballast water exchange or not).

Figure 3.15 summarizes the data reported to USCG on ballast water discharged in the U.S. that originated in Guam and the Northern Mariana Islands. The largest reported volume is from MSC vessels, which reported discharge from Guam to Hawai'i and Puget Sound, Washington. All reported discharge was treated, although treated water may still contain coastal organisms (see Chapter 2 for further detail). Also, as noted throughout, this represents a minimum estimate, as only a fraction of MSC vessels appear to submit reports to USCG (as discussed in Chapter 2).

3.4 Barges

Barge traffic in Guam and Micronesia appears to be highly dynamic, making it particularly difficult to project traffic for future planning purposes. At the same time, barges may pose unique and relatively high risks with respect to transfers of non-native species, both as novel introductions into Micronesia and spreading non-native species within the region, due to the nature of their operation. Here, some of the key issues and uncertainties are highlighted for marine biosecurity associated with barges.

While included in the above analysis of regional traffic patterns, it is evident that fewer barge arrivals to Guam were reported or recorded in the broad-scale datasets used in this analysis (see Section 3.3.1) than were reported by the Port of Guam, suggesting that we have underestimated the magnitude of this traffic. In addition, barge traffic has been low in recent years, with as many as 100 barge arrivals reported to the Port of Guam in 2004 (as noted earlier; see Figure 3.2). We should expect barge traffic to Guam to increase, due to increased importation of materials and increased local activity (e.g., dredging, construction) surrounding the Buildup. The source(s) of these barges are not presently known, nor are the associated husbandry practices. Based upon interviews with DoD personnel, it appears

likely that the geographic source of barges, their movement, and any associated biosecurity measures will be determined by contractors.

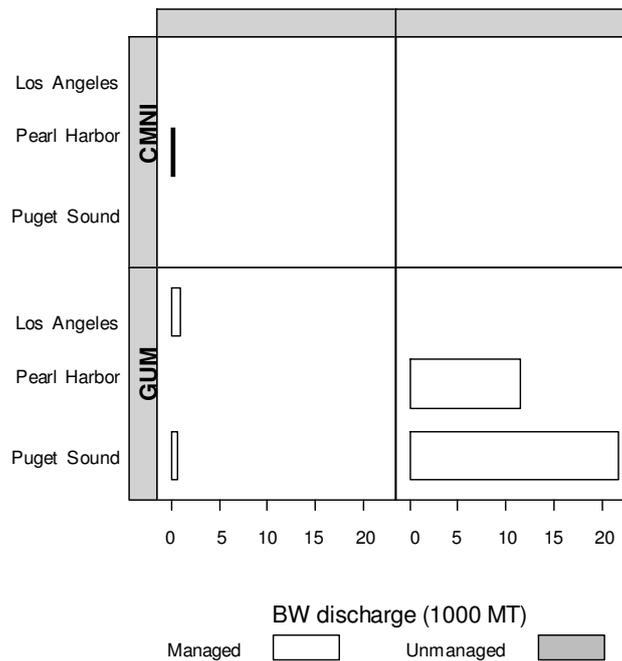


Figure 3.15. Ballast water discharge reported to USCG that originated in the Commonwealth of the Northern Mariana Islands (CNMI) and Guam (GUM) to other ports of the U.S., 2005-2009. Total volumes are shown in thousands of metric tons (MT) as a function of vessel type (commercial versus MSC), geographic recipient, and management (i.e., whether water was reported to be treated with ballast water exchange or not).

In general, barges can have a relatively high potential for transfer of marine species, because of their mode and tempo of operation. These vessels often have long residence times in a particular port or region, residing in shallow and productive waters, compared to a commercial vessel that is in transit and has shorter residence times in port. When barges are moved to new locations, the travel speed is relatively slow. As outlined in Chapter 2, the extent of biofouling is expected to increase with long residence times in port and slow vessel speeds when underway, when controlling for other factors (e.g., husbandry practices). Moreover, long residence time after arrival at a new location can increase the probability that the associated fouling organisms reproduce and colonize the recipient region.

There are several examples of extensive biofouling communities and non-native organisms associated with such slow-moving vessels (Coutts 2002; Coutts et al. 2010a; Hopkins and Forrest 2010), underscoring the biosecurity risks for barges brought into Guam. In an example from the region, a barge from China was brought in as a temporary bridge between Babeldaob and Koror in Palau. The barge did not have antifouling paint and apparently introduced at least one species, a hydroid, to Palau (Colin 2009).

Of additional concern is the potential use of these particular barges and associated construction equipment in other jurisdictions of Micronesia. Once in the region, there may be economic incentives to use such vessels and equipment for projects (e.g., dredging or construction) in other parts of Micronesia, creating the potential for intra-regional transfers of any associated organisms.

Beyond the Guam Buildup, several locations are or have been recently engaged in major construction projects such as roadway expansions/repairs (Chuuk, Yap and Palau) and airport expansions (Pohnpei and Majuro). Pohnpei anticipates that a foreign vessel will be used for its planned harbor dredging. If countries in the region responded to the increased population on Guam with increases in these types of projects, risk associated with this vector could also increase.

Another area of potential concern is a proposed plan to use Pagan Island in the Northern Marianas as a dumping site for debris from the March 2011 Japan tsunami. The proposal put forth by Japanese investors would involve bringing in vessels with tons of tsunami debris to Pagan, and bringing out mined volcanic ash (pozzolan) from the island for use in cement industry. Presumably, slow moving barges would be used for the transport of debris and pozzolan to and from Pagan. Implementation of the plan would furthermore require the construction of a seaport for docking vessels. All these activities could facilitate the establishment of invasive biofoulers originating from Japan. The Pagan dumpsite proposal first made the news in the second quarter of 2012 (Eugenio, 2012). There seem to be no recent updates on the status of the proposed plan, nor of the likelihood that the plan will push through.

While we provided recommendations to DoD in early 2011 to include biosecurity guidelines for barges associated with contracts and construction in Guam, to minimize the probability of marine invasions, it is also evident that barges pose significant risks in other parts of Micronesia, independent of DoD activities. Aggregate, loaded on barges, typically comes to Micronesia from China, Taiwan, and the Philippines. Rather than unloading in port, it appears to be common practice for barges to sit in harbors for long periods, with aggregate removed as needed (Figure 3.16).



Figure 3.16. A barge from the Philippines loaded with aggregate sits in Yap's harbor.

3.5 Fishing Vessels

Historically, Guam and Palau have had the most commercial fishing vessel arrivals in the region. Figure 3.17 shows the average number of arrivals per year for various parts of Micronesia, as provided by the respective regions, Lloyds, NVMC, and NBIC. However, based on discussions with local ports and resource managers, it appears that additional vessels arrive that do (a) come into port and (b) report arrivals to local authorities. Thus, as with commercial cargo vessels, the data presented represent a minimum estimate of actual arrivals.

The number of fishing vessels reported to visit Guam has declined significantly over the past several years. According to port statistics, visits by commercial fishing vessels have declined steadily from 1,332 in 2004 to 499 in 2009 (see Figure 3.3). This decline may be due at least in part to the Shark Finning Act of 2000, which prohibits vessels from countries engaged in shark finning from transshipping through Guam. In addition, there appears to have been a major shift in tuna fishing activities, moving away from Guam. Most other locations in Micronesia have also experienced a downturn in recorded fishing vessel visitation.

Although owned by foreign concerns, most fishing vessels in the region tend to fish within state or territory waters and return to local home ports, and thus represent little risk of non-

native species transfer. However, in Palau, many vessels in the “local” fleet return home to Taiwan or the Philippines for New Year celebrations, staying away for a month or longer. These vessels are likely to be colonized by fouling organisms while abroad, especially given the relatively long residence times, having the potential to transport non- native species to Palau upon return. Fishing vessels based in foreign ports including Taiwan, China, Japan, Korea and Papua New Guinea also arrive to all Micronesian ports, including large “mother ships,” which take off-loaded catch from the locally based fleet (Figure 3.18). To our knowledge, the extent or composition of biofouling on fishing vessels arriving from outside of Micronesia has not been characterized, so the magnitude of any associated species transfers is unknown at the present time.

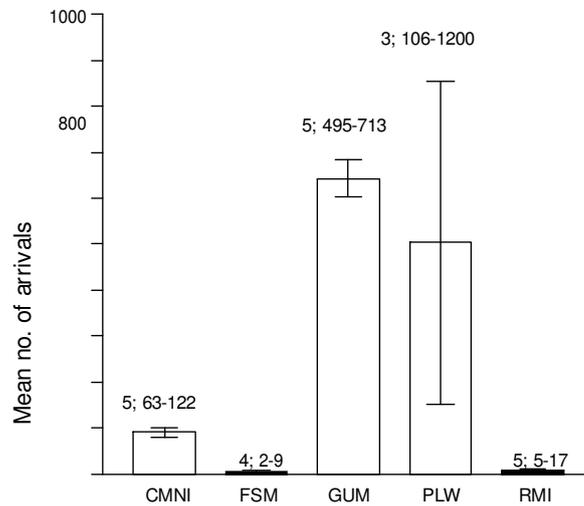


Figure 3.17. Annual mean (\pm standard error) for number of fishing vessel arrivals to countries in Micronesia. Shown are arrivals for Commonwealth of Northern Mariana Islands (CNMI), Federated States of Micronesia (FSM), Guam (GUM), Republic of the Marshall Islands (RMI), and the Republic of Palau (PLW). Above each bar the number of years of available data is indicated, followed by the range (minimum-maximum) in total number of annual arrivals reported per year.



Figure 3.18. A large fishing vessel at mooring in Pohnpei.

Despite a lack of available data, there is certainly a perception within Micronesia that many foreign fishing vessels may be significant sources of both marine and terrestrial non-native species. Scientists from USDA were told by Pohnpeian officials that Japanese long line vessels “are dirty and exchange commodities between ships”. On Kosrae, a new saltwater catfish reportedly first appeared in the area where Chinese vessels anchor, and locals associate this fish with those vessels. On Yap, invasive species managers suggest that the Norway rat may have been introduced to the islands from Chinese fishing vessels. The concern over the perceived and in some cases demonstrated dirtiness of some fishing vessels in regards to potential invasive species is well known throughout the region.

In addition to vessel arrivals themselves, fishing vessels seized on suspicion of illegal fishing are another potential source of non-native species transfers, which may be unintentionally facilitated (enhanced) by increased residence times in port due to impoundment. Illegal fishing is a problem in most locations in Micronesia. Typically, following apprehension by marine patrols, these vessels are seized and brought into the nearest harbor, where they may sit for long periods as cases progress through the courts. Most locations report one to three such cases per year. Palau, the only locality for which we were able to obtain records, had 45 cases between 1994 and 2010. Vessels included steel and wooden hulled boats of various sizes and types, mostly from the Philippines, Indonesia, China and Taiwan.

There is no clear link between the population on Guam and the volume of fishing-vessel traffic; however, if new species become established in the region as a result of the Buildup, these vessels could provide a vector for the spread of non-native species within the region.

3.6 Cruise Ships

Cruise ship traffic to Guam is relatively minor, with six to eight calls on average each year in recent years. Cruise ships visiting Guam have ranged from 400 to 800 feet in length and tend to stay for only part of a day in port (PB International 2008).

Worldwide, cruising is expected to increase 4.5% to 5.5% from 2007-2017, then by 3.5% to 4.5% by 2017-2020, according to information collected from the International Cruise Line Association for the Guam's Port Master Plan (PB International 2008). However, cruise traffic to Guam may increase more rapidly. Several cruise lines have expressed interest in coming to Guam, with some projections of 20 to 30 vessel visits per year, if port improvements are made.

Cruise ships appear to be a minor part of shipping traffic to other locations in the region; most locations reported one to three ship arrivals per year with short (one day or less) stays. Palau receives about five to 10 ships a year, which typically stay three to four days, and arrive from Japan, the Philippines, and Australia. Few locations have sufficient harbor depth and dock capacity for large ships; those that do arrive tend to anchor outside the harbor, with smaller boats bringing passengers ashore. Pohnpei is intending to dredge its harbor channel with the goal of providing appropriate anchorage for cruise ships; cruise ships arriving in Pohnpei tend to have stopped previously in Guam and Papua New Guinea.

3.7 Private Yachts/Other Recreational Vessels

There are three marinas under control of the Port Authority of Guam, as well as a privately run marina and a private yacht club on Guam. The Gregorio D. Perez Marina near downtown (also known as Agana Boat Basin or Hagatna Marina) provides berthing and mooring space for approximately 165 recreational, charting, fishing and public agency boats. The Agat Marina, on Guam's west coast, has capacity for 150 boats. Both the Perez and Agat marinas have launch ramps for trailered boats. The Port of Guam also controls the Harbor of Refuge, at the eastern end of Piti Channel, which is primarily used as shelter for boats during typhoons and for long-term storage for boat owners. Aqua World Marina, which leases land adjacent to the Harbor of Refuge, also has a small number of berths as well as commercial marine-based businesses. The nearby Marianas Yacht Club has moorings for members, which are also used by visitors.

We were unable to determine the volume of recreational boating in the region. The yacht club currently has 90 members. There are several races each year, including one from Guam to Rota, and an annual fishing derby on Saipan, which attracts upwards of 70 boaters from different parts of Micronesia and farther abroad. The number of participants coming from afar is at least partially dependent on weather conditions and fuel costs in a given year. The Marianas Yacht Club hosts only four to five visiting yachts each year. Many of these boats come from Southeast Asian and long stays are fairly typical. Although we could not find any projections for recreational boating traffic during the Buildup and post-

Buildup, it is reasonable to assume that the number of recreational boaters will increase to some extent with the influx of new island residents. Membership at the yacht club was higher before the recent decline in military personnel on the island, so it is likely to rise again when greater numbers of troops move to Guam.

The master plan for the port calls for expansion of Gregorio D. Perez marina, where there is a waiting list for slips (PB International 2008). At Agat, the master plan recommends the replacement of slips and piers and potentially the extension of a breakwater. General repairs to anchorages are proposed for the Harbor of Refuge, along with maintenance and repair facility and a haul out facility.

Yacht arrivals to many parts of Micronesia appear to be a minor component of boating traffic. A few details from visits to some locations throughout the region serve to illustrate this:

- Chuuk reported between two and 11 yacht arrivals a year over the past four years, and some of these stayed a week or longer. Previous ports of call included many locations in Japan, Australia, Solomon Islands, and elsewhere in Micronesia. About 1/3 of these vessels were headed to Guam from Chuuk, and nearly all were planning to stop elsewhere in Micronesia.
- Palau receives about two yachts a month, and many of these travel to Guam and have stopped previously in the Philippines.
- Kosrae receives about eight to 10 yachts a month from numerous locations including Panama, U.S., Netherlands, and elsewhere in Europe. Most of these have stopped in either Fiji or Pohnpei before arriving to Kosrae.
- Yap reports about six yacht arrivals a year. Data on LPOC were not available, but in 2005 and 2007, Koror was the next port of call for over half of the yachts calling on Yap. Other vessels went to Rota, Cebu and Kosrae from Yap.
- Pohnpei also has small vessel traffic (Figure 3.19) from Australia, New Zealand, and possibly the Philippines; these rarely travel to Guam or CNMI, but more regularly visit Palau, other states of the FSM, and RMI.



Figure 3.19. Recreational vessels in Pohnpei's Harbor.

3.8 Miscellaneous Small Vessels

This group includes any small craft, including research vessels, training or educational vessels ("semester at sea" type vessels), missionary boats, traditional voyaging canoes, etc. that fall outside of the normal vessel traffic. Research vessels occasionally visit Guam and Saipan, sometimes without having made prior contacts with the port, management agencies, and/or educational organizations. Saipan has also hosted a Japanese "school afloat" vessel, and Palau has been visited by a heavily fouled missionary boat from Korea. Traditional voyaging canoes also sometimes visit Guam; in the past these have come from the Carolines and Hawai'i.

For these vessels in Micronesia, as well as for recreational vessels discussed in the previous section, there was no information available about the marine biota (biofouling) that may be associated with them.

There are also various passenger/cargo vessels that run between islands within and between some of the Micronesia jurisdictions. These would include vessels which go from the main islands in most jurisdictions such as Majuro, Chuuk, Pohnpei, Yap, and Palau to smaller islands within the jurisdictional boundaries of these island groups, but some vessels also cross between jurisdictions, especially within the FSM where vessels travel between the four states and the various islands within each of the states. For these types of vessels as well as private yachts, there is typically little to no biosecurity mechanisms currently in

place when arriving at an outer island group port of call.

3.9 Grounded and Abandoned Vessels

Shipwrecks, vessel groundings on the reef, and abandoned vessels are not uncommon on Guam or elsewhere in Micronesia (Figure 3.20). While the Buildup is not expected to directly result in more groundings, there is a higher likelihood of such incidents as vessel traffic of all kinds increases. In Guam, previous cases of grounded vessels that were reportedly abandoned by owners remained on the reef for months, while agencies attempted to determine who was responsible for cleanup. Although jurisdictions in Micronesia appear to often have the legal authority to collect damages and payment for cleanup from ship owners, logistical difficulties of removal or prosecution appear to hinder actions, especially when vessels have been abandoned by the owners. Again, no information is available on biofouling associated with these vessels, but long residence times can facilitate species transfer (as discussed above), and vessels on reefs can potentially release species directly into highly valued natural habitats (versus harbors).



Figure 3.20. Abandoned vessels are a problem in all locations in Micronesia.

3.10 Laid-up Vessels

Worldwide, shipping is down due to the economic downturn, and commercial vessels are sitting in ports while shipping agencies wait for shipping to pick up (Floerl and Coutts, 2009). We are unaware of any plans in Guam to allow such laid-up vessels to reside locally, but such a plan was being discussed in Palau, and it is possible that this may come under consideration for Guam or elsewhere in Micronesia in the future. Palau was approached by a group that wished to explore moving 30 vessels laid up in Davao, Philippines to the Palau harbor, where mooring spaces are less costly; any action on this proposal had been deferred at the time of this report.

Pearl Harbor in Hawai'i has recently received decommissioned U.S. Navy vessels from the West Coast of the U.S. Additional decommissioned vessels are expected to be moved to Pearl Harbor, but information was not available on how many of these vessels are expected or what the ultimate plans are for them. While these vessels are expected to adhere to U.S. Navy protocols with regards to ballast water (see Chapter 2), we were unable to determine if and how hull fouling is addressed for these and other inactive Navy vessels surrounding movements. Given that the existing protocols for hull maintenance are motivated by the need to maintain operational readiness (see Chapter 2), it is not clear whether these also apply to (and are implemented for) decommissioned vessels, which can have extensive biofouling communities and may be transferred to other locations (Davidson et al. 2008, deFelice and Godwin 1999), presenting a risk of non-native species transfer.

3.11 Ship Breaking

There are no current plans in Guam for breaking of decommissioned vessels for scrap metal, but this is being discussed for a location just south of the port in Saipan. If this plan goes forward in Saipan, it could lead to increased species introductions (for the same reasons outlined above), depending on the extent and nature of biosecurity protocols that could be used.

3.12 Fish Aggregating Devices

On Guam, the Department of Aquatic and Wildlife Resources (DAWR) uses old U.S. Navy buoys from Portland, Oregon as fish aggregating devices (FADs). These arrive clean and dry and are assembled on Guam. There are 14 designated locations for FAD deployment at depths between 500 and 3,000 fathoms. FADs are monitored by aerial survey twice a year. On Yap, FADs are constructed on island using coconut fronds and other local materials; these are fished regularly by the local fleet with the Yap Fishing Authority in control of deployment and maintenance.

While these particular practices appear to be extremely low risk for non-native species introductions and spread, elsewhere in Micronesia abandoned boats and other floating objects are sometimes deployed as FADs and are not well-monitored. We are aware of several that have been deployed around Saipan and Palau. One of the Palauan FADs, an abandoned vessel, ran aground and had to be broken up and sunk. In such cases, the source(s) and relocation of floating objects is of paramount concern in minimizing the potential translocation of non-native species; it is often not clear what policies or practices

may exist for use of vessels or other floating materials throughout the region.

3.13 Dry-docks

Guam has two floating dry-docks, owned and operated by the Guam Shipyard. Both dry-docks were towed to Guam from other locations: the Adept, from Subic Bay, Philippines and the Machinist (“Big Blue”) from Pearl Harbor, Hawai’i. Based on interviews with U.S. Navy and Port of Guam personnel, there are currently no plans to bring in additional dry-docks to Guam associated with the Buildup.

There is a proposed transfer of a dry-dock from Guam to Saipan by a ship maintenance company. A new dry-dock has been proposed for Majuro to service the purse seiner fleet, and permits have been approved, but problems with the site are holding up development; the proposed dry-dock, Ching Fu, would come from Taiwan. There have been some discussions about bringing a dry-dock to Pohnpei in the future. Small non-floating dry-docks (slipways) also exist on Yap and Kosrae (Figure 3.21), but no plans for changes to these facilities were reported.



Figure 3.21. A slipway in Yap servicing a small vessel.

In addition to concerns about biofouling on floating dry-docks that may be moved from one location to another, as observed with the transfer of the Machinist to Guam (Paulay et al. 2002), biofouling organisms removed from ships in the dry-dock and released to local

waters may affect invasion probability. There are currently no management practices in place addressing biofouling organisms released by dry-docks. In Guam, Hawai'i and Saipan, the EPA regulates dry-dock activities under the Clean Water Act, specifically focusing on the prevention of water pollution from rinse water and from dry materials removed from ships in dry-dock. These regulations do not specifically address the risks of non-native species transfers. Resource managers and officials throughout Micronesia expressed concerns with such issues and unregulated boat maintenance associated with dry-docks.

The DoD runs a dry-dock on Kwajalein Atoll. Information was not available to determine how frequently this dry-dock is used and what environmental regulations the DoD might have in place to prevent non-native species transfers from dry-dock activities.

3.14 Floating Docks/Pontoons and Other Structures

The docks at Perez and Agat marinas on Guam are floating structures, moored to fixed structures. Many of these are in disrepair. The Port Master Plan (DB International 2008) calls for replacing and expanding the floating docks and slips in these two marinas. Floating security barriers are planned for the DoD side of Apra Harbor.

The Port Master Plan for Guam proposes the construction of an additional 2,250 feet of refurbished and new wharf structures on the commercial side of the harbor. At the Agat Marina, the plan proposes extending the existing breakwater and general repairs and expansions at both Perez and Agat marinas which include the placement of concrete and/or metal fixed piers and pilings.

Significant additions to the DoD side of Apra Harbor are planned and/or are in progress, including dredging to create a new deep-draft channel, construction of a new wharf at Polaris Point to accommodate an aircraft carrier, a rip-rapped revetment, and an extension of Kilo Wharf using concrete caissons. The concrete caissons brought to Guam for Kilo Wharf construction were built in Japan and towed to Guam, after several months of sitting in the water. It is not clear what biofouling organisms were associated and transferred to Guam on these structures, which were cleaned only after being sunk in Apra Harbor.

The source of materials for the proposed structures on Guam was not known at the time of this report, and the development or application of any biosecurity protocols to minimize associated species transfers is also uncertain.

No other ports in the region except Guam report current plans for construction or replacement of existing floating or other structures. Most port agencies indicated that they were under capacity in terms of operations, with the exception of being able to accommodate cruise ships, and did not believe the Guam Buildup would require port expansions. Only Pohnpei was considering dredging and construction for cruise ships; this idea is still in an initial phase and is not yet part of any written plan.

3.15 Oil Drilling Platforms, Oil Production, and Exploration Vessels

Exploratory drilling for oil is being proposed in Palau. As with barges, drilling platforms

can reside in one location for long periods and develop extensive biofouling communities and are transferred (under slow speed) to other locations, posing a high risk of species introductions. There are currently no regulations on Palau for biofouling on drilling rigs and platforms.

As far as we could determine, there are no drilling or underwater exploration plans elsewhere in Micronesia. Nonetheless, given the shipping connection between Palau and Guam, activities in Guam could affect regional spread of species, should an invasion occur in Palau.

3.16 Buoys and Channel Markers

Navigation aids, such as buoys and channel markers, are maintained in Guam and CNMI by harbor staff, the USCG, and (in the case of CNMI channel markers) by the Division of Fish and Wildlife. Elsewhere in the region, navigation aids are maintained by harbors and marine resources agencies. As with other floating artificial substrata, these navigation aids become covered with biofouling. As long as they remain in place (and are generally not moved to other locations for relocation or cleaning), they do not present a high risk of non-native species transfer.

3.17 Dive and Recreational Fishing Gear

Scuba diving and recreational fishing are popular activities on Guam for military personnel, locals, and tourists alike. Scuba gear is also used for work activities for military and research personnel. If wet gear is moved between locations, there is a possibility of transferring organisms. Although we have not seen any official estimates of predicted growth in participation in these activities, we expect that an increase in population will result in an increase in recreational/charter fishing activities and snorkeling and scuba both on Guam and within the region in general.

Palau, Chuuk, and Yap are considered world-class dive destinations, with many divers visiting each of these islands in turn. Currently about 40,000 visitors come to Palau annually; about 80% of these are divers. Chuuk receives 3,000 visitors a year, nearly all of whom come to dive; Yap receives 4,000-5,000 a year, with 80-90% coming to dive. Tourism increases are also anticipated on Pohnpei, which, along with Palau, is expanding its airport to accommodate more visitors. Palau has officially invited the U.S. military for R&R (rest and relaxation); the Chuuk Visitor's Bureau was planning to attend a tourism trade show to court military visitors, and is working to get direct flights to Chuuk from the Philippines (and/or Taiwan).

To our knowledge, there are no management practices in place in the U.S. military, Guam or elsewhere in Micronesia to reduce the risk of transfer of non-native species through recreational fishing or diving activities. In the Papahānaumokuākea Marine National Monument (Northwestern Hawai'ian Islands), strict protocols are in place to prevent transfer of organisms on scuba gear, clothing or research equipment (PMHM Best Management Practices 2009).

3.18 Kayaks, Outriggers, and Personal Watercraft

Water activities are popular on Guam and elsewhere in the region for military personnel, locals, and tourists. Although there are no official estimates of predicted growth in participation in these activities, it is likely that increases in the local population size will result in an increase in water activities of all sorts, including those that involve small boats and personal watercraft. Military personnel coming to Guam may also ship such vessels with their personal goods. We are unaware of any existing management practices in Micronesia to reduce the transfer of marine organisms on or in small watercraft.

3.19 Summary

The goal of this chapter was to review current and projected future activities surrounding vessels, considering what is known about magnitude of these activities and existing practices from a marine biosecurity perspective. The treatment here summarizes available details compiled during the scope of the current project, but this is by no means a comprehensive or complete view of all relevant information. As noted at various points throughout this treatment, there are some gaps in the available data, such that the analysis presented here provides a minimum estimate of magnitude and geographic connectivity for some key mechanisms for species introduction and spread.

Conspicuous gaps in the current analysis exist for traffic patterns and ballast water delivery patterns associated with U.S. Navy ships and other military vessels. While estimates were made available for the number of arrivals for these vessels to Guam, but the following limitations exist:

- LPOC and voyage histories were not made available for U.S. Navy vessels, or other military vessels, except for those provided by MSC for supply vessels.
- While voyage histories were available for many MSC vessels, these were often limited to a short time horizon and appear to be incomplete records.
- Most vessels that operated under MSC did not report ballast water discharge or management data to USCG, so there is a major gap in information about the volume, geographic source(s), and management for water discharged in Guam and CNMI.
- No information was provided from DoD on ballast water discharge and management for any U.S. Navy, MSC, or other military vessels arriving to Micronesia or Hawai'i.

For non-military vessels, some additional information gaps are also apparent for Micronesia, as follows:

- Except for Guam and CNMI, commercial ships arriving to ports in Micronesia do not report ballast water discharge and management information, as there are no existing requirements or programs for this purpose.
- Information on voyage histories (and even LPOC) is only available for a small

fraction of fishing vessels and barges arriving in Guam and other jurisdictions of Micronesia.

- The numbers of barge arrivals in Micronesia appear to be underestimated in many of the existing datasets.

Despite these limitations, the current analysis provides an estimate of current vector activity in Micronesia and illustrates the connectivity that exists, both within the region and globally, especially for vessels. This information, along with that presented in other chapters, provides an important background for developing the biosecurity plan and recommendations outlined in the final chapter. Toward that end, we have included above some activities that are not currently prevalent, or even now in operation, within Micronesia but may become relevant in the near future; in nearly all cases, these activities are at least under consideration, even if they are not now operating in the region. This approach was intended to be as comprehensive as possible, in order to advance a biosecurity plan that captures as many future activities as possible that are relevant to the region.

Chapter 4: Live Marine Organism Importation and Trade

By Chela J. Zabin, Lucius G. Eldredge, and Gregory M. Ruiz

4.1 Importation Regulations and Enforcement

Trade in certain live organisms is regulated at the international level by CITES, to which the U.S. and Palau are signatories, and whose conventions are followed by the FSM and RMI. With the goal of protecting endangered or threatened species, CITES restricts the trade of organisms appearing in its three appendices. Of relevance to the region, giant clams (those in the Family Tridacnidae) and many coral species are CITES species, and are thus subject to specific restrictions. However, there are no international conventions prohibiting trade of marine organisms considered to be non-native, invasive⁴ or nuisance species.

In the U.S., some non-native species are specifically listed and prohibited from importation by the Lacey Act 1900 (for animals) and the Plant Protection Act 2000 (for plants and plant pests). Few marine and estuarine organisms are prohibited under these statutes. Exceptions under the Lacey Act include mitten crabs (crabs in the genus *Eriocheir*) and snakehead fishes (in the family Channidae, largely restricted to freshwater), which are listed as “injurious wildlife,” prohibiting any foreign export or interstate movement of live organisms without a federal permit. To similar purpose, the marine alga *Caulerpa taxifolia* (aquarium strain) is listed as a “noxious weed” under the Plant Protection Act, which prohibits importation into the U.S. or transportation across state boundaries without federal permit.

Current regulations for the importation and movement of live marine organisms in Micronesia are summarized in Table 4.1 and are reviewed in more detail below.

⁴ Note: in this section, the term “invasive” is used to describe non-native species that are perceived to be or perceived to have the potential to be problematic, as opposed to those being imported purposely. Worldwide, most aquaculture species and other live trade (pets, live food) species are non-native to the regions to which they are imported.

4.1.1 Importation Regulations

4.1.1.1 Guam.

DAWR maintains an informal “white list” of marine and aquatic organisms that can be imported live, including aquarium species and food species, such as New England lobster (*Homarus americanus*) and Pacific oysters (*Crassostrea gigas*). The white list mainly includes species already present on Guam (native or already established non-natives) and those that have a long history of importation into Guam with no known negative impacts. A few organisms are allowed for import only for Underwater World, Guam’s aquarium, as the biosecurity and sanitation procedures at the aquarium presumably meet high standards.

Permits must be obtained to bring in species on the white list, even small numbers of individuals for personal use. Importers can submit requests for permits to import organisms not on the list; these are reviewed and approved on a case-by-case basis, with the onus on the importer to prove an organism is not harmful. Importers must have a certificate of health from the point of origin for organisms being brought to Guam.

4.1.1.2 Hawai’i.

Hawai’i’s Department of Agriculture maintains a list of organisms that cannot be brought into the state, including many marine fishes and some species of crabs, octopus and jellyfish (scyphozoans), as well as a list of conditionally approved and restricted organisms, both of which contain numbers of marine species. An importer must have a permit to import anything on the list of conditionally approved organisms. Businesses wishing to import organisms on the restricted list must, as a condition of obtaining a permit, undergo a site inspection. Although terrestrial plants, microorganisms and pathogens appear on the various lists, we could find no lists for macroalgae. The state’s rules and lists are available on the state Department of Agriculture’s website <http://Hawai’i.gov/hdoa/pi/pq/import>.

4.1.1.3 Commonwealth of the Northern Marianas Islands (CNMI).

Imports to CNMI are regulated by USFWS and the Commonwealth’s Department of Fish and Wildlife (DFW) and Department of Agriculture. The DFW website (<http://www.dfw.gov.mp/Enforcement/Fishing%20Regulations.html>) lists species that are allowed for importation; these include several species of birds and mammals. No amphibians or reptiles are permitted. For invertebrates, including marine invertebrates, only those that can be demonstrated to be “not harmful” are permitted. Marine invertebrate importations tend not to be closely regulated. Giant clam spat have been provided to the CNMI from Palau on several occasions over the past 25 years. The only requirements were health certificates from Palau that stated that the clams were not harmful for human consumption. No fish or algae are listed on the DFW website, although enforcement officers are using an unofficial “white list” of freshwater fish species from Australia to make determinations for import permits to CNMI. These rules apply regardless of the number of individuals or purpose of the importation.

4.1.1.4 Republic of the Marshall Islands.

Republic of the Marshall Islands (RMI) does not maintain a list of either prohibited or allowed marine species. Requests for importation permits are decided on a case-by-case basis by Marine Resources and Agricultural Quarantine. For a permit to be approved, an importer must make the case that a proposed species does not pose an environmental threat. A health certificate from an independent veterinarian must accompany live imports. RMI is in the process of reviewing its quarantine regulations. A draft biosecurity bill is also now in progress, which may revise import and export regulations and practices.

4.1.1.5 Federated States of Micronesia.

By federal law, Federated States of Micronesia (FSM) prohibits the importation of exotic plants or animals, except under permit by the Director of Resources and Development (FSM Code, Title 23, Resource Conservation, Section 315). The code also states that no CITES species can be imported (FSM Code, Title 23, Section 8). All import permits must be approved by federal quarantine and undergo a pest risk analysis before a permit is approved. Under Kosrae State Code, if a plant or animal is not already found in the state, an importer must apply to the Department of Agriculture, Land and Fisheries for permission (KSC Title 14 Section 14.204), but it appears that review of permit applications happens at the federal level. Importers must have a certificate of health from the point of origin. Elsewhere in FSM, there do not appear to be any additional regulations at the state level regarding the importation of live marine species. All these regulations will be reviewed and updated after the approval of the new biosecurity bill.

4.1.1.6 Palau.

Palau's Plant and Animal Quarantines and Regulations (1999) contain schedules of prohibited plants and animals. These schedules were updated in 2002 to include any species or hybrid of tilapia (*Oreochromis* spp.), which is currently the only listed marine or aquatic species; however, the government is currently considering removing tilapia from the prohibited list, to promote its use in agriculture (see Section 4.2.1).

In 2006, the regulations were again amended, giving the Palau National Invasive Species Council (Palau NISC) the responsibility of reviewing an application for the importation of any species not already present on Palau. The Palau NISC has 30 days to carry out its review, but may request longer if further study (at the importer's expense) is required. This amendment also gives the Palau NISC the responsibility of advising the Palau Department of Agriculture on species that should be added or removed from the prohibited species schedules.

At ports of entry, including the post office, inspectors from the Palau Department of Agriculture are charged with carrying out inspections of cargo, mail, baggage, passengers, ships and airplanes. All live imports must have a permit issued by the Palau Department of Agriculture and live organisms must have received a certificate of health from their country of origin. Imported organisms can be placed in quarantine for further observation and treatment at the importer's cost if necessary. Although we were told that no live organisms could be imported for food, we did not find this restriction in the regulations.

In Palau, species intended for aquaculture must be approved by the Bureau of Aquaculture,

and are to be held in quarantine for seven days for observation by the Marine Resources Bureau. Nonetheless, there appears to be little capacity to do more than qualitative, visual screening to make a judgment about whether organisms “look healthy” and to sort out obvious non-target species accidentally included in shipments before release. Quarantine officials have the legal authority to inspect an importer’s facilities after organisms have passed through quarantine and can order organisms back into quarantine and/or destroy them after release, but it is not clear how frequently, if ever, this has been done.

4.1.3 Effectiveness of Port Inspections.

Details on interceptions of non-native marine and aquatic species were not available from local agencies, but anecdotal information suggests that smuggling of these organisms certainly occurs at some locations:

- The golden apple snail (*Pomacea canaliculata*) was discovered in Guam in 1984 in Agana Spring and 1986 in Laguas River, where it was being collected for food by local residents (Smith 1992). As the two water bodies are not connected, it is likely that the snail was moved by humans (See Section 4.2.2).
- Saipan has a large population of workers from countries that prize live food, especially fish and other seafood. Officials from management agencies there report having seen Chinese mitten crabs (*Erocheir sinensis*), non-native snails, non-native groupers, (subfamily Epinephelinae) and live swamp eel (probably *Monopterus albus*), for sale at local markets three to four years ago. None of these species can be legally imported.
- On Palau, it is assumed there is a large amount of unregulated trade between the southwestern islands, the Philippines and Indonesia.
- On Majuro, a crocodile apparently smuggled in as a pet was later released on the island and had to be captured by management agencies.

4.2. Aquaculture

4.2.1 Regulations and Industry Standards

Import regulations provide one level of biosecurity, providing pre-border protection from introductions of unwanted species. Another level of protection can result from post-border regulations or practices, which limit potential movement of organisms (and any associated biota) through various means. In many regions of the world, aquaculture species are typically non-native to the areas where they are raised. Even with permitted use, regulations or guidelines are sometimes used to prevent escape of the target organisms or associated species, especially parasites and pathogens, into natural habitats (e.g., National Research Council 2003, European Union 2007, Padilla et al. 2011).

Currently, there are no international conventions that address aquaculture practices to reduce the risk of invasive species. Despite the lack of binding instruments, there are several voluntary guidelines regarding the introduction and transfer of aquatic organisms.

The Convention on Biological Diversity, acknowledging the risk of invasive species transfer via this vector, strongly urges the consideration of native species for aquaculture and requests signatory countries to conduct scientific risk assessments for introductions before allowing the importation of new species (COP 7 Decision VII/5 45: <http://www.cbd.int/decision/cop/?id=7742>). Guidelines for the prevention of invasive-species transfers from aquaculture have been developed by the Food and Agriculture Organization (Food and Agriculture Organization 1995, 1996, 1997; Arthur et al. 2008; Bondad-Reantaso et al. 2008), the International Council for the Exploration of the Sea (International Council for the Exploration of the Sea 2005), and the World Conservation Union (IUCN) (Hewitt et al 2006) These guidelines have not been adopted by the U.S. or any of the countries in Micronesia. Recommendations for quarantine procedures for the region were made by the Secretariat of the Pacific Community (Humphries 1995), but most of the localities in Micronesia do not presently follow these recommendations, likely due to lack of capacity. SPC is currently working on an Aquatic Biosecurity Regional Strategy, as it has been identified as one of the main priorities at the SPC Head of Fisheries meeting held in Noumea in 2011. This regional strategy will have several components, one of which will be exclusively focused on aquatic species introductions. This component will include technical guidelines for import risk analysis, minimum requirements for pre and post-border quarantine methods, species lists, countries/competent authorities' lists, diseases list, among others.

The U.S. Department of Commerce is developing a national aquaculture policy that would provide a uniform set of regulations for all open ocean aquaculture in federal waters (<http://aquaculture.noaa.gov/>). However, at this time in the U.S., there is no single body that regulates aquaculture; a number of federal, state and local agencies may have jurisdiction, and oversight has been characterized as inadequate for dealing with invasive species (Naylor et al. 2010).

Despite a long history of aquaculture, and significant current official investment and interest, the Micronesian region has not had a uniform aquaculture policy and little attention appears to be focused on the issue of marine invasions. As an example, the alga *Kappaphycus alvarezii* has been brought to numerous Pacific Island countries and territories, beginning in the 1970s. A review of these introductions (Sulu et al. 2004) found only a single case in which a documented quarantine effort was made. Within individual countries, permits and approvals for aquaculture ventures are needed from multiple agencies, most of which deal with issues such as water pollution, earthmoving and construction, but none specifically address non-native species transfer. However, recently there have been several examples of introductions of aquatic species for aquaculture purposes within the Pacific where a risk analysis prior the introduction was carried out, and proper pre- and post-border quarantine measures were implemented. These include introduction of seaweeds from Indonesia to FSM, introduction of sandfish (holothurians) from Fiji into Kiribati, introduction of seaweed (improved variety) from Indonesia to Fiji, introduction of red tilapia from American Samoa to Samoa, introduction of GIFT tilapia from Malaysia to Solomon Islands, introduction of freshwater prawn from Thailand to Fiji, introduction of seaweeds from Malaysia to Papua New Guinea (PNG), and introduction of blue shrimp from Brunei to Fiji.

Other than import regulations, we were not able to find regulations that dealt with

preventing escapes (or movement) of non-native species or genetic material (although the new biosecurity bills being developed for Palau, FSM and RMI have specific sections dealing with the introduction and transfer of live organisms, including pre- and post-border quarantine measures, required certificates, and health certificates). On the whole, aquaculture policies and practices generally do not seem to be integrated with biosecurity plans or concerns. For example, the government of Palau is now considering the removal of tilapia from its list of prohibited species, and promotion of its use in aquaculture, despite many years of effort on the part of conservation agencies and community volunteers to eradicate tilapia there. The new plan, however, is an improvement over earlier tilapia introductions into Palau because it involves the introduction of GIFT Nile tilapia, which is a good option for aquaculture development and income generation. Previous introductions of tilapia in Palau involved the mossambicus tilapia (*O. mossambicus*), which is not only less suited for aquaculture, but also has a high invasiveness potential.

Biosecurity issues, both in terms of aquaculture disease and non-native species that might escape into the wild, are addressed in a draft version of CNMI's Aquaculture Development Plan. The policy is being developed by the Northern Marianas College Cooperative Research Extension and Education Service (NMC-CREES); its overarching goal is to increase aquaculture over the next five years. The plan specifically identifies the need to (a) establish a quarantine facility, (b) improve the capacity to diagnose aquaculture diseases, (c) carry out a risk assessment for any aquaculture species proposed for import into CNMI and (d) develop a list of potentially invasive species for CNMI. The draft plan lays out the need for funding for additional personnel with technical expertise in several areas. However, there also was no specific request that would increase local capacity to carry out risk assessments for proposed non-native species introductions, to monitor for escapes, or to carry out a rapid response if such escapes are detected; it is not clear what resources would be available to implement this plan.

A draft Guam Aquaculture Plan is currently being reviewed by the SPC and the University of Guam, but the plan does not directly address biosecurity issues.

In the FSM, the National Aquaculture Plan will be developed through a national consultation which will be held in 2013. A profile of aquaculture on Pohnpei (Pohnpei Marine Development 2004) outlines opportunities and constraints for further development of the industry. Non-native species are addressed only briefly. The report acknowledges the lack of regulation on the importation of aquaculture species and on the industry itself, as well as the lack of ability to enforce any existing permit requirements.

The aquaculture policy for RMI is currently under revision. We were unable to obtain a copy of the current plan but were told that issues of non-native species would be addressed in the revised version.

4.2.2 Compliance with Regulations and Practices

We were unable to determine the degree of compliance with existing regulations for import and use of aquaculture species, or the ability of agencies to enforce them. Data collected by relevant agencies are sparse; most available information was anecdotal, being limited to observations and incidents with little or no documentation.

Within Micronesia, as elsewhere, there is likely some amount of unofficial or unapproved aquaculture using non-native species. We were told of such attempts that were started without the approval of relevant agencies, including the following:

- In 2009, an algal species (*Gracilaria* sp.) from the Philippines and approximately 5,000 Japanese abalone (*Haliotis asinina*) were reportedly set out in pens near the Tinian port without an environmental review. We were told that the algae were hand-carried on an airplane to Tinian in coolers, which were not inspected by quarantine officers. The operation has since been shut down by management agencies, but approximately 1,700 abalones are apparently still present on the island.
- In 1989, the introduced golden apple snail (*Pomacea canaliculata*) was discovered growing in tilapia aquaculture ponds on Guam. The snail was being harvested and sold by the farmer, who told government officials that it had arrived accidentally with the tilapia fry imported from Taiwan (Smith 1992). In 1990, officials ordered the farmer to destroy the snails and subsequent surveys of his ponds and nearby stream indicated that he had complied. However, a dense population of the snail was found one year later in a Mangilao wetland, some 20 miles from the aquaculture facility, where it was being collected by local people.
- A student at the University of Guam reportedly planted two non-native oyster species from the Solomon Islands and Palau in Sasa Bay (Apra Harbor), Guam, in 1978 and 1979 as an aquaculture experiment. At least one of these two non-native species successfully spawned and recruited (Braley 1984); oysters were stolen from one of the student's study sites. The outcome of this intended transplant is unknown.
- On Kosrae, there are reports of a non-native, salt-water catfish species that first appeared around the harbor area where Chinese fishing vessels anchor, according to officials there. It is unclear whether this species was intentionally brought or might have been an accidental release.

In addition, poaching is reported to be a problem for aquaculture on Chuuk, and could potentially compromise any biosecurity measures in place. We were told that a Korean operation brought coral perch (family Scorpaenidae) from Korea to Chuuk Lagoon, where they were kept in pens to be raised to market size. In the first year, someone cut the pen net, releasing approximately 1,000 individuals. It is believed that all of the fish were caught, as they tend to school and are unafraid of humans. Poaching of smaller-scale local operations is apparently also not uncommon. Enforcement agencies apparently lack the capacity to deal with this problem.

Table 4.1 Summary of current regulations, standards, enforcement and compliance for the imports of live organisms.

	U.S. Military	Guam	Hawai'i	CNMI	RMI	FSM	Palau
Regulations	Abides by local regulations	No restrictions for 8 or fewer individuals; unofficial white list for >8; additional permits decided case-by- case	Lists of conditional, restricted and prohibited species. Permits for restricted species require site inspection.	“Harmful” invertebrates disallowed; other permits on case-by- case basis; unofficial white list used for freshwater fish	Permits on case-by- case basis	No CITES organisms; organisms not already in FSM, case-by- case basis	Tilapia only prohibited marine/aquatic species; organisms not already in FSM, case-by- case basis with NISC review; aquaculture imports held in quarantine 7 days for observation, sort out non-target species
Enforcement at ports of entry	Civilian enforcement at ports	Seaports/airports: cargo inspected based on bills of lading, baggage based on declarations; no mail inspection without probable cause					
Post-entry enforcement	Same as civilian	Not illegal to possess import- restricted organisms	N/A	No capacity	No capacity	No capacity	Quarantine can seize illegally imported organisms

	U.S. Military	Guam	Hawai'i	CNMI	RMI	FSM	Palau
% cargo, baggage, passengers screened	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Effectiveness of screening	Unknown	Unknown	Unknown	Unknown; reports of illegal organisms in food markets; one case of high-profile illegal aquaculture	Unknown; little anecdotal evidence of smuggling	Unknown; little anecdotal evidence of smuggling	Unknown; suspected smuggling and illegal trade especially in the southwestern islands
Export screenings	Prior to moving personnel, all personal effects screened in-home	Brown tree snake only.	Ag X-ray screening on departure for U.S. Mainland	None			Ag can inspect

4.3 Current and Anticipated Live-organism Trade

4.3.1 Aquaculture

Hawai'i and Micronesia have a long history of moving organisms into and within the region for aquaculture and for restocking declining wild populations. Some of these efforts have ceased, such as the introduction of the topshell (*Trochus niloticus*), which now has protected status on some islands where it has become established; others, such as the intra-regional movement of giant clams (family Tridacnidae), continue to this day. This history of marine species transfers is detailed by Eldredge (1994) and includes fish, crustaceans, mollusks and algae from both temperate and tropical locations. In addition, the spread of diseases and pests of aquaculture species in the Pacific is reviewed by Humphries (1995). Currently, there are a number of aquaculture facilities in the region.

Nearly all countries and island groups in Micronesia promote aquaculture as a way to increase local food supply and income. Below, we outline briefly some of the current activities by location.

4.3.1.1 Guam

On Guam there are three commercial facilities and a facility run by the University of Guam. The main species being imported are tilapia (*Oreochromis* spp.), white-legged shrimp (*Litopenaeus vannamei*), walking catfish (*Clarias batrachus*), and milkfish (*Chanos chanos*); the first three species are raised for food, and the latter is used for bait by tuna longliners. These organisms are generally imported from Taiwan, Malaysia and the Philippines. Some trials are also currently underway for red snapper and humpback grouper imported from Palau. The one facility we visited on Guam is located on a cliff and drains water from its tanks onto a limestone pond above the reef flat. Stock of the diatom *Chaetoceros gracilis* culture for this facility is occasionally imported from Hawai'i, and brine shrimp (*Artemia* sp.) is ordered from various off-island businesses; neither food source is included on Guam's white list.

Other marine species that have been imported for the aquaculture trade include giant clams, the Australian oyster (*Crassostrea echinata*), the Pacific oyster (*Crassostrea gigas*), the Australian rock oyster (*Saccostrea commercialis*), the Solomon Island mangrove oyster (*Saccostrea cucullata tuberculata*), the topshell (*Trochus niloticus*), the limpet (*Cellana mazatlandica*), the penaeid shrimps (*Penaeus monodon* and *P. stylirostris*), the mangrove crab (*Scylla serrata*), and the mullet (*Mugil cephalus*) (reviewed in Eldredge 1994).

The draft Development Plan for Aquaculture on Guam includes a section evaluating high-potential species for aquaculture development. For several of the candidate aquaculture products (e.g., grouper, mangrove crabs, freshwater prawn), the fry will probably need to be imported from overseas.

4.3.1.2 Commonwealth of Northern Mariana Islands.

On Saipan, NMC-CREES is active in promoting aquaculture, including tank-reared white-legged shrimp (*Litopenaeus vannamei*), various tilapia, wild-caught rabbitfish (*Siganus*

sp.), and mullets (*Mugil* spp.). NMC-CREES was also involved in a venture on Tinian that involved placing Japanese abalone (*Haliotis asisina*) and algae (*Gracilaria bailinae*) from the Philippines in cages near the seaport (as noted previously). The latter operation was shut down following questions about whether it had received appropriate environmental review. NMC-CREES has recently sponsored a conference on open ocean cage culture, which it is promoting as easy to do and harmless to the environment, and is the lead agency in charge of developing an aquaculture plan for CNMI.

The history of aquaculture on Saipan includes (a) the rearing of shrimp imported from Guam and the Philippines in a flow-through system, (b) giant clams brought from an aquaculture center on Palau and placed in the lagoon (these efforts failed due to poaching), and (c) the importation of the topshell (*Trochus niloticus*) in 1938, during the Japanese period. The last is now a protected species. Currently, a private venture, Saipan Aquaculture, raises white-legged shrimp which it sells locally and exports to Guam for food and to Asia for broodstock. There are eight tilapia growers in CNMI raising three strains of the fish.

4.3.1.3 Republic of the Marshall Islands.

On Majuro, current aquaculture ventures include giant clams (broodstock from various locations in the Marshall Islands), corals raised for the aquarium trade and black pearl oysters (*Pinctada margaritifera*). Microalgae are brought in from Australia, Hawai'i and Florida and used as food for these ventures. A barramundi (*Lates calcarifer*) and cobia (*Rachycentron canadum*) aquaculture project, which brought stock from a hatchery in Australia, failed about two years ago for economic reasons. Marine Resources officials had raised concerns about whether cobia, which are a highly migratory species, were appropriate for aquaculture, but the project was ultimately approved. It appears that all animals were removed when the facility closed. *Trochus niloticus* was also brought to the Marshalls by the Japanese and is still present there.

4.3.1.4 Kosrae.

Giant clams (with broodstock from various locations within Micronesia) and corals are now being raised on Kosrae. A state-funded project to raise local mud crabs (*Scylla serrata*) is also in operation, with crabs cultured in a state-run hatchery and out planted to grow-out tanks. The topshell (*T. niloticus*) from Pohnpei and the green snail (*Turbo marmoratus*) were brought to the island in the 1940s or 1950s, with *T. niloticus* having become established; *T. marmoratus* was an unsuccessful introduction. Kosraean officials report that *T. niloticus* were protected from fishing until they established populations.

4.3.1.5 Federated States of Micronesia.

The development and promotion of aquaculture is one of the major program areas under development for the College of Micronesia, which has campuses in all the FSM states. Among the targeted organisms are pearl oysters, sea cucumbers and rabbit fish (College of Micronesia 2009). The pearl-oyster program is the most developed of these programs, and is underway on Pohnpei. The Pohnpei Agricultural and Trade School previously cultured pearl oysters, sponges, corals, and marine ornamental, but closed in 2005. Other species

recently proposed or tried for aquaculture there include the alga *Kappaphycus* (introduced in the late 1980s from the Philippines, and slated for re-introduction from Indonesia in the near future), white-banded sea perch and milkfish (the latter having been brought in 2004-2005, probably from the Philippines). A successful private sponge culture in Pohnpei Lagoon was established in the 1980s and exported quality sponges. We were unable to determine whether these operations are still in existence. A proposal to farm tilapia was recently turned down by Marine Resources, however these fish have recently become established in the island's streams and are thought to be an escaped or intentional illegal aquaculture species.

The red alga *Euchema spinosum* and one additional *Euchema* species were also attempted for aquaculture on Pohnpei, but low yields due to grazing by rabbit fishes made this economically unfeasible, and the project was abandoned in the early 1980s. However, these algae species were also brought from Pohnpei to Kosrae, Majuro, Mili and Likiep. While it does not seem that the algae survive well on the reef, they were reported growing on aquaculture structures in Likiep (Eldredge 1994). The topshell (*T. niloticus*) was brought to Pohnpei from Chuuk and Palau in the 1930s, resulting in a fishery peaking in 1951 (Eldredge 1994).

On Chuuk, known established non-native species are the result of aquaculture introductions. These include *T. niloticus*, established in the 1930s, and one or two species of sea cucumbers. A more recent attempt at largescale aquaculture by a Korean firm was foiled by poachers (see Section 4.22). The company has an ongoing Memorandum of Understanding with the Chuukese government to continue aquaculture research, but no new activity has occurred for two to three years. A government hatchery raises pearl oysters, but these are derived from local stock. There are about 20 giant clam farms on Chuuk, with seed material coming from Pohnpei. Poaching is reported to be a problem for these smaller local farmers as well.

On Yap, native sea cucumbers, coral and fish are raised in aquaculture, as well as giant clams from Palau. Non-native tilapia have invaded mangrove system and are perceived to be bothering native fishes.

4.3.1.6 Palau.

The Micronesian Aquaculture Demonstration facility on Palau produces giant clams for outplanting and export for aquariums and is involved in pilot projects for the rearing of other local organisms. Other aquaculture species include groupers (*Epinephelus fuscoguttatus*), shrimp, milkfish and mangrove crabs from the Philippines and Taiwan. Species that have also been tried in Palau include the Pacific oyster (*Crassostrea gigas*), rabbit fish (*Siganus* sp.), coral trout (*Plectropomus leopardus* and *P. aerolatus*), and Napoleon wrasse (*Cheilinus undulatus*).

4.3.2 Pet/Aquarium Trade

Because detailed records are not kept in the various jurisdictions of Micronesia on pet trade of aquatic organisms, we were unable to obtain much information on the types and numbers of marine species imported to Micronesia for home and commercial aquaria. Overall, the

region is likely a net exporter of marine aquarium species. However, an estimated 149,650 fish for aquaria (reported only as “tropical fish”) were imported to Guam from foreign sources between 2007-2009 (Walsh et al. 2010). It is unknown how many additional fish may have arrived from domestic sources or how many of the total were marine species. Additional unrecorded sources of marine species for aquaria include species ordered online and arriving to the region via domestic postal mail or courier services. It is expected that most aquarium species are shipped via air (Cole et al. 1999). Inspections are challenging because these shipments tend to not be well-labeled and inspectors have insufficient training to identify species. There is also little self-regulation within the industry to screen for potential invasive species (Gertzen et al. 2008).

There are relatively few retail outlets in Micronesia for aquarium fish, invertebrates and algae. For example, we are aware of two commercial outlets on Guam. Freshwater aquarium plants and animals are also sold at the local farmer’s market and at a store located on one of the U.S. military bases on Guam (the Navy exchange). DAWR receives about 15 import requests a year from pet trade importers, with organisms coming mostly from Taiwan, Malaysia, Philippines, Korea, and the U.S. mainland.

4.3.3 Live Food Imports

On Guam, some 30 importers currently bring in about 50 live-food imports a year. These include live lobster, clams, abalone, mangrove crabs, and coconut crabs. These live-food items are imported from a variety of locations, which include the FSM, Philippines, U.S. mainland and New Zealand. Biologists from the USGS and the Smithsonian Institution visited seafood markets that carried live fish and shrimp on Guam in Feb 2010. Customers had the option of taking home live seafood (Walsh et al. 2010). We also observed live fish, coconut crabs (*Birgus latro*) and shrimp for sale at the Farmers Market in Dededo, Guam.

While it is possible that fishing vessels may also carry live seafood (see Section 4.2.2), we have no data on the frequency or extent to which this occurs or the possible species involved.

4.3.4 Live Bait and Other Vectors

Milkfish, imported from outside the region, are raised commercially for bait. Other than this, there does not seem to be a market in the region for imported live bait. We did not find any evidence of the importation into the region of live marine species for other uses, such as biological control or scientific research.

4.3.5 Expected Increase in Live Organism Importation

Currently, legal importation of live marine organisms appears to be fairly limited in the region; however, this may shift with an increase in population on Guam.

Globally, aquaculture production has more than doubled both in value and volume in the past decade, becoming one of the fastest-growing sectors in the world food economy (Naylor et al. 2010). This trend is likely to increase as pressure increases on dwindling wild populations of fish and other seafood. In the region, aquaculture is expected to increase

(Ponia 2010), and local aquaculture projects will likely continue to be encouraged as the population grows. In addition to increasing the risk of importing pest species (including disease organisms), aquaculture-related activities, such as the movement of stock animals and aquaculture equipment and structures into and within the region may also increase the risk of non-native species transfer.

It is also likely that the number of aquarium enthusiasts and the demand for salt water aquarium species will rise along with the general increase in population related to the Guam buildup.

Relevant to the Buildup, demand for live food could rise with increase in population and prosperity. The species and number of individuals being imported both legally and illegally is likely to be tied to the ethnic makeup of workers and military personnel coming to the region. For example, seizures of illegally imported animals and animal products on Saipan increased with the increase in Chinese nationals who came to work at the island's garment factories (see Section 4.1.3). Among the risks of live-food imports are accidental or intentional releases by individuals hoping to start populations they can harvest. With the closure of the garment factories on Saipan, the grow-out of non-native species for use as a food resource by alien workers is reported to have declined, and will likely continue to decline (barring the growth of similar new industries on the island).

While numbers of organisms and sources are unknown, it is certain that the amount of goods and personnel moving into and within the region will increase. It appears that such an increase could strain the available capacity to inspect and control the flow of these organisms, since there are reported to already be limitations in this regard at the present time.

4.3.5.2 Other Micronesian Countries.

Officials we spoke with at nearly every jurisdiction in the region felt they were understaffed, underequipped, and undertrained to carry out thorough inspections of the current amount of cargo, baggage and passengers, much less handle any potential future increase or carry out any post-border enforcement. Other barriers to effective detection and enforcement include social and cultural factors. For example, one agriculture inspector in FSM indicated that he was embarrassed to search the suitcases of female passengers. Other possible hurdles to biosecurity measures mentioned by inspectors and managers in the region included nepotism, favoritism, public distrust of the government, and land-ownership regulations that hamper government agencies from carrying out management/eradication programs that require access to privately-held lands.

4.4 Conclusions

4.4.1 Pre-border Biosecurity

Trade in live marine organisms is a major vector for the transfer of non-native species around the globe. However, there are no international conventions prohibiting or regulating trade that focus explicitly on non-native species. U.S. federal law prohibits the importation of a few non-native species under the Lacey Act (1900) and the Plant Protection Act (2000), however only a few marine or estuarine species are listed.

Within the Micronesian region, most jurisdictions maintain either “white lists” of allowed species, or lists of prohibited or restricted species. With the exception of Hawai’i, Guam, and Saipan, few lists or regulations address marine species, having been developed primarily to protect agriculture. Several other gaps exist in terms of pre-border biosecurity for movement of live marine organisms:

None of the states or countries in the region appears to have the capacity to carry out thorough inspections of luggage and cargo in terms of trained personnel. Many lack equipment such as X-ray machines and computers that could make enforcement more efficient and effective. Anecdotal information indicates that smuggling of live species is occurring throughout the region, including estuarine and marine organisms.

None have the capacity to carry out investigations or effective enforcement beyond ports of entry. In some cases, this is due to discrepancies between import regulations and other laws, as in Guam, where it is not illegal to possess certain species prohibited for import. Domestic mail is not routinely inspected, providing a potentially important (but poorly documented) pathway for trade in non-native species between the continental U.S. and Hawai’i, Guam and CNMI.

Even for declared or permitted live imports, species-level identifications, labels and any certification (of disease-free status or absence of associated organisms) are often poor, making any assessment and pre-screening difficult at best. Little to no screening of outgoing cargo occurs in the region.

4.4.2 Post-border Biosecurity

While it is clear that live marine species are currently imported into the region and also transferred between island groups for food, bait, pets/aquaria and aquaculture, there are few regulations, guidelines, and plans to minimize potential invasion risks. This is perhaps most relevant for aquaculture, because (a) the Micronesian region has a long history of aquaculture and (b) most countries and island groups are actively encouraging the expansion of aquaculture.

Few countries or island groups in the region have an articulated plan for aquaculture development and practices (such plans are being developed for Saipan and the RMI). We did not encounter any regulations that dealt with preventing escapes of non-native species or genetic material. Many of the species used for aquaculture are non-native and potentially carry a high risk of invasion, relative to accidental introductions, having been selected explicitly for traits including hardiness, rapid growth, and large body sizes, and for the ability to do well in the salinity and temperature regimes in the region.

Aquaculture species also present a risk of introducing plant pests, animal parasites, pathogens, and other hitchhikers that could impact the aquaculture species, native communities, or natural resources.

We found several gaps in biosecurity related to aquaculture, including:

- The decision process for permitting use of selected species for aquaculture, in terms

of assessing possible risks of invasion, is often not well defined.

- While many of the countries and states in the region have regulations aiming at insuring that such imports arrive disease- and pest-free, there appears to be little capacity (including quarantine facilities and technical staff) to ensure that this is the case.
- Measures to prevent the escape of non-native aquaculture species have not been entirely successful. Breakage of pens, poaching, natural disasters (e.g. typhoons, floods), and other incidents have resulted in the release of non-native species.

Illegal aquaculture using non-native species also appears to be occurring to some extent in the region, in the form of small scale backyard aquaculture setups. On the whole, aquaculture policies and practices generally do not seem to be integrated with biosecurity plans or concerns, either on a regional basis or even within individual countries.

4.4.3 Live Trade and the Buildup

It is likely that the Buildup will result indirectly in some increased trade in live marine organisms for the following reasons:

- An increased demand for live seafood. Construction workers and other workers moving to the region to provide services for the increased number of service personnel and their families are expected to come from Asian countries in which fresh food, including live seafood, is highly prized. An increase in the island's population due to the Buildup is also likely generally to result in a greater number of people who can afford to purchase fresh, imported seafood.
- An increased demand for pets and aquarium species due to the expected increase in population and income.
- An increase in aquaculture ventures. As the population of Guam increases, aquaculture may be increasingly promoted as a way to provide local food and to replenish or replace dwindling wild-caught stocks.

It is not clear how management agencies will respond to minimize risks of invasions associated with any such increase in live organism trade. The enforcement of border and post-border regulations on trade in live organisms is the responsibility of civilian governments and outside of the jurisdiction of the U.S. military. Management agencies throughout the region appear to be operating at or beyond capacity at the present time, and are likely to be further taxed by any increases in activity unless systems across the board are enhanced and improved in step with any increases.

PART II.
Risk Assessment

Chapter 5: Assessment of Marine Invasion Risks Associated With Relocation of U.S. Marine Corps Forces to Guam

By Chad L. Hewitt, Marnie Campbell, Paul W. Fofonoff, and Mark Minton

5.1 Introduction

Global marine biosecurity efforts for the last several decades have focused on ballast water (and sediment) mediated species transfers, with several nations developing independent management arrangements while the international community moved towards a binding agreement (e.g., Gollasch et al. 2007; Hewitt et al. 2009a). Ballast water had been implicated as the most likely vector responsible for several high profile marine species invasions (e.g., Carlton 1985; 2001; Carlton and Geller 1993). Examples include:

- the global increase in toxic dinoflagellate blooms (Hallegraeff 1993);
- the introduction of the comb-jelly (*Mnemiopsis leidyi*) into the Black, Azov and Caspian Seas contributing to the collapse of the anchovy fishery (e.g., Kideys 2002);
- the dominance of the Asian clam (*Corbula (Potamocorbula) amurensis*) in San Francisco Bay, California (Nichols et al. 1990); and
- the invasion of the northern Pacific seastar (*Asterias amurensis*) into Hobart, Tasmania and Port Phillip Bay, Victoria (Ross et al. 2003).

The finalization of a ballast water convention by the IMO (International Maritime Organization 2005; see also Chapter 2 for discussion), following more than fourteen years of negotiations (Gollasch et al. 2007; Hewitt et al. 2009b, b), has resulted in a refocus on the potential for biofouling to transport species (e.g., Hewitt et al. 2009c, d). Biofouling has long been recognized as an introduction mechanism (e.g., Carlton 1979; Carlton and Hodder 1995) and has been increasingly identified as an equal if not greater risk than ballast water during the last decade (e.g., Hewitt et al. 1999, 2004; Thresher 2000; Gollasch 2002; Hewitt 2002, 2003; Lewis et al. 2003, 2004; Minchin 2006, 2007; Schaffelke et al. 2006; Schaffelke and Hewitt 2007; Hewitt and Campbell 2008, 2010; Lewis and Coutts 2010).

Despite increasing awareness of these transport mechanisms, our knowledge base is limited, resulting in the need for decision support tools that provide consistency and transparency during decision making in the face of uncertainty. Risk based decision frameworks for the management of ballast water mediated introductions have been under development since the mid-1990s. The implementation of these Decision Support Systems (DSS) has demonstrated the utility of risk analysis in the field of marine biosecurity.

Application to biofouling however has been slow.

Risk analysis is commonly used for management of such issues because pragmatic decisions can be made that provide a balance between competing environmental and socio-economic interests, despite limited availability of information (e.g., Hayes and Hewitt 1998; Campbell 2005, 2006, 2008, 2009; Hayes et al. 2004a; Hewitt et al. 2006; Barry et al. 2008; Campbell and Hewitt 2008, 2011).

In a marine biosecurity context, conventional risk assessment methodology consists of five steps:

1. Identifying endpoints (within biosecurity common endpoints are a breach in quarantine or a subsequent impact)
2. Identifying hazards
3. Determining likelihood
4. Determining consequences and
5. Calculating risk

This process is similar (following the five step process) to the risk management standard used in Australia and New Zealand (Standards Australia 2000, 2004) and the risk framework agreed by U.S. Aquatic Nuisance Species Task Force and National Invasive Species Council (2007). Marine biosecurity risk endpoints are typically (a) inoculation (breaking the quarantine barrier), (b) establishment, and (c) spread (Figure 5.1).

This chapter concentrates on developing an understanding of the hazards (i.e., potential non-native species which could be transported to Micronesia) and the relative likelihoods of their arrival, based on records of shipping over an 11-year period, resulting in an assessment of the most likely species to arrive in Guam which would break the quarantine barrier (inoculation endpoint) and spread subsequently to other jurisdictions of Micronesia and Hawai'i. Based on information collected from USCG ballast water reporting forms (see Chapter 4), the majority of vessels arrive fully laden and do not discharge ballast in Guam. The situation is less clear for the rest of Micronesia and for vessels transiting from Micronesia to Hawaii. Where vessels arriving to Guam do arrive in ballast, or need to undertake ballast management for trim during off-loading, the discharges are generally small. As a consequence of these low ballast discharge volumes, and also limited data availability for many parts of Micronesia, this risk evaluation concentrated on biofouling related transport alone.

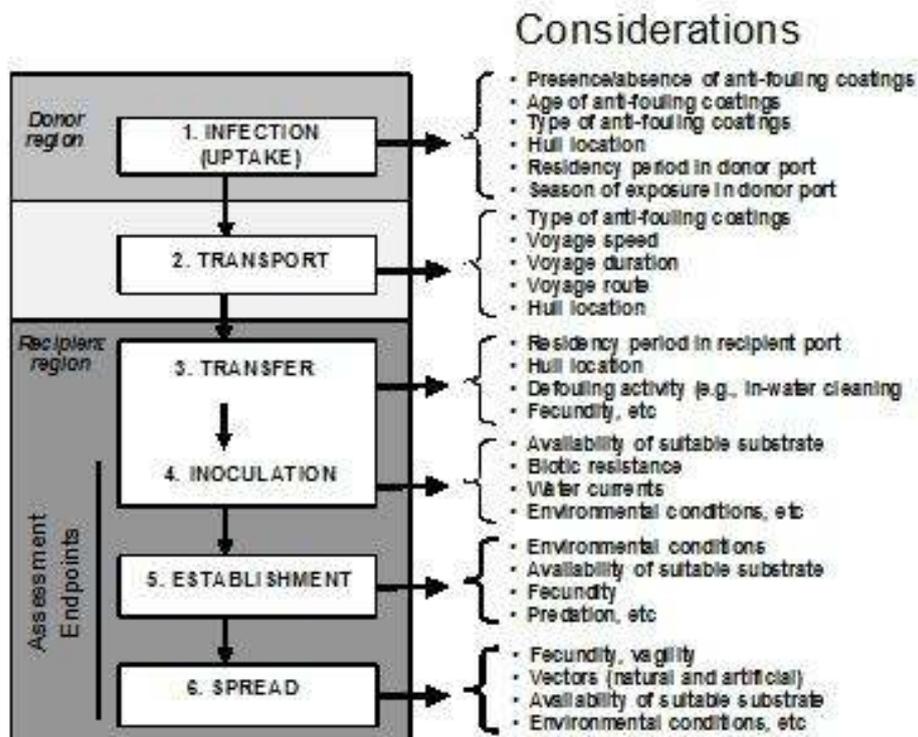


Figure 5.1. Conceptual model of the invasion process, with explicit identification of assessment endpoints in the recipient region and considerations in the risk analysis (adapted from Lewis and Coutts 2010).

5.2 Methods

This risk assessment followed the previously described five step process: identify endpoints; identify hazards; determine consequences; determine likelihood; and calculating risk (*sensu* Standards Australia 2000, 2004). For this assessment, consequence was deemed to be high for any species that was capable of “breaking” the quarantine barrier. Therefore, it evaluates risk across two identified endpoints, inoculation and spread (Figure 5.1), including the initial likelihood of inoculation to Guam was subsequently evaluated for spread to other jurisdictions of Micronesia and Hawai’i (Figure 5.2). This risk assessment focused on two elements: (a) the likelihood of a species’ arrival to Guam, and to Micronesia as a whole and Hawai’i, and (b) evaluating the arrival likelihood independently for each Micronesian State and Hawai’i and via Guam. Likelihood was determined based on analysis of international vessel voyages prior to entry into Micronesia between 1999 and 2009, and Hawai’i between 2006 and 2011, to determine the exposure to global bioregions and using information on the global distribution of known non-native marine species to

determine the likelihood of transport. This data range was the most recently available at the time that the analysis was undertaken and the period for which information on the majority of vessel types was available. Earlier records were not used due to data inconsistencies and cost constraints.

Global non-native marine and estuarine species data derived from Hewitt and Campbell (2008, 2010) were used as a starting point to identify hazards (i.e., marine and estuarine species with known invasion history), with significant effort by the current team to update the known information on global marine and estuarine invasions through literature and web-based reviews of species reports for known invaders and collection of reports of new invaders.

Global non-native marine and estuarine species were categorized as hazards based upon their potential to breach the Micronesian quarantine border, as demonstrated by a history of invasions in other regions.

Based on information collected from ballast water reporting forms, the majority of vessels arrive fully laden and do not discharge ballast in Guam (see Chapter 3). Where these vessels do arrive in ballast, or need to undertake ballast management for trim during off-loading, the discharges are generally small. However, as outlined in Chapter 3, the data for ballast water discharges is incomplete for Guam, especially for U.S. Navy vessels, and also for all ships in other countries throughout Micronesia.

This risk evaluation concentrated exclusively on biofouling related transport alone. The movement of vessel's hulls themselves (instead of ballast water) is the mode of transport for organisms which is analyzed here, and extensive information on geographic origins and traffic history for commercial and MSC vessels was obtained for this analysis. Data on vessel traffic was not available for U.S. Navy combatants, due to concerns about national security (see Chapter 1), and were therefore excluded entirely from this analysis. Hull biofouling is a key vector for marine introductions, as summarized below (see also Chapter 1), and biofouling by ships may provide a useful model for evaluating marine invasion risks.

5.2.1 Identifying Endpoints

The endpoint of the risk analysis is a critical stage in scoping the context of the assessment and determines the detail of consequence analysis to be used (e.g., Campbell 2006, 2008). For example, unintentional introductions of non-native marine species associated with the movements of species, feed stocks, and movement of equipment would typically consider quarantine endpoints – that is any un-permitted breach of the border (e.g., Hewitt and Hayes 2001, 2002; Hayes 2002; Campbell 2006, 2009). Marine biosecurity risk can be evaluated across three endpoints, inoculation (or entry), establishment, and spread.

This risk assessment focuses primarily on the international entry of vessels (inoculation endpoint) into Guam and the subsequent assessment of spread to other jurisdictions of Micronesia and Hawai'i, with less extensive evaluations of establishment. It is worthwhile to note that while the role of Guam as a shipping hub for the Micronesia region and as a primary departure point for shipping heading from Micronesia to Hawaii is important, there

are other potential direct and indirect routes for shipping in the region, all of which may assist in the spread of non-native species to both individual jurisdictions as well as the region as a whole. For example, there is shipping from various Asian ports directly and indirectly to a variety of the jurisdictions of Micronesia as well as ship movement between various islands of Micronesia that may or may not include stops in Guam.

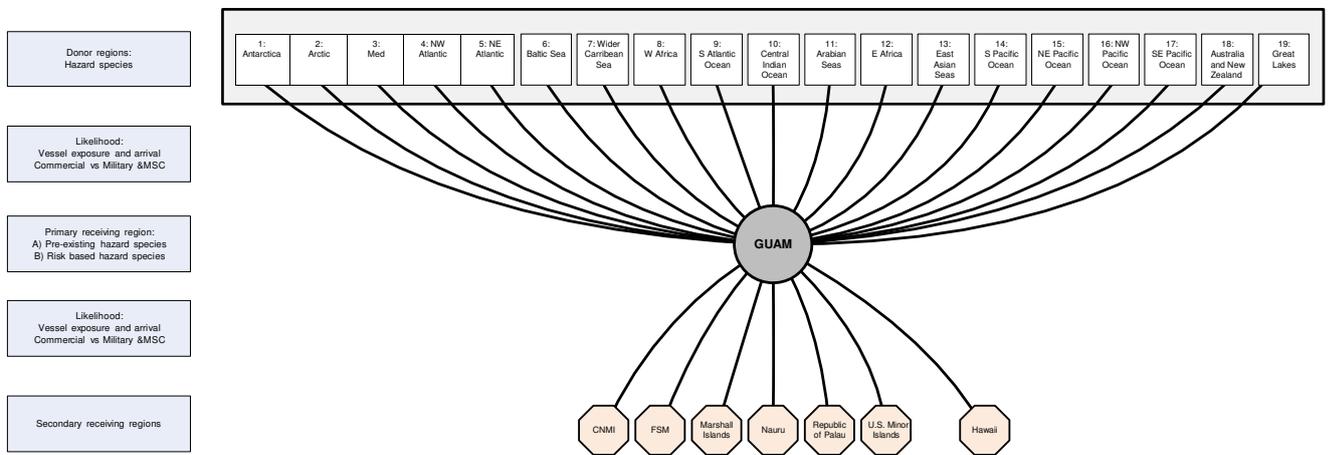


Figure 5.2. Conceptual model of this risk assessment.

5.2.2 Identifying Hazards

Hazards have been defined in this context as non-native marine and estuarine species that:

- have the potential to transcend the Micronesian quarantine border and
- have demonstrated or inferred potential to cause impact.

A comprehensive assessment of the recognized marine and estuarine invasions from throughout the globe was conducted building upon the work undertaken by Hewitt and Campbell (2008) and Hayes et al. (2004a). This provided the basis for identifying species level hazards. This report has compiled information from over 1,000 data sources including primary (peer reviewed journals and books) and secondary ('grey' literature such as websites, policy documents, online databases, reports; typically not peer-reviewed) literature, and information derived from a number of researchers.

Data for global species distribution was recorded using the 18 large scale IUCN marine bioregions (Kelleher et al. 1995) identified in Hewitt and Campbell (2008) (Figure 5.3). These are considered close representatives of widely accepted biological provinces rather than the finer scale ecoregions of Spalding et al. (2007) or the Large Scale Marine Ecosystems (Watling and Gerken 2004). The designation and use of biogeographic boundaries has engendered significant debate in the literature, however the use of provinces with recognition of overlapping boundaries provides the basis for the Kelleher et al. (1995) designation. This system creates a sequence of 'core' and 'transitional' areas which are roughly equivalent to the Spalding et al. (2007) 'ecoregions' used by Molnar et al. (2008). Hayes et al. (2004a) used these 'core' and 'transitional' areas described by Kelleher et al. (1995) in their identification of 'next pests.' However, these finer scale regions do not represent provincial boundaries and therefore do not offer a conservative approach to estimating species distributions.

By recording species at the bioregion level it is assumed that the species is present in all ports in the bioregion. Due to limitations on the data available from many parts of the world, and the rapidity with which species can be transported and spread within a region, this assumption avoids an overly restrictive data collection exercise. Also, pragmatically, data are simply not available on occurrence for a finer-grain spatial scale for many marine species.

The database of global marine and estuarine introductions developed here now includes 2,365 species. Over 98% of the 2,365 species were allocated to possible transport vectors. This followed the criteria and methods proposed by Hewitt and Campbell (2008, 2010) and was based on:

- examination of life history characteristics (at the species level where available);
- morphological characteristics and
- habitat distribution.

Where species-level information was not readily available, genus-level characteristics were used to classify morphological characteristics and habitat associations.

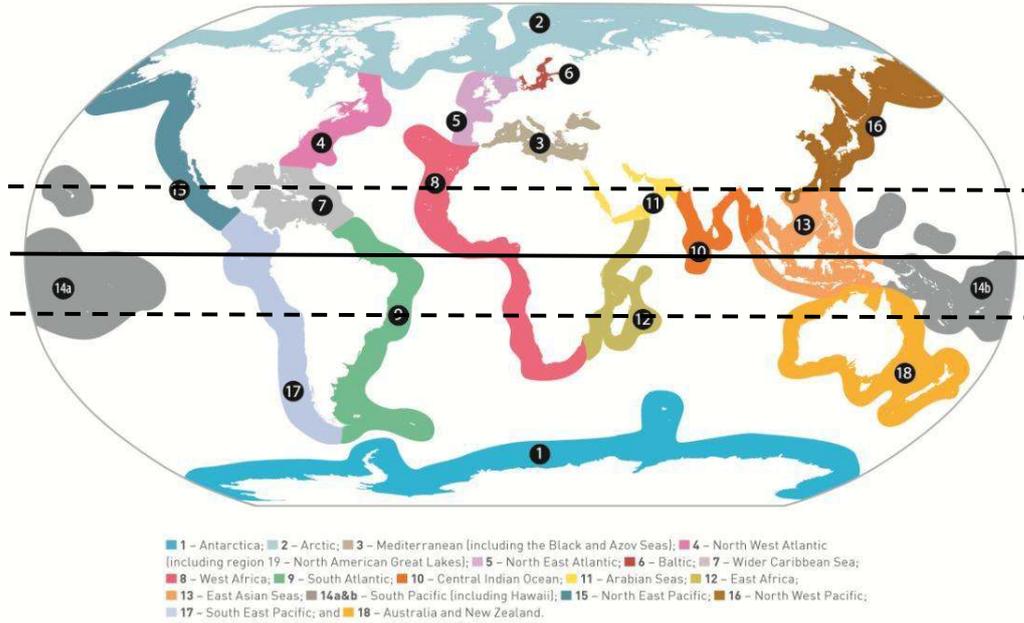


Figure 5.3. IUCN Bioregions as defined by Kelleher et al. (1995) and modified following Hewitt and Hayes (2002). Solid line represents the equator (0°) and dashed lines represent the tropics ($\pm 23.5^\circ$) [Figure from Hewitt et al. 2011; provided with permission from Australian Department of Agriculture, Fisheries, and Forestry (DAFF)]

The global dataset indicates that more species have life history characteristics associated with vessel traffic (ballast water and biofouling combined) than any other vector (Figure 5.4).

This species dataset was restricted further on the basis of records of species in each of the jurisdictions of Micronesia. Within the global dataset, 136 species are recognized as native to Micronesia resulting in a reduction to 2,229 species that have a known history of invasions and are not naturally present in jurisdictions of Micronesia. An additional 109 species are recognized as non-native or cryptogenic in Guam, restricting the hazards to Guam to 2,120 species. A total of 1,358 species were identified as being associated with vessel biofouling in the global dataset, and 1,241 of these species were not known to be present in Guam. Of the 109 non-native or cryptogenic species to Guam, 84 are associated with biofouling. Not all species currently introduced to Guam are present at other Micronesian locations resulting in a latent risk to the various jurisdictions of Micronesia (except Guam) and Hawai'i from Guam identified in Table 5.1.

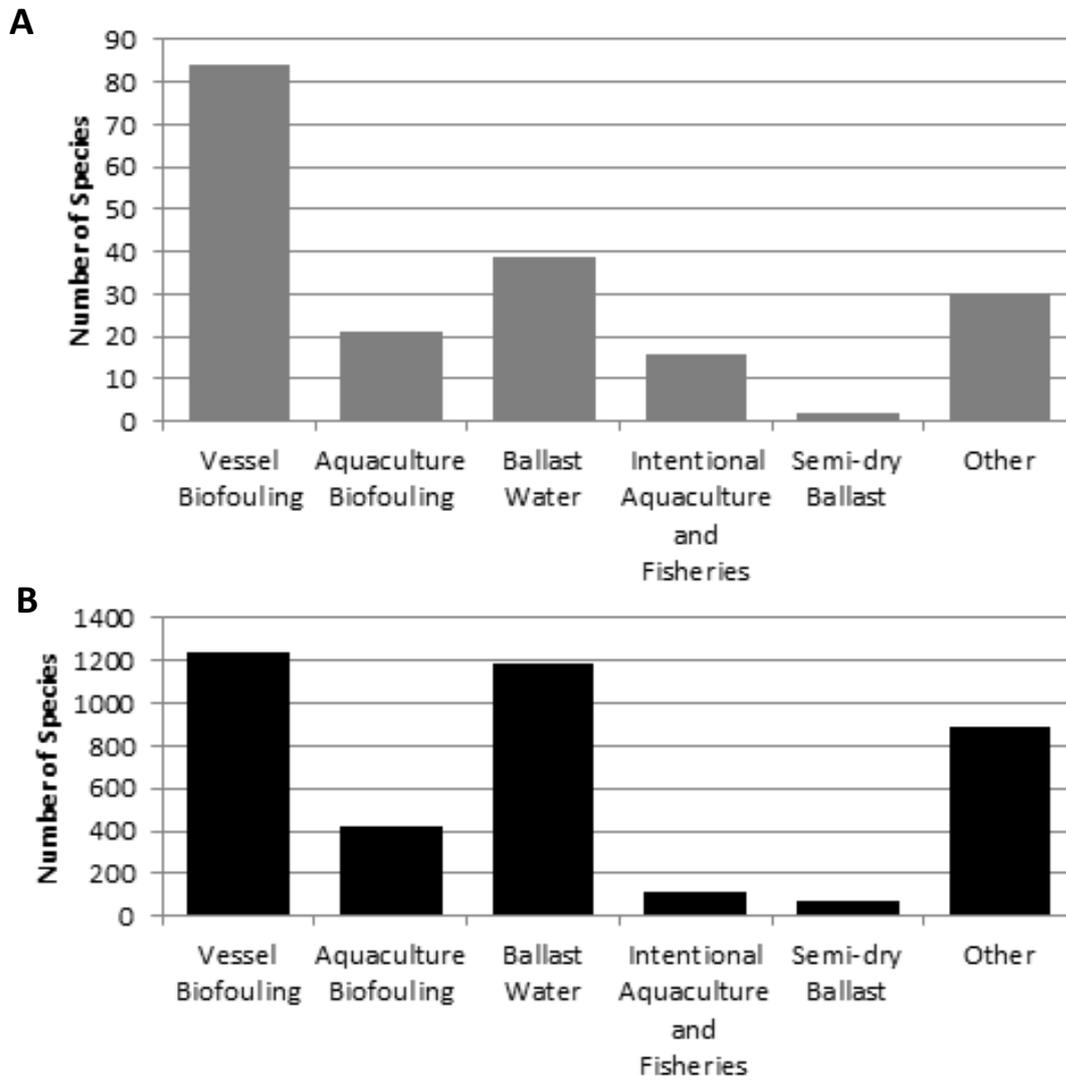


Figure 5.4. Number of non-native and cryptogenic species identified in the global dataset as present in Guam (A) or absent from Guam (B), which are likely to be transported by different vectors.

Table 5.1. Potential exposure to non-native and cryptogenic species already present in Guam (109) or globally (2,365) that are not known to be present in the various jurisdictions of Micronesia (except Guam) or Hawai'i, for A) all transport vectors and B) restricted to species inferred to be transported by biofouling. FSM = Federated States of Micronesia; RMI = Marshall Islands; CNMI = Commonwealth of the Northern Mariana Islands; Palau = Republic of Palau; UMI = United States Minor Islands; HI = U.S. State of Hawai'i

A) All Transport Vectors

<i>Potential Exposure</i>	<i>Guam</i>	<i>FSM</i>	<i>RMI</i>	<i>CNMI</i>	<i>Palau</i>	<i>UMI</i>	<i>HI</i>
Guam (109)		83	79	91	82	100	30
Global (2365)	2,120	2,226	2,238	2,256	2,242	2,297	1,898

B) Biofouling Transport

<i>Potential Exposure</i>	<i>Guam</i>	<i>FSM</i>	<i>RMI</i>	<i>CNMI</i>	<i>Palau</i>	<i>UMI</i>	<i>HI</i>
Guam (84)		65	61	74	66	77	20
Global (1358)	1,241	1,293	1,297	1,333	1,324	1,341	1,018

5.2.3 Determination of Likelihood

The likelihood (or probability) of an event occurring was categorized using a likelihood matrix (Table 5.2). In this risk assessment the likelihood of a biofouling species not currently present in Guam was assessed as a function of the proportion of vessel arrivals in Guam that were likely to transport a species based on the voyage histories of vessels and the global distribution of species. For example, if more than 75% of the vessel arrivals in Guam had visited bioregions with Species X during a voyage duration of 365 days, then Species X would be categorized as having a “high” likelihood of inoculation for the 365 day window: this is an expansion (to include probabilities) on the standard likelihood matrix that has been used in marine biosecurity assessments in New Zealand

(Campbell 2005, 2008; Campbell et al. in review), Australia (Campbell and Hewitt 2011) and the Mediterranean (Campbell 2006). Two significant likelihood endpoints were identified for evaluation of international biofouling species:

- inoculation of species to Guam
- spread from Guam to other jurisdictions of Micronesia.

Table 5.2. Likelihood measures for marine biosecurity risk analysis (modified from Campbell and Gallagher 2007). An event is defined as an activity that may lead to an undesirable outcome.

Descriptor	Description	Probability of event occurring
Negligible (N)	The event is unlikely to occur	<1%
Extremely Low (EL)	The event will only occur in exceptional circumstances	1-10%
Very Low (VL)	The event could occur but not expected	10-25%
Low (L)	The event could occur	26-50%
Moderate (M)	The event will occur in many circumstances	51-75%
High (H)	The event will occur in most circumstances	76-100%

5.3 Inoculation to Guam

The likelihood of species inoculation to Guam was evaluated as transport pressure for each species (ranked negligible to high). Transport pressure can be derived from:

- the species uptake/settlement opportunity to colonize the vessel based on connection with overseas ports,
- the number of vessels arriving from regions where the species is present based on extended voyage characteristics (ranging from 30 days to 5 years) and
- species transport survival based on physical and physiological stress during the voyage.

Several assumptions were made in this analysis:

1. Species were assumed to be able to infect a vessel (via biofouling settlement) at any time throughout the year (equivalent to assuming reproductive activity throughout the year).
2. Species detected in a bioregion and reported in the literature were assumed to have established in the bioregion.
3. Species detected in one location within a bioregion were assumed to be present in all areas (ports) of a bioregion.
4. Vessels were assumed to have some areas without fully active antifouling coatings, such that they were vulnerable to colonization by biofouling organisms;
5. Vessels were assumed to have some areas protected from the hydrodynamic (sheer) forces created by vessel speed.
6. Inoculum pressure was calculated for all of the target locations (jurisdictions of Micronesia or Hawai'i) rather than on a port by port basis.
7. All vessel categories were assumed to be equally able to transport all species.
8. All pathways from various bioregions to Micronesia are equally 'stressful' (e.g. no influence of trans-equatorial transits).
9. Only species listed in the invasive species database are considered a threat, or can be introduced.
10. The invasive species database has complete distribution records for all species.
11. Cryptic diversity, while known to be common in marine organisms, is ignored.

5.3.1 Transport Pressure

Transport pressure was comprised of several elements including:

- the transport frequency (number of opportunities for transport),
- a measure of how readily a species can survive the transport process and
- the inoculation opportunity for a species to depart the vessel and settle in the receiving port.

Similar to the analysis by Hayes et al. (2004a), this assessment assumes that the opportunity for organisms to be transported is directly correlated with the number of ship visits from a region. In keeping with previous assessments (Hayes and Hewitt 1998, 2000; Hayes and Sliwa 2003; Hayes et al. 2004a; Barry et al. 2008), it also assumes that a species record in a bioregion is considered a demonstration of establishment throughout the bioregion, and that all ports in that bioregion are infected.

For the purposes of transport pressure the element of assessment is the vessel, therefore the demonstration of a species likely presence in/on a vessel is the focus, rather than the abundance of a species in/on any individual vessel.

Analysis of vessel activity was initially based on the Lloyds Maritime Intelligence Unit dataset (hereafter Lloyds MIU dataset) representing commercial vessels, petroleum vessels, non-trading vessels, naval vessels, commercial fishing vessels and recreational vessels (>25

m) entering Micronesia from 1999 – 2009 and including all ports of call during this period (this of course does not include items such as the numerous smaller yacht which enter and depart the various jurisdictions of Micronesia and Hawaii). The Lloyds MIU dataset allowed a further differentiation of vessel categories, including separating petroleum vessels from commercial (merchant) vessels, and identifying sub-categories of non-trading vessels.

The Lloyds MIU dataset represents an accumulation of Port State reports and does not represent a complete set for a number of vessel categories. Vessels not able to be self-propelled (barges) are rarely recorded by Port State control. Similarly vessels under 25m length, such as recreational vessels and fishing vessels, are rarely recorded. Military vessels frequently claim sovereign immunity and do not report to Port State control but are hosted by local military. As a consequence, the DoD was requested to provide entry and voyage information on Military vessels, specifically MSC and Warships. Entry information was provided for MSC vessels with limited voyage history; however Warship entry information was only provided for a three year period (2008-2010) and did not include voyage history (see Chapter 3). As a consequence, warships (combatants) could not be assessed herein.

The Lloyds MIU dataset required significant error checking for overlapping voyage statistics. To reduce the overlapping voyage statistics in which individual vessels are represented in multiple records (i.e., locations) at the same time, records from earlier than 1999 were removed as consistency of reporting could not be verified. Poor spatial resolution such as designation of ports as ‘Pacific Ocean,’ ‘Australasia,’ and ‘Southeast Asia’ were assigned to IUCN bioregions where unequivocal, or removed from the dataset. These changes resulted in <5% removal rate for the Lloyds MIU dataset.

Vessels are not of a consistent size, nor do they ‘behave’ in an identical fashion (e.g., Carlton 1985, 1996, 2001; Hewitt et al. 1999, 2004; Ruiz et al. 2000; Gollasch 2002; Fofonoff et al. 2003; Minchin 2006). As a consequence, vessels were divided into a number of categories (and further into subcategories where appropriate) to reflect the various management regimes and previously recognized differences in vessel activity (e.g., Ribera and Bouderesque 1995; Ruiz et al. 2000; Carlton 2001; Lewis et al. 2004; Floerl and Inglis 2005; Floerl et al. 2005; Minchin 2006; Hulme 2009). These are assumed to approximately correspond to vessel behaviors (e.g., maintenance history, voyage characteristics, speed [see Section 5.3.1.3]) however; it has been assumed here that no particular vessel characteristic is more or less likely to transport a species.

Vessel categories identified in the Lloyds MIU dataset include (see glossary also):

- **commercial vessels** including merchant vessels and cruise ships,
- **petroleum production and exploratory industry vessels** including offshore anchor handling/support/supply, pipe laying vessels, drilling platforms/ships and floating production, storage and offloading (FPSO) given they are solely employed within the sector,
- **naval vessels** (both foreign and domestic) including primarily naval auxiliary tankers and MSC vessels,

- **non-trading vessels** which encompass a wide variety of vessel types including the sub-categories of tugs, research vessels, dredges, barges and yachts > 25 m or super yachts (differentiated based on differing behaviors including speed, duration in port, and voyage characteristics) and
- **fishing vessels** including commercial vessels engaged in the industry of capturing wild stocks of living marine resources: fishing (general); trawler (all types); whaler; fish carrier; and fish factory.

As stated above, petroleum industry vessels represent a significant class of commercial (merchant) vessel with widely varying characteristics including long residence times and slow speeds for some vessel types.

Elements of transport pressure are further analyzed below.

5.3.1.1 Opportunity to Infect the Vessel in the Donor Port.

The opportunity for a species to infect (e.g., be taken up in ballast water, settle on or recruit to) a vessel is a combination of the location of operations, the timing of the opportunity being coincident with a reproductively active period for sessile and sedentary species, maintenance history (including antifouling paint condition), and the amount of time available for a species to settle or colonize the vessel.

Biofouling community development begins as soon as materials are placed in the water (e.g., Sutherland and Karlson 1977; Floerl 2002; Prendergast 2010). As a consequence, shortly after being cleaned (in dry-dock or in the water), the settlement of marine organisms and development of a biofouling community begins (see Hayes et al. 2004b; Lewis et al. 2004; Jenkins and Martins 2010). The rate of this development can be reset or delayed through various means, including in-water cleaning and appropriate application of antifouling paints. However, when the vessel is taken as a whole, the 'niche' biofouling areas including sea-chests, bow and stern thrusters, propellers, propeller shafts and rudder areas are likely to have established biofouling communities shortly (3 – 6 months) after cleaning or antifouling paint application (e.g., James and Hayden 2000; Floerl 2002; Hayes 2002; Coutts et al. 2003; Coutts and Taylor 2004; Hayes et al. 2004b; Lewis et al. 2004; Piola et al. 2009). Therefore, few limitations to settlement exist for any individual species when considering the vessel as a whole, hence, all vessels can be colonized.

Settlement opportunity for some species also involves an element of timing. Mobile species associated with biofouling have the ability to swim to the vessel hull or into niche areas; therefore no restriction on the timing of settlement occurs. For species that are sessile or sedentary, typical means of establishing in a new location are either by accidentally getting 'swept' to another location by hydrodynamic forces (e.g., waves, propeller wash, currents), or by reproduction. Many sessile or sedentary marine species spawn gametes (reproductive elements) into the water column where fertilization and development occurs, or hatch larvae directly into the water column – these species are known as meroplankton since they spend a portion of their life-cycle in the water column. Once development has progressed sufficiently (ranging from minutes to months for different species), the larval form is able

to settle onto hard substrate by metamorphosing into an adult.

In order for a meroplanktonic species to be taken into the ballast of a vessel or to settle on a vessel, it is necessary that the species' timing of reproduction (reproductive phenology), and settlement viability for biofouling species, is coincident with the duration in port. Assessing settlement opportunity directly requires a significant increase in our current state of knowledge – there is limited data on the timing or triggers (cues) of reproduction for many non-native marine and estuarine species, particularly in non-native regions. This is particularly important as non-native species expanded on their realized niche to utilize their fundamental niche and hence they often behave in ways that are not recorded within the literature. For example, *Mytilopsis sallei* (black striped mussel) in Darwin harbor, Northern Territory, Australia, produced two, potentially three cohorts in a seven-month period (Campbell and Hewitt unpubl. manuscript). In Hong Kong Harbor, where it is also introduced, it produces two cohorts per 12 months (Morton 2009). In its native environment, *M. sallei* reproduces once every 12-18 months (e.g., Kalyanasundaram 1975). Similarly, the larval durations and metamorphosis requirements have yet to be determined for many non-native species.

Given that settlement opportunity acts to reduce risk, it is more conservative to assume that all species reproduce year-round and therefore have the ability to inoculate any vessel that comes to port, regardless of port stay duration. As more information comes to light, or when the focus is reduced to a smaller subset of species, better life-history information can be obtained and applied to refine predictions in a management context.

5.3.1.2 Transport Frequency.

The number of vessel entries arriving from each bioregion (LPOC) over the period from 1999 to 2009 was calculated as a total across all vessel categories and for MSC. For each of the 1,241 biofouling species not currently established in Guam, the number of vessels arriving from bioregions in which the species was known to be present, either as a native, cryptogenic or a non-native marine species based upon the revised species database from Hewitt and Campbell (2008; 2010), was calculated to represent the raw transport frequency of each species. This number represents the number of potential opportunities for the species to have been transported into Guam waters over the 11-year period based on voyage histories.

In contrast to ballast water transported species, biofouling species accumulate since the last cleaning (including in-water cleaning, dry-docking or antifouling paint application); however this data is infrequently available for evaluation. Most commercial vessels have dry-docking rotations of greater than three years and up to five years (Lewis 2002a; Davidson et al. 2009). In order to capture the likely accumulation of species, the influence of voyage duration on species exposure was assessed by creating voyages into classes of 30 days, 60 days, 90 days, 183 days, 365 days (1 year), 730 days (2 years), 1,095 days (3 years), 1,460 days (4 years), and 1,825 days (5 years) prior to entry into Guam.

The commercial and MSC fleet entering Guam traded with all global bioregions within voyage durations of 365 days (1 year) for either commercial or MSC vessels (Figure 5.5). In other words, the vessels entering Guam had visited all 18 global bioregions within 365

days prior to arrival.

Transport patterns differed between bioregions (Figure 5.6). The increase in transport frequency from bioregions (i.e., number of vessels that had previously visited a particular bioregion) as voyage durations are increased from 30 days to 365 days can be seen with the addition of lighter shades of grey. As would be expected, more distant bioregions such as the North West and North East Atlantic, Wider Caribbean, and the Arabian Seas are largely represented in voyage lengths greater than 183 days.

Commercial vessels (Figure 5.7A) are unevenly distributed across bioregions (Simpsons Evenness = 0.518), with a higher connection (>800 vessel entries) to the East Asian Seas and South Pacific Ocean and a second tier of association (>400 vessel entries) to NE Atlantic and Central Indian Ocean. In contrast, MSC vessels (Figure 5.7B) are more even in their biogeographic spread (Simpsons Evenness = 0.658) with high connectedness (>800 vessel entries) to the Wider Caribbean, NW Atlantic, NW Pacific East Asian Seas and Arabian Seas, and a second tier of association (>400 vessel entries) to the South Pacific, NE Pacific, SE Pacific and Australasia.

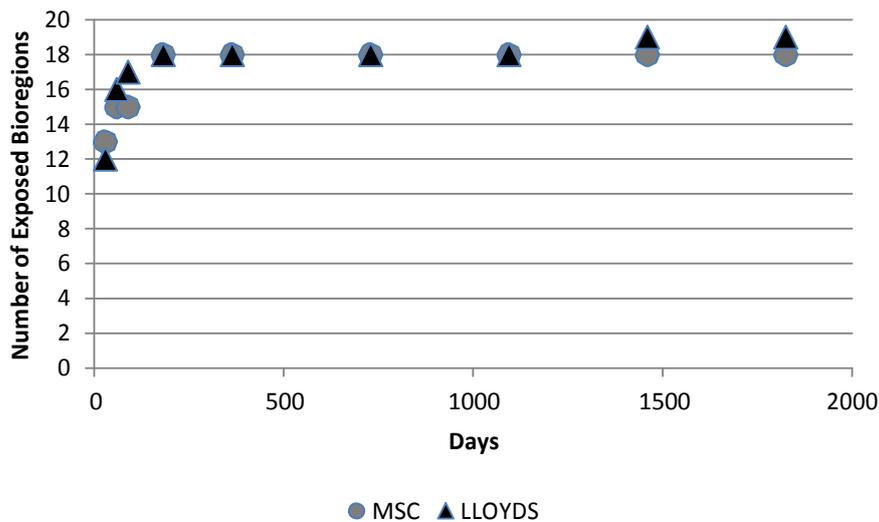


Figure 5.5. Number of bioregions visited by vessels entering Guam between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DoD datasets).

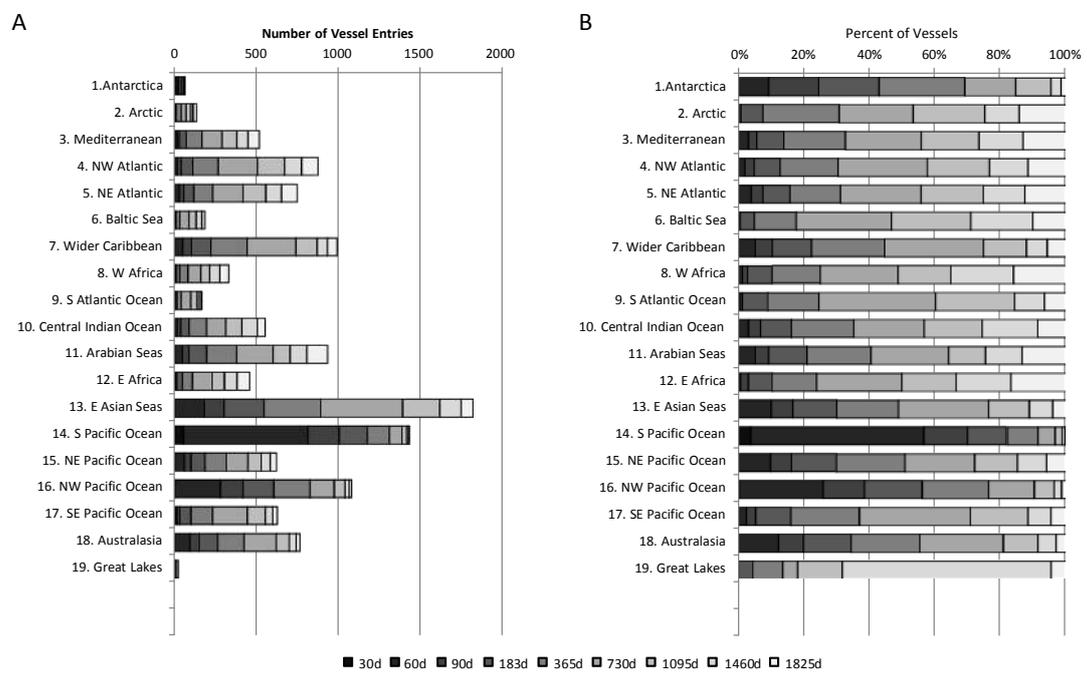


Figure 5.6. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to Guam from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU dataset and DoD dataset).

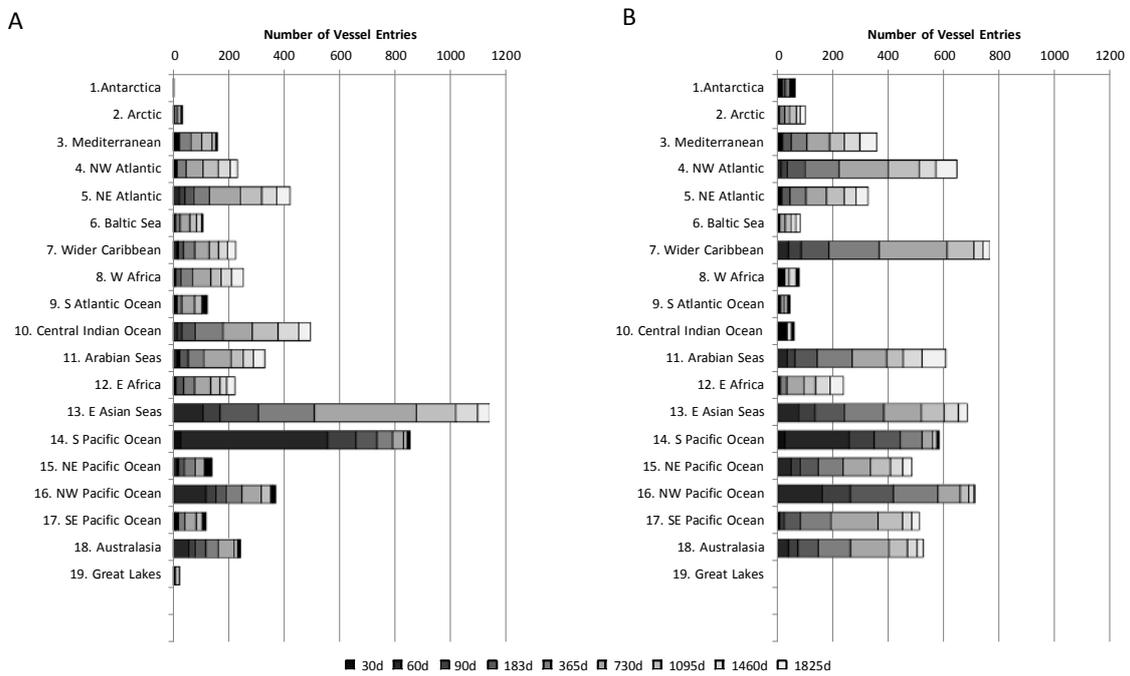


Figure 5.7. Number of A) commercial vessels (all categories) and B) MSC vessel (all categories) entries to Guam from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period (Lloyds MIU and DoD datasets).

5.3.1.3 Transport Survival.

The transport process can create significant physical and physiological stresses on species that influences the ability of a species to survive a voyage.

Physical stress on species is primarily associated with vessel speed, with several studies demonstrating the relationship between speed and shear stress on species survival (e.g. Coutts 1999; Davidson et al. 2009; Coutts et al. 2010a, b). Analyzing the Lloyds MIU dataset for vessel speeds across vessel categories (Figure 5.8) revealed no significant differences across the broad vessel categories, despite significant differences between individual vessels within categories. Vessels in the categories commercial, petroleum, non-trading (specifically tugs, barges, and dredges), illegal foreign fishing vessels (IFFVs) and recreational vessels are known to operate under slow speeds, which can support significantly increased survival (e.g., Floerl and Inglis 2005; Floerl et al 2005; Davidson et al. 2009; Coutts et al. 2010a, b).

Additionally, while vessel speed is correlated with species presence on exposed hull surfaces (e.g. Coutts et al. 2010a, b), numerous protected niche areas such as sea-chests (e.g., Coutts et al. 2003; Coutts and Taylor 2004; Coutts and Dodgshun 2007), bow and stern thrusters, propellers and propeller shafts, will act to provide species the opportunity to survive despite high vessel speeds (e.g., James and Hayden 2000; Hayes 2002; Coutts and Taylor 2004; Hayes et al. 2004b). As a consequence, speed may not provide differentiation between vessel types or significantly reduce risk.

Physiological stress can be created by the type and condition of antifouling paints (e.g., Piola and Johnston 2006) as well as the voyage route. Antifouling paints are explicitly designed to minimize and delay the settlement of epibenthic species on the hull surface. Exhaustive research accounts detail the efficacy and various failures of antifouling paints (e.g., Minchin 2006; Dafforn et al. 2008; see also various publications in the journal *Biofouling*). Most recently, the ban on organotin paints, specifically tri-butyltins (TBTs) has increased the investigations into viable alternatives and resurrected the concerns over biofouling mediated invasions. Note, that Navy and Coast Guard vessels are exempt from the ban on organotin paints. Antifouling paints differ significantly in their intrinsic effectiveness, but also vary according to the method and location of application (Lewis 2002; Lewis et al. 2004; Piola et al. 2009). From a management perspective, information on antifouling paint type, application procedures, efficacy and timing of application is difficult to obtain. As a consequence, the use of antifouling paint information was not considered in this risk assessment.

Physiological stress associated with exposure to changing environmental conditions is likely for biofouling species associated with the external hulls of vessels. Transport between high or mid-latitude regions on either side of the equator will expose species to the physiological stresses of increased water temperature during transit. Similarly, freshwater species in transit across oceanic barriers (e.g., between the North American Great Lakes and the inland waters of Europe) will experience fully marine waters during transit across the North Atlantic. Many trade routes to Micronesia include a significant change in latitude, or transits accompanied by a freshwater transit through the Panama Canal, or a high salinity transit of the Suez Canal. Quantifying the effect of these transits is difficult without specific laboratory analyses of physiological tolerance and exposure for individual species. As this factor only acts to **decrease** the likelihood of transit survival, leaving it out of the current assessment provides a conservative result until definitive information is available. Therefore we have assumed that all voyage pathways are equally stressful.

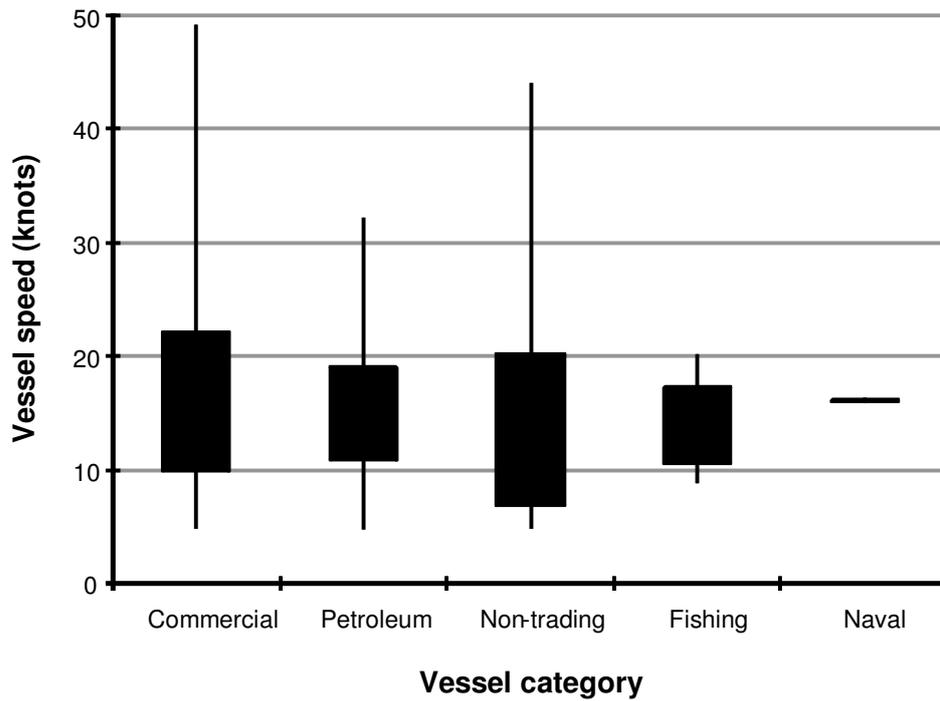


Figure 5.8. Reported speeds for vessels based on vessel categories (maximum/minimum reported range indicated by line, 90% confidence intervals around the mean represented by blocks). Slow moving drill rigs and drill ships have been estimated to have a vessel speed of 5 knots and are included in with petroleum vessels; recreational vessels >25 m are included in non-trading vessels. Vessel speeds for IFFVs and recreational vessels <25 m could not be obtained. Data from the Lloyds MIU dataset (Hewitt et al. 2009e).

5.3.1.4 Inoculation Opportunity.

Similar to the opportunity for species to settle in the donor port, attached biofouling species need to either reproduce (sexually or asexually) or be scraped off the hull to inoculate a receiving port. Any sedentary, infaunal and mobile fauna associated with biofouling assemblages (e.g., gastropods, crabs and other mobile crustaceans, small fishes such as blennies and gobies, seastars), including those occurring in sea-chests, will have increased opportunity to depart the vessel either by being dislodged or by swimming or dropping off the vessel. Inoculation opportunity is typically believed to be a function of port duration, and the reproductive maturity or vagility (ease of movement) of individual species.

As with the previous discussion, reproductive activity can be influenced by many factors including the intrinsic maturation rate of the individual, and extrinsic factors such as temperature and day length (e.g., Minchin and Gollasch 2003). These influences on reproduction are difficult to ascertain and expected to vary among ports. The action of being scraped off a hull is a stochastic process and depends on a number of elements including the species location on the hull, type of antifouling coating, its attachment mode, and the handling of the vessel in port. The vagility of sedentary and mobile fauna associated with biofouling is, by definition, high. These species are capable of moving and will therefore have the opportunity to leave the vessel at any time once in port. As a consequence, biofouling and biofouling associated species were assumed to have the ability to reproduce (sexually or asexually), escape and/or swim away or be scraped off, all year around.

5.3.2 Summary of Inoculation to Guam Likelihood

One approach to estimate likelihood is to determine the relative number of opportunities for a species arrival and entry into a new location as outlined previously. To reiterate the various assumptions used in this approach: species were assumed to be present in all areas (ports) of bioregions to which they had been introduced or were native; all vessels were deemed to have an equal opportunity of a species settling, regardless of time of year or of time since dry-docking, in-water cleaning or antifouling paint application; and all transport pathways were considered to be equally stressful. Note that this is a conservative estimate and it is not currently possible to refine further as data are not sufficient at the present time for this.

To determine likelihood of inoculation for an individual species, the number of vessels arriving from all bioregions where that species was present (as a native, cryptogenic or non-native population) was summed to provide a cumulative number of vessel opportunities for that species to be transported into Guam. This value was then divided by the number of vessels entering Guam to provide the percentage of total opportunities for entry as a relative measure. This relative probability was then categorized into Likelihood probabilities (Table 5.2) to provide a categorical rank for each of the nine voyage periods (30 days, 60 days, 90 days, 183 days, 365 days, 730 days, 1,095 days, 1,460 days, 1,825 days) as a function of percentage of total visits (Figures 5.9 & 5.10).

Twenty-one per cent (n=264) of the 1,241 biofouling associated non-native species not present in Guam were identified as having a negligible inoculation likelihood in the initial 30 day voyage period (Figure 5.9B), however the number of species categorized as “Negligible” reduced to 8% for 60 day voyages and subsequently to <1% for voyages greater than 365 days. In other words, as the assessment examined longer voyage durations, more bioregions were visited resulting in fewer species assessed as having less than 1% of vessels likely to transport the species.

In contrast, more than 18 per cent of the 1,241 biofouling associated non-native species not in

Guam were ranked as having Moderate or High inoculation likelihood across all voyage lengths and vessel types (ranging from 26.3% in 30 day voyages to 18.3% in 1,825 day voyages), with **72 biofouling species having a “High” likelihood** (>75% probability) and **155 biofouling species having a “Medium” likelihood** (>50% probability) of inoculation to Guam after 1,825 day voyages (5 years) (Table 5.3).

In evaluating the inoculation likelihoods, the relative contribution of MSC vessels to the number of “High” and “Medium” likelihood species were examined. Military vessels were found to increase the “High” likelihood of inoculations for voyages greater than 60 days (2 months), with a peak after voyages of 183 days (40 species), reducing to a shift of 10 species for 1,460 days (4 years) and 1,825 days (5 years) voyage lengths (Figures 5.9, 5.10 & 5.11). These shifts in additive inoculation likelihood attributed to military vessels is greater than their contribution to vessel numbers alone, particularly recognizing the significant limitations of data gaps and noting that MSC vessels are likely to spend a greater amount of time in port, thus increasing both the vessel infection and port infection likelihoods.

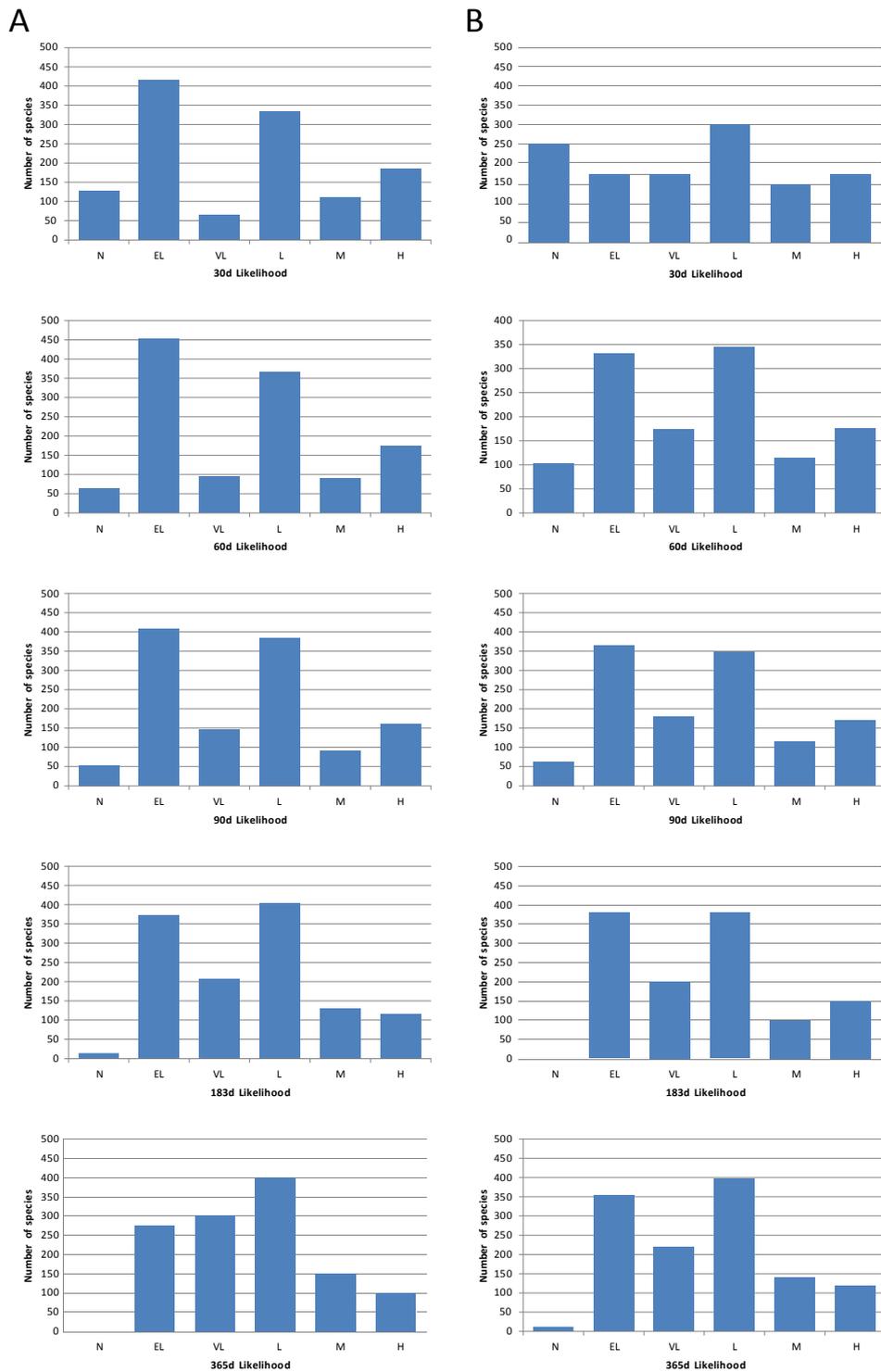


Figure 5.9. Number of species for Inoculation Likelihood Ranks to Guam for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

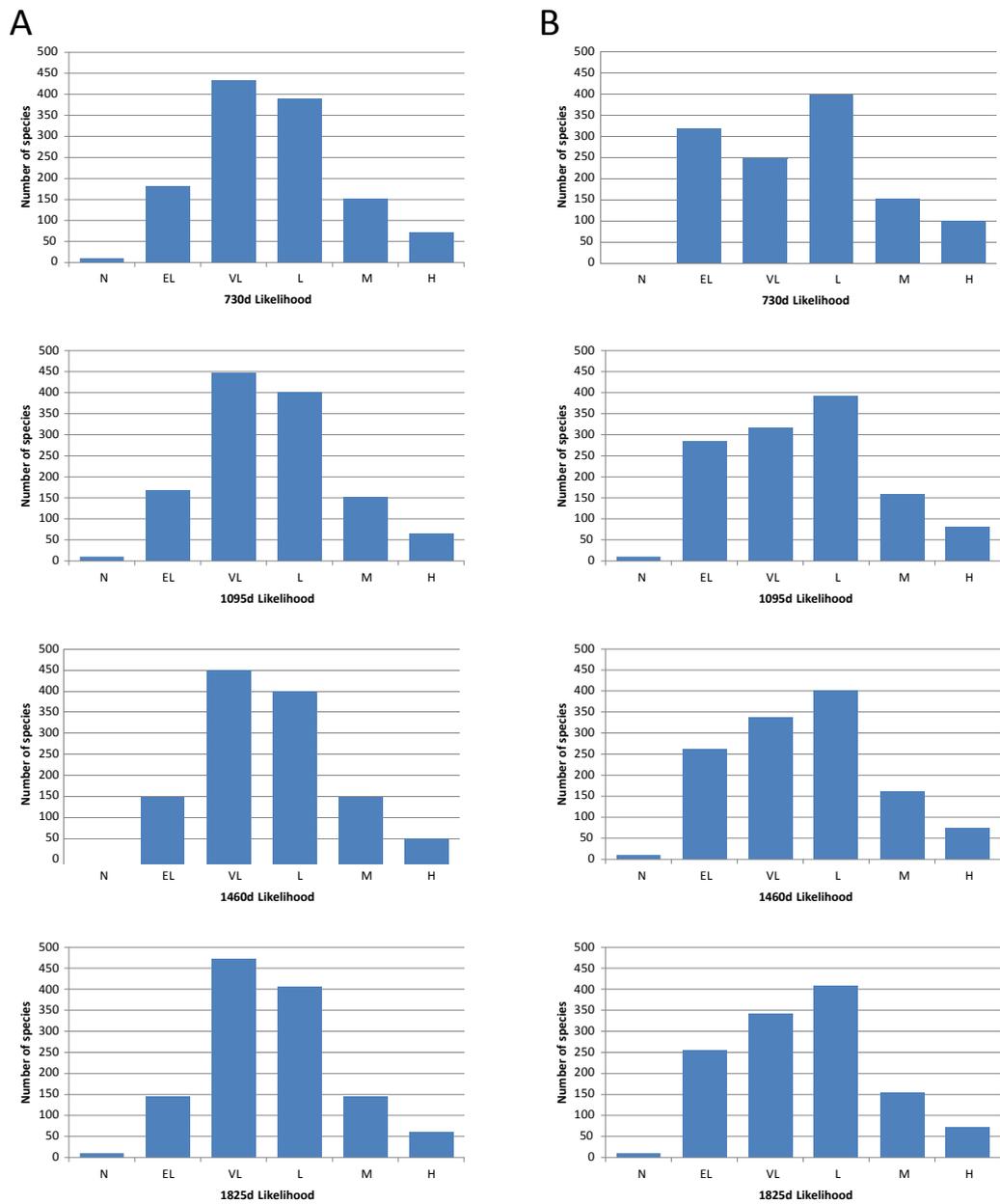


Figure 5.10. Number of species for Inoculation Likelihood Ranks to Guam for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoDdatasets.

Table 5.3. Biofouling species with a “High” (n=72) and “Medium” (n=155) likelihood of arrival in Guam associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Annelida	<i>Dipolydora armata (=armarta)</i>	H
Annelida	<i>Eumida sanguineum</i>	M
Annelida	<i>Eunice antennata</i>	H
Annelida	<i>Ficopomatus enigmaticus</i>	H
Annelida	<i>Ficopomatus uschakovi</i>	M
Annelida	<i>Glycera capitata</i>	M
Annelida	<i>Heteromastus filiformis</i>	M
Annelida	<i>Hydroides albiceps (casual)</i>	M
Annelida	<i>Hydroides diramphus</i>	H
Annelida	<i>Hydroides elegans</i>	H
Annelida	<i>Janua pagenstecheri</i>	H
Annelida	<i>Lysidice collaris</i>	M
Annelida	<i>Myrianida pachycera</i>	M
Annelida	<i>Neodexiospira brasiliensis (=Janua (Dexiospira) brasiliensis)</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Polydora cornuta</i>	M
Annelida	<i>Polydora websteri</i>	M
Annelida	<i>Pomatoleios kraussii</i>	M
Annelida	<i>Pseudopolydora paucibranchiata</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Chlorophyta	<i>Avrainvillea amadelpha</i>	M
Chlorophyta	<i>Bryopsis pennata</i>	H
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Caulerpa mexicana</i>	M
Chlorophyta	<i>Caulerpa racemosa var. lamourouxii</i>	M
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Cladophoropsis herpestica</i>	M

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Chlorophyta	<i>Cladophora patentiramea</i>	M
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Cladophora sericea</i>	H
Chlorophyta	<i>Cladophoropsis membranacea</i>	M
Chlorophyta	<i>Codium ovale</i>	M
Chlorophyta	<i>Derbesia marina</i>	H
Chlorophyta	<i>Dictyosphaeria cavernosa</i>	M
Chlorophyta	<i>Neomeris annulata</i>	H
Chlorophyta	<i>Ulva clathrata</i> (= <i>Enteromorpha clathrata</i> <i>var. crinata</i>)	H
Chlorophyta	<i>Ulva flexuosa</i>	H
Chlorophyta	<i>Ulva pertusa</i>	M
Chlorophyta	<i>Ulva reticulata</i>	M
Chlorophyta	<i>Ulva rigida</i>	H
Chlorophyta	<i>Ulva taeniata</i>	M
Chlorophyta	<i>Valonia fastigiata</i>	M
Chordata (Ascidieacea)	<i>Ascidia archaia</i>	M
Chordata (Ascidieacea)	<i>Botrylloides leachi</i>	M
Chordata (Ascidieacea)	<i>Botrylloides perspicuum</i>	M
Chordata (Ascidieacea)	<i>Botryllus schlosseri</i>	H
Chordata (Ascidieacea)	<i>Ciona intestinalis</i>	H
Chordata (Ascidieacea)	<i>Cnemidocarpa irene</i>	M
Chordata (Ascidieacea)	<i>Didemnum candidum</i>	H
Chordata (Ascidieacea)	<i>Microcosmus squamiger</i>	M
Chordata (Ascidieacea)	<i>Perophora multiclathrata</i>	M
Chordata (Ascidieacea)	<i>Polyandrocarpa zorritensis</i>	M
Chordata (Ascidieacea)	<i>Styela plicata</i>	M
Chordata (Ascidieacea)	<i>Symplegma reptans</i>	M
Cnidaria	<i>Blackfordia virginica</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	H
Cnidaria	<i>Cladonema radiatum</i>	M

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Cnidaria	<i>Clytia hemisphaerica</i>	H
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Coryne eximia</i> (=Sarsia eximia)	M
Cnidaria	<i>Coryne pusilla</i>	M
Cnidaria	<i>Diadumene lineata</i>	H
Cnidaria	<i>Eucheilota paradoxica</i>	M
Cnidaria	<i>Eudendrium capillare</i>	H
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Gonothyraea loveni</i>	M
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Phyllorhiza punctata</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Scolionema suvaensis</i>	M
Cnidaria	<i>Sertularia tongensis</i> (=Sertularia <i>stechowi</i> , <i>S. theocarpa</i>)	M
Cnidaria	<i>Tubastraea coccinea</i>	H
Arthropoda	<i>Alpheus rapacida</i>	M
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	M
Arthropoda	<i>Amphibalanus reticulatus</i>	H
Arthropoda	<i>Balanus trigonus</i>	H
Arthropoda	<i>Caprella danilevskii</i>	M
Arthropoda	<i>Caprella equilibra</i>	H
Arthropoda	<i>Caprella penantis</i>	H
Arthropoda	<i>Caprella scaura</i>	H
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Chelura terebrans</i>	M
Arthropoda	<i>Conchoderma virgatum</i>	M
Arthropoda	<i>Dromia wilsoni</i>	M
Arthropoda	<i>Elasmopus rapax</i>	H

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Arthropoda	<i>Erichthonius brasiliensis</i>	H
Arthropoda	<i>Eucrate crenata</i>	M
Arthropoda	<i>Idotea metallica</i>	M
Arthropoda	<i>Jassa marmorata</i>	M
Arthropoda	<i>Kotoracythere inconspicua</i>	M
Arthropoda	<i>Laticorophium baconi</i>	H
Arthropoda	<i>Lepas (Anatifa) anatifera</i>	H
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	H
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M
Arthropoda	<i>Leptochela dubia</i>	H
Arthropoda	<i>Ligia exotica</i>	H
Arthropoda	<i>Megabalanus occator</i>	M
Arthropoda	<i>Menaethius monoceros</i>	M
Arthropoda	<i>Merocryptus lambriformis</i>	M
Arthropoda	<i>Monocorophium acherusicum</i>	H
Arthropoda	<i>Monocorophium insidiosum</i>	H
Arthropoda	<i>Nanosesarma minutum</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	H
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Paradella diana</i>	M
Arthropoda	<i>Plagusia depressa tuberculata</i>	M
Arthropoda	<i>Porcellio lamellatus lamellatus</i>	M
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M
Arthropoda	<i>Sphaeroma quoianum</i>	M
Arthropoda	<i>Sphaeroma walkeri</i>	H
Arthropoda	<i>Stenothoe gallensis</i>	H
Arthropoda	<i>Stenothoe valida</i>	H
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Dinophyta	<i>Ostreopsis ovata</i>	M
Dinophyta	<i>Prorocentrum lima</i>	H
Echinodermata	<i>Protoreaster nodosus</i>	M

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Bowerbankia gracilis</i>	H
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Bugula dentata</i>	M
Bryozoa	<i>Bugula stolonifera</i>	H
Bryozoa	<i>Caberea boryi</i>	M
Bryozoa	<i>Celleporaria brunnea</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	H
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	H
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Tricellaria occidentalis</i>	M
Bryozoa	<i>Victorella pavida</i>	M
Bryozoa	<i>Watersipora arcuata</i>	M
Bryozoa	<i>Watersipora subtorquata</i>	H
Bryozoa	<i>Zoobotryon verticillatum</i>	M
Mollusca	<i>Anadara granosa</i>	M
Mollusca	<i>Anteaeolidiella foulisi</i> (=Anteaeolidiella <i>indica</i>)	H
Mollusca	<i>Bankia bipalmulata</i>	M
Mollusca	<i>Caloria indica</i>	M
Mollusca	<i>Cycloscala hyalina</i>	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Diodora ruppelli</i>	M
Mollusca	<i>Doxander vittatus</i>	M
Mollusca	<i>Elysia tomentosa</i>	M
Mollusca	<i>Hiatella arctica</i>	H
Mollusca	<i>Hypselodoris infucata</i>	M

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Mollusca	<i>Isognomon ehippium</i>	M
Mollusca	<i>Lienardia mighelsi</i>	M
Mollusca	<i>Martesia striata</i>	M
Mollusca	<i>Musculista senhousia</i>	H
Mollusca	<i>Mytilopsis sallei</i>	M
Mollusca	<i>Mytilus galloprovincialis</i>	M
Mollusca	<i>Nanostrea fluctigera (=Nanostrea exigua)</i>	M
Mollusca	<i>Okenia pellucida</i>	M
Mollusca	<i>Perna viridis</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Strombus mutabilis</i>	M
Mollusca	<i>Syrnola cinctella</i>	M
Mollusca	<i>Tenellia adpersa</i>	M
Mollusca	<i>Teredo clappi</i>	M
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Teredora princesae</i>	M
Mollusca	<i>Thecacera pennigera</i>	H
Phaeophyta	<i>Chnoospora minima</i>	M
Phaeophyta	<i>Cutleria multifida</i>	M
Phaeophyta	<i>Ectocarpus fasciculatus</i>	M
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Hincksia granulosa</i>	M
Phaeophyta	<i>Hincksia mitchelliae</i>	H
Phaeophyta	<i>Hincksia ovata</i>	M
Phaeophyta	<i>Hincksia sandriana</i>	M
Phaeophyta	<i>Leathesia marina (=Leathesia difformis)</i>	M
Phaeophyta	<i>Macrocystis pyrifer</i>	M
Phaeophyta	<i>Myrionema strangulans</i>	M
Phaeophyta	<i>Nemacystus decipiens</i>	M
Phaeophyta	<i>Padina antillarum</i>	M
Phaeophyta	<i>Padina boryana</i>	M

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Phaeophyta	<i>Pylaiella littoralis</i>	H
Phaeophyta	<i>Punctaria latifolia</i>	M
Phaeophyta	<i>Rugulopteryx okamurae</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Halichondria panicea</i>	M
Porifera	<i>Mycale parishii</i> (=Zygomycale parishii)	H
Pycnogonida	<i>Ammothea hilgendorfi</i>	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	H
Rhodophyta	<i>Acanthophora spicifera</i>	M
Rhodophyta	<i>Agardhiella subulata</i>	M
Rhodophyta	<i>Aglaothamnion cordatum</i>	H
Rhodophyta	<i>Antithamnion hubbsii</i> (=nipponicum, <i>pectinatum</i>)	M
Rhodophyta	<i>Apoglossum gregarium</i>	M
Rhodophyta	<i>Asparagopsis taxiformis</i>	H
Rhodophyta	<i>Bangia atropurpurea</i>	H
Rhodophyta	<i>Caulacanthus ustulatus</i>	H
Rhodophyta	<i>Centroceras clavulatum</i>	H
Rhodophyta	<i>Ceramium virgatum</i>	M
Rhodophyta	<i>Chondria arcuata</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
Rhodophyta	<i>Corallina officinalis</i>	M
Rhodophyta	<i>Dasya baillouviana</i>	H
Rhodophyta	<i>Eucheuma denticulatum</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
Rhodophyta	<i>Grateloupia subpectinata</i> (=Grateloupia <i>filicina</i> var <i>luxurians</i>)	M
Rhodophyta	<i>Gymnothamnion elegans</i>	H
Rhodophyta	<i>Herposiphonia parca</i>	M
Rhodophyta	<i>Centroceras clavulatum</i>	H

Table 5.3: Continued.

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Ceramium virgatum</i>	M
Rhodophyta	<i>Hildenbrandia rubra</i>	H
Rhodophyta	<i>Hypnea anastomosans</i> (=Hypnea esperi)	M
Rhodophyta	<i>Hypnea cornuta</i>	H
Rhodophyta	<i>Hypnea nidifica</i>	M
Rhodophyta	<i>Hypnea spinella</i> (=Hypnea cervicornis)	H
Rhodophyta	<i>Hypnea charoides - valentiae</i>	H
Rhodophyta	<i>Kappaphycus striatum</i>	M
Rhodophyta	<i>Laurencia brongniartii</i>	M
Rhodophyta	<i>Laurencia okamurae</i>	M
	<i>Neosiphonia harveyi</i> (=Polysiphonia	
Rhodophyta	<i>harveyi</i>)	M
Rhodophyta	<i>Polysiphonia brodiei</i>	M
Rhodophyta	<i>Polysiphonia sertularioides</i>	M
Rhodophyta	<i>Polysiphonia subtilissima</i>	M
Rhodophyta	<i>Porphyra suborbiculata</i>	M
Rhodophyta	<i>Pterosiphonia bipinnata</i>	M
Rhodophyta	<i>Sarconema filiforme</i>	M
	<i>Spongoclonium caribaeum</i>	
Rhodophyta	(=Pleonosporium caribaeum)	M
Rhodophyta	<i>Symphyocladia marchantioides</i>	M

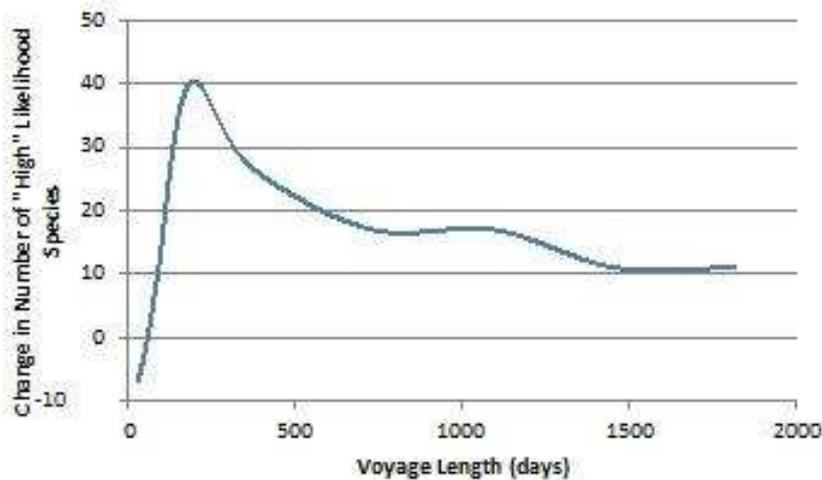


Figure 5.11: The estimated change in the number of “High” likelihood of inoculation species between analysis of commercial vessels alone and commercial and MSC vessels.

5.4 Spread from Guam to other jurisdictions of Micronesia

Spread is the progressive expansion and establishment in locations beyond the first site of establishment in the receiving region. This can be facilitated either by natural or human mediated means, however in this assessment the evaluation is restricted to human mediated spread. This assessment is interested in the increased likelihood of inoculation into a jurisdiction of Micronesia or Hawai’i as a consequence of trading activity in Guam. For this evaluation each jurisdiction of Micronesia (CNMI, FSM, RMI, Palau, and also the UMI) was evaluated for species arrival likelihoods based on direct entry (following the methods described in Section 5.2), with comparison between commercial vessel entries and the additive effect of MSC vessels.

Ultimately, once a species has become established in a high traffic port, or ‘transport hub’, there is some probability that domestic vessels will be colonized by non-native species and translocated to more locations across a region. As successive hubs are colonized, the number of populations from which natural spread can occur increases via natural dispersal (Floerl 2002). This pattern of spread, termed the ‘hub and spoke’ dispersal (*sensu* Carlton 1996) is typical of marine non-native species (Carlton 1996, Cranfield et al. 1998). Recent modeling analysis indicates that spread of non-native organisms can not only occur from hubs, but also from seemingly unimportant transport nodes (Floerl et al. 2009). Nonetheless, transport hubs were consistently more likely to become infested by an invader and to accelerate spread to secondary locations faster when compared with low traffic nodes (Floerl et al. 2009).

The role of Guam as an entry port to Micronesia and Hawai'i using a "hub and spoke" model was assessed, where the likelihood species already present in Guam or deemed to have a high likelihood of inoculation in Guam (Section 5.2, above) was compared with the species with high likelihoods of direct entry to determine the extent to which increased likelihood of transfer and arrival to a jurisdiction of Micronesia other than Guam. The likelihood of arrival of species to each jurisdiction of Micronesia (other than Guam) and Hawai'i for commercial, MSC and all (commercial and MSC) vessels across the nine voyage durations was assessed.

5.4.1 Commonwealth of the Northern Mariana Islands (CNMI)

The CNMI received 3,312 commercial and 4,769 MSC vessel entries during the assessed period (Figures 5.12 and 5.13). Approximately 19% of these vessels arrived directly from Guam. Commercial vessels had strong affinities with the NE Atlantic (5) and the East Asian Seas (13) bioregions, with a decreased trade across a wide number of bioregions. The NE Atlantic and East Asian Seas bioregions represent more than 20% of commercial vessel trade. In contrast, Military vessels exhibit a much broader exposure to bioregions, particularly Indian Ocean and Pacific Basin bioregions and therefore broader exposure to a wider suite of species. The trading activities of vessels visiting CNMI are broad with the 30 day voyages sampling nine bioregions, rapidly reaching 18 bioregions with voyages of 365 days (Figure 5.14).

The inoculation likelihoods of species increase with the addition of MSC vessels (Figures 5.15, 5.16). No species were categorized as having "High" likelihood of inoculation when assessed for commercial vessels alone, with the addition of MSC vessels increasing the "High" risk species to 15 species for voyages of 1,825 days (5 years) (Table 5.4).

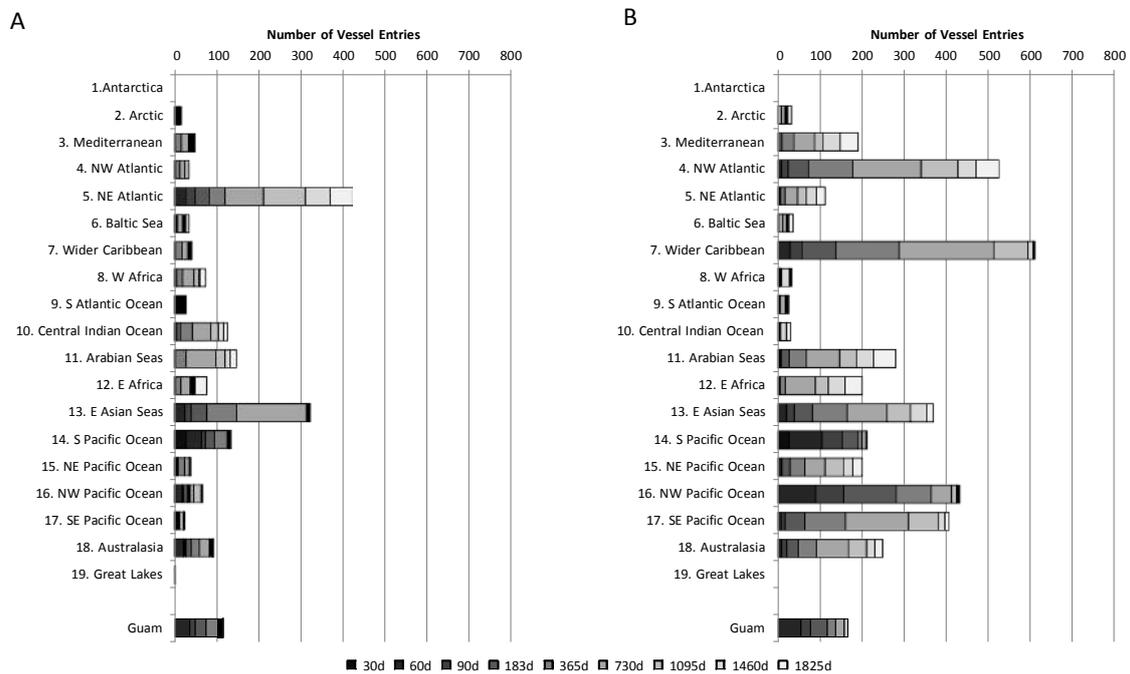


Figure 5.12. Number of A) commercial vessel (all categories) and B) MSC vessel (all categories) entries to CNMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries vessels (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

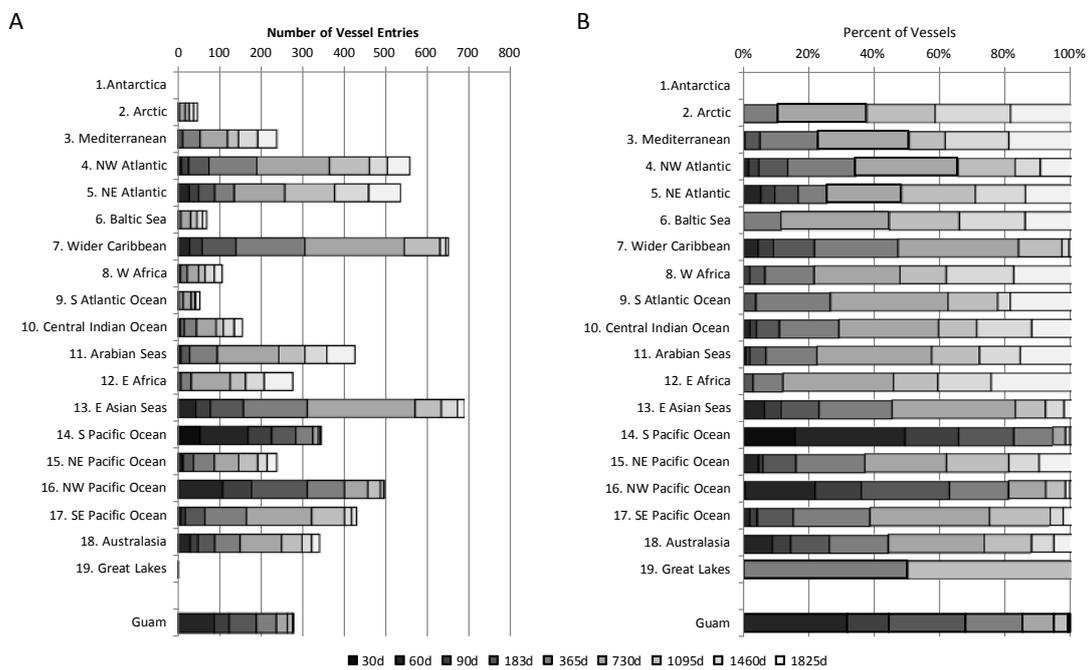


Figure 5.13. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to CNMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

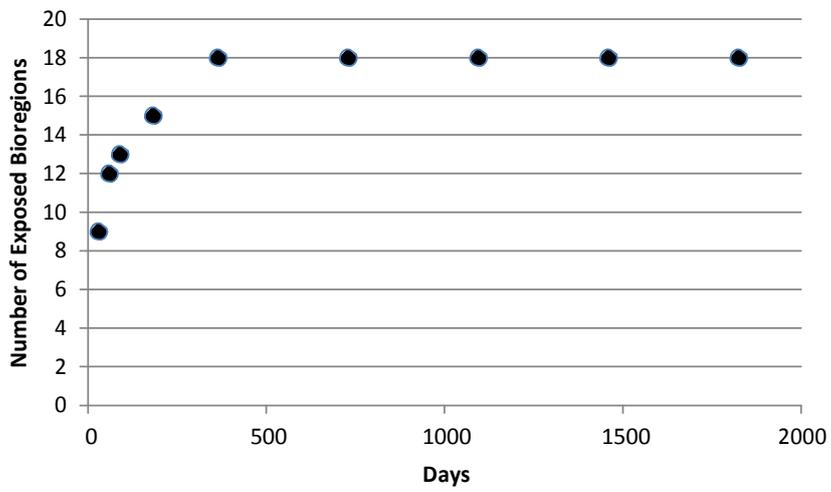


Figure 5.14. Number of bioregions visited by vessels entering the CNMI between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DoD datasets).

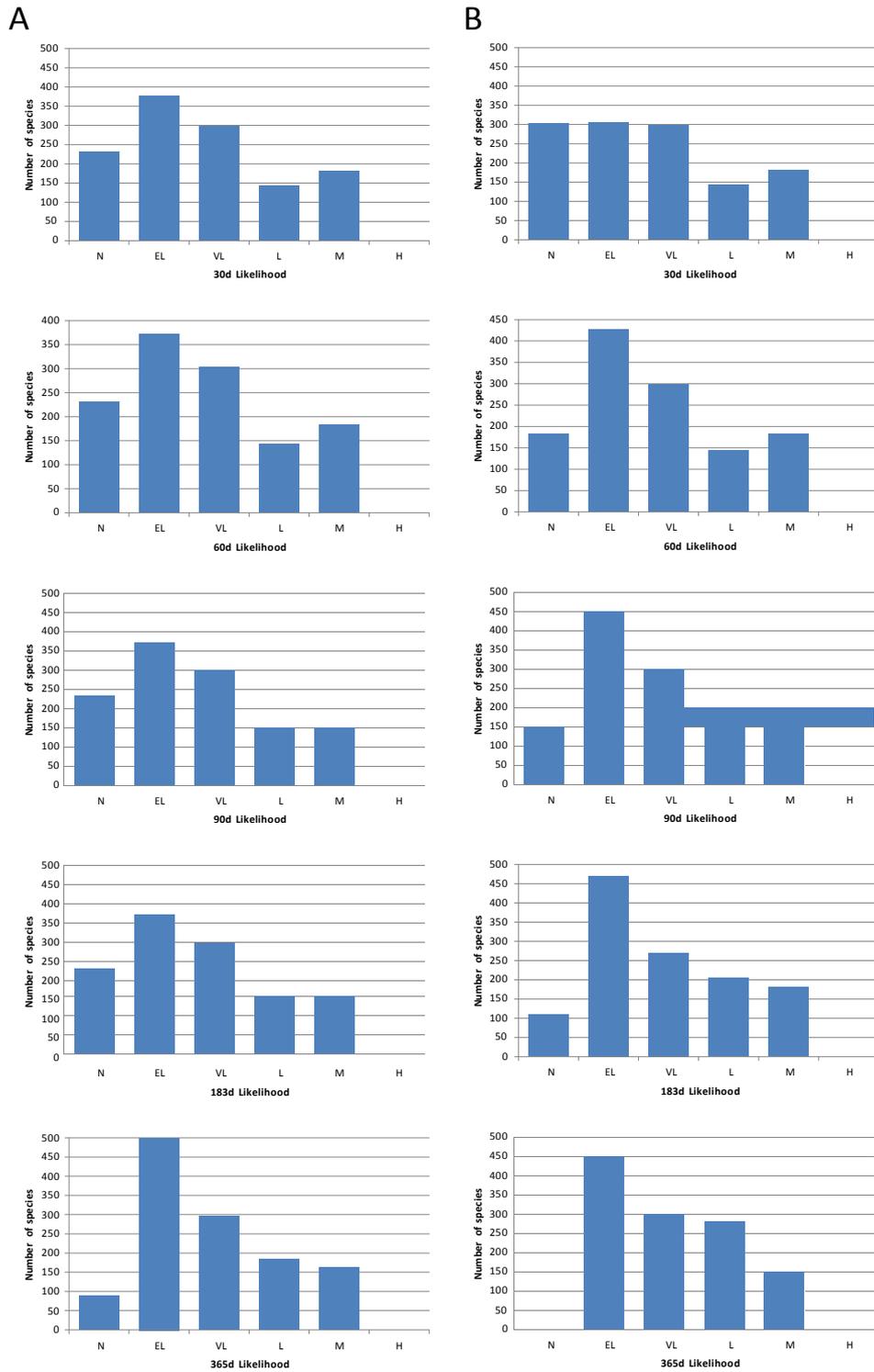


Figure 5.15. Number of species for Inoculation Likelihood Ranks to CNMI for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

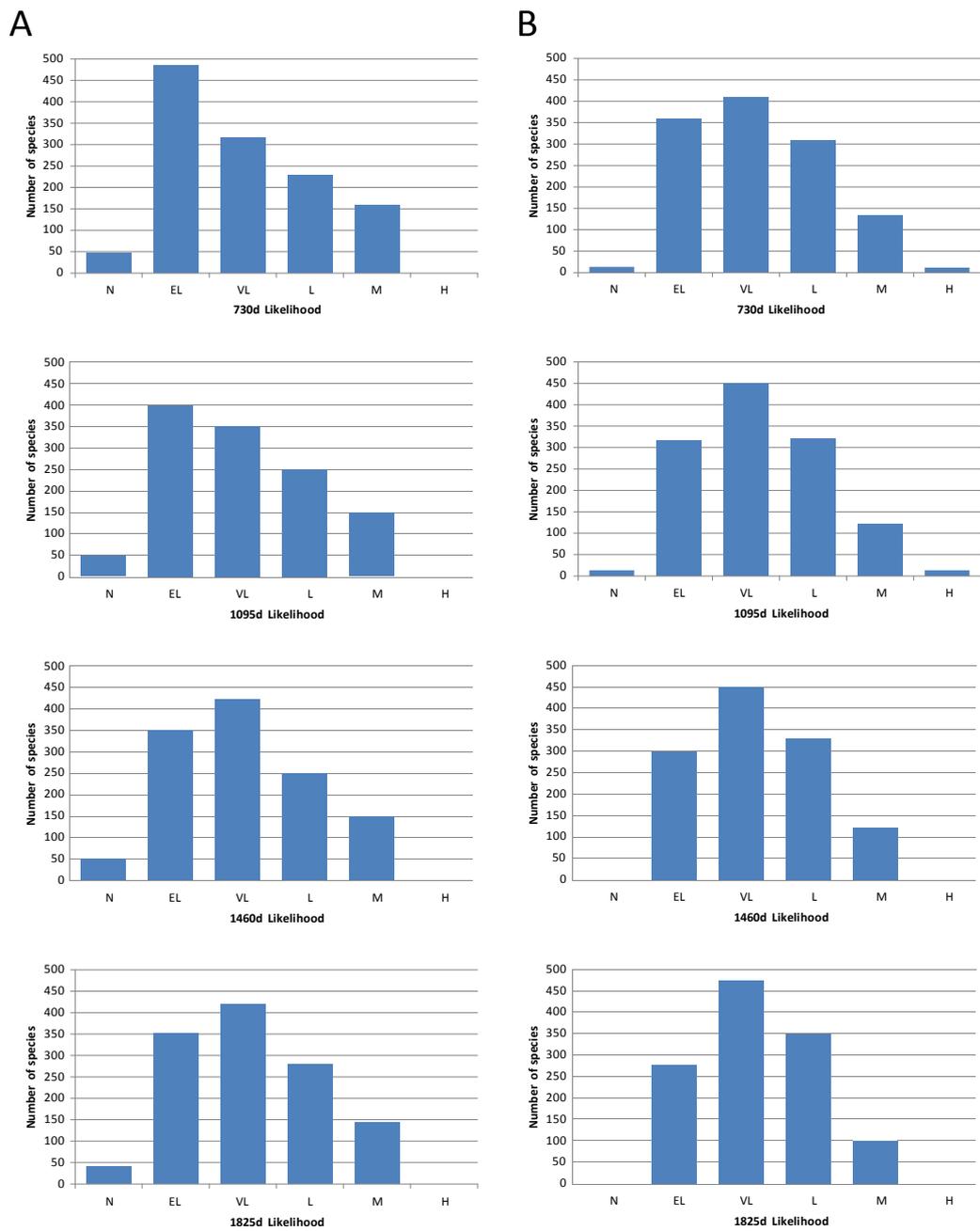


Figure 5.16. Number of species for Inoculation Likelihood Ranks to CNMI for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.4. Biofouling species with a “High” (n=15) and “Medium” (n=116) likelihood of arrival in the CNMI associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Annelida	<i>Dipolydora armata (=armarta)</i>	M
Annelida	<i>Eumida sanguineum</i>	M
Annelida	<i>Ficopomatus enigmaticus</i>	M
Annelida	<i>Hydroides diramphus</i>	M
Annelida	<i>Hydroides elegans</i>	M
Annelida	<i>Janua pagenstecheri</i>	H
Annelida	<i>Lysidice collaris</i>	M
Annelida	<i>Neodexiospira brasiliensis (=Janua (Dexiospira) brasiliensis)</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Pomatoleios kraussii</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Chlorophyta	<i>Bryopsis pennata</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Caulerpa mexicana</i>	M
Chlorophyta	<i>Caulerpa racemosa var. lamourouxii</i>	M
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Cladophora herpestica</i>	M
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Cladophora sericea</i>	M
Chlorophyta	<i>Cladophoropsis membranacea</i>	M
Chlorophyta	<i>Derbesia marina</i>	M
Chlorophyta	<i>Dictyosphaeria cavernosa</i>	M
Chlorophyta	<i>Neomeris annulata</i>	M
Chlorophyta	<i>Ulva clathrata (=Enteromorpha clathrata var. crinata)</i>	H
Chlorophyta	<i>Ulva flexuosa</i>	H
Chlorophyta	<i>Ulva reticulata</i>	M

Table 5.4: Continued

Phylum	Scientific name	Likelihood
Chlorophyta	<i>Ulva rigida</i>	H
Chordata (Asciacea)	<i>Botrylloides perspicuum</i>	M
Chordata (Asciacea)	<i>Botryllus schlosseri</i>	M
Chordata (Asciacea)	<i>Ciona intestinalis</i>	H
Chordata (Asciacea)	<i>Didemnum candidum</i>	M
Chordata (Asciacea)	<i>Perophora multiclathrata</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	M
Cnidaria	<i>Clytia hemisphaerica</i>	M
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Diadumene lineata</i>	M
Cnidaria	<i>Eudendrium capillare</i>	M
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Tubastraea coccinea</i>	M
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Amphibalanus reticulatus</i>	M
Arthropoda	<i>Balanus trigonus</i>	M
Arthropoda	<i>Caprella equilibra</i>	M
Arthropoda	<i>Caprella penantis</i>	M
Arthropoda	<i>Caprella scaura</i>	M
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Dromia wilsoni</i>	M
Arthropoda	<i>Elasmopus rapax</i>	M
Arthropoda	<i>Erichthonius brasiliensis</i>	M
Arthropoda	<i>Eucrate crenata</i>	M
Arthropoda	<i>Kotoracythere inconspicua</i>	M
Arthropoda	<i>Laticorophium baconi</i>	M
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	M

Table 5.4: Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M
Arthropoda	<i>Leptochela dubia</i>	M
Arthropoda	<i>Ligia exotica</i>	M
Arthropoda	<i>Menaethius monoceros</i>	M
Arthropoda	<i>Monocorophium acherusicum</i>	M
Arthropoda	<i>Monocorophium insidiosum</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	M
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Paradella diana</i>	M
Arthropoda	<i>Plagusia depressa tuberculata</i>	M
Arthropoda	<i>Sphaeroma walkeri</i>	M
Arthropoda	<i>Stenothoe gallensis</i>	M
Arthropoda	<i>Stenothoe valida</i>	M
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Dinophyta	<i>Prorocentrum lima</i>	M
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Bowerbankia gracilis</i>	M
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Bugula dentata</i>	M
Bryozoa	<i>Bugula stolonifera</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	M
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	M
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Watersipora subtorquata</i>	M
Bryozoa	<i>Zoobotryon verticillatum</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M

Table 5.4: Continued

Phylum	Scientific name	Likelihood
Mollusca	<i>Anadara granosa</i>	M
Mollusca	<i>Anteaeolidiella foulisi</i> (=Anteaeolidiella <i>indica</i>)	M
Mollusca	<i>Caloria indica</i>	M
Mollusca	<i>Cycloscala hyalina</i>	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Elysia tomentosa</i>	M
Mollusca	<i>Hiatella arctica</i>	M
Mollusca	<i>Lienardia mighelsi</i>	M
Mollusca	<i>Martesia striata</i>	M
Mollusca	<i>Musculista senhousia</i>	M
Mollusca	<i>Mytilopsis sallei</i>	M
Mollusca	<i>Perna viridis</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Teredo navalis</i>	M
Mollusca	<i>Thecacera pennigera</i>	M
Phaeophyta	<i>Chnoospora minima</i>	M
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Hincksia mitchelliae</i>	H
Phaeophyta	<i>Padina boryana</i>	M
Phaeophyta	<i>Pylaiella littoralis</i>	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Mycale parishii</i> (=Zygomycale parishii)	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	M
Rhodophyta	<i>Acanthophora spicifera</i>	M
Rhodophyta	<i>Aglaothamnion cordatum</i> <i>Antithamnion hubbsii</i> (=nipponicum, <i>pectinatum</i>)	M
Rhodophyta	<i>Asparagopsis taxiformis</i>	M
Rhodophyta	<i>Bangia atropurpurea</i>	H

Table 5.4: Continued

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Caulacanthus ustulatus</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
Rhodophyta	<i>Dasya baillouviana</i>	M
Rhodophyta	<i>Eucheuma denticulatum</i>	M
Rhodophyta	<i>Gymnothamnion elegans</i>	M
Rhodophyta	<i>Herposiphonia parca</i>	M
Rhodophyta	<i>Hildenbrandia rubra</i>	H
Rhodophyta	<i>Hypnea anastomosans</i> (=Hypnea esperi)	M
Rhodophyta	<i>Hypnea cornuta</i>	M
Rhodophyta	<i>Hypnea spinella</i> (=Hypnea cervicornis)	M
Rhodophyta	<i>Hypnea valentiae</i>	M
Rhodophyta	<i>Polysiphonia subtilissima</i>	M
Rhodophyta	<i>Sarconema filiforme</i>	M
Rhodophyta	<i>Spongoclonium caribaeum</i> (=Pleonosporium caribaeum)	M

5.4.2 Federated States of Micronesia

The Federated States of Micronesia (FSM) received 783 commercial vessels and 28 MSC vessel entries during the assessed period (Figures 5.17, 5.18). Approximately 15.5% of these vessels arrived directly from Guam. Commercial vessels had strong affinities with a restricted suite of Pacific bioregions (East Asian Seas-13, South Pacific-14, and Northwest Pacific-16), representing more than 62% of total trade. In contrast, few military vessels traded with FSM and were restricted to the South Pacific Ocean and NW Pacific. As a consequence, military vessels contribute little to the likelihood of species inoculations based on vessel entries alone. The trading activities are widespread initially, with 30 day voyages reaching seven bioregions, however only after 730 day voyages the maximum of 17 bioregions are reached (Figure 5.19).

The inoculation likelihoods of species do not change with the addition of military vessels (Figures 5.20 and 5.21) due to the limited number of military vessel entries. The overall result is 42 species identified as ‘High’ likelihood of inoculation for voyages of 1,825 days (5 years) (Table 5.5).

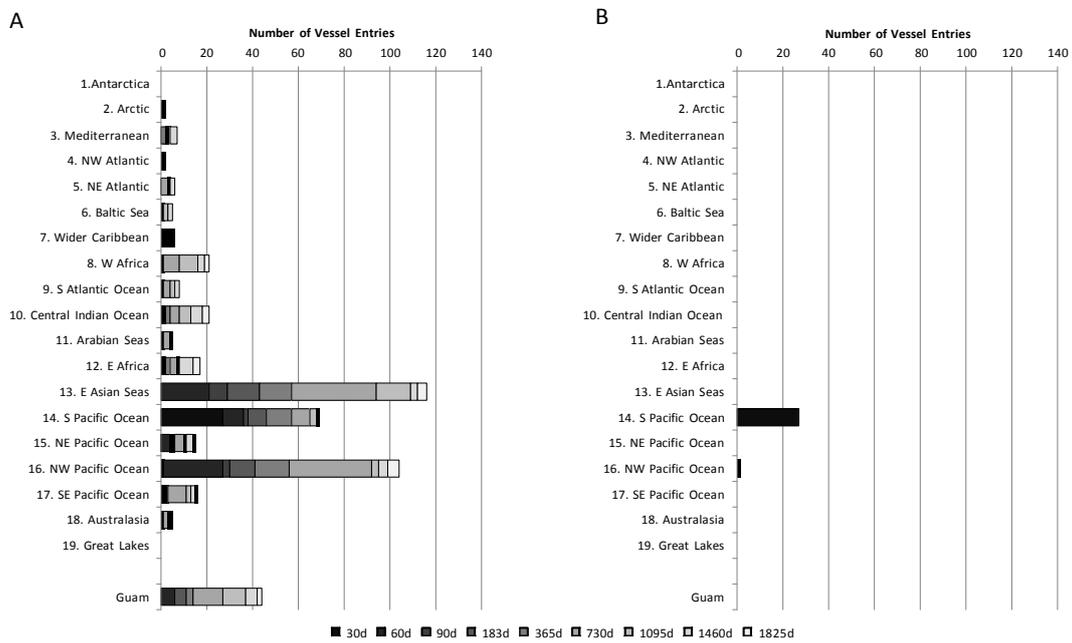


Figure 5.17. Number of A) commercial vessel (all categories) and B) MSC vessel (all categories) entries to the FSM from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

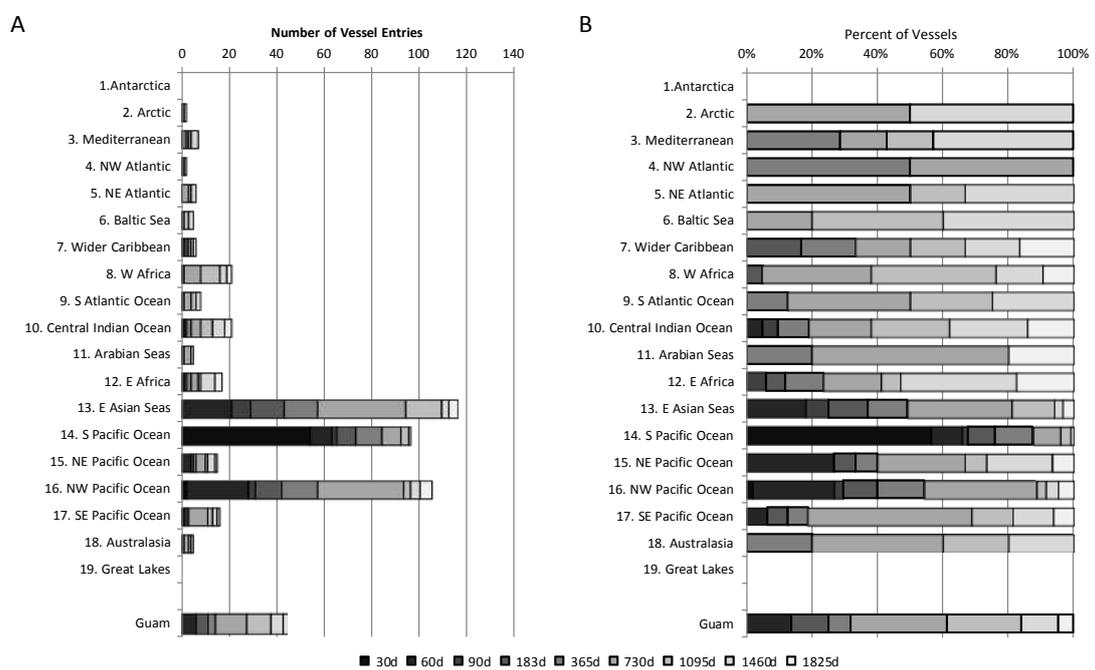


Figure 5.18. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to FSM from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

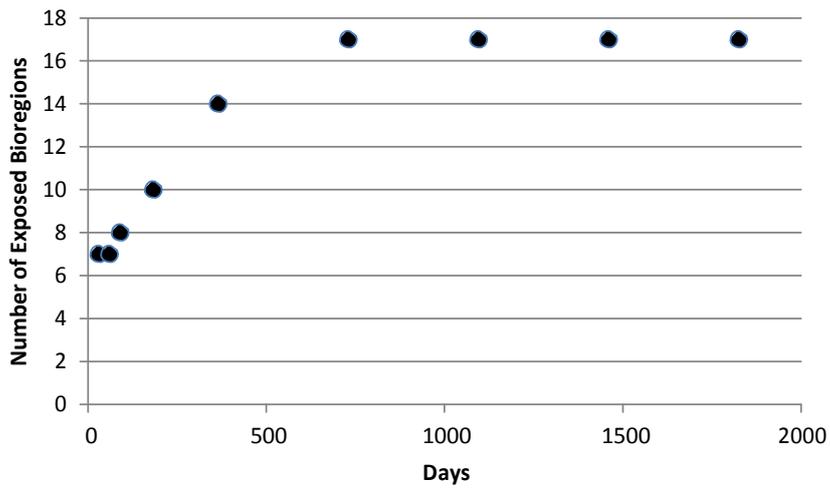
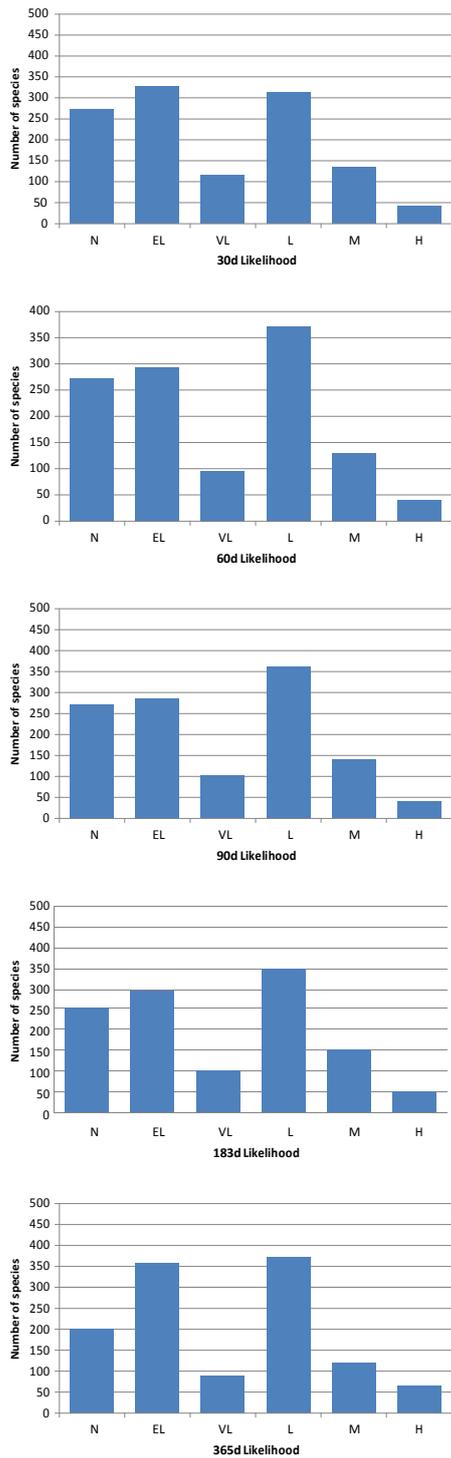


Figure 5.19: Number of bioregions visited by vessels entering FSM between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DoD datasets).

A



B

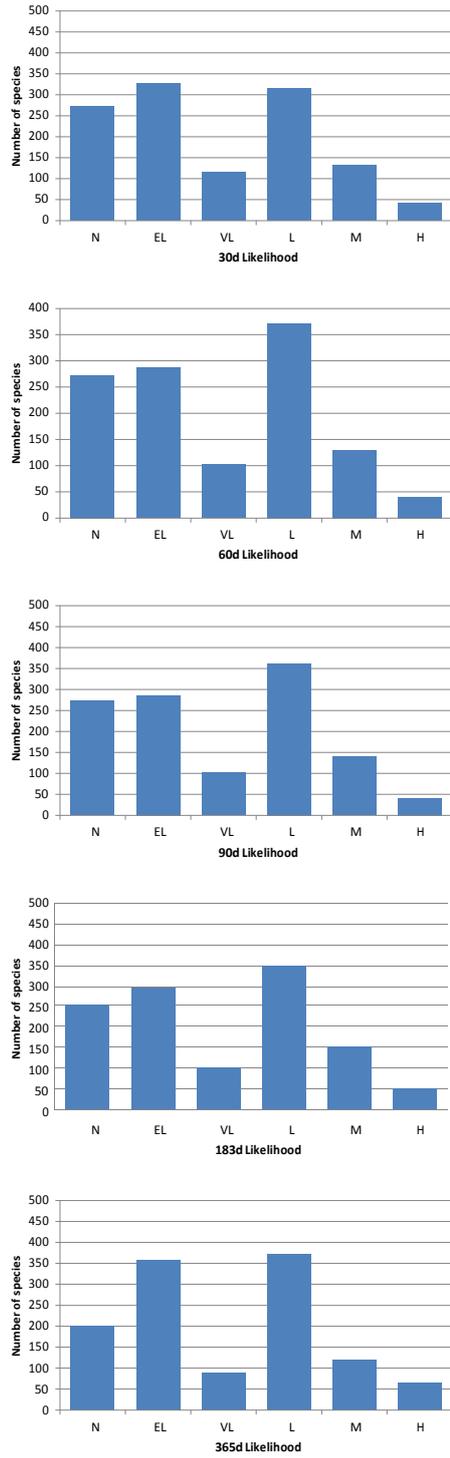


Figure 5.20. Number of species for Inoculation Likelihood Ranks to FSM for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

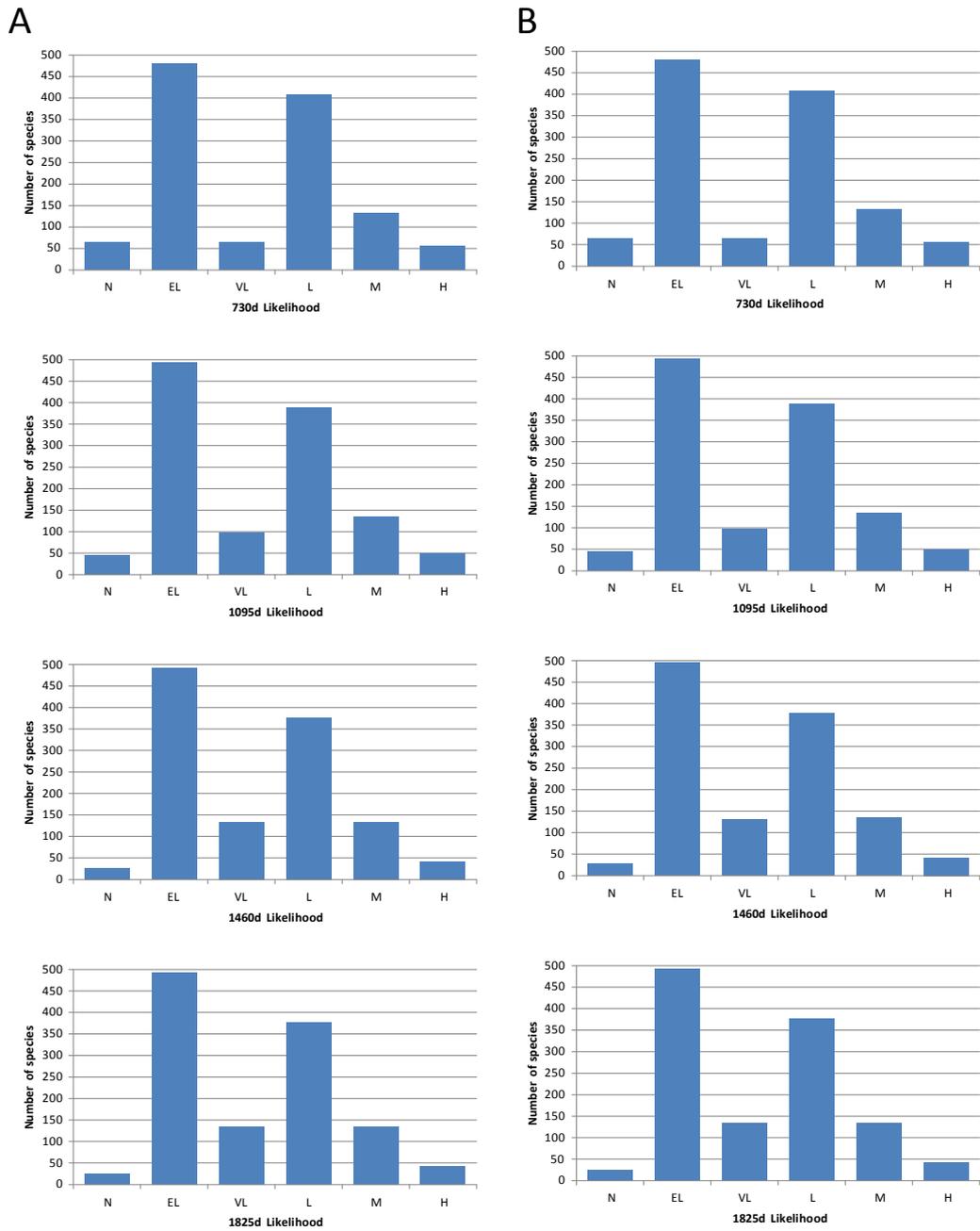


Figure 5.21. Number of species for Inoculation Likelihood Ranks to FSM for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.5. Biofouling species with a “High” (n=42) and “Medium” (n=135) likelihood of arrival in FSM associated with all vessel traffic.

Phylum	Scientific Name	Likelihood
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Annelida	<i>Dipolydora armata (=armarta)</i>	H
Annelida	<i>Dorvillea similis</i>	M
Annelida	<i>Eumida sanguineum</i>	M
Annelida	<i>Ficopomatus enigmaticus</i>	M
Annelida	<i>Hydroides albiceps (casual)</i>	M
Annelida	<i>Hydroides diramphus</i>	H
Annelida	<i>Hydroides elegans</i>	H
Annelida	<i>Janua pagenstecheri</i>	H
Annelida	<i>Lysidice collaris</i>	M
Annelida	<i>Myrianida pachycera</i>	M
Annelida	<i>Ophryotrocha labronica pacifica</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Polydora websteri</i>	M
Annelida	<i>Pomatoleios kraussii</i>	H
Annelida	<i>Pseudopolydora paucibranchiata</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Chlorophyta	<i>Avrainvillea amadelpha</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Caulerpa racemosa var. lamourouxii</i>	M
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Codium ovale</i>	M
Chlorophyta	<i>Ulva clathrata (=Enteromorpha clathrata var. crinata)</i>	H
Chlorophyta	<i>Ulva flexuosa</i>	H
Chlorophyta	<i>Ulva pertusa</i>	M
Chlorophyta	<i>Ulva reticulata</i>	M
Chlorophyta	<i>Ulva rigida</i>	H
Chlorophyta	<i>Ulva taeniata</i>	M

Table 5.5: Continued

Phylum	Scientific Name	Likelihood
Chlorophyta	<i>Valonia fastigiata</i>	M
Chordata (Asciacea)	<i>Ascidia archaia</i>	M
Chordata (Asciacea)	<i>Botrylloides leachi</i>	M
Chordata (Asciacea)	<i>Botrylloides perspicuum</i>	M
Chordata (Asciacea)	<i>Botryllus schlosseri</i>	H
Chordata (Asciacea)	<i>Ciona intestinalis</i>	H
Chordata (Asciacea)	<i>Cnemidocarpa irene</i>	M
Chordata (Asciacea)	<i>Didemnum candidum</i>	H
Chordata (Asciacea)	<i>Microcosmus squamiger</i>	M
Chordata (Asciacea)	<i>Molgula ficus</i>	M
Chordata (Asciacea)	<i>Perophora multiclathrata</i>	M
Chordata (Asciacea)	<i>Polyandrocarpa zorritensis</i>	M
Chordata (Asciacea)	<i>Symplegma reptans</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	M
Cnidaria	<i>Clytia hemisphaerica</i>	H
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Diadumene lineata</i>	H
Cnidaria	<i>Eudendrium capillare</i>	H
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Scolionema suvaensis</i>	M
Cnidaria	<i>Sertularia tongensis (=Sertularia stechowi, S. theocarpa)</i>	M
Cnidaria	<i>Tubastraea coccinea</i>	H
Arthropoda	<i>Alpheus rapacida</i>	M
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	M
Arthropoda	<i>Amphibalanus reticulatus</i>	H
Arthropoda	<i>Balanus trigonus</i>	H

Table 5.5: Continued

Phylum	Scientific Name	Likelihood
Arthropoda	<i>Caprella danilevskii</i>	M
Arthropoda	<i>Caprella equilibra</i>	M
Arthropoda	<i>Caprella penantis</i>	M
Arthropoda	<i>Caprella scaura</i>	H
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Conchoderma virgatum</i>	M
Arthropoda	<i>Dromia wilsoni</i>	M
Arthropoda	<i>Elasmopus rapax</i>	M
Arthropoda	<i>Erichthonius brasiliensis</i>	M
Arthropoda	<i>Eucrate crenata</i>	M
Arthropoda	<i>Glabropilumnus seminudus</i>	M
Arthropoda	<i>Gnorimosphaeroma rayi</i>	M
Arthropoda	<i>IncisCALLiope derzhavini</i>	M
Arthropoda	<i>Kotoracythere inconspicua</i>	M
Arthropoda	<i>Laticorophium baconi</i>	H
Arthropoda	<i>Lepas (Anatifa) anatifera</i>	H
Arthropoda	<i>Leptochela dubia</i>	H
Arthropoda	<i>Ligia exotica</i>	H
Arthropoda	<i>Megabalanus occator</i>	M
Arthropoda	<i>Menaethius monoceros</i>	M
Arthropoda	<i>Merocryptus lambriformis</i>	M
Arthropoda	<i>Monocorophium acherusicum</i>	M
Arthropoda	<i>Monocorophium insidiosum</i>	M
Arthropoda	<i>Nanosesarma minutum</i>	M
Arthropoda	<i>Pachygrapsus crassipes</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	H
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Paradella diana</i>	M
Arthropoda	<i>Plagusia depressa tuberculata</i>	M
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M
Arthropoda	<i>Sphaeroma quoianum</i>	M

Table 5.5: Continued

Phylum	Scientific Name	Likelihood
Arthropoda	<i>Sphaeroma walkeri</i>	H
Arthropoda	<i>Stenothoe gallensis</i>	M
Arthropoda	<i>Stenothoe valida</i>	M
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Dinophyta	<i>Ostreopsis ovata</i>	M
Dinophyta	<i>Prorocentrum lima</i>	M
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Bowerbankia gracilis</i>	M
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Bugula dentata</i>	M
Bryozoa	<i>Bugula stolonifera</i>	M
Bryozoa	<i>Caberea boryi</i>	M
Bryozoa	<i>Celleporaria brunnea</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	H
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	M
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Tricellaria occidentalis</i>	M
Bryozoa	<i>Watersipora arcuata</i>	M
Bryozoa	<i>Watersipora subtorquata</i>	H
Bryozoa	<i>Zoobotryon verticillatum</i>	M
Mollusca	<i>Anadara granosa (casual)</i>	M
Mollusca	<i>Anteaeolidiella foulisi (=Anteaeolidiella indica)</i>	H
Mollusca	<i>Bankia bipalmulata</i>	M
Mollusca	<i>Caloria indica</i>	M
Mollusca	<i>Crepidatella lingulata (=Crepidula lingulata)</i>	M

Table 5.5: Continued

Phylum	Scientific Name	Likelihood
Mollusca	<i>Cycloscala hyalina</i>	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Diodora ruppelli</i>	M
Mollusca	<i>Doxander vittatus</i>	M
Mollusca	<i>Elysia tomentosa</i>	M
Mollusca	<i>Hiatella arctica</i>	M
Mollusca	<i>Isognomon ephippium</i>	M
Mollusca	<i>Lienardia mighelsi</i>	M
Mollusca	<i>Martesia striata</i>	M
Mollusca	<i>Musculista senhousia</i>	H
Mollusca	<i>Mytilopsis sallei</i>	M
Mollusca	<i>Mytilus galloprovincialis</i>	M
Mollusca	<i>Nanostrea fluctigera (=Nanostrea exigua)</i>	M
Mollusca	<i>Okenia pellucida</i>	M
Mollusca	<i>Ostrea conchaphila</i>	M
Mollusca	<i>Perna viridis</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Strombus mutabilis</i>	M
Mollusca	<i>Syrnola cinctella</i>	M
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Teredora princesae</i>	M
Mollusca	<i>Thecacera pennigera</i>	M
Phaeophyta	<i>Chnoospora minima</i>	M
Phaeophyta	<i>Cutleria multifida</i>	M
Phaeophyta	<i>Dictyota flabellata</i>	M
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Leathesia marina (=Leathesia difformis)</i>	M
Phaeophyta	<i>Macrocystis pyrifera</i>	M
Phaeophyta	<i>Myrionema strangulans</i>	M
Phaeophyta	<i>Nemacystus decipiens</i>	M
Phaeophyta	<i>Padina antillarum</i>	M

Table 5.5: Continued

Phylum	Scientific Name	Likelihood
Phaeophyta	<i>Padina boryana</i>	M
Phaeophyta	<i>Pylaiella littoralis</i>	H
Phaeophyta	<i>Rugulopteryx okamurae</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Mycale parishii</i> (= <i>Zygomycale parishii</i>)	H
Pycnogonida	<i>Ammothea hilgendorfi</i>	M
Pycnogonida	<i>Anoplodactylus erectus</i>	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	M
Rhodophyta	<i>Acanthophora spicifera</i>	M
Rhodophyta	<i>Aglaothamnion cordatum</i>	H
Rhodophyta	<i>Antithamnion hubbsii</i> (= <i>nipponicum</i> , <i>pectinatum</i>)	M
Rhodophyta	<i>Apoglossum gregarium</i>	M
Rhodophyta	<i>Asparagopsis taxiformis</i>	H
Rhodophyta	<i>Bangia atropurpurea</i>	H
Rhodophyta	<i>Caulacanthus ustulatus</i>	H
Rhodophyta	<i>Chondria arcuata</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
Rhodophyta	<i>Dasya baillouviana</i>	H
Rhodophyta	<i>Eucheuma denticulatum</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
Rhodophyta	<i>Hypnea cornuta</i>	M
Rhodophyta	<i>Hypnea nidifica</i>	M
Rhodophyta	<i>Laurencia brongniartii</i>	M
Rhodophyta	<i>Porphyra suborbiculata</i>	M
Rhodophyta	<i>Pterosiphonia bipinnata</i>	M
Rhodophyta	<i>Sarconema filiforme</i>	M

5.4.3 Republic of the Marshall Islands

Republic of the Marshall Islands (RMI) received 540 commercial vessels and 630 MSC vessel entries during the assessed period (Figures 5.22 and 5.23). Approximately 6% of these vessels arrived directly from Guam. Commercial vessels had strong affinities with a restricted suite of Pacific Rim bioregions (East Asian Seas-13, South Pacific-14, Northeast Pacific-15, and Northwest Pacific-16), representing more than 47% of total trade. In contrast, military vessels exhibit a much broader exposure to bioregions, particularly Atlantic and Mediterranean bioregions, and therefore broader exposure to a wider suite of species. The trading activities rapidly sampled a wide variety of bioregions, with vessels arriving from 10 bioregions in 30 day voyages and reaching saturation (18 bioregions) with voyages of 365 days (Figure 5.24).

The inoculation likelihoods of species decrease with the addition of military vessels (Figures 5.25 and 5.26), in part due to the reduction of emphasis on Northeast and Northwest Pacific bioregions as trading partners. The combined result of commercial and military (MSC) traffic is 34 species identified as ‘High’ likelihood of inoculation for voyages of 1,825 days (5 years) (Table 5.6).

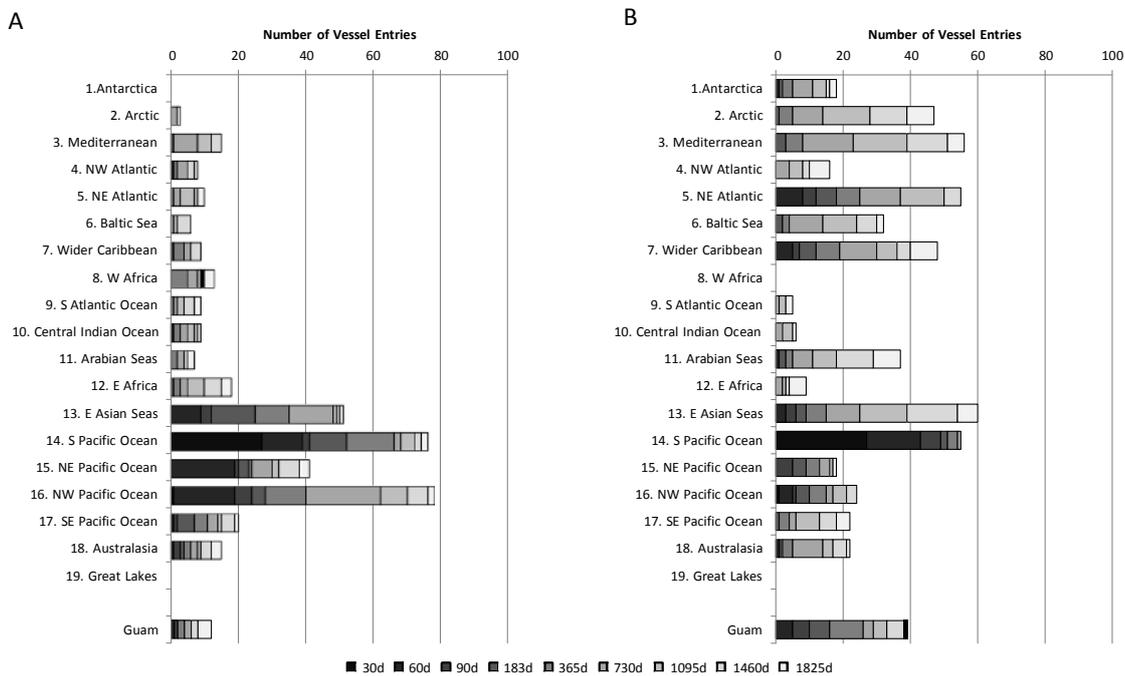


Figure 5.22. Number of A) commercial vessel (all categories) and B) MSC vessel (all categories) entries to RMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

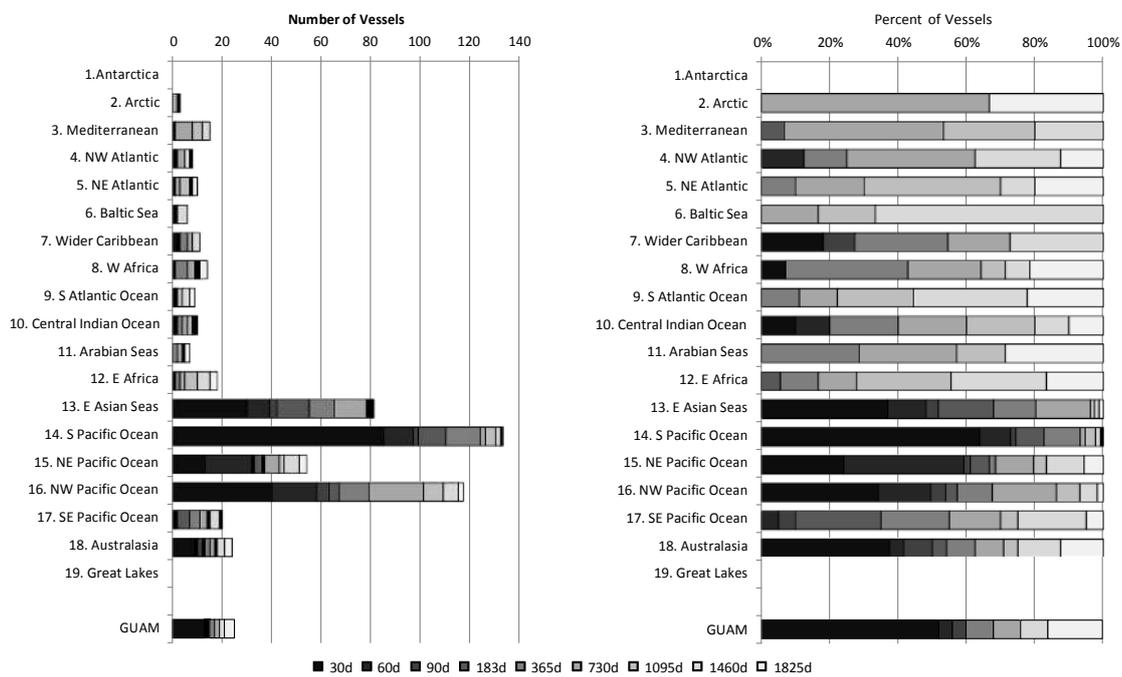


Figure 5.23. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to RMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

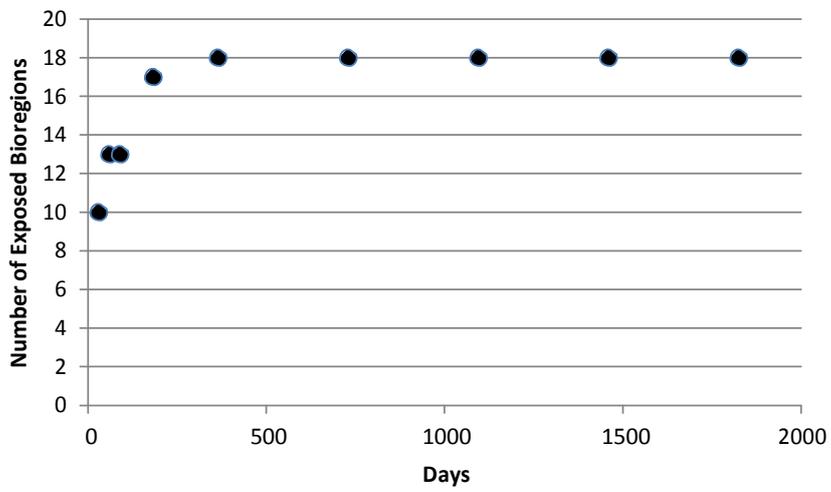


Figure 5.24. Number of bioregions visited by vessels entering RMI between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DoD datasets).

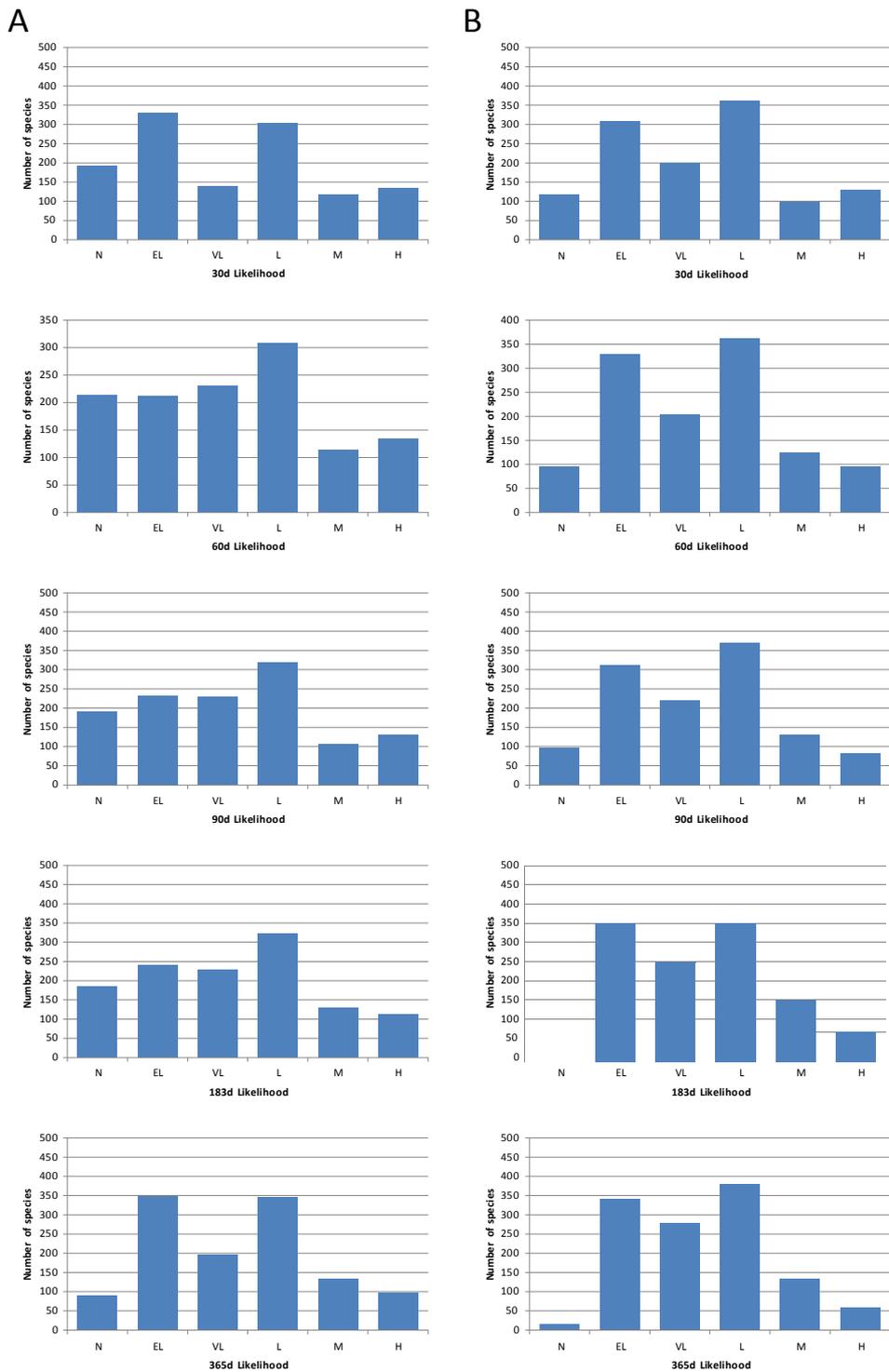
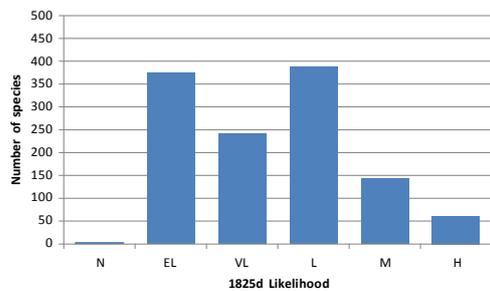
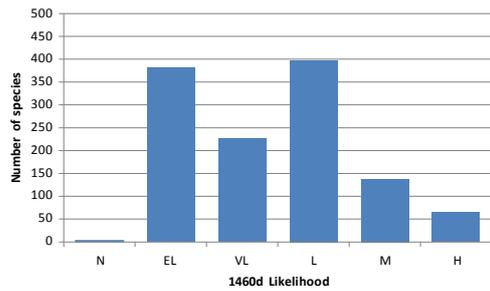
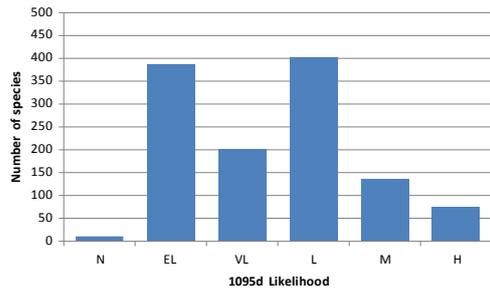
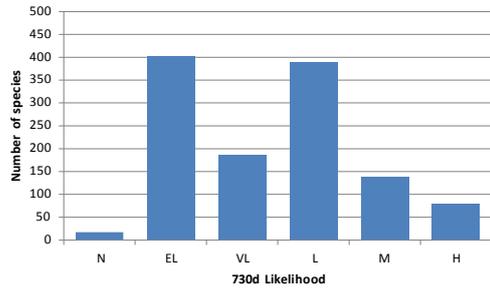


Figure 5.25. Number of species for Inoculation Likelihood Ranks to RMI for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

A



B

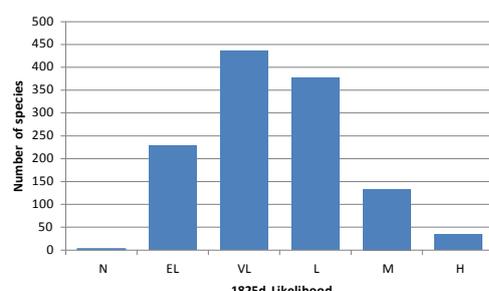
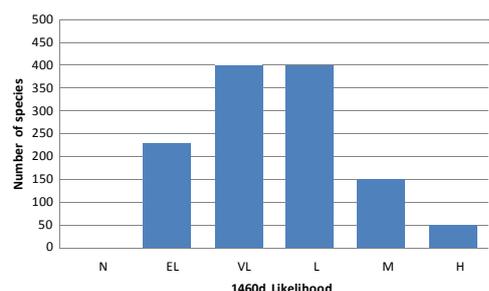
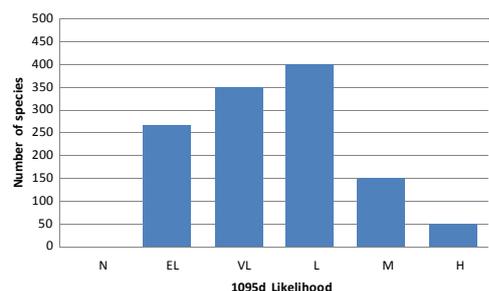
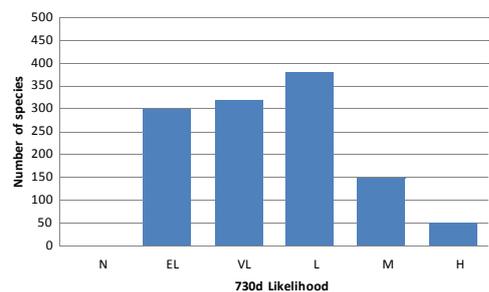


Figure 5.26. Number of species for Inoculation Likelihood Ranks to RMI for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.6. Biofouling species with a “High” (n=34) AND “Medium” (n=133) likelihood of arrival in RMI associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Janua pagenstecheri</i>	H
Annelida	<i>Hydroides elegans</i>	H
Annelida	<i>Hydroides diramphus</i>	M
Annelida	<i>Ficopomatus enigmaticus</i>	M
Annelida	<i>Eunice antennata</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Pomatoleios kraussii</i>	M
Annelida	<i>Lysidice collaris</i>	M
Annelida	<i>Neodexiospira brasiliensis</i> (=Janua (<i>Dexiospira</i>) <i>brasiliensis</i>)	M
Annelida	<i>Glycera capitata</i>	M
Annelida	<i>Heteromastus filiformis</i>	M
Annelida	<i>Hydroides albiceps</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Annelida	<i>Pseudopolydora paucibranchiata</i>	M
Annelida	<i>Polydora websteri</i>	M
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Ulva rigida</i>	H
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Ulva clathrata</i> (=Enteromorpha <i>clathrata</i> <i>var. crinata</i>)	H
Chlorophyta	<i>Cladophora sericea</i>	H
Chlorophyta	<i>Bryopsis pennata</i>	H
Chlorophyta	<i>Neomeris annulata</i>	H
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Ulva reticulata</i>	M
Chlorophyta	<i>Ulva pertusa</i>	M

Table 5.6: Continued

Phylum	Scientific name	Likelihood
Chlorophyta	<i>Cladophora patentiramea</i>	M
Chlorophyta	<i>Ulva taeniata</i>	M
Chlorophyta	<i>Caulerpa racemosa var. lamourouxii</i>	M
Chlorophyta	<i>Codium ovale</i>	M
Chordata (Ascidiacea)	<i>Ciona intestinalis</i>	H
Chordata (Ascidiacea)	<i>Botryllus schlosseri</i>	H
Chordata (Ascidiacea)	<i>Perophora multiclathrata</i>	M
Chordata (Ascidiacea)	<i>Botrylloides leachi</i>	M
Chordata (Ascidiacea)	<i>Microcosmus squamiger</i>	M
Chordata (Ascidiacea)	<i>Polyandrocarpa zorritensis</i>	M
Chordata (Ascidiacea)	<i>Didemnum candidum</i>	M
Chordata (Ascidiacea)	<i>Botrylloides perspicuum</i>	M
Cnidaria	<i>Diadumene lineata</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Eudendrium capillare</i>	H
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	M
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Scolionema suvaensis</i>	M
Cnidaria	<i>Coryne eximia (=Sarsia eximia)</i>	M
Cnidaria	<i>Coryne pusilla</i>	M
Cnidaria	<i>Cladonema radiatum</i>	M
Cnidaria	<i>Phyllorhiza punctata</i>	M
Arthropoda	<i>Caprella scaura</i>	H
Arthropoda	<i>Monocorophium acherusicum</i>	M
Arthropoda	<i>Elasmopus rapax</i>	M
Arthropoda	<i>Stenothoe gallensis</i>	M
Arthropoda	<i>Stenothoe valida</i>	M

Table 5.6: Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Monocorophium insidiosum</i>	M
Arthropoda	<i>Caprella equilibra</i>	M
Arthropoda	<i>Caprella penantis</i>	M
Arthropoda	<i>Laticorophium baconi</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	M
Arthropoda	<i>Erichthonius brasiliensis</i>	M
Arthropoda	<i>Caprella danilevskii</i>	M
Arthropoda	<i>Jassa marmorata</i>	M
Arthropoda	<i>Amphibalanus reticulatus</i>	H
Arthropoda	<i>Balanus trigonus</i>	H
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	M
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M
Arthropoda	<i>Pleopis polyphemoides</i>	M
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Eucrate crenata</i>	M
Arthropoda	<i>Menaethius monoceros</i>	M
Arthropoda	<i>Dromia wilsoni</i>	M
Arthropoda	<i>Plagusia depressa tuberculata</i>	M
Arthropoda	<i>Sphaeroma walkeri</i>	H
Arthropoda	<i>Ligia exotica</i>	M
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Idotea metallica</i>	M
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Arthropoda	<i>Leptochela dubia</i>	H
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M
Dinophyta	<i>Prorocentrum lima</i>	M
Dinophyta	<i>Ostreopsis ovata</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	H
Bryozoa	<i>Watersipora subtorquata</i>	H

Table 5.6: Continued

Phylum	Scientific name	Likelihood
Bryozoa	<i>Bowerbankia gracilis</i>	M
Bryozoa	<i>Bugula stolonifera</i>	M
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Zoobotryon verticillatum</i>	M
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Bugula dentata</i>	M
Bryozoa	<i>Tricellaria occidentalis</i>	M
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Caberea boryi</i>	M
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Musculista senhousia</i>	H
Mollusca	<i>Hiatella arctica</i>	M
Mollusca	<i>Mytilus galloprovincialis</i>	M
Mollusca	<i>Martesia striata</i>	M
Mollusca	<i>Anadara granosa</i>	M
Mollusca	<i>Mytilopsis sallei</i>	M
Mollusca	<i>Isognomon ephippium</i>	M
Mollusca	<i>Nanostrea fluctigera (=Nanostrea exigua)</i>	M
Mollusca	<i>Perna viridis</i>	M
Mollusca	<i>Thecacera pennigera</i>	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Cycloscala hyalina</i>	M
Mollusca	<i>Lienardia mighelsi</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Elysia tomentosa</i>	M
Mollusca	<i>Caloria indica</i>	M

Table 5.6: Continued

Phylum	Scientific name	Likelihood
Mollusca	<i>Syrnola cincitella</i>	M
Mollusca	<i>Tenellia adspersa</i>	M
Mollusca	<i>Doxander vittatus</i>	M
Mollusca	<i>Strombus mutabilis</i>	M
Mollusca	<i>Okenia pellucida</i>	M
	<i>Anteaeolidiella foulisi</i> (=Anteaeolidiella	
Mollusca	<i>indica</i>)	M
Phaeophyta	<i>Pylaiella littoralis</i>	H
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Myrionema strangulans</i>	M
Phaeophyta	<i>Leathesia marina</i> (=Leathesia difformis)	M
Phaeophyta	<i>Ectocarpus fasciculatus</i>	M
Phaeophyta	<i>Hincksia ovata</i>	M
Phaeophyta	<i>Cutleria multifida</i>	M
Phaeophyta	<i>Chnoospora minima</i>	M
Phaeophyta	<i>Hincksia granulosa</i>	M
Phaeophyta	<i>Punctaria latifolia</i>	M
Phaeophyta	<i>Sargassum muticum</i>	M
Phaeophyta	<i>Macrocystis pyrifera</i>	M
Phaeophyta	<i>Hincksia sandriana</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M
Porifera	<i>Mycale parishii</i> (=Zygomycale parishii)	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Halichondria panicea</i>	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	M
Pycnogonida	<i>Ammothea hilgendorfi</i>	M
Rhodophyta	<i>Bangia atropurpurea</i>	H
Rhodophyta	<i>Asparagopsis taxiformis</i>	H
Rhodophyta	<i>Centroceras clavulatum</i>	H
Rhodophyta	<i>Gymnothamnion elegans</i>	H
Rhodophyta	<i>Hypnea valentiae</i>	H

Table 5.6: Continued

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Dasya baillouviana</i>	H
Rhodophyta	<i>Aglaothamnion cordatum</i>	M
Rhodophyta	<i>Caulacanthus ustulatus</i>	M
Rhodophyta	<i>Hypnea anastomosans (=Hypnea esperi)</i>	M
Rhodophyta	<i>Hypnea cornuta</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
	<i>Antithamnion hubbsii (=nipponicum,</i>	
Rhodophyta	<i>pectinatum)</i>	M
Rhodophyta	<i>Herposiphonia parca</i>	M
Rhodophyta	<i>Sarconema filiforme</i>	M
Rhodophyta	<i>Ceramium virgatum</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
	<i>Neosiphonia harveyi (=Polysiphonia</i>	
Rhodophyta	<i>harveyi)</i>	M
Rhodophyta	<i>Eucheuma denticulatum</i>	M
Rhodophyta	<i>Corallina officinalis</i>	M
	<i>Spongoclonium caribaeum</i>	
Rhodophyta	<i>(=Pleonosporium caribaeum)</i>	M
Rhodophyta	<i>Apoglossum gregarium</i>	M
Rhodophyta	<i>Polysiphonia brodiei</i>	M
Rhodophyta	<i>Polysiphonia sertularioides</i>	M

5.4.4 Republic of Palau

The Republic of Palau received 707 commercial vessels and 159 MSC vessel entries during the assessed period (Figures 5.27 and 5.28). Approximately 15% of these vessels arrived directly from Guam. Commercial vessels had strong affinities with a restricted suite of bioregions (East Asian Seas-13, Central Indian Ocean-10, South Pacific-14, and Arabian Seas-11), representing more than 46% of total trade. In contrast, military vessels exhibit a much broader, albeit minor, exposure to bioregions. The trading activities initially had a small sample of bioregions at short voyage durations (30 days = 5 bioregions, 90 days = 8 bioregions) but reached 17 bioregions with voyages of 365 days and saturation after 1,460 days (4 years) (Figure 5.29).

The inoculation likelihoods of species are not significantly affected with the addition of military vessels (Figures 5.30 and 5.31), largely due to the minor contribution military vessels make to the trading activities of Palau. The combined trading activities result in 31 species identified as ‘High’ likelihood of inoculation for voyages of 1,825 days (5 years) (Table 5.7).

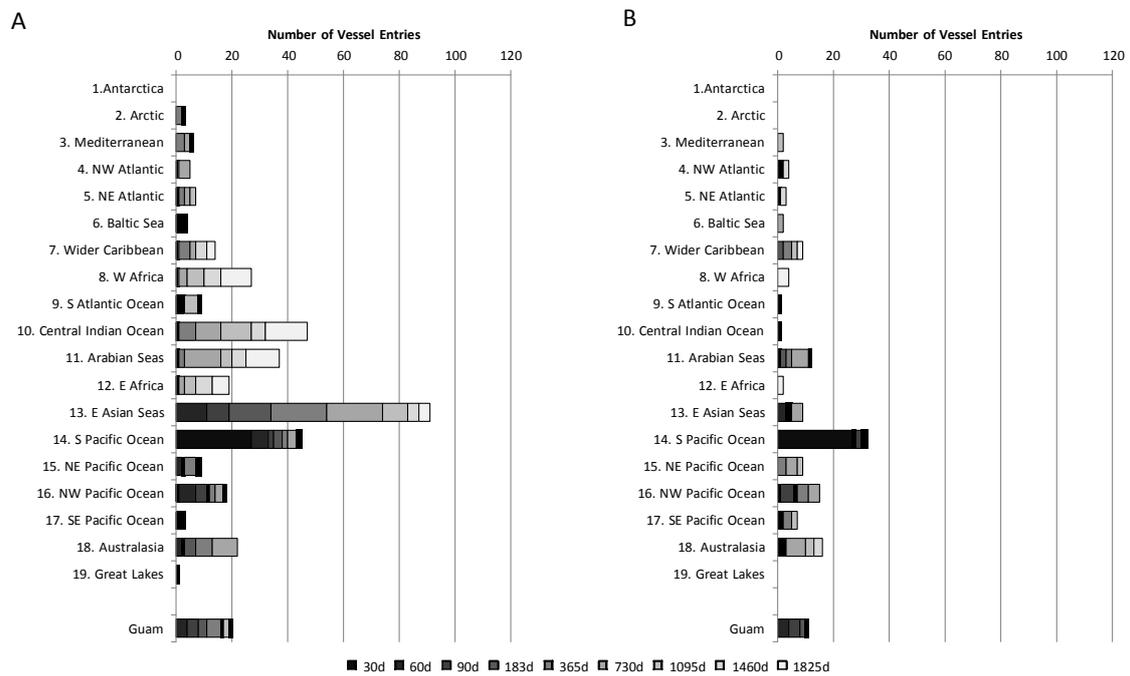


Figure 5.27. Number of A) commercial vessel (all categories) and B) MSC vessel (all categories) entries to the Republic of Palau from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

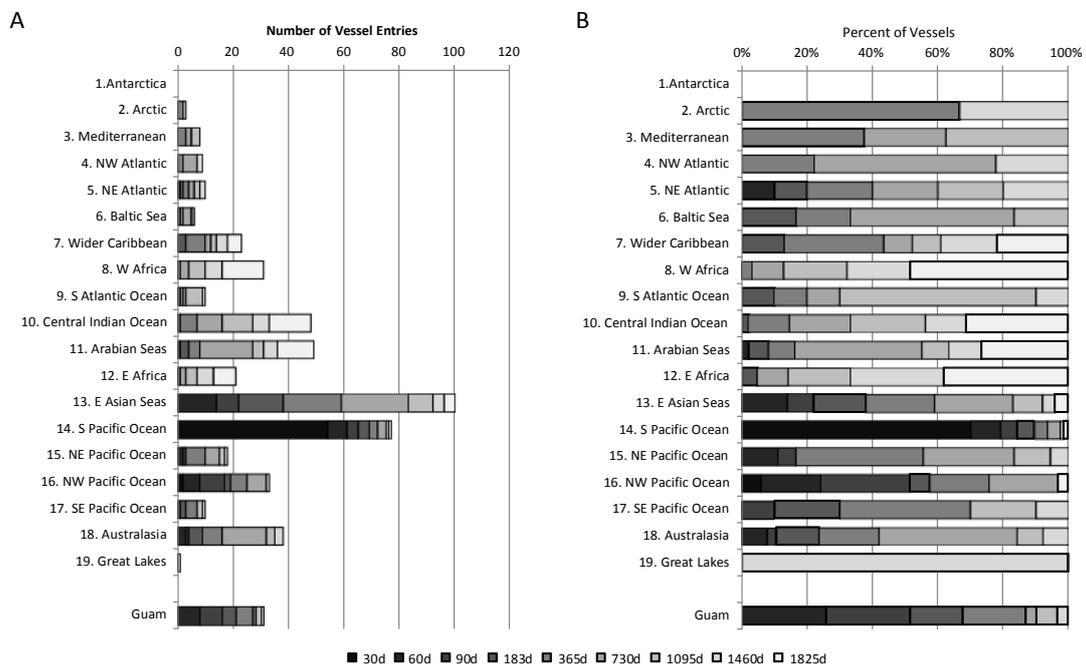


Figure 5.28. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to the Republic of Palau from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

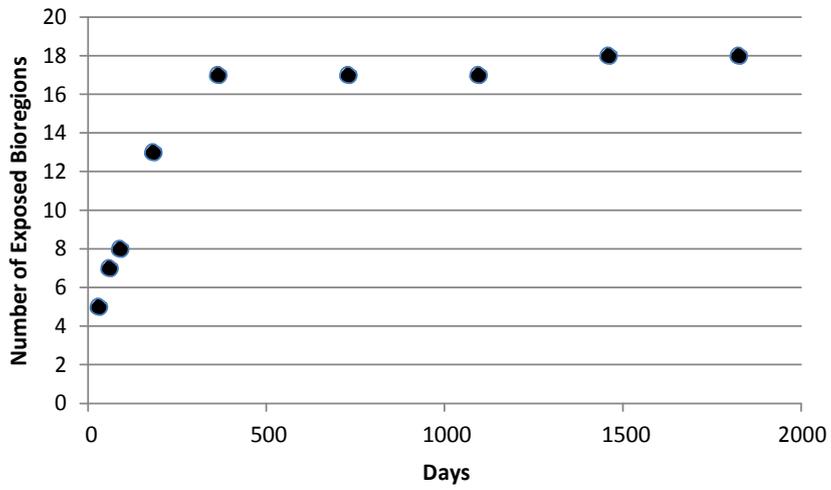


Figure 5.29. Number of bioregions visited by vessels entering the Republic of Palau between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DoD datasets).

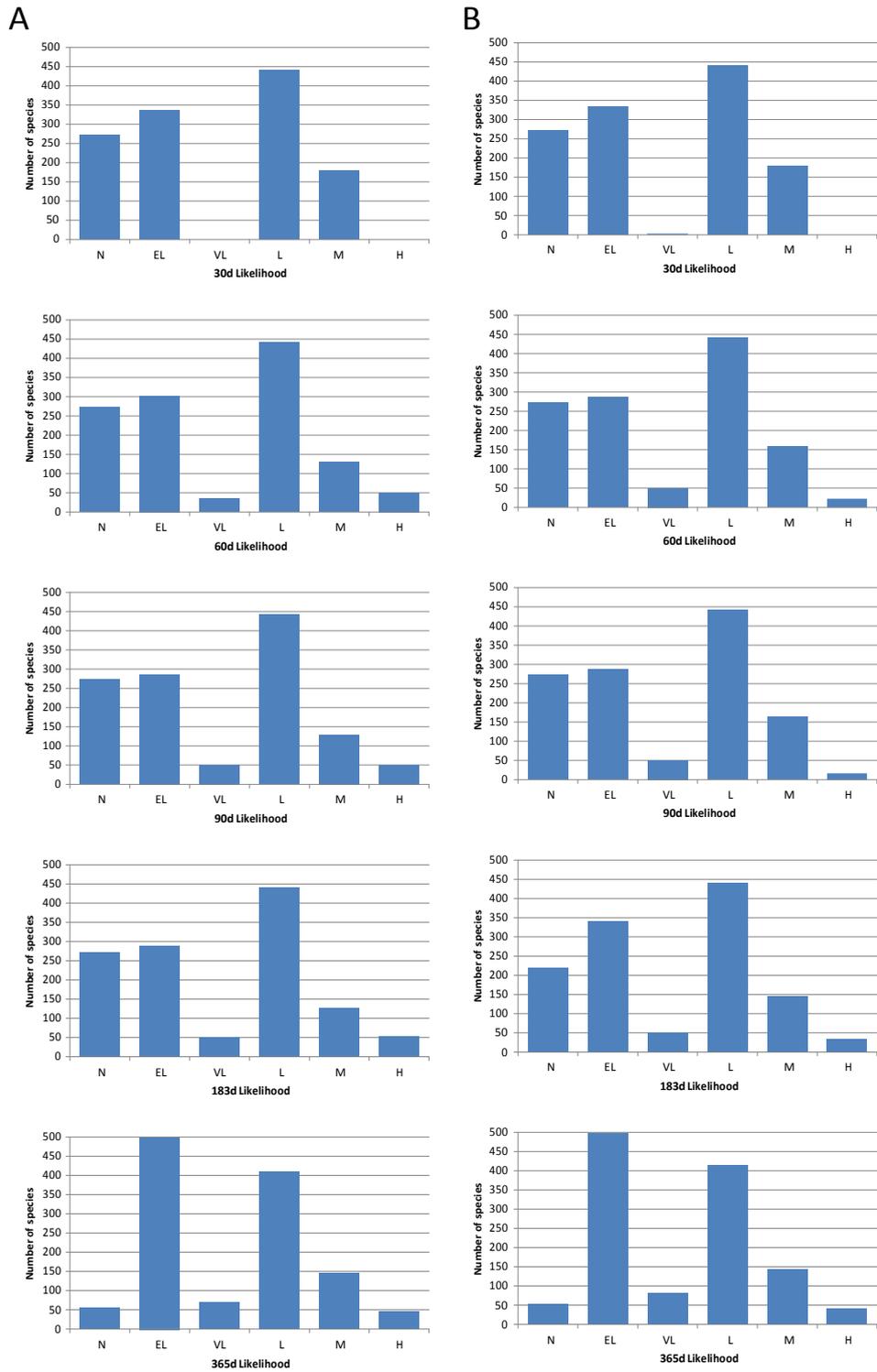
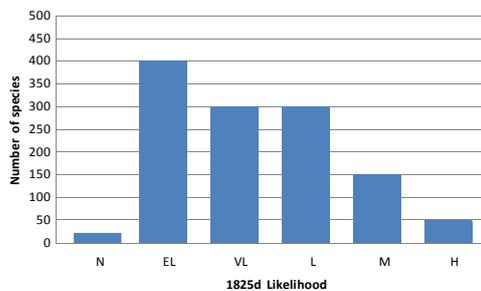
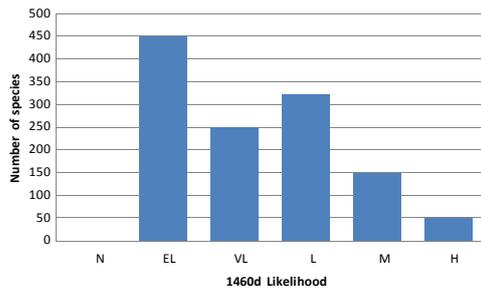
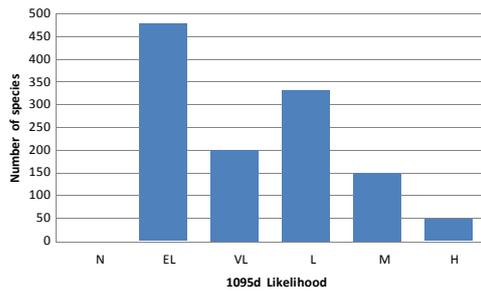
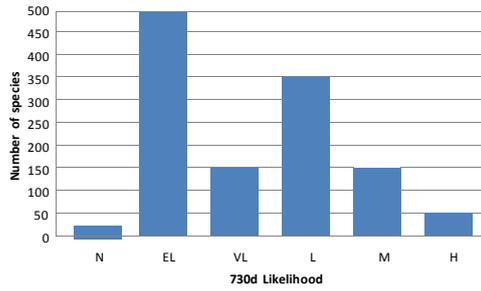


Figure 5.30. Number of species for Inoculation Likelihood Ranks to the Republic of Palau for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

A



B

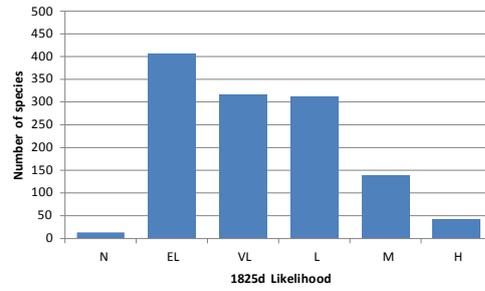
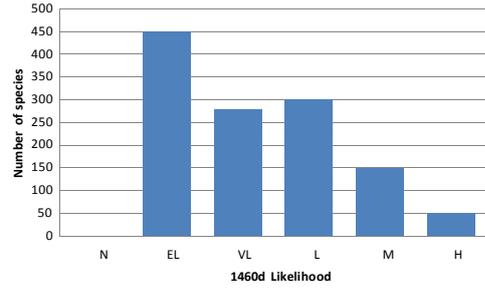
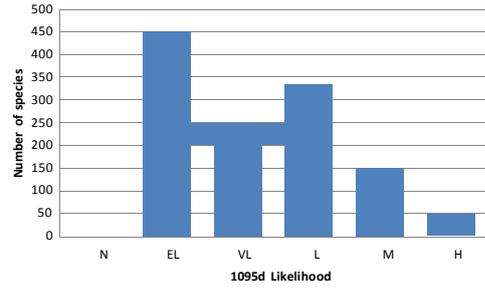
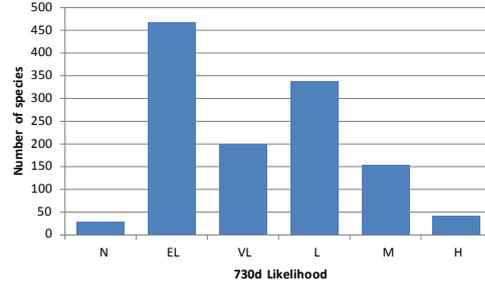


Figure 5.31. Number of species for Inoculation Likelihood Ranks to the Republic of Palau for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.7. Biofouling species with a “High” (n=31) and “Medium” (n=108) likelihood of arrival in the Republic of Palau associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Annelida	<i>Dipolydora armata (=armarta)</i>	M
Annelida	<i>Eumida sanguineum</i>	M
Annelida	<i>Eunice antennata</i>	M
Annelida	<i>Ficopomatus enigmaticus</i>	M
Annelida	<i>Glycera capitata</i>	M
Annelida	<i>Heteromastus filiformis</i>	M
Annelida	<i>Hydroides diramphus</i>	M
Annelida	<i>Janua pagenstecheri</i>	H
	<i>Neodexiospira brasiliensis (=Janua</i>	
Annelida	<i>(Dexiospira) brasiliensis)</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Chlorophyta	<i>Bryopsis pennata</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Cladophora herpestica</i>	M
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Cladophora sericea</i>	H
Chlorophyta	<i>Codium fragile (=C. f. tomentosoides)</i>	M
Chlorophyta	<i>Derbesia marina</i>	H
Chlorophyta	<i>Neomeris annulata (casual)</i>	M
	<i>Ulva clathrata (=Enteromorpha clathrata</i>	
Chlorophyta	<i>var. crinata)</i>	H
Chlorophyta	<i>Ulva flexuosa</i>	H
Chlorophyta	<i>Ulva pertusa</i>	M
Chlorophyta	<i>Ulva reticulata</i>	M
Chlorophyta	<i>Ulva rigida</i>	H
Chordata (Ascidiacea)	<i>Botrylloides perspicuum</i>	M

Table 5.7: Continued

Phylum	Scientific name	Likelihood
Chordata (Asciacea)	<i>Botryllus schlosseri</i>	H
Chordata (Asciacea)	<i>Ciona intestinalis</i>	H
Chordata (Asciacea)	<i>Didemnum candidum</i>	M
Chordata (Asciacea)	<i>Molgula manhattensis</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	M
Cnidaria	<i>Cladonema radiatum</i>	M
Cnidaria	<i>Clytia hemisphaerica</i>	H
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Coryne eximia (=Sarsia eximia)</i>	M
Cnidaria	<i>Coryne pusilla</i>	M
Cnidaria	<i>Diadumene lineata</i>	M
Cnidaria	<i>Eudendrium capillare</i>	H
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Gonothyraea loveni</i>	M
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Tubastraea coccinea</i>	M
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	M
Arthropoda	<i>Amphibalanus reticulatus</i>	H
Arthropoda	<i>Balanus trigonus</i>	H
Arthropoda	<i>Caprella equilibra</i>	M
Arthropoda	<i>Caprella penantis</i>	M
Arthropoda	<i>Caprella scaura</i>	M
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Elasmopus rapax</i>	M
Arthropoda	<i>Erichthonius brasiliensis</i>	M
Arthropoda	<i>Idotea metallica</i>	M
Arthropoda	<i>Jassa marmorata</i>	M
Arthropoda	<i>Laticorophium baconi</i>	M

Table 5.7: Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Lepas (Anatifa) anatifera</i>	H
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	H
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M
Arthropoda	<i>Leptochela dubia</i>	H
Arthropoda	<i>Ligia exotica</i>	M
Arthropoda	<i>Monocorophium acherusicum</i>	M
Arthropoda	<i>Monocorophium insidiosum</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	M
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Paradella diana</i>	M
Arthropoda	<i>Pleopis polyphemoides</i>	M
Arthropoda	<i>Porcellio lamellatus lamellatus</i>	M
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M
Arthropoda	<i>Sphaeroma walkeri</i>	M
Arthropoda	<i>Stenothoe gallensis</i>	M
Arthropoda	<i>Stenothoe valida</i>	M
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Dinophyta	<i>Prorocentrum lima</i>	M
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Bowerbankia gracilis</i>	M
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Bugula stolonifera</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	H
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	M
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Victorella pavida</i>	M
Bryozoa	<i>Watersipora subtorquata</i>	M

Table 5.7: Continued

Phylum	Scientific name	Likelihood
Bryozoa	<i>Zoobotryon verticillatum</i>	M
	<i>Anteaeolidiella foulisi</i> (=Anteaeolidiella	
Mollusca	<i>indica</i>)	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Hiatella arctica</i>	H
Mollusca	<i>Musculista senhousia</i>	M
Mollusca	<i>Mytilus galloprovincialis</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Tenellia adspersa</i>	M
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Thecacera pennigera</i>	M
Phaeophyta	<i>Cutleria multifida</i>	M
Phaeophyta	<i>Desmarestia viridis</i>	M
Phaeophyta	<i>Ectocarpus fasciculatus</i>	M
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Hincksia granulosa</i>	M
Phaeophyta	<i>Hincksia mitchelliae</i>	H
Phaeophyta	<i>Hincksia ovata</i>	M
Phaeophyta	<i>Hincksia sandriana</i>	M
Phaeophyta	<i>Leathesia marina</i> (=Leathesia difformis)	M
Phaeophyta	<i>Myrionema strangulans</i>	M
Phaeophyta	<i>Pylaiella littoralis</i>	H
Phaeophyta	<i>Punctaria latifolia</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Halichondria panicea</i>	M
Porifera	<i>Mycale parishii</i> (=Zygomycale parishii)	M
Pycnogonida	<i>Ammothea hilgendorfi</i>	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	M
Rhodophyta	<i>Aglaothamnion cordatum</i>	M

Table 5.7: Continued

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Antithamnion hubbsii</i> (= <i>nipponicum</i> , <i>pectinatum</i>)	M
Rhodophyta	<i>Asparagopsis taxiformis</i>	H
Rhodophyta	<i>Bangia atropurpurea</i>	H
Rhodophyta	<i>Caulacanthus ustulatus</i>	M
Rhodophyta	<i>Centroceras clavulatum</i>	H
Rhodophyta	<i>Ceramium virgatum</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
Rhodophyta	<i>Corallina officinalis</i>	M
Rhodophyta	<i>Dasya baillouviana</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
Rhodophyta	<i>Gymnothamnion elegans</i>	M
Rhodophyta	<i>Hildenbrandia rubra</i>	H
Rhodophyta	<i>Hypnea anastomosans</i> (= <i>Hypnea esperi</i>)	M
Rhodophyta	<i>Hypnea cornuta</i>	M
Rhodophyta	<i>Hypnea spinella</i> (= <i>Hypnea cervicornis</i>)	M
Rhodophyta	<i>Hypnea valentiae</i>	M
Rhodophyta	<i>Neosiphonia harveyi</i> (= <i>Polysiphonia</i> <i>harveyi</i>)	M
Rhodophyta	<i>Polysiphonia brodiei</i>	M
Rhodophyta	<i>Polysiphonia sertularioides</i>	M
Rhodophyta	<i>Polysiphonia subtilissima</i>	M

5.4.5 United States Minor Islands

The United States Minor Islands (UMI) received 58 commercial vessels and 762 MSC vessel entries during the assessed period (Figures 5.32 and 5.33). Approximately 7% of these vessels arrived directly from Guam. Commercial vessels were of insufficient number to ascertain string trade affinities other than relationships within the South Pacific. In contrast, military vessels exhibit a much broader exposure to bioregions, particularly throughout the Atlantic, Mediterranean and Pacific basins, and therefore broader exposure to a wider suite of species. The trading activities slowly sampled bioregions, with only five bioregions being visited for 30 day voyage windows and only reaching saturation (18 bioregions) after 1,460 days (4 years) (Figure 5.34).

The inoculation likelihoods of species should only be considered for all vessels (commercial and military) due to the inability to assess on the basis of insufficient numbers of commercial vessel entries (Figures 5.35 and 5.36). Military vessels therefore significantly increase the risk of species entry. This results in 31 species identified as ‘High’ likelihood of inoculation for voyages of 1,825 days (5 years) (Table 5.8).

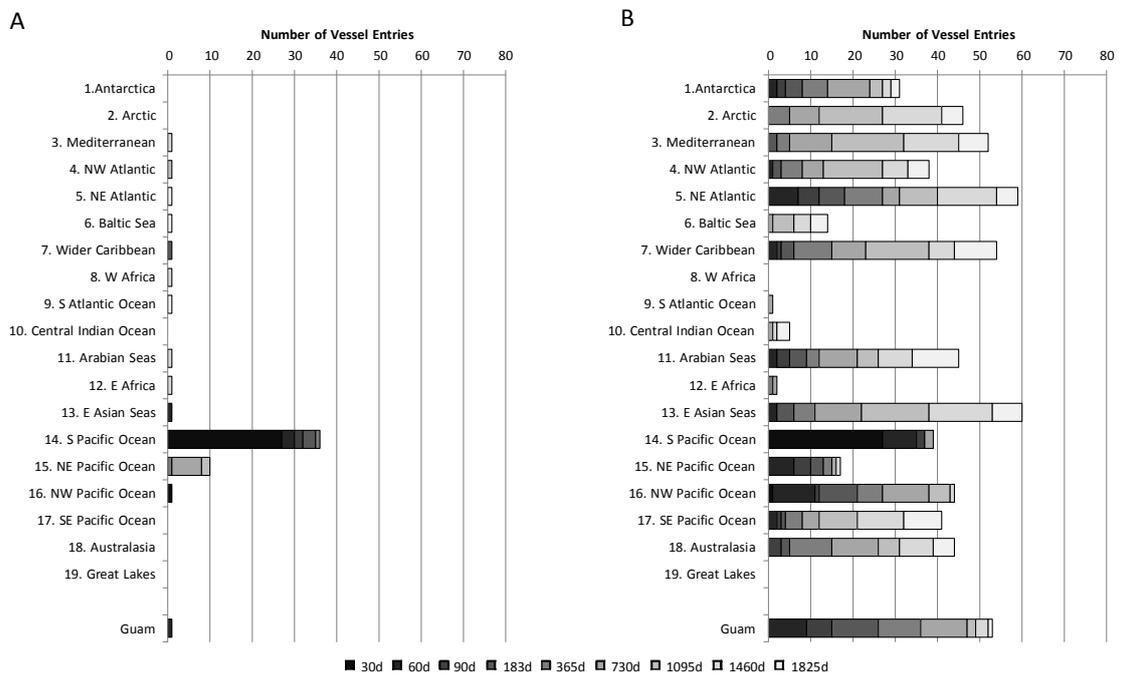


Figure 5.32. Number of A) commercial vessel (all categories) and B) MSC vessel (all categories) entries to UMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

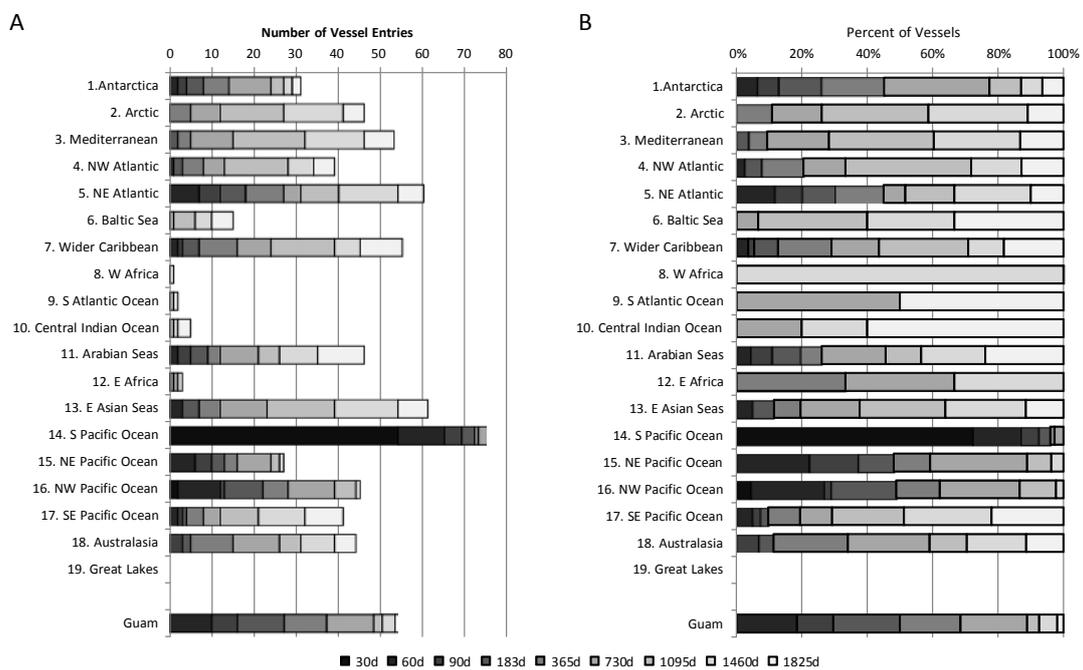


Figure 5.33. Number and percentage within a bioregion of all vessel (all categories of commercial and MSC vessels) entries to UMI from 1999 to 2009 which had traded with specific bioregions for voyages of 30d, 60d, 90d, 183d, 365d (1yr), 730d (2yrs), 1095d (3yrs), 1460d (4yrs), or 1825d (5yrs) during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels transiting Guam are also represented in Bioregion 14 South Pacific Ocean.

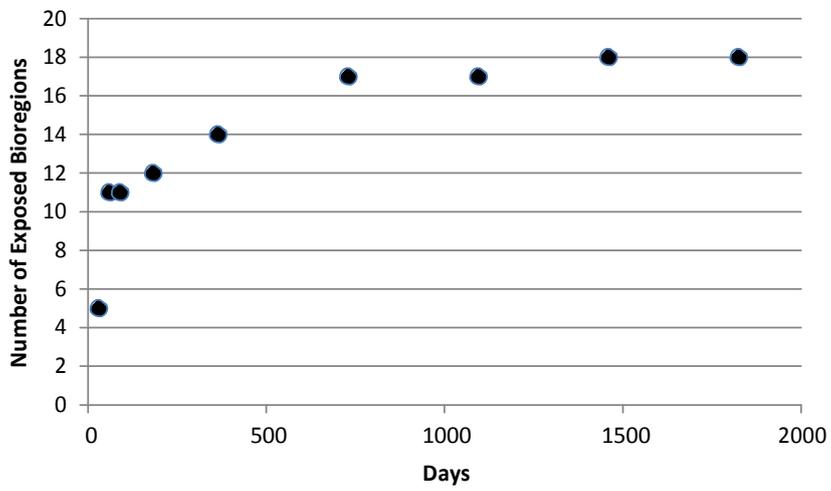


Figure 5.34. Number of bioregions visited by vessels entering the UMI between 1999 and 2009 with increasing voyage duration (data from Lloyds MIU and DOD datasets).

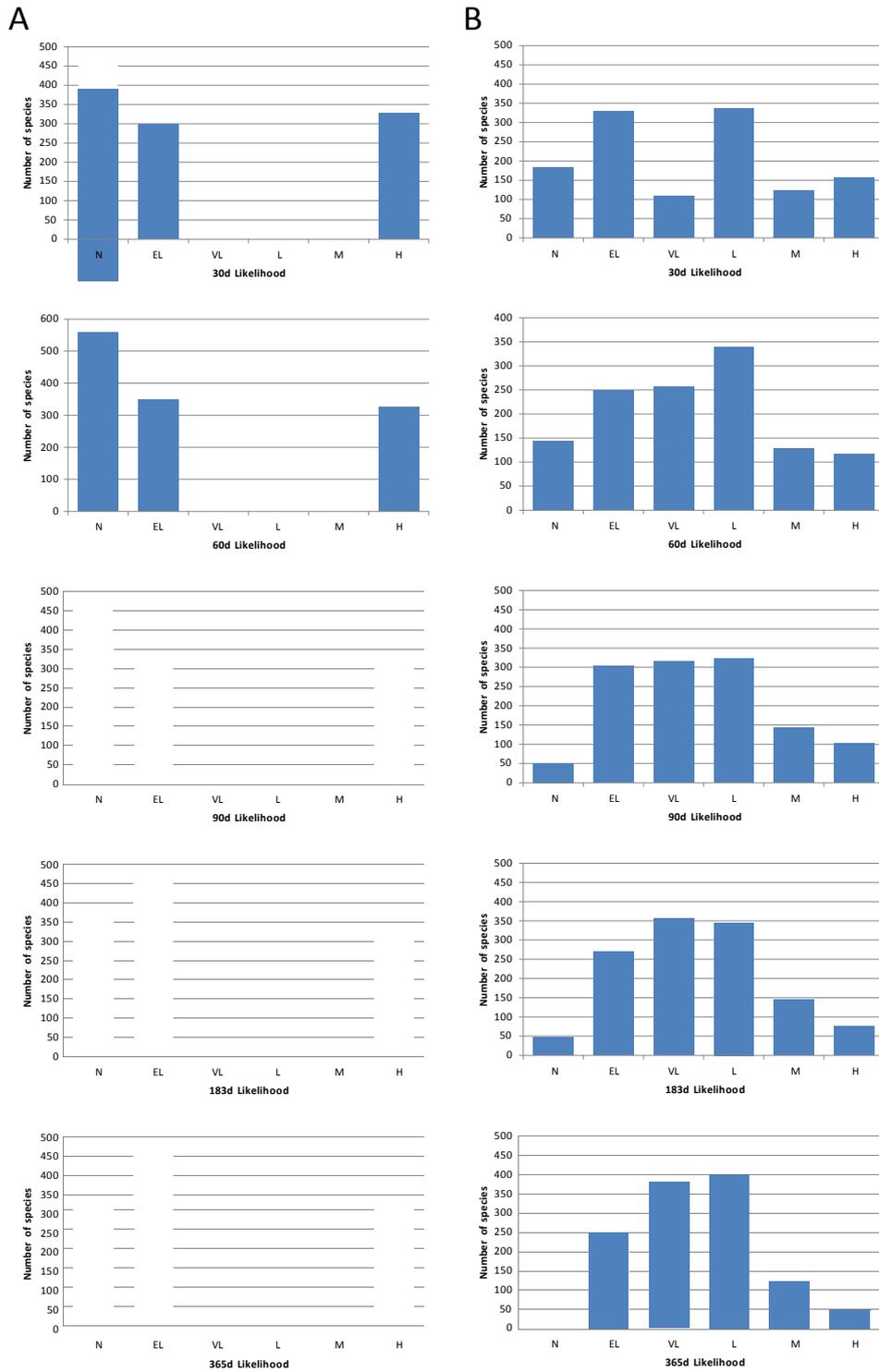


Figure 5.35. Number of species for Inoculation Likelihood Ranks to UMI for voyage durations less than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

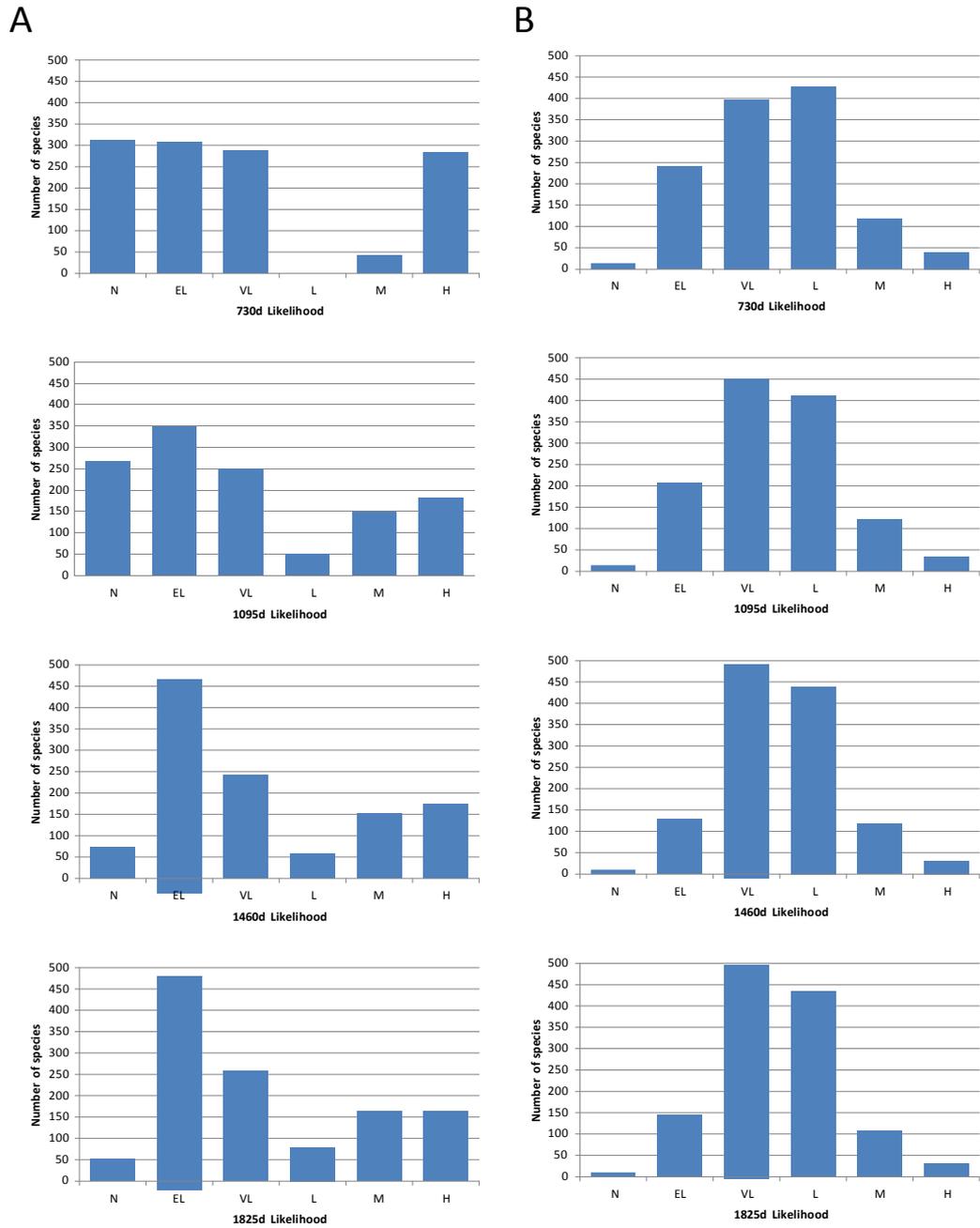


Figure 5.36. Number of species for Inoculation Likelihood Ranks to UMI for voyage durations greater than 365 days (1 year). A) commercial vessels alone, B) commercial and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.8. Biofouling species with a “High” (n=31) and “Medium” (n=108) likelihood of arrival in the UMI associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Alitta (Neanthes) succinea</i>	M
Annelida	<i>Dipolydora armata (=armarta)</i>	M
Annelida	<i>Eumida sanguineum</i>	M
Annelida	<i>Eunice antennata</i>	M
Annelida	<i>Ficopomatus enigmaticus</i>	M
Annelida	<i>Glycera capitata</i>	M
Annelida	<i>Heteromastus filiformis</i>	M
Annelida	<i>Hydroides diramphus</i>	M
Annelida	<i>Janua pagenstecheri</i>	H
Annelida	<i>Neodexiospira brasiliensis (=Janua (Dexiospira) brasiliensis)</i>	M
Annelida	<i>Pileolaria berkeleyana</i>	M
Annelida	<i>Streblospio benedicti</i>	M
Chlorophyta	<i>Bryopsis pennata</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Chaetomorpha aerea</i>	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Cladophora herpestica</i>	M
Chlorophyta	<i>Cladophora prolifera</i>	M
Chlorophyta	<i>Cladophora sericea</i>	H
Chlorophyta	<i>Codium fragile (=C. f. tomentosoides)</i>	M
Chlorophyta	<i>Derbesia marina</i>	H
Chlorophyta	<i>Neomeris annulata</i>	M
Chlorophyta	<i>Ulva clathrata (=Enteromorpha clathrata var. crinata)</i>	H
Chlorophyta	<i>Ulva flexuosa</i>	H
Chlorophyta	<i>Ulva pertusa</i>	M
Chlorophyta	<i>Ulva reticulata</i>	M
Chlorophyta	<i>Ulva rigida</i>	H
Chordata (Ascidiacea)	<i>Botrylloides perspicuum</i>	M

Table 5.8: Continued

Phylum	Scientific name	Likelihood
Chordata (Asciacea)	<i>Botrylloides perspicuum</i>	M
Chordata (Asciacea)	<i>Botryllus schlosseri</i>	H
Chordata (Asciacea)	<i>Ciona intestinalis</i>	H
Chordata (Asciacea)	<i>Didemnum candidum</i>	M
Chordata (Asciacea)	<i>Molgula manhattensis</i>	M
Cnidaria	<i>Bougainvillia muscus</i>	M
Cnidaria	<i>Cladonema radiatum</i>	M
Cnidaria	<i>Clytia hemisphaerica</i>	H
Cnidaria	<i>Cordylophora caspia</i>	H
Cnidaria	<i>Coryne eximia (=Sarsia eximia)</i>	M
Cnidaria	<i>Coryne pusilla</i>	M
Cnidaria	<i>Diadumene lineata</i>	M
Cnidaria	<i>Eudendrium capillare</i>	H
Cnidaria	<i>Eudendrium carneum</i>	M
Cnidaria	<i>Gonothyraea loveni</i>	M
Cnidaria	<i>Obelia longissima</i>	M
Cnidaria	<i>Plumularia setacea</i>	H
Cnidaria	<i>Sarsia tubulosa</i>	M
Cnidaria	<i>Tubastraea coccinea</i>	M
Arthropoda	<i>Amphibalanus amphitrite</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	M
Arthropoda	<i>Amphibalanus reticulatus</i>	H
Arthropoda	<i>Balanus trigonus</i>	H
Arthropoda	<i>Caprella equilibra</i>	M
Arthropoda	<i>Caprella penantis</i>	M
Arthropoda	<i>Caprella scaura</i>	M
Arthropoda	<i>Carcinus maenas</i>	H
Arthropoda	<i>Elasmopus rapax</i>	M
Arthropoda	<i>Erichthonius brasiliensis</i>	M
Arthropoda	<i>Idotea metallica</i>	M
Arthropoda	<i>Jassa marmorata</i>	M

Table 5.8: Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Laticorophium baconi</i>	M
Arthropoda	<i>Lepas (Anatifa) anatifera</i>	H
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	H
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M
Arthropoda	<i>Leptochela dubia</i>	H
Arthropoda	<i>Ligia exotica</i>	M
Arthropoda	<i>Monocorophium acherusicum</i>	M
Arthropoda	<i>Monocorophium insidiosum</i>	M
Arthropoda	<i>Paracaprella pusilla</i>	M
Arthropoda	<i>Paracerceis sculpta</i>	M
Arthropoda	<i>Paradella diana</i>	M
Arthropoda	<i>Pleopis polyphemoides</i>	M
Arthropoda	<i>Porcellio lamellatus lamellatus</i>	M
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M
Arthropoda	<i>Sphaeroma walkeri</i>	M
Arthropoda	<i>Stenothoe gallensis</i>	M
Arthropoda	<i>Stenothoe valida</i>	M
Arthropoda	<i>Synidotea laevidorsalis</i>	M
Dinophyta	<i>Prorocentrum lima</i>	M
Bryozoa	<i>Aetea anguina</i>	M
Bryozoa	<i>Aetea truncata</i>	M
Bryozoa	<i>Bowerbankia gracilis</i>	M
Bryozoa	<i>Bowerbankia imbricata</i>	M
Bryozoa	<i>Bugula stolonifera</i>	M
Bryozoa	<i>Cryptosula pallasiana</i>	H
Bryozoa	<i>Hippopodina feegensis</i>	M
Bryozoa	<i>Hippothoa distans</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	M
Bryozoa	<i>Scruparia ambigua</i>	M
Bryozoa	<i>Synnotum aegyptiacum</i>	M
Bryozoa	<i>Victorella pavida</i>	M

Table 5.8: Continued

Phylum	Scientific name	Likelihood
Bryozoa	<i>Watersipora subtorquata</i>	M
Bryozoa	<i>Zoobotryon verticillatum</i>	M
	<i>Anteaolidiella foulisi</i> (=Anteaolidiella	
Mollusca	<i>indica</i>)	M
Mollusca	<i>Dendrodoris fumata</i>	M
Mollusca	<i>Hiatella arctica</i>	H
Mollusca	<i>Musculista senhousia</i>	M
Mollusca	<i>Mytilus galloprovincialis</i>	M
Mollusca	<i>Sabia conica</i>	M
Mollusca	<i>Tenellia adspersa</i>	M
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Thecacera pennigera</i>	M
Phaeophyta	<i>Cutleria multifida</i>	M
Phaeophyta	<i>Desmarestia viridis</i>	M
Phaeophyta	<i>Ectocarpus fasciculatus</i>	M
Phaeophyta	<i>Ectocarpus siliculosus</i>	M
Phaeophyta	<i>Hincksia granulosa</i>	M
Phaeophyta	<i>Hincksia mitchelliae</i>	H
Phaeophyta	<i>Hincksia ovata</i>	M
Phaeophyta	<i>Hincksia sandriana</i>	M
Phaeophyta	<i>Leathesia marina</i> (=Leathesia difformis)	M
Phaeophyta	<i>Myrionema strangulans</i>	M
Phaeophyta	<i>Pylaiella littoralis</i>	H
Phaeophyta	<i>Punctaria latifolia</i>	M
Phoronida	<i>Phoronis hippocrepia</i>	M
Porifera	<i>Dysidea fragilis</i>	M
Porifera	<i>Halichondria panicea</i>	M
Porifera	<i>Mycale parishii</i> (=Zygomycale parishii)	M
Pycnogonida	<i>Ammothea hilgendorfi</i>	M
Pycnogonida	<i>Pigrogromitus timsanus</i>	M
Rhodophyta	<i>Aglaothamnion cordatum</i>	M

Table 5.8: Continued

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Antithamnion hubbsii</i> (= <i>nipponicum</i> , <i>pectinatum</i>)	M
Rhodophyta	<i>Asparagopsis taxiformis</i>	H
Rhodophyta	<i>Bangia atropurpurea</i>	H
Rhodophyta	<i>Caulacanthus ustulatus</i>	M
Rhodophyta	<i>Centroceras clavulatum</i>	H
Rhodophyta	<i>Ceramium virgatum</i>	M
Rhodophyta	<i>Chroodactylon ramosum</i>	M
Rhodophyta	<i>Corallina officinalis</i>	M
Rhodophyta	<i>Dasya baillouviana</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
Rhodophyta	<i>Gymnothamnion elegans</i>	M
Rhodophyta	<i>Hildenbrandia rubra</i>	H
Rhodophyta	<i>Hypnea anastomosans</i> (= <i>Hypnea esperi</i>)	M
Rhodophyta	<i>Hypnea cornuta</i>	M
Rhodophyta	<i>Hypnea spinella</i> (= <i>Hypnea cervicornis</i>)	M
Rhodophyta	<i>Hypnea valentiae</i>	M
Rhodophyta	<i>Neosiphonia harveyi</i> (= <i>Polysiphonia</i> <i>harveyi</i>)	M
Rhodophyta	<i>Polysiphonia brodiei</i>	M
Rhodophyta	<i>Polysiphonia sertularioides</i>	M
Rhodophyta	<i>Polysiphonia subtilissima</i>	M

5.4.6 State of Hawai'i

Hawai'i received 6,380 vessel entries of which 6,030 were commercial vessel entries, 318 were fishing vessel entries, and 54 were MSC vessel entries during the five year period (Figures 5.37). It should be noted that this was only half of the 10-year period for which data were available for Micronesia. It should also be noted that data were only available LPOC, and data for cumulative voyage histories were not available unlike analyses for Micronesia, hence presentation of a single panel for HI (Figure 5.37). Slightly more than 1% of these vessels arrived directly from Guam. Commercial vessels had strong affinities the Northeastern Pacific (15) and the Northwestern Pacific (16) bioregions, with a decreased trade across a wider number of bioregions. The Northeastern Pacific and Northwestern Pacific bioregions represent more than 81% of commercial vessel trade. MSC vessels have a similar level of exposure to bioregions as commercial vessels, with 78% of vessel entries derived from the Northeastern Pacific and Northwestern Pacific bioregions. Fishing vessels primarily arrive from Northwestern Pacific and the South Pacific (14) bioregions, representing 88% of all fishing vessel entries.

LPOC arrivals to Hawai'i during the evaluation period arrived from 15 of the 18 bioregions, with commercial vessels trading across all 15 bioregions, Fishing vessels with 7 bioregions and MSC vessels with 8 bioregions.

The inoculation likelihoods of species only slightly increase with the addition of MSC vessels for biofouling related risk (Figure 5.38). More than 160 species were categorized as having "High" likelihood of inoculation by biofouling for all vessel categories. In total, 317 species are ranked as "High" (167) or "Medium" (150) likelihood of inoculation (Table 5.9), with MSC vessels having no effect in the likelihoods of inoculation.

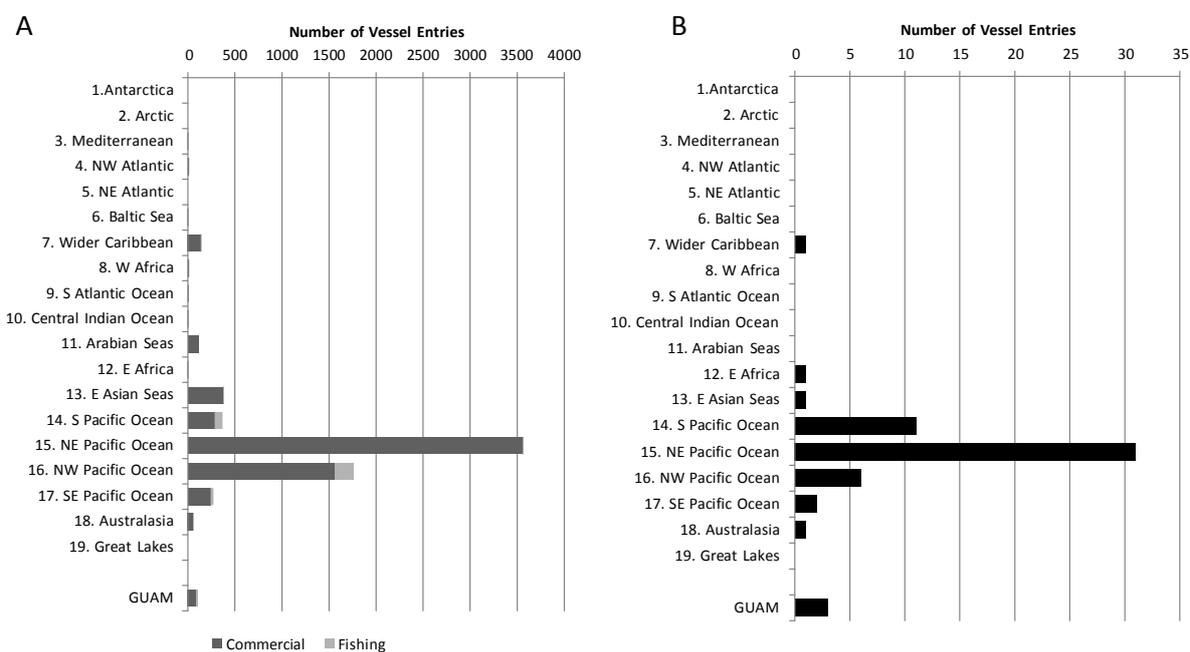


Figure 5.37. A) Number of commercial and fishing vessel and B) MSC vessel entries to HI from 2006-2011 that had traded with specific bioregions Last Port of Call during the evaluation period. Note that vessels may have multiple entries (Lloyds MIU and DoD datasets). Note that vessels arriving from Guam are also represented in Bioregion 14 South Pacific Ocean.

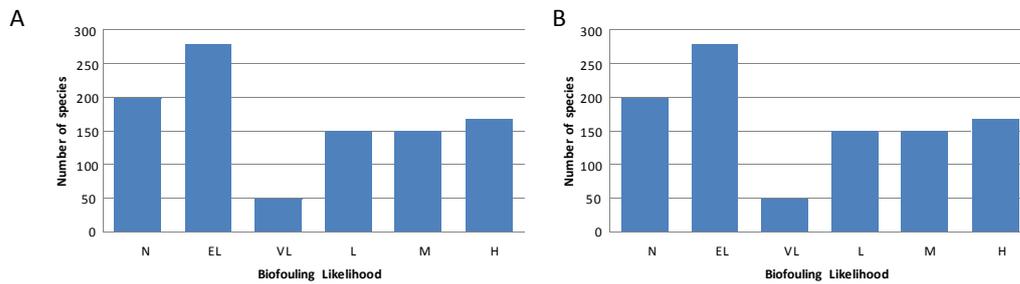


Figure 5.38. Number of Species for Biofouling related Inoculation Likelihood Ranks to HI based on LPOC arrivals. A) commercial vessels and fishing alone, B) commercial, fishing and MSC vessels. Where N = negligible, EL = extremely low; VL = very low, L = low, M = moderate, and H = high. Data from Lloyds MIU and DoD datasets.

Table 5.9. Biofouling species with a “High” (n=167) and “Medium” (n=150) likelihood of arrival in HI associated with all vessel traffic.

Phylum	Scientific name	Likelihood
Annelida	<i>Amaeana sp. A</i>	M
Annelida	<i>Amblyosyllis sp. A</i>	M
Annelida	<i>Boccardiella ligerica</i>	M
Annelida	<i>Branchiomma bairdi</i>	M
Annelida	<i>Ceratonereis mirabilis</i>	M
Annelida	<i>Crucigera websteri</i>	M
Annelida	<i>Dipolydora giardi</i>	M
Annelida	<i>Dipolydora socialis</i>	H
Annelida	<i>Dispio uncinata</i>	H
Annelida	<i>Eteone tchangsii</i>	H
Annelida	<i>Euchone limnicola</i>	M
Annelida	<i>Eunice antennata</i>	H
Annelida	<i>Geminosyllis ohma</i>	H
Annelida	<i>Glycera capitata</i>	H
Annelida	<i>Hesionides arenaria</i>	M
Annelida	<i>Heteromastus filiformis</i>	H

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Annelida	<i>Hobsonia floridana</i>	M
Annelida	<i>Hydroides albiceps</i> +B148	M
Annelida	<i>Limnodrilus monotheucus</i>	M
Annelida	<i>Lumbricillus lineatus</i>	M
Annelida	<i>Marenzelleria viridis</i>	M
Annelida	<i>Marphysa disjuncta</i>	H
Annelida	<i>Neodexiospira brasiliensis</i> (=Janua (<i>Dexiospira</i>) <i>brasiliensis</i>)	H
Annelida	<i>Nicolea sp. A</i>	M
Annelida	<i>Ophryotrocha diadema</i>	M
Annelida	<i>Paranais frici</i>	M
Annelida	<i>Polydora cornuta</i>	H
Annelida	<i>Polydora hoplura</i>	M
Annelida	<i>Polydora limicola</i>	H
Annelida	<i>Prionospio pygmaea</i> (=Apoprionospio <i>pygmaea</i>)	M
Annelida	<i>Pseudopolydora kempii</i>	H
Annelida	<i>Pseudopolydora paucibranchiata</i>	H
Annelida	<i>Pseudopotamilla ocellata</i>	H
Annelida	<i>Sigambra tentaculata</i> (=Ancistrostylis <i>tentaculata</i>)	H
Annelida	<i>Syllis bella</i>	M
Annelida	<i>Tubificoides apectinatus</i>	M
Annelida	<i>Tubificoides benedii</i>	M
Annelida	<i>Tubificoides brownae</i>	M
Annelida	<i>Tubificoides diazi</i>	M
Annelida	<i>Tubificoides pseudogaster</i>	M
Annelida	<i>Tubificoides wasselli</i>	M
Annelida	<i>Typosyllis nipponica</i>	H

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Ascidacea	<i>Ascidia</i> sp. A (SF Bay)	M
Ascidacea	<i>Ascidia zara</i>	H
Ascidacea	<i>Botrylloides perspicuum</i>	H
Ascidacea	<i>Botrylloides violaceus</i> (=Botryllus <i>aurantius</i>)	H
Ascidacea	<i>Botryllus planus</i>	M
Ascidacea	<i>Botryllus schlosseri</i>	H
Ascidacea	<i>Botryllus</i> sp. A (SF Bay)	M
Ascidacea	<i>Ciona savignyi</i>	H
Ascidacea	<i>Didemnum vexillum</i> (=Didemnum <i>lahillei</i>)	H
Ascidacea	<i>Molgula ficus</i>	H
Ascidacea	<i>Molgula manhattensis</i>	H
Ascidacea	<i>Perophora japonica</i>	H
Ascidacea	<i>Styela clava</i>	H
Ascidacea	<i>Styela plicata</i>	H
Ascidacea	<i>Trididemnum orbiculatum</i>	M
Chlorophyta	<i>Bryopsis plumosa</i>	H
Chlorophyta	<i>Bryopsis</i> sp. A	M
Chlorophyta	<i>Caulerpa filiformis</i>	M
Chlorophyta	<i>Caulerpa taxifolia</i> (aquarium strain)	H
Chlorophyta	<i>Chaetomorpha linum</i>	H
Chlorophyta	<i>Cladophora prolifera</i>	H
Chlorophyta	<i>Codium fragile</i> (=C. f. <i>tomentosoides</i>)	H
Chlorophyta	<i>Derbesia marina</i>	H
Chlorophyta	<i>Pilinella californica</i>	M
Chlorophyta	<i>Ulva californica</i>	M
Chlorophyta	<i>Ulva pertusa</i>	H
Chlorophyta	<i>Ulva stenophylla</i>	M
Cnidaria	<i>Amphinema dinema</i>	M
Cnidaria	<i>Amphinema</i> sp.	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Cnidaria	<i>Aurelia</i> sp.	H
Cnidaria	<i>Bimeria vestita</i>	M
Cnidaria	<i>Blackfordia virginica</i>	H
Cnidaria	<i>Bunodeopsis</i> sp.	M
Cnidaria	<i>Cladonema pacificum</i> (= <i>uchidai</i>)	H
Cnidaria	<i>Clava multicornis</i>	M
Cnidaria	<i>Corymorpha bigelowi</i> (= <i>Euphysora bigelowi</i>)	H
Cnidaria	<i>Corymorpha</i> sp.	M
Cnidaria	<i>Coryne eximia</i> (= <i>Sarsia eximia</i>)	H
Cnidaria	<i>Coryne japonica</i> (= <i>Sarsia japonica</i>)	H
Cnidaria	<i>Diadumene cincta</i>	M
Cnidaria	<i>Eudendrium carneum</i>	H
Cnidaria	<i>Garveia franciscana</i>	M
Cnidaria	<i>Gonionemus vertens</i>	H
Cnidaria	<i>Gonothyraea clarki</i>	M
Cnidaria	<i>Gonothyraea loveni</i>	H
Cnidaria	<i>Halitholus pauper</i>	H
Cnidaria	<i>Hartlaubella gelatinosa</i>	H
Cnidaria	<i>Laomedea calciolifera</i>	H
Cnidaria	<i>Lensia challengerii</i>	M
Cnidaria	<i>Maeotias marginata</i>	H
Cnidaria	<i>Metridium senile</i>	H
Cnidaria	<i>Mitrocomium cirratum</i> (= <i>Campalecium medusifera</i>)	M
Cnidaria	<i>Moerisia</i> sp.	M
Cnidaria	<i>Nematostella vectensis</i>	M
Cnidaria	<i>Obelia longissima</i>	H
Cnidaria	<i>Octotiarra russelli</i>	M
Cnidaria	<i>Pinauay</i> (<i>Ectopleura</i>) <i>larynx</i>	H

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Cnidaria	<i>Pinauay crocea</i>	M
Cnidaria	<i>Rathkea octopunctata</i>	H
Cnidaria	<i>Stomolophus meleagris</i>	M
Cnidaria	<i>Tubularia indivisa</i> (=Pinauay (<i>Ectopleura</i>) <i>indivisa</i>)	H
Arthropoda	<i>Abludomelita rylovae</i>	H
Arthropoda	<i>Ampelisca abdita</i>	M
Arthropoda	<i>Amphibalanus albicostatus</i>	H
Arthropoda	<i>Amphibalanus improvisus</i>	H
Arthropoda	<i>Amphibalanus subalbidus</i>	M
Arthropoda	<i>Ampithoe longimana</i>	M
Arthropoda	<i>Ampithoe valida</i>	H
Arthropoda	<i>Aoroides secunda</i>	H
Arthropoda	<i>Aspidoconcha limnoriae</i>	M
Arthropoda	<i>Balanus glandula</i>	H
Arthropoda	<i>Balanus uliginosus</i>	M
Arthropoda	<i>Briarosaccus callosus</i>	H
Arthropoda	<i>Caprella californica</i>	H
Arthropoda	<i>Caprella drepanochir</i>	H
Arthropoda	<i>Caprella mutica</i>	H
Arthropoda	<i>Caprella simia</i>	H
Arthropoda	<i>Chelura terebrans</i>	H
Arthropoda	<i>Cirolana harfordi</i>	M
Arthropoda	<i>Concavus concavus</i> species group (= <i>Balanus concavus</i>)	M
Arthropoda	<i>Conchoderma auritum</i>	M
Arthropoda	<i>Corophium alienense</i>	M
Arthropoda	<i>Corophium heteroceratum</i>	H
Arthropoda	<i>Dynoides dentisinus</i>	H
Arthropoda	<i>Elminius kingii</i>	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Eobrolgus spinosus</i>	M
Arthropoda	<i>Eochelidium miraculum</i>	H
Arthropoda	<i>Eochelidium sp.</i>	M
Arthropoda	<i>Eurylana arcuata</i>	H
Arthropoda	<i>Fistulobalanus dentivarians</i>	M
Arthropoda	<i>Gammarus daiberi</i>	M
Arthropoda	<i>Iais californica</i>	M
Arthropoda	<i>Ianiropsis serricaudis</i>	H
Arthropoda	<i>Idotea metallica</i>	H
Arthropoda	<i>Jassa marmorata</i>	H
Arthropoda	<i>Jassa morinoi</i>	H
Arthropoda	<i>Jassa slatteryi</i>	H
Arthropoda	<i>Lepas (Anatifa) hillii</i>	H
Arthropoda	<i>Limnoria quadripunctata</i>	M
Arthropoda	<i>Megabalanus coccopoma</i>	H
Arthropoda	<i>Melita nitida</i>	M
Arthropoda	<i>Microdeutopus gryllotalpa</i>	M
Arthropoda	<i>Monocorophium uenoi</i>	H
Arthropoda	<i>Mytilicola orientalis</i>	H
Arthropoda	<i>Palaemon macrodactylus</i>	H
Arthropoda	<i>Paracorophium lucasi</i>	M
Arthropoda	<i>Paradexamine sp.</i>	M
Arthropoda	<i>Paranthura japonica</i>	H
Arthropoda	<i>Percnon gibbesi</i>	M
Arthropoda	<i>Petrolisthes armatus</i>	H
Arthropoda	<i>Pleopis polyphemoides</i>	H
Arthropoda	<i>Pseudomyicola ostreae</i>	H
Arthropoda	<i>Pseudosphaeroma campbellensis</i>	M
Arthropoda	<i>Pyromaia tuberculata</i>	H
Arthropoda	<i>Redkea californica</i>	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Arthropoda	<i>Rhithropanopeus harrisii</i>	H
Arthropoda	<i>Sinelobus cf. stanfordi</i>	H
Arthropoda	<i>Synidotea laevidorsalis</i>	H
	<i>Tetraclita japonica</i> (= <i>Tetraclita</i>	
Arthropoda	<i>squamosa japonica</i>)	M
Arthropoda	<i>Uromunna sp.</i> (= <i>Munna reynoldsi</i>)	M
Bryozoa	<i>Aeverrillia armata</i>	M
Bryozoa	<i>Alcyonidium polyoum</i>	M
Bryozoa	<i>Anguinella palmata</i>	M
Bryozoa	<i>Aspidelectra melolontha</i>	M
Bryozoa	<i>Bugula californica</i>	H
Bryozoa	<i>Bugula flabellata</i>	M
Bryozoa	<i>Bugula sp. 1</i> (Puget Sound)	M
Bryozoa	<i>Bugula sp. 2</i> (Puget Sound)	M
Bryozoa	<i>Celleporella hyalina</i>	M
Bryozoa	<i>Conidophrys pilisuctor</i>	M
Bryozoa	<i>Conopeum tenuissimum</i>	M
	<i>Einhornia crustulenta</i> (= <i>Electra</i>	
Bryozoa	<i>crustulenta</i>)	H
Bryozoa	<i>Hippothoa divaricata</i>	M
Bryozoa	<i>Jellyella tuberculata</i>	H
Bryozoa	<i>Nolella stipata</i>	M
Bryozoa	<i>Pherusella brevituba</i> (casual)	M
Bryozoa	<i>Schizoporella japonica</i> (= <i>unicornis</i>)	H
Bryozoa	<i>Scruparia ambigua</i>	H
Bryozoa	<i>Scrupocellaria bertholetii</i>	M
Bryozoa	<i>Tricellaria inopinata</i>	H
Bryozoa	<i>Tricellaria occidentalis</i>	H
Bryozoa	<i>Victorella pavida</i>	H
Entoprocta	<i>Barentsia benedeni</i>	H

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Mollusca	<i>Anadara kagoshimensis</i> (=Anadara <i>inaequivalvis</i> , =Scapharca <i>inaequivalvis</i>)	M
Mollusca	<i>Assimineia parasitologia</i>	H
Mollusca	<i>Babakina festiva</i>	H
Mollusca	<i>Bankia cieba</i>	M
Mollusca	<i>Bankia destructa</i>	M
Mollusca	<i>Bankia gouldi</i>	M
Mollusca	<i>Boonea cincta</i>	M
Mollusca	<i>Catriona rickettsi</i>	M
Mollusca	<i>Cenchritis muricatus</i> (=Tectarius <i>muricatus</i>)	M
Mollusca	<i>Chromodoris annulata</i>	M
Mollusca	<i>Crepidula convexa</i>	M
Mollusca	<i>Crepidula fornicata</i>	M
Mollusca	<i>Crepidula plana</i>	M
Mollusca	<i>Cuthona columbiana</i>	H
Mollusca	<i>Eubranchus inabai</i>	M
Mollusca	<i>Eubranchus misakiensis</i>	H
Mollusca	<i>Geukensia demissa</i>	M
Mollusca	<i>Glossodoris sedna</i>	M
Mollusca	<i>Guildfordia yoka</i>	H
Mollusca	<i>Hopkinsia (Okenia) plana</i>	H
Mollusca	<i>Hypselodoris infurcata</i>	M
Mollusca	<i>Ischadium recurvum</i>	M
Mollusca	<i>Ividella navisa</i>	M
Mollusca	<i>Littorina littorea</i>	M
Mollusca	<i>Meretrix lusoria</i>	H
Mollusca	<i>Musculista senhousia</i>	H
Mollusca	<i>Myosotella myosotis</i> (=Phytia <i>myosotis</i>)	M
Mollusca	<i>Mytilopsis adamsi</i>	H

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Mollusca	<i>Mytilus edulis</i>	M
Mollusca	<i>Nassarius fraterculus</i>	H
Mollusca	<i>Ostrea edulis</i>	H
Mollusca	<i>Ostrea puelchana</i> (= <i>Ostrea chilensis</i>)	M
Mollusca	<i>Polycera hedgpethi</i>	H
Mollusca	<i>Rapana venosa</i> (= <i>thomasiana</i>)	H
Mollusca	<i>Sakuraeolis enosimensis</i>	H
Mollusca	<i>Stiliger fuscovitattus</i>	M
Mollusca	<i>Tenellia adspersa</i>	H
Mollusca	<i>Teredo navalis</i>	H
Mollusca	<i>Xenostrobus securis</i>	H
Nematoda	<i>Angiostrongylus cantonensis</i>	M
Nemertea	<i>Lineus ruber</i>	M
Osteichthyes	<i>Acanthogobius flavimanus</i>	H
Osteichthyes	<i>Gobiosoma nudum</i>	M
Osteichthyes	<i>Stathmonotus stahli</i>	M
Osteichthyes	<i>Tridentiger trigenocephalus</i>	H
Phaeophyta	<i>Acrothrix gracilis</i>	H
Phaeophyta	<i>Chnoospora minima</i>	H
Phaeophyta	<i>Chorda filum</i>	H
Phaeophyta	<i>Cladostephus spongiosus</i>	M
Phaeophyta	<i>Colpomenia durvillei</i>	H
Phaeophyta	<i>Colpomenia peregrina</i>	H
Phaeophyta	<i>Cutleria cylindrica</i>	H
Phaeophyta	<i>Desmarestia viridis</i>	H
Phaeophyta	<i>Ectocarpus fasciculatus</i>	H
Phaeophyta	<i>Ectocarpus siliculosus</i>	H
Phaeophyta	<i>Endarachne binghamiae</i>	H
Phaeophyta	<i>Fucus evanescens</i>	H
Phaeophyta	<i>Fucus spiralis</i>	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Phaeophyta	<i>Hincksia granulosa</i>	H
Phaeophyta	<i>Hincksia ovata</i>	H
Phaeophyta	<i>Hincksia sandriana</i>	H
Phaeophyta	<i>Leathesia marina</i> (= <i>Leathesia difformis</i>)	H
Phaeophyta	<i>Macrocystis pyrifera</i>	H
Phaeophyta	<i>Melanosiphon intestinalis</i>	H
Phaeophyta	<i>Microspongium globosum</i>	H
Phaeophyta	<i>Myrionema strangulans</i>	H
Phaeophyta	<i>Punctaria latifolia</i>	H
Phaeophyta	<i>Punctaria tenuissima</i>	M
Phaeophyta	<i>Rugulopteryx okamurae</i>	H
Phaeophyta	<i>Sargassum filicinum</i>	H
Phaeophyta	<i>Sargassum muticum</i>	H
Phaeophyta	<i>Scytosiphon dotyi</i>	H
Phaeophyta	<i>Undaria pinnatifida</i>	H
Platyhelminthes	<i>Leptoplana limnoriae</i>	M
Platyhelminthes	<i>Pseudostylochus ostreophagus</i>	H
	<i>Chalinula loosanoffi</i> (= <i>Haliclona</i>	
Porifera	<i>loosanoffi</i>)	M
Porifera	<i>Chalinula nematifera</i>	M
	<i>Clathria prolifera</i> (= <i>Microciona</i>	
Porifera	<i>prolifera</i>)	M
Porifera	<i>Cliona celata</i>	M
Porifera	<i>Cliona thosina</i>	M
Porifera	<i>Halichondria bowerbanki</i>	M
Porifera	<i>Halichondria panicea</i>	H
Porifera	<i>Lissodendoryx isodictyalis</i>	M
Porifera	<i>Prosuberites</i> sp.	M
Porifera	<i>Stelletta clarella</i>	M
Protozoa	<i>Bonamia ostreae</i>	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Protozoa	<i>Boveria teredinis</i>	M
Protozoa	<i>Cothurnia limnoriae</i>	M
Protozoa	<i>Haplosporidium costale</i>	H
Protozoa	<i>Lagenophrys cochinensos</i>	M
Protozoa	<i>Lankesteria ascidiae</i>	M
Protozoa	<i>Orchitophyra stellarum</i>	H
Protozoa	<i>Trochammia hadai</i>	H
	<i>Heterosigma akashiwo</i> (= <i>Olisthodiscus</i>	
Raphidophyta	<i>luteus</i>)	H
	<i>Acrochaetium pacificum</i> (= <i>Audouinella</i>	
Rhodophyta	<i>pacificum</i>)	H
Rhodophyta	<i>Agardhiella subulata</i>	H
	<i>Aglaothamnion tenuissimum</i>	
Rhodophyta	(= <i>Callithamnion byssoides</i>)	M
Rhodophyta	<i>Anotrichium furcellatum</i>	H
Rhodophyta	<i>Antithamnion densum</i>	H
Rhodophyta	<i>Antithamnionella elegans</i>	H
Rhodophyta	<i>Antithamnionella spirographidis</i>	H
Rhodophyta	<i>Antithamnionella sublittoralis</i>	M
Rhodophyta	<i>Asparagopsis armata</i>	M
Rhodophyta	<i>Audouinella simplex</i>	M
Rhodophyta	<i>Caulacanthus ustulatus</i>	H
Rhodophyta	<i>Centroceras clavulatum</i>	H
Rhodophyta	<i>Ceramium kondoii</i>	H
Rhodophyta	<i>Ceramium sinicola</i>	M
Rhodophyta	<i>Ceramium virgatum</i>	H
Rhodophyta	<i>Gelidium vagum</i>	H
Rhodophyta	<i>Goniotrichiopsis sublittoralis</i>	M
Rhodophyta	<i>Gracilaria gracilis</i>	M
Rhodophyta	<i>Gracilaria vermiculophylla</i>	M

Table 5.9. Continued

Phylum	Scientific name	Likelihood
Rhodophyta	<i>Grateloupia doryphora</i>	H
Rhodophyta	<i>Grateloupia lanceolata</i>	H
Rhodophyta	<i>Gymnogongrus crenulatus</i>	M
Rhodophyta	<i>Haraldiophyllum nottii</i>	M
Rhodophyta	<i>Hildenbrandia occidentalis</i>	M
Rhodophyta	<i>Hildenbrandia rubra</i>	H
Rhodophyta	<i>Hypnea anastomosans (=Hypnea esperi)</i>	H
Rhodophyta	<i>Hypnea spicifera</i>	M
Rhodophyta	<i>Mastocarpus papillatus</i>	M
Rhodophyta	<i>Neosiphonia harveyi (=Polysiphonia harveyi)</i>	H
Rhodophyta	<i>Pikea californica</i>	H
Rhodophyta	<i>Polysiphonia brodiei</i>	H
Rhodophyta	<i>Polysiphonia denudata</i>	M
Rhodophyta	<i>Polysiphonia paniculata</i>	M
Rhodophyta	<i>Polysiphonia senticulosa</i>	H
Rhodophyta	<i>Porphyra suborbiculata</i>	H
Rhodophyta	<i>Prionitis lyallii</i>	M
Rhodophyta	<i>Rhodophysema georgei</i>	H
Rhodophyta	<i>Schizymania pacifica</i>	H

5.5 Summary of Spread from Guam to other jurisdictions of Micronesia and Hawai'i

The jurisdictions of Micronesia are variously exposed to the global suite of non-native marine and estuarine species through commercial and MSC vessel traffic, as discussed above. This exposure has been used to identify the suites of species with “High” likelihoods of arrival. MSC vessels demonstrably increase the exposure of various jurisdictions of Micronesia to novel bioregions, and therefore suites of non-native marine and estuarine species (Table 5.10). For example, MSC vessels increased the exposure of Guam to the Arabian Seas by 2.85 times, which would mean that species found in the Arabian Seas would have a 2.85 times greater likelihood of arrival in Guam when MSC vessels are counted. In contrast, the MSC vessels have no detectable effect on Hawai'i.

A comparison of “High” and “Medium” likelihood of inoculation species identified for various jurisdictions of Micronesia with those identified for Guam (Table 5.11) indicates a significant overlap. A total of 270 species are identified as having “High” or “Medium” likelihoods of arrival in at least one location in Micronesia, with 56 (21%) identified for a single Micronesian

jurisdiction, 24 of which were restricted to Guam. Only four species determined to be of “High” likelihood in another jurisdiction of Micronesia were not identified as a “High” likelihood for Guam. This suggests that similar factors influencing arrival to Guam are acting in other jurisdictions of Micronesia, rather than a formal “hub and spoke” model, as has been previously suggested.

Table 5.10. Increase in exposure to IUCN Bioregions (and Guam) for the jurisdictions of Micronesia and Hawai’i attributed to MSC vessels (1.00 = no increase).

	Guam	CNMI	FSM	RMI	Palau	UMI	HI
1. Antarctica	65.00	-	-	-	-	-	-
2. Arctic	4.03	3.00	1.00	16.67	1.00	-	-
3. Mediterranean	3.25	4.96	1.00	4.73	1.33	53.00	1.00
4. NW Atlantic	3.81	16.38	1.00	3.00	1.80	39.00	1.00
5. NE Atlantic	1.78	1.27	1.00	6.50	1.43	60.00	-
6. Baltic Sea	1.77	2.06	1.00	6.33	1.50	15.00	1.00
7. Wider Caribbean	4.42	15.83	1.00	6.33	1.64	55.00	1.00
8. W Africa	1.31	1.45	1.00	1.00	1.15	1.00	1.00
9. S Atlantic Ocean	1.36	1.96	1.00	1.56	1.11	2.00	1.00
10. Central Indian Ocean	1.12	1.24	1.00	1.67	1.02	-	1.00
11. Arabian Seas	2.85	2.91	1.00	6.29	1.32	46.00	1.00
12. E Africa	2.08	3.63	1.00	1.50	1.11	3.00	1.00
13. E Asian Seas	1.60	2.15	1.00	2.18	1.10	61.00	1.00
14. S Pacific Ocean	1.68	2.59	1.39	1.72	1.71	2.08	1.00
15. NE Pacific Ocean	4.50	6.26	1.00	1.44	2.00	2.70	1.00
16. NW Pacific Ocean	2.93	7.52	1.01	1.31	1.83	45.00	1.00
17. SE Pacific Ocean	5.36	17.88	1.00	2.10	3.33	-	1.00
18. Australasia	3.17	3.69	1.00	2.47	1.73	-	1.00
19. Great Lakes	1.00	1.00	-	-	1.00	-	1.00
20. Guam	N/A	2.44	1.00	4.25	1.55	54.00	1.00

In contrast, the pattern for Hawai’i is substantially different from Micronesia with 318 species identified as having “High” or “Medium” likelihoods of arrival, of which 158 are unique to Hawai’i, with only 9 species ranked as “High” in both Guam and Hawai’i. This infers that invasion risk to Hawai’i is driven by factors independent of Guam or other jurisdictions of Micronesia.

Table 5.11. Comparison of “High” and “Medium” likelihood of inoculation species in all jurisdictions of Micronesia and Hawai’i.

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Annelida	<i>Alitta (Neanthes) succinea</i>	M	M	M	M	M	M	
Annelida	<i>Alitta (Neanthes) succinea</i>						M	
Annelida	<i>Amaeana sp. A</i>							M
Annelida	<i>Amblyosyllis sp. A</i>							M
Annelida	<i>Boccardiella ligerica</i>							M
Annelida	<i>Branchiomma bairdi</i>							M
Annelida	<i>Ceratonereis mirabilis</i>							M
Annelida	<i>Crucigera websteri</i>							M
Annelida	<i>Dipolydora armata (=armata)</i>	H	M	H		M	M	
Annelida	<i>Dipolydora giardi</i>							M
Annelida	<i>Dipolydora socialis</i>							H
Annelida	<i>Dispio uncinata</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Annelida	<i>Dorvillea similis</i>			M				
Annelida	<i>Eteone tchangsii</i>							H
Annelida	<i>Euchone limnicola</i>							M
Annelida	<i>Eumida sanguineum</i>	M	M	M		M	M	
Annelida	<i>Eunice antennata</i>							H
Annelida	<i>Eunice antennata</i>	H						
Annelida	<i>Eunice antennata</i>				M			
Annelida	<i>Eunice antennata</i>					M		
Annelida	<i>Eunice antennata</i>						M	
Annelida	<i>Ficopomatus enigmaticus</i>	H	M	M	M	M	M	
Annelida	<i>Ficopomatus uschakovi</i>	M						
Annelida	<i>Geminosyllis ohma</i>							H
Annelida	<i>Glycera capitata</i>	M			M	M	M	H
Annelida	<i>Hesionides arenaria</i>							M
Annelida	<i>Heteromastus filiformis</i>	M			M	M	M	H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Annelida	<i>Hobsonia floridana</i>							M
Annelida	<i>Hydroides albiceps</i>	M		M				M
Annelida	<i>Hydroides albiceps</i>				M			
Annelida	<i>Hydroides diramphus</i>	H	M	H	M	M	M	
Annelida	<i>Hydroides elegans</i>	H	M	H	H			
Annelida	<i>Janua pagenstecheri</i>	H	H	H	H	H	H	
Annelida	<i>Limnodrilus monotheucus</i>							M
Annelida	<i>Lumbricillus lineatus</i>							M
Annelida	<i>Lysidice collaris</i>	M	M	M	M			
Annelida	<i>Marenzelleria viridis</i>							M
Annelida	<i>Marphysa disjuncta</i>							H
Annelida	<i>Myrianida pachycera</i>	M		M				

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
	<i>Neodexiospira</i>							
	<i>brasiliensis</i>							
Annelida	(= <i>Janua</i> (<i>Dexiospira</i> <i>brasiliensis</i>)	M	M		M	M	M	H
Annelida	<i>Nicolea</i> sp. A							M
Annelida	<i>Ophryotrocha</i> <i>diadema</i>							M
Annelida	<i>Ophryotrocha</i> <i>labronica pacifica</i>			M				
Annelida	<i>Paranaïs frici</i>							M
Annelida	<i>Pileolaria</i> <i>berkeleyana</i>	M	M	M	M	M	M	
Annelida	<i>Polydora cornuta</i>	M						H
Annelida	<i>Polydora hoplura</i>							M
Annelida	<i>Polydora limicola</i>							H
Annelida	<i>Polydora websteri</i>	M		M	M			

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Annelida	<i>Pomatoleios kraussii</i>	M	M	H	M			
Annelida	<i>Prionospio pygmaea</i> (= <i>Apoprionospio pygmaea</i>)							M
Annelida	<i>Pseudopolydora kempi</i>							H
Annelida	<i>Pseudopolydora paucibranchiata</i>	M		M	M			
Annelida	<i>Pseudopolydora paucibranchiata</i>							H
Annelida	<i>Pseudopotamilla ocellata</i>							H
Annelida	<i>Sigambra tentaculata</i> (= <i>Ancistrostylis tentaculata</i>)							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Annelida	<i>Streblospio benedicti</i>	M	M	M	M	M	M	
Annelida	<i>Syllis bella</i>							M
Annelida	<i>Tubificoides apectinatus</i>							M
Annelida	<i>Tubificoides benedii</i>							M
Annelida	<i>Tubificoides brownae</i>							M
Annelida	<i>Tubificoides diazi</i>							M
Annelida	<i>Tubificoides pseudogaster</i>							M
Annelida	<i>Tubificoides wasselli</i>							M
Annelida	<i>Typosyllis nipponica</i>							H
Chlorophyta	<i>Avrainvillea amadelpha</i>	M		M				
Chlorophyta	<i>Bryopsis pennata</i>	H	M		H		M	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chlorophyta	<i>Bryopsis plumosa</i>	H	H	H	H			H
Chlorophyta	<i>Bryopsis plumosa</i>						H	
Chlorophyta	<i>Bryopsis sp. A</i>							M
Chlorophyta	<i>Caulerpa filiformis</i>							M
Chlorophyta	<i>Caulerpa mexicana</i>	M	M					
Chlorophyta	<i>Caulerpa racemosa</i> <i>var. lamourouxii</i>	M	M	M	M			
Chlorophyta	<i>Caulerpa taxifolia</i> <i>(aquarium strain)</i>							H
Chlorophyta	<i>Chaetomorpha</i> <i>aerea</i>	H	H	H	H		H	
Chlorophyta	<i>Chaetomorpha</i> <i>linum</i>	H	H		H		H	H
Chlorophyta	<i>Cladophora</i> <i>herpestica</i>	M	M				M	
Chlorophyta	<i>Cladophora</i> <i>patentiramea</i>	M			M			

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chlorophyta	<i>Cladophora prolifera</i>	M	M	M	M		M	H
Chlorophyta	<i>Cladophora sericea</i>	H	M		H		H	
Chlorophyta	<i>Cladophoropsis membranacea</i>	M	M					
Chlorophyta	<i>Codium fragile</i> (= <i>C. f.</i> <i>tomentosoides</i>)						M	H
Chlorophyta	<i>Codium ovale</i>	M		M	M			
Chlorophyta	<i>Derbesia marina</i>	H	M				H	H
Chlorophyta	<i>Dictyosphaeria cavernosa</i>	M	M					
Chlorophyta	<i>Neomeris annulata</i>	H	M		H		M	
Chlorophyta	<i>Pilinella californica</i>							M
Chlorophyta	<i>Ulva californica</i>							M
Chlorophyta	<i>Ulva clathrata</i> (= <i>Enteromorpha</i> <i>clathrata</i> var. <i>crinata</i>)	H	H	H	H		H	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chlorophyta	<i>Ulva flexuosa</i>	H	H	H			H	
Chlorophyta	<i>Ulva pertusa</i>	M		M	M		M	H
Chlorophyta	<i>Ulva reticulata</i>	M	M	M	M		M	
Chlorophyta	<i>Ulva rigida</i>	H	H	H	H		H	
Chlorophyta	<i>Ulva stenophylla</i>							M
Chlorophyta	<i>Ulva taeniata</i>	M		M	M			
Chlorophyta	<i>Valonia fastigiata</i>	M		M				
Chlorophyta	<i>Bryopsis pennata</i>					M		
Chlorophyta	<i>Bryopsis plumosa</i>					H		
Chlorophyta	<i>Chaetomorpha aerea</i>					H		
Chlorophyta	<i>Chaetomorpha linum</i>					H		
Chlorophyta	<i>Cladophora herpestica</i>					M		
Chlorophyta	<i>Cladophora prolifera</i>					M		
Chlorophyta	<i>Cladophora sericea</i>					H		

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chlorophyta	<i>Codium fragile</i> (= <i>C. f.</i> <i>tomentosoides</i>)					M		
Chlorophyta	<i>Derbesia marina</i>					H		
Chlorophyta	<i>Neomeris annulata</i> (<i>casual</i>)					M		
Chlorophyta	<i>Ulva clathrata</i> (= <i>Enteromorpha</i> <i>clathrata</i> var. <i>crinata</i>)					H		
Chlorophyta	<i>Ulva flexuosa</i>					H		
Chlorophyta	<i>Ulva pertusa</i>					M		
Chlorophyta	<i>Ulva reticulata</i>					M		
Chlorophyta	<i>Ulva rigida</i>					H		
Chordata (Asciacea)	<i>Ascidia archaia</i>			M				
Chordata (Asciacea)	<i>Ascidia</i> sp. A (<i>SF</i> <i>Bay</i>)							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chordata (Asciacea)	<i>Ascidia zara</i>							H
Chordata (Asciacea)	<i>Botrylloides leachi</i>			M	M			
Chordata (Asciacea)	<i>Botrylloides perspicuum</i>		M	M	M	M	M	H
Chordata (Asciacea)	<i>Botrylloides violaceus</i> (= <i>Botryllus aurantius</i>)							H
Chordata (Asciacea)	<i>Botryllus planus</i>							M
Chordata (Asciacea)	<i>Botryllus schlosseri</i>		M	H	H	H	H	H
Chordata (Asciacea)	<i>Botryllus sp. A (SF Bay)</i>							M
Chordata (Asciacea)	<i>Ciona intestinalis</i>		H	H	H	H	H	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chordata (Asciacea)	<i>Ciona savignyi</i>							H
Chordata (Asciacea)	<i>Cnemidocarpa irene</i>			M				
Chordata (Asciacea)	<i>Didemnum candidum</i>		M	H	M	M	M	
Chordata (Asciacea)	<i>Didemnum vexillum</i> (= <i>Didemnum lahillei</i>)							H
Chordata (Asciacea)	<i>Microcosmus squamiger</i>			M	M			
Chordata (Asciacea)	<i>Molgula ficus</i>							H
Chordata (Asciacea)	<i>Molgula ficus</i>			M				
Chordata (Asciacea)	<i>Molgula manhattensis</i>					M	M	H
Chordata (Asciacea)	<i>Perophora japonica</i>		M	M	M			H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chordata (Ascidieacea)	<i>Polyandrocarpa zorritensis</i>			M	M			
Chordata (Ascidieacea)	<i>Styela clava</i>							H
Chordata (Ascidieacea)	<i>Styela plicata</i>							H
Chordata (Ascidieacea)	<i>Symplegma reptans</i>			M				
Chordata (Ascidieacea)	<i>Trididemnum orbiculatum</i>							M
Chordata (Ascidieacea)	<i>Ascidia archaia</i>	M						
Chordata (Ascidieacea)	<i>Botrylloides leachi</i>	M						
Chordata (Ascidieacea)	<i>Botrylloides perspicuum</i>	M						
Chordata (Ascidieacea)	<i>Botryllus schlosseri</i>	H						

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Chordata (Ascidieacea)	<i>Ciona intestinalis</i>	H						
Chordata (Ascidieacea)	<i>Cnemidocarpa irene</i>	M						
Chordata (Ascidieacea)	<i>Didemnum candidum</i>	H						
Chordata (Ascidieacea)	<i>Microcosmus squamiger</i>	M						
Chordata (Ascidieacea)	<i>Perophora multiclathrata</i>	M						
Chordata (Ascidieacea)	<i>Polyandrocarpa zorritensis</i>	M						
Chordata (Ascidieacea)	<i>Styela plicata</i>	M						
Chordata (Ascidieacea)	<i>Symplegma reptans</i>	M						
Cnidaria	<i>Amphinema dinema</i>							M
Cnidaria	<i>Amphinema sp.</i>							M
Cnidaria	<i>Aurelia sp.</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Cnidaria	<i>Bimeria vestita</i>							M
Cnidaria	<i>Blackfordia virginica</i>							H
Cnidaria	<i>Blackfordia virginica</i>	M						
Cnidaria	<i>Bougainvillia muscus</i>	H	M	M	M	M	M	
Cnidaria	<i>Bunodeopsis sp.</i>							M
Cnidaria	<i>Cladonema pacificum</i> (= <i>uchidai</i>)							H
Cnidaria	<i>Cladonema radiatum</i>	M			M	M	M	
Cnidaria	<i>Clava multicornis</i>							M
Cnidaria	<i>Clytia hemisphaerica</i>	H	M	H		H	H	
Cnidaria	<i>Cordylophora caspia</i>	H	H	H	H	H	H	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Cnidaria	<i>Corymorpha bigelowi</i> (= <i>Euphysora bigelowi</i>)							H
Cnidaria	<i>Corymorpha</i> sp.							M
Cnidaria	<i>Coryne eximia</i> (= <i>Sarsia eximia</i>)	M			M	M	M	
Cnidaria	<i>Coryne eximia</i> (= <i>Sarsia eximia</i>)							H
Cnidaria	<i>Coryne japonica</i> (= <i>Sarsia japonica</i>)							H
Cnidaria	<i>Coryne pusilla</i>	M			M	M	M	
Cnidaria	<i>Diadumene cincta</i>							M
Cnidaria	<i>Diadumene lineata</i>	H	M	H	M	M	M	
Cnidaria	<i>Eucheilota paradoxica</i>	M						
Cnidaria	<i>Eudendrium capillare</i>	H	M	H	H	H	H	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Cnidaria	<i>Eudendrium carneum</i>	M	M	M	M	M	M	H
Cnidaria	<i>Garveia franciscana</i>							M
Cnidaria	<i>Gonionemus vertens</i>							H
Cnidaria	<i>Gonothyraea clarki</i>							M
Cnidaria	<i>Gonothyraea loveni</i>	M				M	M	H
Cnidaria	<i>Halitholus pauper</i>							H
Cnidaria	<i>Hartlaubella gelatinosa</i>							H
Cnidaria	<i>Laomedea calciolifera</i>							H
Cnidaria	<i>Lensia challengerii</i>							M
Cnidaria	<i>Maeotias marginata</i>							H
Cnidaria	<i>Metridium senile</i>							H
Cnidaria	<i>Mitrocomium cirratum</i> (= <i>Campalecium medusifera</i>)							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Cnidaria	<i>Moerisia sp.</i>							M
Cnidaria	<i>Nematostella vectensis</i>							M
Cnidaria	<i>Obelia longissima</i>	M	M	M	M	M	M	H
Cnidaria	<i>Octotiarra russelli</i>							M
Cnidaria	<i>Phyllorhiza punctata</i>	M						
Cnidaria	<i>Phyllorhiza punctata</i>				M			
Cnidaria	<i>Pinauay (Ectopleura) larynx</i>							H
Cnidaria	<i>Pinauay crocea</i>							M
Cnidaria	<i>Plumularia setacea</i>	H	H	H	H	H	H	
Cnidaria	<i>Rathkea octopunctata</i>							H
Cnidaria	<i>Sarsia tubulosa</i>	M	M	M	M	M	M	
Cnidaria	<i>Scolionema suvaensis</i>	M		M	M			

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
	<i>Sertularia tongensis</i>							
Cnidaria	(= <i>Sertularia</i> <i>stechowi</i> , <i>S.</i> <i>theocarpa</i>)	M		M				
Cnidaria	<i>Stomolophus</i> <i>meleagris</i>							M
Cnidaria	<i>Tubastraea</i> <i>coccinea</i>	H	M	H		M	M	
	<i>Tubularia indivisa</i>							
Cnidaria	(= <i>Pinauay</i> (<i>Ectopleura</i>) <i>indivisa</i>)							H
Arthropoda	<i>Abludomelita</i> <i>rylovae</i>							H
Arthropoda	<i>Alpheus rapacida</i>	M		M				
Arthropoda	<i>Ampelisca abdita</i>							M
Arthropoda	<i>Amphibalanus</i> <i>albicostatus</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Amphibalanus amphitrite</i>	H	H	H	H	H	H	
Arthropoda	<i>Amphibalanus improvisus</i>	M		M	M	M	M	H
Arthropoda	<i>Amphibalanus reticulatus</i>	H	M	H	H	H	H	
Arthropoda	<i>Amphibalanus subalbidus</i>							M
Arthropoda	<i>Ampithoe longimana</i>							M
Arthropoda	<i>Ampithoe valida</i>							H
Arthropoda	<i>Aoroides secunda</i>							H
Arthropoda	<i>Aspidoconcha limmoriae</i>							M
Arthropoda	<i>Balanus glandula</i>							H
Arthropoda	<i>Balanus trigonus</i>	H	M	H	H	H	H	
Arthropoda	<i>Balanus uliginosus</i>							M
Arthropoda	<i>Briarosaccus callosus</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Caprella californica</i>							H
Arthropoda	<i>Caprella danilevskii</i>	M		M	M			
Arthropoda	<i>Caprella drepanochir</i>							H
Arthropoda	<i>Caprella equilibra</i>	H	M	M	M	M	M	
Arthropoda	<i>Caprella mutica</i>							H
Arthropoda	<i>Caprella penantis</i>	H	M	M	M	M	M	
Arthropoda	<i>Caprella scaura</i>	H	M	H	H	M	M	H
Arthropoda	<i>Caprella simia</i>							H
Arthropoda	<i>Carcinus maenas</i>	H	H	H	H	H	H	
Arthropoda	<i>Chelura terebrans</i>	M						H
Arthropoda	<i>Cirolana harfordi</i>							M
Arthropoda	<i>Concavus concavus</i> <i>species group</i> (= <i>Balanus concavus</i>)							M
Arthropoda	<i>Conchoderma auritum</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Conchoderma virgatum</i>	M		M				
Arthropoda	<i>Corophium alienense</i>							M
Arthropoda	<i>Corophium heteroceratum</i>							H
Arthropoda	<i>Dromia wilsoni</i>	M	M	M	M			
Arthropoda	<i>Dynoides dentisinus</i>							H
Arthropoda	<i>Elasmopus rapax</i>	H	M	M	M	M	M	
Arthropoda	<i>Elminius kingii</i>							M
Arthropoda	<i>Eobrolgus spinosus</i>							M
Arthropoda	<i>Eochelidium miraculum</i>							H
Arthropoda	<i>Eochelidium sp.</i>							M
Arthropoda	<i>Erichthonius brasiliensis</i>	H	M	M	M	M	M	
Arthropoda	<i>Eucrate crenata</i>	M	M	M	M			
Arthropoda	<i>Eurylana arcuata</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Fistulobalanus dentivarians</i>							M
Arthropoda	<i>Gammarus daiberi</i>							M
Arthropoda	<i>Glabropilumnus seminudus</i>			M				
Arthropoda	<i>Gnorimosphaeroma rayi</i>			M				
Arthropoda	<i>Iais californica</i>							M
Arthropoda	<i>Ianiropsis serricaudis</i>							H
Arthropoda	<i>Idotea metallica</i>	M			M	M	M	H
Arthropoda	<i>Incisalliope derzhavini</i>			M				
Arthropoda	<i>Jassa marmorata</i>	M			M	M	M	H
Arthropoda	<i>Jassa morinoi</i>							H
Arthropoda	<i>Jassa slatteryi</i>							H
Arthropoda	<i>Kotoracythere inconspicua</i>	M	M	M				

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Laticorophium baconi</i>	H	M	H	M	M	M	
Arthropoda	<i>Lepas (Anatifa) anatifera</i>	H		H		H	H	
Arthropoda	<i>Lepas (Anatifa) anserifera</i>	H	M		H	H	H	
Arthropoda	<i>Lepas (Anatifa) hillii</i>	M	M		M	M	M	H
Arthropoda	<i>Leptochela dubia</i>	H	M	H	H	H	H	
Arthropoda	<i>Ligia exotica</i>	H	M	H	M	M	M	
Arthropoda	<i>Limnoria quadripunctata</i>							M
Arthropoda	<i>Megabalanus coccopoma</i>							H
Arthropoda	<i>Megabalanus occator</i>	M		M				
Arthropoda	<i>Melita nitida</i>							M
Arthropoda	<i>Menaethius monoceros</i>	M	M	M	M			

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Merocryptus lambriiformis</i>	M		M				
Arthropoda	<i>Microdeutopus gryllotalpa</i>							M
Arthropoda	<i>Monocorophium acherusicum</i>	H	M	M	M	M	M	
Arthropoda	<i>Monocorophium insidiosum</i>	H	M	M	M	M	M	
Arthropoda	<i>Monocorophium uenoi</i>							H
Arthropoda	<i>Mytilicola orientalis</i>							H
Arthropoda	<i>Nanosesarma minutum</i>	M		M				
Arthropoda	<i>Pachygrapsus crassipes</i>			M				
Arthropoda	<i>Palaemon macrodactylus</i>							H
Arthropoda	<i>Paracaprella pusilla</i>	H	M	H	M	M	M	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Paracerceis sculpta</i>	M	M	M	M	M	M	
Arthropoda	<i>Paracorophium lucasi</i>							M
Arthropoda	<i>Paradella diana</i>	M	M	M		M	M	
Arthropoda	<i>Paradexamine sp.</i>							M
Arthropoda	<i>Paranthura japonica</i>							H
Arthropoda	<i>Percnon gibbesi</i>							M
Arthropoda	<i>Petrolisthes armatus</i>							H
Arthropoda	<i>Plagusia depressa tuberculata</i>	M	M	M	M			
Arthropoda	<i>Pleopis polyphemoides</i>				M	M	M	H
Arthropoda	<i>Porcellio lamellatus lamellatus</i>	M				M	M	
Arthropoda	<i>Pseudomyicola ostreae</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Pseudosphaeroma campbellensis</i>							M
Arthropoda	<i>Pyromaia tuberculata</i>							H
Arthropoda	<i>Redkea californica</i>							M
Arthropoda	<i>Rhithropanopeus harrisi</i>							H
Arthropoda	<i>Sinelobus cf. stanfordi</i>	M		M	M	M	M	H
Arthropoda	<i>Sphaeroma quoianum</i>	M		M				
Arthropoda	<i>Sphaeroma walkeri</i>	H	M	H	H	M	M	
Arthropoda	<i>Stenothoe gallensis</i>	H	M	M	M	M	M	
Arthropoda	<i>Stenothoe valida</i>	H	M	M	M	M	M	
Arthropoda	<i>Synidotea laevidorsalis</i>	M	M	M	M	M	M	H
Arthropoda	<i>Tetraclita japonica</i> (= <i>Tetraclita squamosa japonica</i>)							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Arthropoda	<i>Uromunna sp.</i> (= <i>Munna reynoldsi</i>)							M
Dinophyta	<i>Ostreopsis ovata</i>	M		M	M			
Dinophyta	<i>Prorocentrum lima</i>	H	M	M	M	M	M	
Echinodermata	<i>Protoreaster nodosus</i>	M						
Bryozoa	<i>Aetea anguina</i>	M	M	M	M	M	M	
Bryozoa	<i>Aetea truncata</i>	M	M	M	M	M	M	
Bryozoa	<i>Aeverrillia armata</i>							M
Bryozoa	<i>Alcyonidium polyoum</i>							M
Bryozoa	<i>Anguinella palmata</i>							M
Bryozoa	<i>Aspidelectra melolontha</i>							M
Bryozoa	<i>Bowerbankia gracilis</i>	H	M	M	M	M	M	
Bryozoa	<i>Bowerbankia imbricata</i>	M	M	M	M	M	M	
Bryozoa	<i>Bugula californica</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Bryozoa	<i>Bugula dentata</i>	M	M	M	M			
Bryozoa	<i>Bugula flabellata</i>							M
Bryozoa	<i>Bugula sp. 1 (Puget Sound)</i>							M
Bryozoa	<i>Bugula sp. 2 (Puget Sound)</i>							M
Bryozoa	<i>Bugula stolonifera</i>	H	M	M	M	M	M	
Bryozoa	<i>Caberea boryi</i>	M		M	M			
Bryozoa	<i>Celleporaria brunnea</i>	M		M				
Bryozoa	<i>Celleporella hyalina</i>							M
Bryozoa	<i>Conidoprhys pilisuctor</i>							M
Bryozoa	<i>Conopeum tenuissimum</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Bryozoa	<i>Cryptosula pallasiana</i>	H	M	H	H	H	H	
Bryozoa	<i>Einhornia crustulenta</i> (= <i>Electra crustulenta</i>)							H
Bryozoa	<i>Hippopodina feegensis</i>	M	M	M	M	M	M	
Bryozoa	<i>Hippothoa distans</i>	M	M	M	M	M	M	
Bryozoa	<i>Hippothoa divaricata</i>							M
Bryozoa	<i>Jellyella tuberculata</i>	H	M	M	M	M	M	H
Bryozoa	<i>Nolella stipata</i>							M
Bryozoa	<i>Pherusella brevituba</i> (casual)							M
Bryozoa	<i>Schizoporella japonica</i> (= <i>unicornis</i>)							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Bryozoa	<i>Scruparia ambigua</i>	M	M	M	M	M	M	H
Bryozoa	<i>Scrupocellaria bertholetii</i>							M
Bryozoa	<i>Synnotum aegyptiacum</i>	M	M	M	M	M	M	
Bryozoa	<i>Tricellaria inopinata</i>							H
Bryozoa	<i>Tricellaria occidentalis</i>	M		M	M			H
Bryozoa	<i>Victorella pavida</i>	M				M	M	H
Bryozoa	<i>Watersipora arcuata</i>	M		M				
Bryozoa	<i>Watersipora subtorquata</i>	H	M	H	H	M	M	
Bryozoa	<i>Zoobotryon verticillatum</i>	M	M	M	M	M	M	
Entoprocta	<i>Barentsia benedeni</i>							H
Mollusca	<i>Anadara granosa</i>	M	M	M	M			

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Anadara kagoshimensis</i> (= <i>Anadara inaequalvis</i> , = <i>Scapharca inaequalvis</i>)							M
Mollusca	<i>Anteaolidiella foulisi</i> (= <i>Anteaolidiella indica</i>)	H	M	H	M	M	M	
Mollusca	<i>Assiminea parasitologia</i>							H
Mollusca	<i>Babakina festiva</i>							H
Mollusca	<i>Bankia bipalmulata</i>	M						
Mollusca	<i>Bankia bipalmulata</i>			M				
Mollusca	<i>Bankia cieba</i>							M
Mollusca	<i>Bankia destructa</i>							M
Mollusca	<i>Bankia gouldi</i>							M
Mollusca	<i>Boonea cincta</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Caloria indica</i>	M						
Mollusca	<i>Caloria indica</i>		M					
Mollusca	<i>Caloria indica</i>			M				
Mollusca	<i>Caloria indica</i>				M			
Mollusca	<i>Catriona rickettsi</i>							M
	<i>Cenchritus</i>							
	<i>muricatus</i>							
Mollusca	(= <i>Tectarius muricatus</i>)							M
	<i>Chromodoris</i>							
Mollusca	<i>annulata</i>							M
	<i>Crepidatella</i>							
	<i>lingulata</i>							
Mollusca	(= <i>Crepidula lingulata</i>)			M				
	<i>lingulata</i>							
Mollusca	<i>Crepidula convexa</i>							M
Mollusca	<i>Crepidula fornicata</i>							M
Mollusca	<i>Crepidula plana</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Cuthona columbiana</i>							H
Mollusca	<i>Cycloscala hyalina</i>	M	M	M	M			
Mollusca	<i>Dendrodoris fumata</i>	M	M	M	M	M	M	
Mollusca	<i>Diodora ruppelli</i>	M		M				
Mollusca	<i>Doxander vittatus</i>	M		M	M			
Mollusca	<i>Elysia tomentosa</i>	M	M	M	M			
Mollusca	<i>Eubranchus inabai</i>							M
Mollusca	<i>Eubranchus misakiensis</i>							H
Mollusca	<i>Geukensia demissa</i>							M
Mollusca	<i>Glossodoris sedna</i>							M
Mollusca	<i>Guildfordia yoka</i>							H
Mollusca	<i>Hiatella arctica</i>	H	M	M	M	H	H	
Mollusca	<i>Hopkinsia (Okenia) plana</i>							H
Mollusca	<i>Hypselodoris infucata</i>	M						M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Ischadium recurvum</i>							M
Mollusca	<i>Isognomon ephippium</i>	M		M	M			
Mollusca	<i>Ividella navisa</i>							M
Mollusca	<i>Lienardia mighelsi</i>	M	M	M	M			
Mollusca	<i>Littorina littorea</i>							M
Mollusca	<i>Martesia striata</i>	M	M	M	M			
Mollusca	<i>Meretrix lusoria</i>							H
Mollusca	<i>Musculista senhousia</i>	H	M	H	H	M	M	H
Mollusca	<i>Myosotella myosotis</i> (= <i>Phytia myosotis</i>)							M
Mollusca	<i>Mytilopsis adamsi</i>							H
Mollusca	<i>Mytilopsis sallei</i>	M	M	M	M			
Mollusca	<i>Mytilus edulis</i>							M
Mollusca	<i>Mytilus galloprovincialis</i>	M		M	M	M	M	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Nanostrea fluctigera</i> (= <i>Nanostrea exigua</i>)	M		M	M			
Mollusca	<i>Nassarius fraterculus</i>							H
Mollusca	<i>Okenia pellucida</i>	M		M	M			
Mollusca	<i>Ostrea conchaphila</i>			M				
Mollusca	<i>Ostrea edulis</i>							H
Mollusca	<i>Ostrea puelchana</i> (= <i>Ostrea chilensis</i>)							M
Mollusca	<i>Perna viridis</i>	M	M	M	M			
Mollusca	<i>Polycera hedgpethi</i>							H
Mollusca	<i>Rapana venosa</i> (= <i>thomasiana</i>)							H
Mollusca	<i>Sabia conica</i>	M	M	M	M	M	M	
Mollusca	<i>Sakuraeolis enosimensis</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Mollusca	<i>Stiliger fuscovittatus</i>							M
Mollusca	<i>Strombus mutabilis</i>	M		M	M			
Mollusca	<i>Syrnola cincitella</i>	M		M	M			
Mollusca	<i>Tenellia adspersa</i>	M			M	M	M	H
Mollusca	<i>Teredo clappi</i>	M						
Mollusca	<i>Teredo navalis</i>	H	M	H	H	H	H	
Mollusca	<i>Teredo navalis</i>							H
Mollusca	<i>Teredora princesae</i>	M		M				
Mollusca	<i>Thecacera pennigera</i>	H	M	M	M	M	M	
Mollusca	<i>Xenostrobus securis</i>							H
Nematoda	<i>Angiostrongylus cantonensis</i>							M
Nemertea	<i>Lineus ruber</i>							M
Osteichthyes	<i>Acanthogobius flavimanus</i>							H
Osteichthyes	<i>Gobiosoma nudum</i>							M
Osteichthyes	<i>Stathmonotus stahli</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Osteichthyes	<i>Tridentiger trigonocephalus</i>							H
Phaeophyta	<i>Acrothrix gracilis</i>							H
Phaeophyta	<i>Chnoospora minima</i>	M	M	M	M			H
Phaeophyta	<i>Chorda filum</i>							H
Phaeophyta	<i>Cladostephus spongiosus</i>							M
Phaeophyta	<i>Colpomenia durvillei</i>							H
Phaeophyta	<i>Colpomenia peregrina</i>							H
Phaeophyta	<i>Cutleria cylindrica</i>							H
Phaeophyta	<i>Cutleria multifida</i>	M		M	M	M	M	
Phaeophyta	<i>Desmarestia viridis</i>					M	M	H
Phaeophyta	<i>Dictyota flabellata</i>			M				
Phaeophyta	<i>Ectocarpus fasciculatus</i>	M			M	M	M	H
Phaeophyta	<i>Ectocarpus siliculosus</i>	M	M	M	M	M	M	H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Phaeophyta	<i>Endarachne binghamiae</i>							H
Phaeophyta	<i>Fucus evanescens</i>							H
Phaeophyta	<i>Fucus spiralis</i>							M
Phaeophyta	<i>Hinckesia granulosa</i>	M			M	M	M	H
Phaeophyta	<i>Hinckesia mitchelliae</i>	H	H			H	H	
Phaeophyta	<i>Hinckesia ovata</i>	M			M	M	M	H
Phaeophyta	<i>Hinckesia sandriana</i>	M			M	M	M	H
Phaeophyta	<i>Leathesia marina</i> (= <i>Leathesia difformis</i>)	M		M	M	M	M	H
Phaeophyta	<i>Macrocystis pyrifera</i>	M		M	M			H
Phaeophyta	<i>Melanosiphon intestinalis</i>							H
Phaeophyta	<i>Microspongium globosum</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Phaeophyta	<i>Myrionema strangulans</i>	M		M	M	M	M	H
Phaeophyta	<i>Nemacystus decipiens</i>	M		M				
Phaeophyta	<i>Padina antillarum</i>	M		M				
Phaeophyta	<i>Padina boryana</i>	M	M	M				
Phaeophyta	<i>Phoronis hippocrepia</i>		M					
Phaeophyta	<i>Pylaiella littoralis</i>	H	M	H	H	H	H	
Phaeophyta	<i>Punctaria latifolia</i>	M			M	M	M	
Phaeophyta	<i>Punctaria latifolia</i>							H
Phaeophyta	<i>Punctaria tenuissima</i>							M
Phaeophyta	<i>Rugulopteryx okamurae</i>	M		M				H
Phaeophyta	<i>Sargassum filicinum</i>							H
Phaeophyta	<i>Sargassum muticum</i>				M			H
Phaeophyta	<i>Scytosiphon dotyi</i>							H
Phaeophyta	<i>Undaria pinnatifida</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Phoronida	<i>Phoronis hippocrepia</i>	M		M	M	M	M	
Platyhelminthes	<i>Leptoplana limnoriae</i>							M
Platyhelminthes	<i>Pseudostylochus ostreophagus</i>							H
Porifera	<i>Chalinula loosanoffi</i> (= <i>Haliclona loosanoffi</i>)							M
Porifera	<i>Chalinula nematifera</i>							M
Porifera	<i>Clathria prolifera</i> (= <i>Microciona prolifera</i>)							M
Porifera	<i>Cliona celata</i>							M
Porifera	<i>Cliona thoosina</i>							M
Porifera	<i>Dysidea fragilis</i>	M	M	M	M	M	M	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Porifera	<i>Halichondria bowerbanki</i>							M
Porifera	<i>Halichondria panicea</i>	M			M	M	M	H
Porifera	<i>Lissodendoryx isodictyalis</i>							M
Porifera	<i>Mycale parishii</i> (= <i>Zygomycale parishii</i>)	H	M	H	M	M	M	
Porifera	<i>Prosuberites sp.</i>							M
Porifera	<i>Stelletta clarella</i>							M
Protozoa	<i>Bonamia ostreae</i>							M
Protozoa	<i>Boveria teredinis</i>							M
Protozoa	<i>Cothurnia limnoriae</i>							M
Protozoa	<i>Haplosporidium costale</i>							H
Protozoa	<i>Lagenophrys cochinchinensis</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Protozoa	<i>Lankesteria</i> <i>ascidiae</i>							M
Protozoa	<i>Orchitophyra</i> <i>stellarum</i>							H
Protozoa	<i>Trochammina hadai</i>							H
Pycnogonida	<i>Ammothea</i> <i>hilgendorfi</i>	M		M	M	M	M	
Pycnogonida	<i>Anoplodactylus</i> <i>erectus</i>			M				
Pycnogonida	<i>Pigrogromitus</i> <i>timsanus</i>	H	M	M	M	M	M	
Raphidophyta	<i>Heterosigma</i> <i>akashiwo</i> (= <i>Olisthodiscus</i> <i>luteus</i>)							H
Rhodophyta	<i>Acrochaetium</i> <i>pacificum</i> (= <i>Audouinella</i> <i>pacificum</i>)							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Rhodophyta	<i>Acanthophora spicifera</i>	M	M	M				
Rhodophyta	<i>Agardhiella subulata</i>	M						H
Rhodophyta	<i>Aglaothamnion cordatum</i>	H	M	H	M	M	M	
Rhodophyta	<i>Aglaothamnion tenuissimum</i> (= <i>Callithamnion byssoides</i>)							M
Rhodophyta	<i>Anotrichium furcellatum</i>							H
Rhodophyta	<i>Antithamnion densum</i>							H
Rhodophyta	<i>Antithamnion hubbsii</i> (= <i>nipponicum</i> , <i>pectinatum</i>)	M	M	M	M	M	M	

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Rhodophyta	<i>Antithamnionella elegans</i>							H
Rhodophyta	<i>Antithamnionella spirographidis</i>							H
Rhodophyta	<i>Antithamnionella sublittoralis</i>							M
Rhodophyta	<i>Apoglossum gregarium</i>	M		M	M			
Rhodophyta	<i>Asparagopsis armata</i>							M
Rhodophyta	<i>Asparagopsis taxiformis</i>	H	M	H	H	H	H	
Rhodophyta	<i>Audouinella simplex</i>							M
Rhodophyta	<i>Bangia atropurpurea</i>	H	H	H	H	H	H	
Rhodophyta	<i>Caulacanthus ustulatus</i>	H	M	H	M	M	M	H
Rhodophyta	<i>Centroceras clavulatum</i>	H	M		H	H	H	H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Rhodophyta	<i>Ceramium kondoi</i>							H
Rhodophyta	<i>Ceramium sinicola</i>							M
Rhodophyta	<i>Ceramium virgatum</i>	M			M	M	M	H
Rhodophyta	<i>Chondria arcuata</i>	M		M				
Rhodophyta	<i>Chroodactylon ramosum</i>	M	M	M	M	M	M	
Rhodophyta	<i>Corallina officinalis</i>	M			M	M	M	
Rhodophyta	<i>Dasya baillouviana</i>	H	M	H	H	M	M	
Rhodophyta	<i>Eucheuma denticulatum</i>	M	M	M	M			
Rhodophyta	<i>Gelidium vagum</i>							H
Rhodophyta	<i>Goniotrichiopsis sublittoralis</i>							M
Rhodophyta	<i>Gracilaria gracilis</i>	M		M	M	M	M	M
Rhodophyta	<i>Gracilaria vermiculophylla</i>							M
Rhodophyta	<i>Grateloupia doryphora</i>							H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Rhodophyta	<i>Grateloupia lanceolata</i>							H
Rhodophyta	<i>Grateloupia subpectinata</i> (= <i>Grateloupia filicina</i> var <i>luxurians</i>)	M						
Rhodophyta	<i>Gymnogongrus crenulatus</i>							M
Rhodophyta	<i>Gymnothamnion elegans</i>	H	M		H	M	M	
Rhodophyta	<i>Haraldiophyllum nottii</i>	M	M					M
Rhodophyta	<i>Herposiphonia parca</i>				M			
Rhodophyta	<i>Hildenbrandia occidentalis</i>							M
Rhodophyta	<i>Hildenbrandia rubra</i>	H	H			H	H	H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
	<i>Hypnea</i>							
Rhodophyta	<i>anastomosans</i>	M	M		M	M	M	H
	(= <i>Hypnea esperi</i>)							
Rhodophyta	<i>Hypnea cornuta</i>	H	M	M	M	M	M	
Rhodophyta	<i>Hypnea nidifica</i>	M		M				
Rhodophyta	<i>Hypnea spicifera</i>							M
	<i>Hypnea spinella</i>							
Rhodophyta	(= <i>Hypnea cervicornis</i>)	H	M			M	M	
Rhodophyta	<i>Hypnea valentiae</i>	H	M		H	M	M	
Rhodophyta	<i>Kappaphycus striatum</i>	M						
Rhodophyta	<i>Laurencia brongniartii</i>	M		M				
Rhodophyta	<i>Laurencia okamurae</i>	M						
Rhodophyta	<i>Mastocarpus papillatus</i>							M

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
	<i>Neosiphonia</i>							
Rhodophyta	<i>harveyi</i> (= <i>Polysiphonia</i> <i>harveyi</i>)	M			M	M	M	H
Rhodophyta	<i>Pikea californica</i>							H
Rhodophyta	<i>Polysiphonia</i> <i>brodiei</i>	M			M	M	M	H
Rhodophyta	<i>Polysiphonia</i> <i>denudata</i>							M
Rhodophyta	<i>Polysiphonia</i> <i>paniculata</i>							M
Rhodophyta	<i>Polysiphonia</i> <i>senticulosa</i>							H
Rhodophyta	<i>Polysiphonia</i> <i>sertularioides</i>	M			M	M	M	
Rhodophyta	<i>Polysiphonia</i> <i>subtilissima</i>	M	M			M	M	
Rhodophyta	<i>Porphyra</i> <i>suborbiculata</i>	M		M				H

Table 5.11. Continued

Phylum	Scientific name	Guam	CNMI	FSM	RMI	Palau	UMI	HI
Rhodophyta	<i>Prionitis lyallii</i>							M
Rhodophyta	<i>Pterosiphonia bipinnata</i>	M		M				
Rhodophyta	<i>Rhodophysema georgei</i>							H
Rhodophyta	<i>Sarconema filiforme</i>	M	M	M	M			
Rhodophyta	<i>Schizymenia pacifica</i>							H
Rhodophyta	<i>Spongoclonium caribaeum</i> (= <i>Pleonosporium caribaeum</i>)	M	M		M			
Rhodophyta	<i>Symphyocladia marchantioides</i>	M						

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5.6 Discussion and Conclusions

This study clearly demonstrates that a number of non-native species associated with biofouling represent a risk to Micronesia. Out of the global suite of 2,365 marine species identified with a recognized invasion history, 136 were considered native to Micronesia and 109 species have been previously introduced to Guam (but may or may not also be present in one or more of the other jurisdictions of Micronesia), leaving 2,120 species from our database with an invasion history that represent a novel risk of invasion to Guam (Table 5.1). Of these 2,120 species, 1,241 were deemed to have some likely association with biofouling of vessels. Micronesia has a relatively poor taxonomic knowledge base despite high endemism and high levels of interest, and has not invested in significant evaluations of its current state of marine introductions, although Guam has had investigation of its non-native marine biota through literature and museum collection evaluations and a baseline survey of Apra Harbor (Paulay et al 2002). In contrast, the knowledge base for biological introductions is perhaps greatest in Guam relative to the other jurisdictions of Micronesia (but see Campbell et al 2007).

In order to advance the understanding of risk exposure it is imperative that a greater knowledge base is developed. Targeted field surveys are especially critical to determine the current levels of introductions, particularly in high risk areas (e.g., ports, marinas, aquaculture facilities) using a consistent suite of protocols and a shared taxonomic dataset. At a more fundamental level, studies on the alpha taxonomy of species with potential for invasiveness need to be undertaken, in order to better understand the diversity, ecology, and current geographic ranges of invasive species. A DNA barcoding study would help provide an indication of the unaccounted 'cryptic' species-level diversity present in the Micronesian region.

For the biofouling species assessed in this report, an evaluation of transport pressure was based on global distribution of the species (in native, cryptogenic and introduced bioregions). This enabled identification of the number of arriving vessels into Micronesia that **could have transported** the species to Micronesian waters. This required a number of critical assumptions:

- that a species presence in a bioregion represents an established population **throughout** the bioregion,
- that all vessel categories are equally able to transport all species and
- that all trade routes from bioregions to Micronesia are equally 'stressful'.

These assumptions represent conservative approaches to the information available. The ability to discern a non-native marine species presence in overseas ports has been demonstrated to be problematic (e.g., Hayes and Hewitt 1998, 2000; Hewitt and Hayes 2001, 2002; Barry et al. 2008). While there have been numerous efforts to provide up-to-date information on invasions into various global regions (see review by Campbell et al. 2007), the information is typically out-of-date by the time it is in the peer reviewed literature. Assuming that a report for a species in a bioregion represents an established population in that bioregion allows a risk manager to use the information in making an assessment. Similarly, assuming that a species is spread throughout the bioregion, when it may have only been reported from one location, may assist in addressing the

significant lag time between incursion, detection and reporting. During this period, which can encompass more than a decade, the opportunity for the species to have spread through natural and human-mediated means creates the high likelihood that nearby regions and ports will have been infected. It is worth noting though that assuming a species is spread through a region based on detections in one or several places within that region may be an erroneous conclusion and when considering how best to increase biosecurity for Micronesia and Hawaii, such assumptions should not be readily applied.

Differences among vessel categories (types) can clearly influence inoculation pressure elsewhere (e.g., Carlton 1985, 2001; Carlton and Hodder 1995; Coutts 1999; Wonham et al. 2000; Floerl 2002; Coutts and Dodgshun 2007; Piola et al. 2008). Vessel behaviors differ significantly both individually and across vessel categories. These behavioral differences include, but are not limited to, vessel speed, time spent in port, and maintenance history.

An evaluation of vessel speed based on the Lloyds MIU dataset indicated that at the gross scale of vessel categories used here, no clear differentiation could be discerned. Clearly, some vessel types move at much slower speeds than others, and recent reports suggest that these slower moving and sedentary vessels, including barges, dredges, drilling rigs and floating production, storage and offloading units (FPSOs), may harbor larger quantities and diversity of species than other vessels (e.g., Coutts 2002; Floerl 2002; Floerl and Inglis 2005; Davidson et al. 2009; Coutts et al. 2009, 2010a, b). The relationship, however, between a vessel's maximum, or even mean, speed (representing sheer forces) and the successful transport of species to new regions remains unclear.

The presence of hydrodynamically protected areas on a vessel's hull, such as sea-chests, rudders, and propeller shafts (e.g., Gollasch 2002; Hayes 2002; Coutts et al. 2003; Coutts and Taylor 2004; Hayes et al. 2004b; Coutts and Dodgshun 2007) nevertheless suggests that speed alone will not preclude a species presence on a vessel but may significantly reduce the abundance of a species. Coutts (1999) evaluated commercial (merchant) vessels entering Bell Bay in Tasmania, Australia and found that speed was a good correlate of species abundance and a moderate correlate for diversity. However, this study concentrated on the uniform areas of the hull surface and did not explore niche or protected areas of a ship's hull.

A time in port analysis was not undertaken in this study due to the limitations on data availability, particularly for military vessels. In previous studies (Hewitt et al. 2009e, 2010) differences between time spent in port for the various vessel categories provided a clear indication of differences in opportunity for species to settle on the vessel (assumed to correlate with time in port). This factor was used in previous studies as a multiplier of vessel visits from a bioregion to account for the increased likelihood that a species would be transported. However, the accumulation of biofouling in a small area of a vessel is unlikely to be a linear process. Indeed the accumulation of species onto settlement panels often follows an exponential increase in diversity as the habitat, increases in complexity (Sutherland and Karlson 1978). At some point however, an asymptote (a leveling off) of the species accumulation is expected to occur in the local patch, or more broadly once the community accumulates the entire species pool from a bioregion (Rosenzweig 2001). How rapidly the community is assembled varies widely across regions and time of year (Sutherland and Karlson 1978; Lewis 2002; Lewis et al. 2004; Dunstan and Johnson 2006).

As voyage duration increases, the number of bioregions visited by vessels entering Guam was found to encompass 12 bioregions after 30 days, reaching saturation (all 18 bioregions) after 183 days. Taking into account the expected operational cycle of vessels between dry-docking and antifouling paint applications, coupled with the restrictions placed on in-water cleaning in many jurisdictions, most vessels will be expected to have significant communities of species drawn from a wide suite of bioregions. Based on the assessment of voyage duration, multiple bioregions are visited by half of the vessels travelling for periods of less than one year. This in turn increases the opportunity for species from disparate regions to attach to the hull and also increases the total opportunity for individual species to be transported.

A number of vessel characteristics could not be evaluated and did not contribute to the final evaluation. As noted above, vessel speed did not appear to differentiate between vessel categories but varied widely within several categories. The implications that hydrodynamically protected areas may continue to harbor communities of biofouling associated species make this variable unlikely to fully eliminate any species from a vessel. Similarly, antifouling paint has been deemed to provide prophylactic protection, however the incomplete and often inappropriate applications of antifouling paints are unlikely to result in the complete elimination of a species from a vessel. While antifouling paint history coupled with more generic hull husbandry information could potentially provide significant information on the likely state of biofouling, this information could not be obtained at the scale required, and therefore could not be included in this assessment.

Biosecurity risk is typically derived from assessing both the arrival likelihood and the species consequence (impact). In this evaluation, a species' successful inoculation has been deemed to have an unacceptable consequence in keeping with a quarantine endpoint. A quarantine consideration, where the arrival of a new species is deemed to represent an unacceptable impact, is frequently employed where the desire is to prevent new invasions. In this report, the desire was to identify the species most likely to be introduced without differentiation with regard to the potential impacts they might cause. Consequently, the predictions made in this report necessarily relied on the most probable arrivals into Guam and subsequent transfer to other jurisdictions of Micronesia.

This assessment has concentrated on the likelihood of transport and inoculation, however not all species will have the physiological tolerances to establish and survive the environmental conditions found in nearshore waters of Micronesia. Establishment represents the survival and development of a self-sustaining population once a species has been inoculated into a new (receiving) environment (e.g., Occipinti-Ambrogi and Galil 2004). The likelihood of establishment has been theorized to relate to characteristics of the invading species (and its inoculation) as well as characteristics of the receiving environment (e.g., Carlton 1985; Lodge 1993; Ruiz et al. 2000; Hewitt and Huxel 2002; Lockwood et al. 2007).

Species characteristics which influence establishment likelihood include the physiological tolerance to the new (receiving) environment sufficient for reproduction to occur and all life history stages to survive. These are typically based on empirical evaluations of species' tolerances to a suite of environmental factors, such as temperature, salinity, light, dissolved oxygen, however these empirical evaluations have been carried out for a relatively small number of species (e.g., Hayes and Hewitt 1998, 2000; Campbell 2009).

Given these constraints, a second method of estimating probable survival in a new region is to

match the environmental characteristics of the donor region where a species is known to exist, with a recipient region – environmental matching (e.g., Hilliard and Raaymakers 1997; Kilroy et al. 2008; see also Hewitt and Hayes 2001, 2002). As Barry et al. (2008) suggest, evidence to support the utility of environmental matching in the marine environment is limited, largely due to the inappropriate selection of environmental characteristics and scale by various authors. The ability for environmental matching to provide realistic risk evaluations becomes increasingly limited as nonsensical or irrelevant environmental factors are included in the analysis (Barry et al. 2008).

One of the greatest errors in environmental matching assessments is the inappropriate use of scale. As Hewitt and Hayes (2002) demonstrate, environmental matching is meant to create a surrogate measure for the species of concern's tolerances. This is done by selecting a location where a species is known to exist (the donor location), and using the range of environmental values to compare with a potential recipient location. If the donor location is restricted to a port, rather than the entire province or bioregion in which the species resides, then an artificial limit to the range of environmental values will be derived. To illustrate this, Hewitt and Hayes (2002) demonstrated that the temperature ranges of the Port of Sydney and the Port of Hobart do not overlap and hence, based on a simple environmental match, species would not be expected to survive in both. Regardless, Sydney and Hobart reside within a single large scale province and share many species. For example, when their temperature ranges are compared with the temperature tolerances of the non-native seastar, *Asterias amurensis*, they both fall well within the range of its survival (Hewitt and Hayes 2002).

Non-native marine species have been shown to fully realize their fundamental niche (*sensu* Hutchinson 1957), suggesting that their physiological tolerances are conservatively represented by the wide ranging environmental conditions in their native distribution (e.g., salinities and water temperatures). In a previous evaluation (Campbell and Hewitt 2011), the known temperature tolerances of several non-native marine species in Australian waters were compared with the sea surface temperature maxima and minima (over a ten year period) for their native provinces (Figure 5.37A). The environmental range of temperatures in a species' native provinces conservatively describes the temperature tolerances of the species in most cases, suggesting that the environmental ranges of provinces can be used as conservative surrogates of species' tolerances.

As a consequence, the environmental overlaps of different provinces may indicate the likelihood of species' survival in various regions. Significant provincial overlap occurs from the Arctic to the Antarctic along the eastern Pacific basin (Figure 5.37B), suggesting that many species could survive within a wide range of provinces across the eastern basin, and that their restricted distributions may be constrained more by other factors (e.g., transport opportunity, receiving community resistance including predation and competition) than significant physiological 'resistance'. The northern and southern distribution of the large brown kelp, *Macrocystis integrifolia* is a case in point (Graham et al. 2007).

Undertaking an assessment of the physiological constraints of the risk species identified here would require a significant effort and result in a large amount of remaining unknowns, given existing data limitations for many marine and estuarine species. Similarly, developing an understanding of the environmental constraints of Guam and other Micronesian environments to challenge species is beyond the scope of the current assessment.

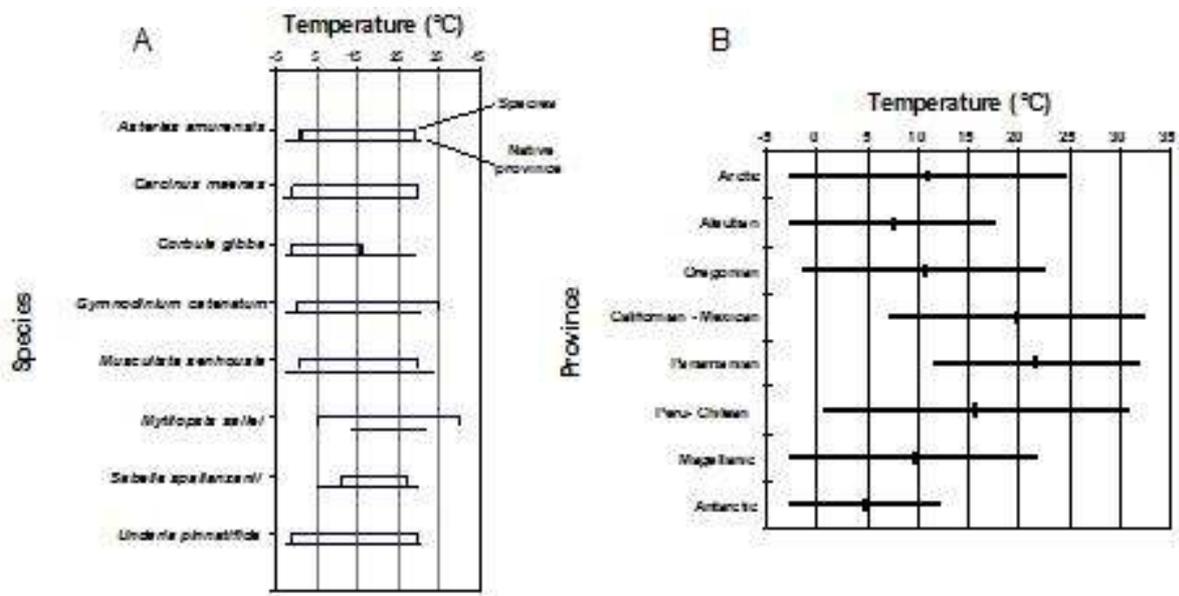


Figure 5.37. A) comparison of species' physiological tolerances (top line) versus native province Sea Surface Temperature range (bottom line); B) Comparison of Sea Surface Temperature for the eastern Pacific provinces (from Hewitt and Campbell unpublished data).

A posthoc assessment of species impact could lead to a greater refinement of the lists provided here, identifying those species which once inoculated and established could result in unacceptable impacts to economic, environmental, social or cultural values. Predicting impact (or consequence) of potential non-native marine species is problematic. In previous work, Hewitt et al. (2009e) evaluated the biofouling species risks to Australia and determined that of 657 species which were deemed to pose a threat to Australia, impact information could only be derived for 162 (24.7%). This information included both demonstrated impacts (or lack of impact) based on scientific assessment, as well as inferred impact based on expert opinion. For the remaining approximately 75% of species, no inferred or demonstrated impacts could be derived from the literature.

More recently, Dahlstrom (2012) evaluated the ability of biosecurity impact studies to detect an impact where the outcomes were non-significant. Dahlstrom focused on 31 algal and crustacean evaluations that have been cited to support an assessment of “no threat” by managers. Dahlstrom found consistently low power which led to an acceptance of Type II (false positive) errors at rates 5 to 19 times greater than acceptance of Type I (false negative) errors. These results suggest that for the suite of studied species for which no impact was discerned, 95% were unlikely to detect an impact due to poor design, and these species may have large impacts that have been missed due to high variation or small sample sizes.

These two examples suggest that researchers have no ability at the present time to assign consequence (impact) scores for between 75% and 90% of known invading species due to either a lack of scientific investigation, or poor implementation of impact studies leading to false conclusions. As a result, this study has focused on the quarantine endpoint to aid determination of species which require further study.

This study has identified 243 species which have a “High” likelihood of inoculation into at least one Micronesian jurisdiction or Hawai’i, with 85 species presenting a “High” likelihood of inoculation in at least one Micronesian jurisdiction, and an additional 168 species in Hawai’i. The 85 species representing an increased risk to Micronesia appear to be heavily influenced by traffic activities associated with Guam and with MSC vessels. These species include species that may impact aquaculture activities, coastal industries, wild fisheries and other living marine resources, protected and habitat-forming species, social/cultural values and human health.

PART III.
Marine Biosecurity Plan

Chapter 6: Marine Biosecurity Plan Recommendations for Micronesia

by Gregory M. Ruiz and Chela J. Zabin

6.1 Introduction

The purpose of this chapter is to outline key elements of a regional marine biosecurity plan for Micronesia. This begins with a brief review of the types of biosecurity plans that have been developed or proposed within the region. Next, a conceptual framework is outlined for vector management, serving as an operational structure to develop and advance biosecurity. Within this framework, specific recommendations are made for management practices, actions, and focused research and analyses needed to respond effectively to the threat of marine biological invasions. Finally, the structural (institutional) components necessary to meet these recommendations are considered. Throughout this approach, we draw upon information presented in the preceding chapters on (a) existing knowledge about marine invasion processes throughout the world, (b) the operation and management practices for vectors that transfer non-native marine species in Micronesia, (c) some critical gaps in baseline knowledge about regional vectors and invasions, and (d) the state of existing infrastructure (programs and capacity) for marine biosecurity.

While we identify critical components and actions for the regional biosecurity plan, a detailed implementation plan to achieve these goals is not presented here. The latter is clearly beyond the scope of the current project and represents a next step in the process. Pragmatically, it is important to recognize that any implementation plan is a political process, which requires (a) direct engagement and participation of the parties — countries, organizations, and people — involved in Micronesia, (b) consideration of possible legal instruments and approaches (i.e., regulations, agreements, partnerships, policies), and (c) assessment of available resources and institutional capacities to meet specific goals and timelines. In September 2011, the U.S. Navy entered into an agreement with the University of Guam to create a strategic implementation plan. The goal of this chapter, and indeed the entire report, is therefore to set the stage for this process, providing the necessary framework, activities, and actions.

The major impetus for this report is the current DoD Buildup in Guam, and associated activities, but the biosecurity plan recommendations are intended to be broader in spatial and temporal extent. For this reason, we have considered activities throughout Micronesia, as well as the linkage between Micronesia and Hawai'i. In addition, we have included consideration of some activities that may change through time. For example, it is clear that the magnitude and type of construction and vessel activities will change throughout the Buildup, and some transport mechanisms for marine species that are currently rare (or not in operation) in Micronesia may become important in the future. While we have attempted to capture this broad spatial and temporal scope, it is also important to acknowledge that our treatment cannot be comprehensive and anticipate all possibilities in this respect, especially given the time provided for this analysis. Nonetheless, we hope that the conceptual framework and rationale developed here can be applied broadly to any omissions or unanticipated future concerns.

In this chapter, as elsewhere in the report, the terms “non-native species” and “invasive species” are used unavoidably as synonyms. The term “invasive species” is variously and often vaguely defined throughout the literature (Ruiz and Carlton 2003). In general, it is meant to refer to species that have a negative or undesirable impact, but the effects of most non-native marine species have never been assessed in this regard (see Chapter 1, Section 1.4). The term “invasive” is used commonly in legislation, guidelines and management plans (see next section), and we refer to “invasive species” where it is used in this way. Elsewhere, we use the term “non- native species”.

6.2 Existing Plans and Recommendations for the Region

6.2.1 Ship-Mediated Invasions: Secretariat of the Pacific Regional Environment Program and The International Maritime Organization

A strategy for addressing shipping-related marine invasions in the region (SRIMP-PAC) was developed by the Secretariat of the Pacific Regional Environment Program (SPREP) in cooperation with the IMO (South Pacific Regional Environment Programme 2006). The SRIMP-PAC strategy takes a broad view, aiming to reduce the spread of marine invasive species to all Pacific Island countries and territories (PICTs). It emphasizes “pre-border” controls, or regulations, inspections and management actions in Pacific Rim countries to reduce biofouling on vessels and the uptake of organisms in ballast tanks before vessels leave port, as the most effective and cost-efficient approach. Such measures would also be taken in PICTs, along with at-border strategies to assess risk of incoming vessels and management strategies for reducing release of non-native species in ports and coastal waters. The plan also recommends the development of “post-border” strategies, such as early detection through monitoring, rapid- response plans, and eradication and control measures, while acknowledging that these are more costly and less-effective than prevention measures.

Other components of the SRIMP-PAC plan include structural and political components such as building an organization to carry out the plan (with SPREP/IMO as leads); mounting a major awareness campaign in all Pacific Rim countries; working to implement laws, regulations, and standards for ballast water and hull fouling; and building capacity for participating countries to carry out the plan elements. The strategy calls for a formal overall risk assessment for the region, with the intention of identifying high-, medium- and low-risk ports, as well as identifying risks posed by specific vessel types or voyages. The risk assessment would be used to guide the further development of management plans. In addition, the plan calls for a formal risk assessment for transiting vessels in the region, specifically for an analysis of regions where ballast water is discharged and a determination as to whether these pose a risk to PICTs.

Acknowledging the lack of baseline information about non-native species already present in the Pacific, the plan calls for initial surveys, along with three levels of ongoing monitoring for new invaders: comprehensive surveys at high-risk ports (based on the protocol developed by the Australian Centre for Research on Introduced Marine Pests); reduced scale surveys at medium risk ports (based on methods developed by Hawai’i’s Bishop Museum); passive settling plates at low-risk ports (based on methods developed by the Smithsonian Environmental Research Center). The document also notes the lack of taxonomic expertise in the region, and recommends coordination

between countries in the region and scientific experts elsewhere, as well as the need for a coordinated database for information on species, ship movements and ballast water and hull fouling management issues. Taxonomic and DNA barcoding studies on invasive species may also be considered.

The SRIMP-PAC strategy includes a work plan which outlines what is to be done, when, by whom, as well as potential funding sources and existing models to follow. It does not specifically address military vessels.

6.2.2 Aquaculture Imports and Quarantine: Secretariat of the Pacific Community

SPC has developed quarantine guidelines for aquatic species introduced to the region for aquaculture (Humphries 1995). A draft version of these guidelines and recommendations was adopted by SPC in 1994. Essentially, the guidelines provide minimum standards for quarantine, including the following:

- Evaluating each proposed introduction on a case-by-case basis
- Risk assessment to assign risk categories for proposed introductions
- Health certification as well as pre- and post-entry examination for disease
- Secure quarantine facilities (including consideration of site of facility to minimize accidental releases due to natural disasters, e.g. floods and tsunamis) and training to improve ability to test for disease
- Preparation of a regional strategy on aquatic biosecurity
- Development of a regional disease database

6.2.3 General Invasive Species Plans: Secretariat of the Pacific Regional Environment

Program

Guidelines for the development of national invasive species management plans (across all habitat types) for Pacific Island countries were drafted by the Secretariat of the Pacific Regional Environment Program, following a series of meetings and discussions with various agencies in the region (Tye 2009). The document advocates use of the precautionary principle in the management of invasive species, assuming, in the absence of information to the contrary, that any non-native species will become problematic and should be prevented from spreading and/or becoming established. As does the SRIMP-PAC document, it emphasizes a hierarchical approach to dealing with invasive species, i.e., prioritizing prevention, which is less costly and more effective than managing invasive species post-establishment, and advocating eradication where possible rather than long-term management. Biological control, using host-specific species, is recommended as a potential management strategy where eradication is not possible; with containment and long-term management by chemical or physical methods as last-resort actions.

The document addresses non-native species across all habitat types and presents an excellent

overall framework for the development of invasive-species management plans. Unlike SRIMP-PAC, it focuses on species entering the country via imports; ballast water and hull fouling are not mentioned in the document. It contains guidelines broadly organized into three major thematic areas, which are further broken down into nine sub-themes as follows:

I. Foundations

A. Generating support for actions to manage and prevent invasions

B. Building capacity

C. Legislation, policy and protocols

II. Problem definition, prioritization and decision-making

A. Baseline and monitoring, specifically the development of baseline information on the abundance and distribution of invasive species

1) Prioritization of management activities

2) Research on priority species

III. Management Action

A. Biosecurity, defined as prevention of the spread of invasive species

B. Management of established invasive species

C. Restoration of native species

These thematic areas are further developed in the document, with steps and actions to be taken toward specific goals, but the SPREP plan does not provide specific strategies or methods. For example, the plan advocates the development of monitoring programs for invasive species but offers no details of best approaches for monitoring. Best management practices for different vectors or pathways are also not detailed.

6.2.4 Pacific Invasives Initiative

The Pacific Invasives Initiative reviewed national biosecurity/biodiversity plans and invasive species management activities (Pacific Invasives Initiative 2010) for 12 Pacific Island countries, to assess alignment with the SPREP document and to identify existing gaps in the plans. The countries reviewed in the Micronesian region were the RMI, FSM, and Palau. The review found that all countries except for RMI had addressed invasive species in their national biodiversity strategy and action plans (a biosecurity plan for RMI is currently in draft form; see next section). RMI, FSM (Pohnpei, Kosrae and Yap) and Palau had also completed invasive species action plans (Chuuk now has a draft plan; see Section 6.2.5 below). The review found that while all countries had taken some steps to address the issue of invasive species, major gaps existed in invasive species plans and activities.

In general, countries had done well in recognizing the need for public education and outreach and had engaged in such activities (Pacific Invasives Initiative 2010). Most countries recognized the

need to build capacity of local agencies to address invasive species. Most also had management plans for some species and/or were already engaged in invasive-species management; most acknowledged the need for increasing capacity for invasive-species detection at ports of entry and for revising, coordinating, and streamlining legislation and policy related to invasive species.

Major gaps existed on several fronts: few of the countries recognized the need or had taken steps to gather baseline data on the abundance and distribution of non-native species already present; approximately half of the countries had not recognized the need for or taken action to prioritize which species should be targeted for management or to carry out research necessary for building a best approach to management of priority species. Countries in general had also done poorly in terms of garnering political support, developing pre-export protections (to reduce spread from a country), and including restoration of native species into invasive-eradication projects. Overall, the report concluded that most of the countries did not know how to plan an effective invasive species management program or how to identify and incorporate best-management practices into their programs (Pacific Invasives Initiative 2010).

6.2.5 Local Area Plans in Micronesia

Most of the countries in the region are addressing invasive species either in biosecurity legislation or invasive species plans or both. However, efforts to date have been limited and are mostly focused on terrestrial and to some extent freshwater species. Palau seems to have advanced the furthest in addressing invasive species in general and marine species in particular.

6.2.5.1 Palau.

Palau's National Invasive Species Strategy (2004) includes consideration of marine species and outlines a number of action items:

- 1) periodic review of the country's legal and regulatory framework with regards to invasive species, and the revision and adoption of updates to these as needed;
- 2) preparation of a National Invasive Species Strategy (below), which was drafted nearly simultaneously with the National Invasive Species Policy;
- 3) thorough initial surveys in terrestrial and marine environments to identify and quantify invasive species;
- 4) identification of priority species for management actions, and the identification of areas at greatest risk for entry and establishment of invasive species
- 5) prevention of new invasions, detection through regular monitoring, and management/eradication of established species;
- 6) restoration and re-establishment of native species to be included as part of management activities; and
- 7) cooperation between various local, regional and international agencies working on invasive species.

Many of these items have since moved forward.

Palau's National Invasive Species Strategy (2004), or NISS, acknowledges explicitly the potential importance of marine invasions in a country that depends heavily on a healthy marine

environment. The NISS was written by the country's National Invasive Species Committee, after a review of relevant documents from Australia, SPREP, the Global Invasive Species Programme, the Convention on Biological Diversity, and the Bahamas National Invasive Species Strategy. The NISS lays out a series of objectives to meet four major goals:

- 1) the provision of a national framework for dealing with invasive species;
 - 2) the prevention of new invasions;
 - 3) management of invasive species already in Palau; and
 - 4) coordination with other regional and international organizations dealing with invasive species.
- Additionally, the document details the roles and responsibilities for dealing with invasive species for the national and state governments, traditional leaders and community members.

The NISS was formed after a SPREP-led workshop in 2003, and recommendations from this workshop appear as an appendix to the strategy document. Two specific recommendations for dealing with aquatic/marine species in Palau came out of this workshop: 1) immediate action to eradicate tilapia and 2) working with dive operators to involve recreational divers in hull inspections of yachts and commercial vessels. In addition, the appendices include voluntary codes of conduct for many sectors (vectors), including aquaculture. It was agreed that use of non-native species for aquaculture ought to be discouraged generally, and, wherever used, the species should be contained in secure facilities.

In 2006, the Palau National Invasive Species Committee reviewed the NISS. The committee modified language for clarity and to make several of the major goals and objectives more comprehensive (Palau Invasive Species Committee 2006a, 2006b). The NISS added a fifth major goal, that of increasing public awareness and support for invasive species prevention and management.

Following its review of the NISS, Palau's National Invasive Species Council developed an Action Plan (Palau National Invasive Species Committee 2007). The Action Plan follows the structure of the NISS closely, laying out specific actions to be taken to achieve the goals and objectives of the NISS as well as time frames for these.

Palau took some initial steps to gather baseline data on invasive marine species within its borders. With help from Australian scientists, the NISC and other agencies carried out a training workshop and a baseline survey of its major port in 2007. Several new non-native species were found as a result of this survey and a manual removal of some of these was attempted. In addition, a public awareness campaign was carried out by Koror state on an invasive anemone in Jellyfish Lake (Palau National Invasive Species Committee 2007). To the best of our knowledge, however, there have been no follow-up marine surveys, nor is it clear that any actions are being taken to prevent further introductions to Jellyfish Lake.

Palau also launched major campaigns to eradicate tilapia that involved the assistance and support of many agencies and community members (reviewed by Walsh et al. 2010). Tilapia was also added to the list of species prohibited for import into Palau, although the government is now

reconsidering this (as noted in Chapter 4).

In 2010, during the present analysis, Palau was considering the adoption of a biosecurity bill. The bill would create a Division of Biosecurity, increasing the ability of biosecurity agents to inspect incoming vessels and goods and to act to control or eradicate pest or disease outbreaks. The bill would specifically prohibit the release of bilge or ballast water in Palauan ports (draft version February 2010), but otherwise would not address ship-mediated invasions. Many of its provisions, such as requiring an incoming vessel to submit voyage records prior to arrival, and granting biosecurity agents the power to sample vessels or parts of vessels, would create an initial framework to reduce ship-mediated invasions associated with ballast water and hull biofouling .

6.2.5.2 Republic of the Marshall Islands

At the time of our analysis, the Republic of the Marshall Islands (RMI) was also considering a biosecurity bill, which was nearly identical to Palau's (based on a draft version as of September 2010). In this bill, discharge of ballast or bilge water is prohibited "at sea" in the Marshall Islands rather than specifically in port and the maximum fine for such discharge is \$100,000 (no specific fine is listed in the Palauan bill). This is the only specific reference to marine species and their vectors.

6.2.5.3 Federated States of Micronesia

Chuuk State's Invasive Species Taskforce has developed a draft strategic action plan (Chuuk Invasive Species Task Force Strategic Action Plan, draft version November 2010). The plan focuses on programmatic development, including finding funding and resources, building capacity, increasing coordination between agencies, and generating public awareness. However, it also (a) includes eradication/control measures for two terrestrial plants on the island of Weno, (b) identifies one marine species – the crown-of-thorns sea star (*Acanthaster planci*), a native species which can severely impact coral reefs -- for control measures in Chuuk Lagoon as well as some of the outer islands and (c) calls for 10 surveys in the Chuuk Lagoon and six on outer islands to identify other invasive marine species. No measures for preventing non-native species transfers are addressed.

Kosrae's Invasive Species Action Plan is modeled on the SPREP plan, based on that plan's three major theme areas and nine sub-themes (Section 6.1.3). The Kosrae plan lists specific objectives to achieve the more general objectives suggested by SPREP, however the proposed activities do not appear to meet objectives in many instances. For example, the general Objective 2 in Table B1.2 is "Monitoring invasive species movement on island, and between countries and territories." The matching proposed specific objective is to "review existing port and border surveillance and rapid response arrangements" and the proposed activity is "quarterly visits to Quarantine for bio-security updates." It is not evident how this would result in species-level monitoring information. Although marine species are mentioned in the Kosrae plan, no specific vectors are addressed nor are any actions proposed to deal with marine species.

6.2.5.3 Individual U.S. Military Bases

A publication that reviews 12 case studies of invasive species on military bases and lays out some basic recommendations for the military was prepared for the DoD by the National Wildlife Federation (Westbrook et al. 2005). Among the recommendations is the inclusion of an invasive

species management plan in a base's Integrated Natural Resource Management Plan. The document states such plans ought to emphasize prevention and rapid response and identify target species for which management actions should be detailed. The authors emphasized the importance of education and outreach and coordinating efforts with civilian groups and agencies already working on invasive species. Additionally, they called for specific funding for invasive- species management on bases and for bases to support research on prevention and control techniques. Marine species were not addressed specifically in the plan, either in the case studies or recommendations. As far as we can determine, the report's recommendations have not been officially adopted by the DoD.

6.3 Conceptual Framework for Vector Management

In marine ecosystems, invasions have often resulted from the broad scale transfers of entire species assemblages or communities, such as those associated with ships' ballast water or hull fouling communities. These are relatively non-selective mechanisms and literally thousands, if not tens of thousands, of species may be entrained by them. It is difficult to predict which organisms will be associated with any particular transfer (vessel), let alone estimate with any confidence which of these may cause severe ecological or economic impact. Neither is it easy to predict the next 'new' invasive species, particularly in the tropics. While targeted movement of individual marine species also occurs (as noted in Chapter 4), and some of these species have invaded new regions with negative effects, the fact remains that most invasions are attributed to the above "bulk" transfers.

As a result of this history, marine invasion management and policy has focused strongly on treating the vector, rather than taking a species-specific approach. This is particularly evident in the evolution of ballast water treatment (see Chapter 2 for review). This led Ruiz & Carlton (2003) to outline a conceptual framework for vector management, highlighting the interplay of research, management, and policy. Although motivated by a particular vector, they also considered the general principles and approach to have broad application to other vectors and ecosystems, and even to management of single species.

Figure 6.1 illustrates the four core components of vector management. First, vector analysis (research) characterizes the propagule supply, or species composition and abundance, associated with a particular vector, including the operation of the vector and factors that affect the supply of organisms delivered. Second, vector strength assesses the number or proportion of invasions attributed to the vector. Third, vector interruption (or disruption) represents management action or treatment to reduce the likelihood of transfers and invasions. And fourth, efficacy of vector interruption measures the effectiveness of the action on (a) reducing or interrupting organism transfers and (b) decreasing the establishment of new invasions.

Vector management can be characterized as a stepwise and interactive process within this framework (Ruiz & Carlton 2003). Information about transfers and invasions of species associated with a vector (components 1 and 2, Figure 6.1) form the basis for management action (component 3) to interrupt the invasion process. Following management action(s), it is also important to evaluate the efficacy of this action (component 4), in terms of its intended effect on reducing transfers (4a) and also subsequent invasions (4b). The two types of efficacy measures are complementary and necessary. The former measures the short-term proximate effects of

management on species during the transfer process, and the latter assesses whether the ultimate goal of reducing invasions is achieved.

While each of these components plays a clear and important role in vector management, it is important to recognize that it is the interaction among components that plays a vital role in creating an effective program and desired outcomes for biosecurity. This interaction or relationship among the components forms the basis for adaptive management, whereby initial management actions (component 3) are evaluated (component 4), providing feedback about whether these have been sufficiently effective or whether further actions are required.

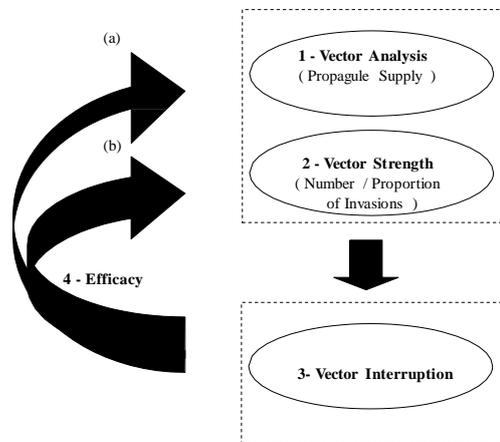


Figure 6.1. Framework for vector management. Vector management consists of four components and the interactions among them: (1) Vector analysis – characterization of vector operation, including organisms transferred by the vector; (2) Vector strength – assessment of the number or percent of invasions attributed to a particular vector; (3) Vector interruption (disruption) – actions taken to reduce the transfer of organisms and likelihood of invasions; (4) Efficacy – measurement of the effect of vector interruption on the transfer of organisms (4a) and number or rate of invasions (4b). [From Ruiz and Carlton 2003, Figure 18.3]

Such a feedback loop is a vital part of biosecurity, as in other areas of environmental management for multiple reasons. First, science often cannot predict the exact quantitative response of actions, due to uncertainties in the available data or sometimes complex mechanisms. Second, management is often based on historical patterns of invasion, which may not anticipate changes that will affect underlying processes and dynamics, such as global trade patterns or climate change (in the case of invasions).

We consider this a useful framework to use in evaluating the operational structure and present gaps for vector management in Micronesia. A successful biosecurity program requires that each of these components, operating together to provide the necessary policy framework, management actions, and directed research for successful management. Moreover, vectors are the functional units that move species, and each vector often involves a specific set of operating requirements, organizations and people, regulations, and information resources. Thus, evaluating biosecurity from a vector management perspective, may more effectively target and transfer specific recommendations to the appropriate user groups.

In the section below, a vector management framework is used to evaluate the existing biosecurity program by vector in Micronesia. This summarizes some information presented previously in the report and uses this background to advance recommendations to address specific gaps for prevention of coastal marine invasions. Additional aspects of biosecurity, beyond those aimed at

prevention, are considered in subsequent sections.

Although the current focus of this analysis is on Micronesia and Hawai'i, many of the same issues and recommendations are relevant to other global regions. This biosecurity plan therefore provides a model to consider for potential broader application, especially for DoD activities, where biosecurity practices are established globally by one entity; in contrast, practices for commercial and other non-DoD activities are highly variable around the world and governed by many different jurisdictions.

6.4 Prevention of Marine Invasions: Vector Management Recommendations

The primary objective of biosecurity is to minimize the likelihood of new invasions and associated undesirable impacts. While biosecurity can include post-border responses to new incursions, such as eradication, containment, and control, a premium is usually placed on pre-border efforts that aim to prevent invasions from occurring in the first place. Prevention, or minimizing the probability and number of new invasions, is usually viewed as the most cost-effective and desirable strategy to pursue, because it can be extremely difficult to eradicate or control species once they have colonized a region (Wittenberg and Cock 2005).

Prevention measures are directed usually at specific vectors and aim to reduce the magnitude (concentration or abundance) and frequency of species transfers to a target area. Such measures may be aimed at entire communities (e.g., ballast water of ships, as discussed in Chapter 2) or particular species of concern, and vectors are an explicit focal point for evaluation and management action(s) in most cases. Thus, vector management is a central aspect of most efforts to prevent invasions, whether on land or in water.

Here, the management of specific vectors is addressed to prevent or minimize marine invasions in Micronesia, considering current efforts and providing recommendations. This is organized by vector, treating separately DoD versus civilian activities, although we recognize that the level of DoD activities (and personnel) in the region also affects commercial and private activities. Our goal is to evaluate and consider three components of vector management (vector analysis, disruption, and efficacy; Section 6.3) in this treatment, focusing on the specific vector itself. This analysis does not yet consider broader issues, such as cross-vector management opportunities, institutional and political frameworks, or coordination and capacity within (and outside of) Micronesia, or post-border management of marine invasions. These other dimensions of biosecurity are discussed in subsequent sections.

In the treatment below, it is assumed that the transfer of non-native species to Guam presents some risk of invasion and impact, as outlined in previous chapters. Controlling for other factors, it is also assumed that the likelihood of establishment increases with (a) increased number of individuals, or propagule supply, of a single species and (b) the number of species. There is strong empirical and theoretical support for these assumptions. While not all species have the same probability of establishment or would result in the same impact(s), both of which would also vary geographically, the information needed to make such distinctions is extensive and simply not available; this limitation results from both a general lack of necessary data and also time. Thus, the evaluation that follows (a) takes a precautionary approach that assumes invasion risk is positively related to magnitude of organism delivery and (b) assumes the goal of vector management is to

reduce the unintentional or unwanted transfer of species and associated probability of invasions; we recognize that the desired level of protection (or acceptable risk) depends upon values, requiring political and social decisions. This approach is consistent with that used to develop existing regulations and guidelines for ballast water management and which is also being used to advance recommendations for management of biofouling on vessels (see Chapter 2).

6.4.1 Military Vessels: (A) Ballast Water

6.4.1.1 Vector Analysis. There have been a few previous studies of organisms in ballast water of U.S. Navy vessels (Holm et al. 2005; Ruiz and Smith 2011), but we could find no such data for vessels arriving to Guam, other parts of Micronesia, or Hawai'i. It is clear from studies of ballast water, that geographic source(s), age, and environmental conditions affect biological contents in ballast water, such that extrapolation from other studies may not be representative of vessels arriving to Micronesia (Verling et al. 2005, National Research Council 2011).

More surprising, there is a conspicuous lack of available information on ballast water discharge and management for most U.S. Navy vessels, or any other military vessels, arriving to Micronesia or Hawai'i. While the Navy has a requirement to record ballast management information in ships' logs, these data are simply not available for analysis. It is not evident that any record keeping is required currently for other DoD vessels. For both U.S. Navy and other DoD vessels, no studies were found that characterize ballast delivery and management patterns in the region.

The lack of data on ballast water discharge and management represents a fundamental gap for effective vector management. Without access to simple reporting data it is not possible to assess the flux (quantity or quality) of ballast, the level of implementation with specific guidelines (see 6.4.1.3), and any gaps in current management practices, as is now undertaken for commercial ships (see Chapter 2).

As noted previously in Chapter 2, there is uncertainty about whether vessels operating under MSC are expected to follow ballast water practices required for U.S. Navy vessels under OPNAVINST 5090.1C, or whether these vessels are expected to follow USCG ballast water regulations for commercial ships when arriving to Guam, CNMI, and Hawai'i. At present, relatively few follow the latter, and most ballast water management and discharge practices are not known for these vessels.

To assess the potential transfers of organisms associated with ships' ballast water, in order to inform appropriate management responses, we recommend that the following minimum steps be adopted by DoD:

- 1. Implement a system for U.S. Navy ships to report ballast water discharge per port arrival in Micronesia and Hawai'i, modeled after that used by USCG, such that the data are compiled electronically at a centralized database.** This should include key information on volumes, sources, and management (treatment). The data are not restricted to port activities but intended to include all ballast operations in Micronesia and Hawai'i. Although the U.S. Navy is required to log these data, none of this information is available, nor has it been examined or evaluated, to our knowledge.
- 2. Extend a ballast water reporting requirement and reporting system to all military vessels operating in Micronesia and Hawai'i, including those operating under MSC and other branches of the military.** This could be the same reporting system outlined in Recommendation #1, to avoid redundancy. If multiple reporting systems, however, they should be designed to assure the same data are collected across vessels, using the same data fields and units of measure.

3. Conduct an initial comprehensive analysis of current ballast water discharge and management patterns by U.S. military vessels, including those operated under MSC and all branches of the DoD, for Micronesia and Hawai'i. This should be part of a report on the current operation of this vector, and it may be repeated at some regular interval, as part of assessing program efficacy (see Section 6.4.1.3).

We note that the number of vessels arriving to these regions is relatively small, compared to similar nationwide and continuous analyses of commercial vessels by USCG. Thus, implementation of these recommendations is not expected to require a large effort, especially as good models for these activities already exist, in the U.S. and other countries, and can serve as blueprints to minimize time and expense in system design.

A reporting and analysis program is a logical and necessary first step in evaluating current marine invasions risks associated with ballast water by military vessels in Micronesia and Hawai'i. Depending on the outcome, an analysis of associated biota may also be needed, as discussed further below.

It is also useful to recognize that such a program for ballast water analysis of DoD vessels in Micronesia could serve as a pilot project for possible broader application. First, this program could be applied to other geographic regions, and perhaps to all regions, because the same issues and information gaps outlined previously apply broadly. Second, an initial analysis would provide a useful baseline, against which ongoing or future data collection and analysis could examine effects or changes in ballast water management and risks (see Section 6.4.1.3).

6.4.1.2 Vector Disruption.

Although the U.S. Navy has requirements for ballast water exchange, these are not as stringent as those for commercial vessels, because the exchange is allowed to occur much closer to shore (see Chapter 2). In addition, the treatment requirements are changing for commercial ships, under pending U.S. regulations and IMO requirements, to the use of technologies to achieve particular concentration-based discharge standards. Although military vessels are not required to comply with the regulations for commercial vessels, it is evident that they frequently will exceed the commercial vessel standards in the future. No plans have been identified or stated by the U.S. Navy to address this disparity.

More broadly, specific guidelines or requirements do not appear to exist for ballast water treatment of vessels operated under other branches of the U.S. military. Under the U.S. Clean Water Act, discharges by military vessels must comply with UNDS. Since 1999, ballast water has been designated as one of the discharges for which standards are being developed, but specific UNDS requirements have not been provided to date (United States Environmental Protection Agency 1999).

Despite the U.S. Navy requirements for ballast water exchange, it is not clear whether vessels operating under MSC — especially those operated under contract that are not Navy-owned must follow Navy requirements for ballast water treatment (as noted above). Moreover, it does not

appear that there are requirements for ballast water treatment by other vessels (e.g., barges and supply vessels) under contract to DoD, including those during the Buildup, other than those that may apply to commercial vessels. As with MSC vessels, however, we believe it is ambiguous to contractors and vessel operators as to which requirements may apply to them, and there are currently no requirements for private or commercial vessels arriving to Micronesia, outside of those in Guam and CNMI (see Chapter 2).

To reduce organisms transferred in ballast water and the associated invasion risks, we recommend the following steps by DoD:

4. Revise and upgrade current treatment requirements for U.S. Navy vessels to converge on those for commercial vessels. The goal should be to (a) increase the distance from shore for ballast water exchange in the immediate and short term and (b) plan for ballast treatment technologies to further reduce the concentrations of coastal organisms in ballast tanks.

5. Clarify explicitly whether current U.S. Navy regulations apply to all MSC vessels. We further recommend that the Navy inform all vessels (including contractors) operating under MSC whether they are subject to U.S. Navy or USCG requirements of ballast water treatment.

6. Establish ballast water treatment requirements for vessels operating under all branches of the U.S. military. We suggest a similar treatment approach to that recommended for U.S. Navy vessels (above), and this could perhaps be accomplished by UNDS. However, there is a premium on timeliness, especially with respect to the Guam Buildup.

7. Establish ballast water treatment requirements for vessels operating under contract to any branch of the U.S. military to include barges, supply vessels, or any other vessel type capable of carrying ballast water. This could include clarification that all U.S. federal regulations apply to these vessels, as well as separate requirements for other countries in Micronesia. We further suggest separate outreach and implementation tools should be considered for contract vessels and contractors, compared to those military- owned or operated vessels (see 6.4.1.3). As above, there is a premium on timeliness, to coincide with the context of expected increases of activity during the Guam Buildup construction phase.

6.4.1.3 Efficacy.

Previous work measures the efficacy of ballast water exchange aboard MSC vessels (Chapter 2), suggesting a greater distance from shore is desirable to minimize transfers of coastal organisms, as recommended above. While these experimental measures or assessments of efficacy are highly informative, there are two other dimensions of efficacy that require additional consideration and attention.

First, it is not clear the extent to which the current U.S. Navy policy is implemented. As discussed above, there has been no evaluation or analysis to verify the frequency of compliance with U.S. Navy requirements. This is perhaps most striking for MSC vessels (as above) and also likely most important here, because these vessels tend to carry and discharge more ballast than surface combatants (United States Environmental Protection Agency 1999). However, we have

highlighted the lack of sufficient data and analyses to assess the performance (compliance) of all U.S. Navy vessels. This is largely an issue of short-term efficacy, evaluating whether the treatment is implemented properly to achieve the desired reduction in abundances of organisms in ballast water (component 4a of vector management; Figure 6.1).

Second, the extent to which new invasions by non-native marine species are accumulating in Guam or other areas is largely undefined. Past surveys indicate invasions are occurring, but the scope and timing of these is poorly resolved, because there are no consistent or long-term programs that exist in Micronesia with this purpose. This data gap presents a challenge for evaluating the long-term efficacy of management for ballast water, as well as all other vectors, to prevent invasions (component 4b of vector management; Figure 6.1). Although such data limitations are not unique to Micronesia (National Research Council 2011), they are more pronounced here than in some other global regions, where (a) more research has been conducted, (b) the biota is less diverse, and (c) the biogeography of organisms is better understood.

While field-based surveys of marine organisms are the only way to address this second measure of efficacy, it is important to also consider briefly the application and interpretation of field survey data. Although this section focuses on ballast water, surveys would in fact have application for other vectors as well. While surveys to test for invasions due to ballast water may focus on particular types of organisms (i.e., those transferred in ballast water), some organisms are specific to ballast water (holoplankton) and others are possibly transferred by ballast and hulls of ships (e.g., many benthic invertebrates with plankton larvae); the potential vectors associated with invasions can be ascribed based upon life-history information of the species (see Chapters 1 and 5). Importantly, for those species invasions attributed to ships, it is usually not possible to know which specific ship(s) caused an invasion, or in many cases whether it was military or commercial. Thus, field surveys provide critical information to know whether particular vectors are allowing invasions to occur, but they usually cannot pinpoint the exact, specific vessel or event responsible. In this sense, such field measures provide a broad indicator of status and trends of invasions, and the extent to which particular vectors continue to result in new invasions, in response to current management practices (vector disruption; Figure 6.1).

Another important application for field surveys is in creating the potential to respond to new incursions, when they occur. There is considerable literature and interest in “Early Detection and Rapid Response” (EDRR) to invasions, which obviously requires a system for detection of new non-native species as they arrive and establish new populations (Wittenberg and Cock 2001; McNeely et al. 2004). Thus, depending on the particular goals for field surveys, they have application for both assessing vector management (invasion prevention) and triggering invasion response (e.g., control, eradication, or containment).

To assess and improve efficacy of ballast water treatment, we recommend that DoD take the following steps:

8. Assess the extent of ballast water treatment (both in terms of percentage of vessel arrivals and discharge volumes) prior to discharge by U.S. Navy and other military vessels arriving to Micronesia. The data for this, as well as the analysis could be a component of Recommendation #3 (above), if implemented. This may need to be done at regular intervals,

especially if and when (a) compliance with existing requirements is low or (b) requirements for ballast water treatment change.

9. Establish a program that implements targeted outreach and administrative tools to increase compliance with ballast water treatment requirements (see Recommendations #4-7) for military and non-military vessels associated with the DoD. This applies to commercial and contracted vessels (including barges and cargo vessels) that operate under contract to the Navy, or MSC, as well as all other vessels that arrive to U.S. Navy or other DoD facilities. For example, requirements could be explained in educational materials and also could be specified in contract agreements. No requirements are specified currently by DoD for many vessel types, and there is uncertainty about what requirements exist (as discussed above). Such a program would apply to U.S. Navy vessels only as needed, if compliance is low or requirements change (see Recommendation #8).

10. Implement a program of field-based surveys in Micronesia, including but not limited to Apra Harbor, to (a) assess efficacy of vector management practices to prevent invasions and (b) provide detection capability for response(s) to new incursions that occur. While this need exists throughout Micronesia, Apra Harbor is a high priority, given the high level of shipping and other vector activities that already exist and are expected to increase as a result of the Guam Buildup (See Chapter 3). This program should involve DoD working in partnership with other federal and local agencies throughout Micronesia. The use of these survey data are not restricted to management of the ballast water vector, but have broad applications. Further aspects of survey design and goals are discussed in Section 6.5.

6.4.2 Military Vessels: (B) Compensating Fuel Tanks

Although the discharge of seawater from compensating fuel tanks by DoD vessels has been suggested to be an activity with a “low risk” of transferring non-native marine species, we were unable to locate any analysis that characterized and evaluated the locations, volumes, and biological content of marine organisms being discharged from these tanks. The classification of “low risk” comes from the Phase I assessment review to develop UNDS, and it results because ships do not generally take on seawater in compensating fuel tanks within ports (United States Environmental Protection Agency 1999). However, vessels do discharge in coastal water or ports, and the sources of seawater in fuel tanks may be near to shore, depending on the particular mode of operations (i.e., where fuel is used and where seawater compensation occurs). Thus, despite the previous assessment, it does appear that transfers of organisms can occur with discharge of seawater from compensating fuel tanks, and that some of these organisms can be coastal species that are non-native at the discharge location.

The extent to which coastal organisms are transferred from one location to another will depend greatly upon the source locations of the seawater used in tanks. Although invasions can occur at many depths and distances offshore, most marine invasions are known from bays or ports, and some are known from adjacent coastal habitats (Chapter 1). Thus, minimizing transfers of coastal organisms, either directly between bays or in close proximity to bays (where adjacent coastal waters be a source or recipient of non-native organisms that can reach suitable habitat for

colonization), has been the main focus of prevention for ballast water management, and a similar rationale would apply to compensating fuel tanks. To our knowledge, the extent (including frequency and volume) with which such transfers occur from discharge of compensating fuel tanks has not been characterized for DoD vessels operating in Micronesia or elsewhere.

Although we recognize many vessels are expected to carry seawater from open ocean sources in their compensating fuel tanks, low frequency discharges of water from coastal sources may pose an elevated risk of invasion. The key question that should be addressed is whether and the extent to which this occurs. To answer this question, and evaluate whether further management is desirable, we recommend that DoD take the following step:

11. Evaluate the locations and volumes of seawater operations (including both uptake and discharge) for compensating fuel tanks discharged in Micronesia. If uptake occurs close to shore, review and revise current practices to achieve one or more of the following outcomes: (a) prevent uptake close to shore, setting specific minimum distance requirements; (b) prevent discharge close to shore, setting a minimum distance requirement, for seawater from coastal sources (as outlined in “a”).

6.4.3 Military Vessels: (C) Biofouling

The U.S. Navy has focused considerable attention and resources in analysis and prevention of biofouling on vessels, as well as the development of methods for hull husbandry. Indeed, it is recognized as a world leader in advancing basic and applied research for this area. However, the primary focus of this effort has been on maintaining operational performance, efficiency, and readiness of the vessel, and not prevention of non-native species transfers and invasions.

As outlined in Chapter 2, a program for maintaining operational performance does not necessarily meet criteria for preventing invasions, as these are two very different objectives that strive for distinctly different outcomes. A vessel can operate within an acceptable range of performance, and still transfer significant numbers of organisms associated with the hull and underwater surfaces, especially in niche areas (e.g., rudders, intakes, thrusters). In the sections that follow immediately, existing practices are evaluated from a biosecurity and vector management perspective.

6.4.3.1 Vector Analysis.

Although the U.S. Navy has specific policies and protocols for assessing biofouling on its vessels (Naval Ships Technical Manual 2006), and collects a significant amount of data in the process, it appears that these have not been used to estimate the extent (including abundance and species composition) of living organisms that arrive on vessels to Guam, other parts of Micronesia, Hawai'i, or other global regions. We did not have access to these data to evaluate their scope and potential application for this purpose.

While the current U.S. Navy program for biofouling assessments applies to Navy-owned vessels, it appears that privately owned vessels under contract to the Navy generally do not participate in this program, including many vessels that operate under MSC. A limited survey of some of the latter vessels, upon arrival to Guam, indicated that the extent of biofouling can be relatively high (Chapter 2).

We are not aware of past analyses or existing programs that are designed to evaluate biofouling associated with amphibious vessels or other DoD vessels that arrive to Guam or other parts of Micronesia.

To assess the potential transfer of non-native species by ship biofouling, we recommend DoD take the following steps:

12. Evaluate the extent (including especially total abundance and species composition) of biofouling on all types of DoD and U.S. Navy vessels operating in Micronesia, including amphibious vessels and vessels operated under MSC. This requires in-water surveys of vessels at multiple time intervals, since biofouling changes through time. Particular attention should be given to “niche” areas (such as sea chests, rudder hinges, intakes, propeller, bilge keels, thrusters, and dry-dock block areas), as these are known to be areas of high-density and diversity. It is also important to include in this evaluation the different types of vessels, operating modes, routes and tempos; all of these characteristics affect biofouling. It may be possible to utilize existing U.S. Navy protocols, or augment these in some fashion, but this should be evaluated to confirm resulting data can address biosecurity dimensions. It should be noted that a small percent cover over much of the vessel can result in a large total number of organisms for the entire vessels, and especially if high-density niche areas are present.

13. Track and evaluate changes in vessel traffic patterns and operations (including vessel types, geographic regions visited, port residence times, and speed) for all types of DoD and U.S. Navy vessels operating in Micronesia, including amphibious vessels and vessels operated under MSC. Variation in vessel traffic patterns and operations affects the quantity and species composition of biofouling organisms and therefore invasion risks (Chapters 2 and 5). While the U.S. Navy collects some of this information on vessel movements and tempo, this is used for a different purpose than biosecurity assessment, and some of these data have not been accessible for this report. An analysis of biofouling on current vessels is proposed in Recommendation # 12 for current military vessel traffic, but this does not evaluate potential future changes in vessel types and behaviors. A system for anticipating and tracking shifts in traffic could serve as an “early-warning” mechanism and trigger an explicit evaluation (as outlined in Recommendation #12; see also next section) for novel types of vessels or vessel operations for the Micronesia region.

Although the DoD must know the voyage histories and other operational details of its vessels, we were not given this information (except for MSC records) and therefore cannot evaluate what exists. However, it appears that a mechanism for ready access and integration of these data across different commands may not exist. Even within a command, there may be missing data for voyage histories, as was found for vessels under MSC. Having an efficient system for access to vessel data, both within and across commands, is necessary to implement Recommendations #12 and #13.

Although we are considering the use of these data for marine biosecurity purposes, such an information resource would no doubt have many other applications within DoD.

It should be noted throughout this discussion on vessel traffic data that no assumptions are made about who would have access to this information. It is understood that security concerns exist for some types of vessels. However, this does not preclude developing an efficient system for vessel information key to biosecurity analysis, and implementation of such an analysis, by DoD or its designees that avoids disclosure of sensitive information.

6.4.3.2 Vector Disruption.

The U.S. Navy has guidelines for management of biofouling to sustain operational performance of vessels (Naval Ships Technical Manual 2006), but it does not have specific guidelines or standards that aim to address the separate biosecurity concerns with biofouling. As noted previously, existing guidelines for both inspections and hull husbandry apply clearly to vessels owned by the U.S. Navy, but there appears to be uncertainty or ambiguity about their application to private vessels operated under MSC, including some prepositioned ships (Chapter 2). In addition, it appears that specific husbandry guidelines or requirements may not exist for the movement of decommissioned DoD vessels or the operation of vessels by DoD contractors (e.g., movement of barges and dredges).

Biosecurity standards for biofouling on commercial vessels are now emerging at the state, country, and international levels (Chapter 2). There is still some uncertainty about acceptable levels of biofouling and also the application of tools (e.g., in-water cleaning and various coatings) to achieve particular standards. Despite some uncertainty about the specific standards, there is nonetheless broad consensus (both in the scientific literature and among advancing standards) that heavily fouled vessels represent a high and undesirable level of marine invasion risk. Thus, a clear priority for vector disruption is in preventing the movement of heavily fouled ships, which carry high abundances of organisms and possibly high diversity.

To reduce the transfer and invasion risk of organisms associated with ship biofouling, we recommend DoD take the following steps:

14. Establish specific biosecurity criteria (requirements) for acceptable levels of hull biofouling for all types of DoD and U.S. Navy vessels, including amphibious vessels and vessels operated under MSC. These criteria should consider and draw upon existing guidelines that have emerged recently in other regions (see Chapter 2). In addition, the biosecurity criteria for biofouling should be included in the Naval Ships Technical Manual (2006) or similar document for application within the U.S. Navy and other branches of the military.

15. Extend DoD biosecurity requirements for acceptable levels of hull biofouling (Recommendation #14) to include vessels under contract to any branch of the U.S. military, such as barges, dredges, and other vessels. Separate outreach and implementation tools should be considered for contract vessels and contractors, compared to those military-owned or operated vessels (see 6.4.3.3).

16. As the highest priority: Implement (a) inspection of vessels operated under DoD with high biofouling potential, due to extended periods of lay ups or port residence times, and (b) cleaning for those that are heavily fouled prior to their movement into, out of, or within Micronesia. This is singled out as the highest priority for immediate action for both military and non-military vessels, as components of Recommendations #14 and #15, because movements of these vessels pose a high risk of invasions. Of great concern are prepositioned ships, barges, dredges, decommissioned vessels, and any other vessels that have extended residence times. To implement this recommendation, residence time (weeks to months) in a port or location should serve as the trigger for such action. While we do not provide a specific model of implementation we note that several options could be considered. The U.S. Navy has an existing program for inspection of vessels, which may serve this purpose for Navy-owned and operated vessels. In addition, the state of California is proposing that commercial operators provide documentation of hull biofouling surveys and cleaning (if needed), at regular intervals and more frequently for vessels with extended residence times; some variation of this approach could also be used for DoD vessels.

17. Review and establish criteria for in-water cleaning methods that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters. The results of this effort should be included in the Naval Ships Technical Manual (2006) or similar document for application within the U.S. Navy and other branches of the military.

6.4.3.3 Efficacy.

As outlined for ballast water in a previous section (6.4.1.3), assessing short-term efficacy of management (prevention) for biofouling transfers focuses on the extent to which biosecurity measures are met. To assess and improve efficacy, we recommend that DoD take the following steps:

18. Assess the extent to which vessels operating in Micronesia under DoD achieve acceptable levels of biofouling, as outlined in Recommendations #14-16. This assessment should include estimates (of percent vessels that meet desired biofouling criteria, as above) according to vessel type, allowing adaptive management to be targeted to address specific issues. The data for this analysis could be a component of Recommendation #12 and #16 (above), if implemented. Additional inspections may be desired, especially where data are insufficient and to ground-truth data for commercial operators. The assessment for this recommendation may need to be done at regular intervals, especially if and when (a) compliance with existing requirements is low, (b) biofouling levels change through time on each vessel, and (c) traffic patterns, vessel types, or vessel behaviors change.

19. Implement targeted outreach and administrative tools to increase compliance with biofouling requirements in Micronesia (see Recommendations #12-16) for military and non-military vessels associated with DoD. This applies primarily to commercial and contracted vessels (including barges, MSC, and other cargo vessels) that operate under contract to the Navy, or MSC, as well as all other vessels that arrive to U.S. Navy or other DoD facilities. For example, requirements could be explained in educational materials and also could be specified in contract

agreements. Such a program would apply to U.S. Navy vessels only as needed, if compliance is low or requirements change (see Recommendation #8).

In addition to these short-term measures of efficacy, there is also a need to assess the extent to which new invasions continue to occur, for which biofouling is a possible vector. The recommended action for this was outlined previously, as Recommendation #10, which was intended to encompass and serve equally to the needs for ballast water, hull biofouling, and many other vectors.

Another potential longer-term approach to assess efficacy (and invasion risk) is in modeling the capacity of organisms associated with biofouling (or other vectors) to colonize environmental conditions present in Micronesia. Since it is likely that some organisms that arrive to Micronesia are not able to survive local conditions, such an approach could refine a risk analysis, removing from further consideration those species that are not able to colonize. Although this is theoretically possible, the necessary data to construct these models are very limited for many species (see Chapter 5), although such studies may be feasible for better-documented taxa, such as marine macroalgae. Perhaps more problematic, the potential number of species being moved on ships in particular is vast, and any modeling would require an extensive program of sampling and taxonomic identification, in addition to knowledge about the organisms' tolerances. This approach certainly has some merits, especially for targeted and limited groups of species, but it also has clear constraints in the scope and speed with which it could be applied from a vector management perspective.

Finally, any specific responses to low compliance or performance of vessels to meet specific criteria for husbandry have not been addressed here, as this is beyond the scope of our analysis and requires consideration of the various institutional tools and approaches available to DoD. However, two different types of responses may be considered here. The first is approaches and tools to increase compliance in the future. The second is a short-term response plan to a breach in biosecurity. For example, if a vessel arrives that is heavily fouled, and may even intend to stay in port for a prolonged period of time, what is the response by DoD? The same question is relevant for vessels expected to discharge untreated ballast water. We recommend that DoD develop a response plan for such breaches in biosecurity, and this may benefit from coordination with other federal and state agencies; this recommendation for such a coordinated response plan is included in a subsequent section.

6.4.4 Commercial Vessels: (A) Ballast Water

Outside of U.S. jurisdictions, there are no existing requirements for ballast water management or reporting by commercial vessels that apply broadly to Micronesia. While a few countries have considered or developed guidelines, it is not clear the extent to which industry (a) knows these exist or (b) follows them. In general, there is a paucity of regional data for vector analysis or to evaluate the extent of vector disruption (ballast water treatment).

While it appears likely that the international treaty (convention) passed by the IMO will come into force in the near future, requiring the global fleet of commercial ships to treat their ballast water before discharge, it is also the case that most countries in Micronesia do not have a program to assess compliance with such ballast water treatment requirements. Thus, outside of U.S.

jurisdictions (which fall under USCG and the Environmental Protection Agency oversight), there is presently no mechanism to enforce or measure efficacy of any international standards for countries throughout the entire region of Micronesia. This gap is largely a lack of capacity, in terms of personnel, training, and supporting data infrastructure. In addition, even if the capacity were to exist, there may also be the need in some countries to legally authorize a lead agency to implement oversight of ballast water management for arriving vessels.

We recommend the following steps for ballast water management of commercial vessels arriving to countries throughout Micronesia:

20. Establish ballast water management and reporting requirements for all commercial vessels (including cargo ships, cruise ships, passenger ships, barges, and any other vessel that can carry ballast water) that operate in Micronesia. While international requirements for ballast management may occur if the IMO requirements are imposed on global shipping, separate regional action may also have advantages, in timeliness or addressing gaps that may exist regionally with IMO requirements. Regardless of the specific requirements implemented, there are currently no reporting systems in place for ballast water management in Micronesia, outside of U.S. jurisdictions, limiting any ability to assess compliance or efficacy of management for this vector. While individual countries could implement this recommendation, a coordinated and consistent regional approach is most desirable, for consistency and efficiency. It may also make sense to establish one regional program for implementation (see Recommendation #21), with participation from member countries.

21. Develop the capacity (personnel, training, and data management infrastructure) to evaluate ballast water management reporting and compliance by commercial vessels that operate in Micronesia. Ideally, this would be an integrated regional program with participation from member countries, because this approach would provide consistency and also economy of scale, especially for data management and analysis. There are many models for structure of such a program, including central coordination and distributed agents in member countries, and participating countries should agree on most desirable and functional model.

22. Review and revise (as needed) legal authority to implement ballast water management program for commercial ships operating in Micronesia, as outlined in Recommendations #20-21. This review should address authority to require reporting, implement inspections of vessels, and any enforcement tools desired in Micronesia.

23. Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of ballast water management requirements (see Recommendations #20) for commercial ships operating in Micronesia. As outlined in previous recommendations, a key component of outreach is regional coordination across the participating countries to provide a concerted and consistent message. A regional program for outreach should be considered, to achieve this outcome as well as economy of scale. If ballast water reporting is required (see Recommendation #20), this could use a web-based reporting system, which could also include a web-based information system on ballast water management requirements for the region.

6.4.5 Commercial Vessels (B) Biofouling

There are presently no requirements for management of biofouling on commercial vessels for biosecurity purposes in Micronesia. When considering a vector management framework, little information is presently available to assess hull husbandry practices or associated biota for vessels that operate in Micronesia. Yet, biofouling is responsible for a relatively large proportion of invasions on a global scale, and it appears to pose significant invasion risks to Micronesia (see Chapters 2 and 5).

Several jurisdictions around the world have voluntary guidelines for hull fouling management, and some of these are moving toward regulations to establish minimum frequency of hull inspection and treatment (e.g., dry-docking, coatings, cleaning). For example, California now requires commercial vessels operating in state waters to submit a Hull Husbandry Reporting Form once a year, as one step to assess potential biofouling based on hull husbandry and operations (especially extended residence periods in port), and has proposed regulations for permissible levels of biofouling.

For some regions, the types of approaches being considered or advanced to identify and treat vessels with potentially high biofouling levels include:

1. Ships agents/captains of vessels must maintain and submit records of anti-fouling measures and recent lay-ups to the harbor staff prior to arrival.
2. Vessels with extended lay-ups must provide evidence of inspection and (if necessary) hull cleaning, to meet acceptable levels of biofouling.
3. Any vessel which cannot present such records must remain in a quarantine area in water greater than 200 meters, in which remote video inspections could be done on the hull of vessels before entry into port is allowed.
4. Harbor staff or other designated enforcement agency staff have the authority to inspect vessels and require out of water cleaning (where possible) and/or refuse entry to heavily fouled vessels.
5. The harbor or other designated enforcement agency retains the right to clean the vessel at the owner's expense (either in dry-dock or with methods that minimize release of organisms to local waters) if it is heavily fouled and/or fouled with species determined to be potentially detrimental to the region.

In general, we recommend that the region develop a similar approach and take the following steps:

24. Establish biosecurity criteria (requirements) for acceptable levels of hull biofouling for all commercial vessels (including cargo ships, cruise ships, passenger ships, barges, dredges, fishing vessels, and other vessel types) that operate in Micronesia. These criteria should consider and draw upon existing guidelines that have emerged recently in other regions (as above; see also Chapter 2).

25. Establish reporting requirements on hull husbandry practices and operational characteristics for commercial vessels (including cargo ships, cruise ships, passenger ships, barges, dredges, fishing vessels, and other vessel types) that operate in Micronesia. Vessels should submit husbandry and operational profile in advance of arrival, and at a minimum frequency (e.g., annually) if in routine operation. If a vessel has a long port residence time or lay up (weeks to months), a new submission should be required.

26. Establish requirements for routine inspection and certification of biofouling levels for any commercial vessel that operates in Micronesia with a long port residence time or lay-up.

Of great concern are barges, dredges, decommissioned vessels, and any other vessels that have extended residence times, because these are prone to heavy biofouling levels. To implement this recommendation, residence time (weeks to months) in a port or location should serve as the trigger for such action. As one model to consider, the state of California is proposing that commercial operators provide documentation of hull biofouling surveys and cleaning (if needed to meet acceptable levels of biofouling).

27. Review and establish criteria for in-water cleaning methods for commercial vessels that do not pose a risk of spreading or releasing non-native organisms (which do not presently occur) in surrounding waters.

In-water cleaning is currently used and is likely to continue as an important management strategy to reduce biofouling on vessels, and there is a need for specific guidelines and protocols aimed specifically at reducing the associated invasion risks. Such guidance is not available in Micronesia.

28. Develop the capacity to (a) assess the extent to which commercial vessels operating in Micronesia achieve acceptable levels of biofouling (see Recommendations #24), and (b) respond to high-risk commercial vessels (i.e., those with high biofouling) that arrive to a port in Micronesia.

The first component requires establishing methods (i.e., protocols for hull biofouling assessment), training, personnel, and data management infrastructure to conduct an independent assessment of vector management efficacy at some interval and stratifies (distributes) measures according to vessel type. This may be repeated if and when traffic patterns, vessel types, or vessel behaviors change. The second component requires development of a response plan to unexpected events, in terms of who responds and the specific details or options for response; the need for response plans has broader application across many vectors, as well as response to new invasions, and is discussed in a subsequent section.

29. Review and revise (as needed) legal authority to implement biofouling management program for commercial ships operating in Micronesia (see Recommendation #24-

26). This review should address authority to require reporting, implement inspections of vessels, and any enforcement tools desired in Micronesia.

30. Implement targeted outreach to inform the shipping industry, ports, and resource management agencies of biofouling management requirements (see Recommendations #24-

26) for commercial ships operating in Micronesia. As outlined in previous recommendations, a key component of outreach is regional coordination across the participating countries to provide a concerted and consistent message.

In addition to measures focusing on incoming vessels, we agree with the recommendations of SRIMP-PAC (South Pacific Regional Environment Programme 2006) that countries should act to ensure that outgoing vessels, particularly those that have been in port for longer than a few days, are not departing with high levels of biofouling. Thus, the above recommendations focus on all operating vessels and are not restricted to just arriving vessels. In this context, relevant authorities may assess vessels prior to arrival or departure and determine that particular actions are required. An ideal long-term goal may be for increasingly broad-based programs, where countries in Micronesia work with SRIMP-PAC and SPREP to encourage Pacific Rim and other importing

countries to develop uniform clean hull standards.

6.4.6 Fishing Vessels

As with other types of commercial and private vessels, there are no marine biosecurity requirements for fishing vessels that operate in Micronesia, except those that may apply to ballast water discharge (see above and Chapter 2). Fishing vessels vary in size, type, and operations, including the extent to which they visit ports. While this may present some challenges in implementation of vector management (including reporting, assessment, and outreach) for these vessels, they are considered here as a type of commercial vessel. **The same recommendations for biosecurity practices on commercial ships, above, apply to commercial fishing vessels that operate in Micronesia.** Those recommendations that focus on biofouling have the most relevance in this regard, as many fishing vessels do not carry ballast water.

In addition to movement of organisms on ships' hulls and ballast water, fishing vessels may transfer live marine organisms in storage tanks (live tanks, storage holds, and wells) and on fishing nets and gear. In many cases, these may not be the fisheries species but incidental associated organisms, which can be small in size and not immediately evident. The extent to which this occurs in Micronesia is not clear, as detailed information is currently not available for the region.

Finally, fishing vessels that are seized and held in port (due to fishing or other violations) may pose an added risk of species introductions, if they are heavily fouled (see Chapter 3). Although a biosecurity program should reduce the occurrence of heavily fouled vessels in the region, it is nonetheless imperative to treat impounded vessels with an added level of scrutiny.

For fishing vessels, we recommend application of the previously outlined recommendations for commercial ships as well as the following:

31. Establish biosecurity practices and requirements for fishing vessels that operate in Micronesia to prevent the release of viable organisms associated with flushing of tanks (live tanks, storage holds, and wells) or cleaning of fishing gear. This should consider (a) the potential use of on-shore facilities for disposal of biological waste and (b) distance from shore (or ports) as a strategy to reduce likelihood of invasions.

32. Implement inspections of any impounded vessel in Micronesia to (a) assess level of hull biofouling and (b) treat vessels (if needed) to reduce biofouling to acceptable level. This recommendation requires specific protocols and capacity, which are addressed in Recommendations #24-29.

33. Implement targeted outreach to inform the fishing industry, ports, and resource management agencies of biofouling management requirements for fishing vessels operating in Micronesia. While this may overlap somewhat with previous outreach recommendations for other types of commercial vessels, it is also important to recognize that this is a unique segment of the vessel traffic. Moreover, outreach for other vessels would not include guidelines for impounded vessels, fishing gear, or unique holding tanks on fishing vessels. Making outreach materials available in multiple languages may be especially important for this segment of the vessel traffic.

6.4.7 Recreational Boats and Yachts

There are no biosecurity guidelines or requirements for hull biofouling associated with recreational vessels that arrive to or operate in Micronesia. Even though some recreational vessels can be heavily fouled, including transient vessels that travel great distances, a lack of biosecurity measures is not unusual for most global regions. However, some programs do exist in some countries to address this gap.

New Zealand has voluntary guidelines for recreational boaters, which are expected to become mandatory shortly. Boaters arriving to New Zealand are asked to arrive with clean hulls, having applied antifouling paint within 1 year of arrival, and to keep logs and records of anti-fouling measures to present to biosecurity agents. These agents inspect a boat's records and carry out hull inspections at ports of first entry into the country. They can also direct boat owners of heavily fouled boats to cleaning facilities where boats are cleaned at the owner's expense.

In Australia's Northern Territory, concern for marine pests (invasions) has led to requirements for recreational vessels entering ports in the Darwin area. Boat owners are being asked to either 1) demonstrate that their boats have been cleaned or painted with antifouling paint in Australia, or 2) undergo a hull inspection and cleaning of internal seawater systems. The cost of inspection and seawater-system cleaning is borne by local government. Both overseas arrivals and boats that have visited other ports in Australia are subject to these inspections.

To reduce risks of species transfers associated with recreational vessels and yachts, we recommend the following steps:

34. Establish biosecurity practices and requirements for recreational vessels that operate in Micronesia to reduce the transfer of biofouling organisms. As the number of recreational vessel arrivals to ports in Micronesia is relatively low, it is feasible to require that all arriving boaters present evidence of anti-fouling measures to port authorities and customs. This paperwork should be reviewed by harbor staff or other management agency prior to a boat's arrival and assessment made of whether a hull inspection is appropriate.

35. Establish the capacity to inspect and treat (if necessary) recreational vessels that operate in Micronesia to reduce associated biofouling to an acceptable level. This recommendation requires identification of acceptable levels of biofouling, methods of assessment (inspection) and treatment, and personnel (with training and authority) to implement. Several risk matrices exist for recreational boats. The matrix developed for the state of Hawai'i (Leonard 2009) should be reviewed and considered for application in Micronesia.

Finally, the Port of Guam master plan suggests that the haul out facility at Perez Marina might not be needed and recommends instead building an inspection, maintenance and repair facility at the Harbor of Refuge. If this occurs, it may have relevance and potential application for biosecurity measures outlined above.

6.4.8 Kayaks, Outriggers and Personal Watercraft

The use of small, personal watercraft can potentially result in transfers of marine organisms. Although the potential magnitude (numbers) of organisms moved may be relatively small via this vector, such transfers can result in new invasions and spread of organisms. Although the current analysis focuses on marine organisms, the potential importance of this mechanism is demonstrated by overland transport of zebra mussels on small craft in North America.

We recommend that the following step be taken:

36. Implement a targeted outreach program for DoD and civilian populations with specific guidelines on methods to minimize species transfers associated with small boats, jet skis, and other water sports gear being moved into or within Micronesia. DoD, Customs, and other agencies could provide DoD personnel, visitors, marinas, and sports shops with a checklist of gear/equipment for use in water that outlines simple, appropriate biosecurity practices. This could be extended to include SCUBA diving, snorkeling, and recreational fishing (see Recommendation # 42).

6.4.9 Amphibious Vehicles

Although protocols exist for removing biota from amphibious vehicles, we were not able to obtain data or locate any reports that assess the efficacy of current protocols in Micronesia, including (a) the extent to which protocols are implemented, (b) the efficacy in removing marine biota, and (c) what residual organisms may exist.

We recommend that DoD take the following approach for biosecurity surrounding amphibious vessels:

37. Assess efficacy of biosecurity protocols and revise (as needed) for DoD amphibious vehicles operating in Micronesia. In general, amphibious vehicles and any in-water gear and equipment that is moved into or within Micronesia should be decontaminated before departure from a location or before redeployment in water elsewhere. If the latter, vehicles and gear should be cleaned onshore, such that all biological material, sediment and wastewater is retained and disposed of properly, to prevent release of biota (including small organisms and resting stages) to waterways in the country or state of entry.

6.4.10 Grounded Vessels

As with impounded vessels, invasion risks may increase for grounded vessels, due to increased residence time for any organisms associated with the vessels' hulls and underwater surfaces. Based on Harbor Rules and Regulations of the Port Authority of Guam (2000), it would appear that the Guam Port Authority has the authority to remove sunken or abandoned vessels on Guam at the owner's expense. However, jurisdiction, response plans, and mechanisms for implementation of desired actions surrounding grounded or abandoned vessels are not so clear in many parts of Micronesia.

From a biosecurity perspective, any response plan should include an assessment of possible biofouling organisms and whether this poses particular risks of invasion, in addition to any

concerns about other impact to the local environment and navigation.

We recommend the following step be taken:

38. Clarify and establish for grounded and abandoned vessels in the various jurisdictions of Micronesia: (a) which agency has the legal authority for removal of grounded and/or abandoned vessels, (b) a response plan that includes assessment and removal of non-native species present, and (c) mechanisms (including funding and training) for implementation.

6.4.11 Other In-Water Structures, Equipment, or Gear

Any objects or surfaces exposed to marine waters can be colonized by marine (biofouling) organisms, and their movement from one location to another poses a risk of non-native species transfer and invasion. In addition to vessels, examples of other in-water structures, equipment, and gear that are moved commonly among locations include:

- Fish aggregating devices (FADs), which are objects deployed for long periods of time to attract fish, including vessels, buoys, and other floating objects.
- Dry-docks.
- Floating docks or pontoons, such as those in marinas.
- Fixed maritime structures, which are sometimes constructed elsewhere from new material or refurbished materials, are held in-water at other locations (including overseas) before transport and deployment.
- Mobile platforms, drilling rigs, and related equipment, such as used for oil and natural gas drilling/exploration.
- Buoys and channel markers.
- Scientific equipment.

All of these particular structures often have extended in-water residence times in one location before movement (if it occurs) to another location. In fact, many of these structures are known to accumulate dense aggregations of biofouling organisms, and examples exist in the published literature that document the movement of these structures (and sometimes very dense biofouling) among locations without any treatment. Importantly, this movement can occur across large geographic distances, introducing novel non-native biota.

At the present time, there are no biosecurity requirements for the movement of these and other similar structures into or within Micronesia. This represents an important gap in preventing non-native species transfers. Even though the frequency of moving these structures may be low, such

rare events have the potential to represent high-density inoculations of marine organisms in the absence of any assessment and management action (where needed to reduce such transfers).

We recommend the following steps be taken:

39. Establish biosecurity practices and requirements for the movement of any in-water structure (including FADs, dry-docks, floating docks, fixed structures, mobile platforms and drilling rigs, buoys and channel markers) to reduce the transfer of biofouling organisms into or within Micronesia. This recommendation includes establishment of acceptable levels of biofouling and also the legal authority to implement these practices in the various jurisdictions.

40. Establish the capacity to inspect and treat (if necessary) in-water structures that are being moved into or within Micronesia to reduce associated biofouling to an acceptable level. This recommendation requires specifying methods of assessment (inspection) and treatment, a lead agency with authority, and personnel (with appropriate training) to implement.

Because the movement of some types of in-water structures by DoD has occurred historically, and may occur in the future, this recommendation applies to both DoD and the various countries of Micronesia, understanding that the particular assets or structures may differ among jurisdictions.

6.4.12 Construction Materials

Movement of construction materials can transfer associated marine organisms, especially when materials are moved directly from one in-water or shore location to another. Examples of construction materials that are commonly moved from one geographic source location for application or disposal at another, which can transfer organisms, include: sand, gravel, rock, coral rubble, and dredge spoils. Even a brief holding period (days to weeks) out of water may not prevent biotic transfers associated with construction materials, because some organisms (and their resting stages) can persist out of water for long periods, especially under damp conditions. We recommend the following biosecurity measure:

41. Establish biosecurity practices and requirements for the movement of any construction materials that are sourced from marine waters and shores (including sand, gravel, rock, coral rubble, and dredge spoils) to reduce the transfer of marine organisms into or within Micronesia. This should include consideration of sources, treatment (including extended holding periods on land), and certification or inspection to confirm implementation.

This recommendation applies to both DoD and the various countries of Micronesia, as construction and construction materials are used by all entities.

6.4.13 Diving and Recreational Fishing Gear

Movement of diving gear and recreational fishing gear has the potential to transfer non-native marine organisms among locations, even though in-water exposure is episodic relative to structures and vessels (above). Invasions appear to have resulted from this mechanism, including invasions by zebra mussels in isolated quarries used for diving in the eastern U.S.

(<http://www.dgif.virginia.gov/wildlife/zebramussels.asp>).

To minimize the transfer of organisms, we recommend the following step:

42. Implement a targeted outreach program for DoD and civilian populations with specific guidelines on methods to minimize species transfers associated with diving gear (whether work or recreational) and fishing gear being moved into or within Micronesia. DoD, Customs, and other agencies could provide DoD personnel, visitors, sports shops, and marinas with a checklist of gear/equipment for use in water that outlines simple, appropriate biosecurity practices. This could be extended to and coordinated with a similar effort for recreational small water craft (see Recommendation # 36).

6.4.14 Live Trade of Marine Organisms

It is evident that live trade, or the moving of live marine organisms, is common practice around the world, especially associated with aquaculture, food, bait, and pets (aquaria). Micronesia is no different in this regard. While there are some current biosecurity measures focused on live imports and aquaculture throughout the region, there are also inconsistencies and some gaps, and no overarching framework has emerged to date.

The International Council for the Exploration of the Sea (ICES), established in 1973, has developed a code of practice for reducing the negative impacts of non-native species associated with aquaculture and fisheries enhancement. This code, which is being promoted by the Food and Agriculture Organization (FAO), the IUCN, the Convention on Biological Diversity (CBD), and other international organizations, has since been revised several times. The current version (International Council for the Exploration of the Sea 2005) also covers organisms imported live for other purposes, such as food and bait, and includes practices to reduce the spread of disease and exotic genetic material.

ICES asks member countries considering new introductions to submit a detailed prospectus, including a risk assessment, to ICES for comment. Following an approval, countries are asked to adhere to a set of management guidelines for that species and to submit follow up reports to ICES. This process is largely advisory in nature, with implementation up to the countries involved, as ICES does not have regulatory oversight for participating countries.

Detailed guidelines for implementing the code are provided in three ICES documents (International Council for the Exploration of the Sea 1984, 1988, 2005). Appendices in these documents detail the preparation of the prospectus, risk assessment, quarantine procedures and monitoring.

Guidelines for species introductions for aquaculture were also developed and adopted by the FAO. These are outlined in two technical reports (Food and Agriculture Organization 1995,1996). The FAO advocates for the use of local species when production strategies are known and feasible; and it recommends the introduction of exotic species when the positive benefits are higher than possible negative impacts, always applying the precautionary approach when there are big information gaps. Taking the stance that all imported species will eventually escape the confines of their facility, the FAO recommends that risk assessments should be based on the assumption that these constitute introductions into the wild. Thus, the guidelines recommend that if a species is

approved for importation, a contingency plan for dealing with escape and mitigation of impacts ought to also be in place, and that the importing country should establish the legal framework for funding for such plans (Food and Agriculture Organization 1995).

The Secretariat for the Convention on Biological Diversity (CBD, 2004) has also published a series of recommendations for the development of sustainable mariculture. Like the FAO, the CBD recommends the use of endemic or native species in mariculture, and whenever possible, of culturing in contained facilities, rather than in open pens.

Finally, as noted previously, guidelines for evaluation of diseases and quarantine measures of aquaculture species have been recommended by SPC (Humphries 1995; see Section 6.2.2 above).

In general, we recommend that Micronesian countries and territories adopt the protocols and approaches outlined by ICES, FAO, CBD, and SPC. While some of these protocols are for a particular segment of live trade (e.g., aquaculture), their application should be considered more broadly to include all movement of all live marine organisms intended for the aquarium or pet trade, bait, scientific research or any other purpose that could result in the organism being released into the environment.

We recommend that the following steps to taken:

43. Establish explicit aquaculture biosecurity practices for Micronesia. This includes identification and adoption of specific protocols for risk assessment (see Recommendation #44, below), screening of pathogens, quarantine, inspection, and regional program oversight or assessment. A key dimension requires coordination and active involvement of relevant agencies and groups such as resources development, community colleges and invasive species management organizations. National, state, local/traditional governing bodies need to specify (and perhaps authorize) lead agencies and also oversight authority.

44. Establish a formal risk assessment process for all marine organisms used or proposed for live trade in Micronesia. The risk assessment should be science-based and applied consistently; the precautionary principle should be applied in cases where data are absent. Many references and toolkits for the development of risk assessment are available (i.e., International Council for the Exploration of the Sea 2005; Secretariat of the Convention on Biological Diversity 2010). Forums for sharing data relevant to risk assessment across the region should be developed. Risk assessments should be carried out for species already in trade or on already-developed “white lists.”

45. Create quarantine facilities for marine organisms for use in Micronesia. This may be a single regional facility or multiple facilities; if the latter, consideration should be given to having at least one facility with high-level technical capability and infrastructure. The facilities should follow specific, accepted protocols (see Recommendation # 43). The facility must have trained staff to carry out protocols, and must be sited in a secure location to minimize risks of accidental releases due to natural disasters such as typhoons, tsunamis, and floods.

46. Improve reporting and screening systems for import of live marine organisms in Micronesia. Ideally, prior to import, organisms would be identified to species and certified as free

of disease or associated by-catch organisms (such as additional species of invertebrates). Reporting or labeling for shipments would facilitate and improve biosecurity screening and reduce unwanted imports.

47. Provide quarantine agents in Micronesia with the necessary legal authority, training, and support to enforce requirements at border entry and post-border locations (e.g., aquaculture facilities and sales outlets). Capacity building and institutional strengthening of quarantine officers and agencies on aquatic biosecurity measures and aquatic animal health will be crucial for biosecurity management. There is currently a large knowledge gap on aquatic biosecurity within the agencies that will be tasked with implementing biosecurity measures.

Although Micronesia is a large and diverse region, with many cultures and jurisdictions, the recommendations for biosecurity practices of live trade apply throughout the region. Advancing a uniform and consistent approach to biosecurity throughout the region is most desirable, because it would likely reduce the effort and cost and would serve to increase clarity and possibly compliance, compared to an uneven patchwork of requirements and guidelines. Thus, communication, coordination, and participation among all member countries and jurisdictions in Micronesia is a critical approach toward this outcome.

6.5 Detection of Marine Invasions: Recommendations

Detection plays a vital role in implementing an effective biosecurity program. First, detection is used in vector management to assess (a) the extent to which new invasions are occurring and (b) the vector(s) responsible for these invasions. Repeated measures over time assess the efficacy of vector management to prevent new invasions, providing a core component of the vector management framework discussed above (Section 6.3; see also Figure 6.1). Second, the detection or occurrence of non-native species, and their geographic distribution, forms the basis for responses to new incursions, including eradication, control, or containment. Put simply, without knowledge of existing invasions no such post-border responses are possible.

Field-based surveys are required for both applications of detection. Moreover, it is critical that surveys are conducted using standardized and quantitative measurements that are repeated over time, if a goal is to understand temporal changes in non-native species diversity (number) at a site associated with particular vectors. It is clearly possible to detect species occurrences with many methods, but we suggest that assessing differences in time or space requires a formal, statistical approach (Ruiz and Hewitt 2002; Ruiz and Carlton 2003).

The design of field-based surveys should be driven by the particular objectives. Some of the key variables to consider include taxonomic focus, habitat focus, frequency, geographic scope, and specific methods. Methods include not only those surrounding the collection and analysis of biotic samples, but also issues of data and sample management or continuity (see Ruiz and Hewitt 2002 for discussion), especially if an objective is to provide comparisons with long-term measures, which engage different people (with staff turnover) through time. In addition, the use of genetic tools is a valuable component of surveys, providing (a) independent verification of taxonomic identification and (b) new methods to efficiently screen large numbers of species, using next generation sequencing /NGS (Hayes et al. 2005; Darling and Blum 2007; see National Research Council 2011 for brief discussion). However, prior to embarking on massive environmental

sequencing using NGS technologies, it will be necessary to build a DNA barcode library for the fauna and flora of the region. This will allow identification of environmental sequences obtained through NGS. One way to achieve this may be to undertake molecular-assisted alpha taxonomic studies (i.e., DNA barcoding-assisted taxonomic studies), which would provide rapid, standardized, quantitative, and reproducible results, particularly for insufficiently studied biota characterized by cryptic species (which is the case for almost all marine benthic taxa). The costs of DNA sequencing are rapidly going down, so in the near future this may be the most cost-efficient, as well as time-efficient, manner to undertake field-based surveys.

We recommended previously that a program of field based surveys be implemented in Micronesia, in part to assess vector management by DoD associated with vessels' ballast water and hull biofouling. Recommendation #10 states: "**Implement a program of field-based surveys in Micronesia, including but not limited to Apra Harbor, to (a) assess efficacy of vector management practices to prevent invasions and (b) provide detection capability for response(s) to new incursions that occur.**"

Here, further detail is provided to design and implement such a program, with a particular focus on these shipping vectors. While this is relevant to DoD activities and associated biosecurity, such a program also has relevance to commercial shipping in Guam and other regions of Micronesia.

We recommend the following steps be taken to advance a program of field-based surveys in Recommendation #10:

48. Develop a specific design for standardized, quantitative, and repeated field-based surveys for detection of non-native marine species in Apra Harbor, Guam, especially to examine species invasions through time associated with DoD and commercial vessels. We recommend that DoD assume a lead role in developing the design of these surveys, as well as their implementation (Recommendation #10), working in close partnership with (a) other federal and local agencies in Guam and (b) other countries and jurisdictions in Micronesia (see below). Surveys should focus on invasions due to shipping, because it is a dominant vector for marine invasions. In addition, an initial focus should be on Guam, because it is a regional hub for shipping in Micronesia (see Chapter 3). The design should explicitly define the taxonomic focus, habitat focus, methods for collection and analysis, frequency of sampling, and study duration to detect changes in non-native species diversity (i.e., new invasions) attributed to ships ballast water and biofouling through time. As noted above, these data examine the efficacy of vector management to prevent new invasions.

49. Develop a specific design for standardized and quantitative field-based surveys to compare non-native marine species present in Apra Harbor to other bays and ports in Micronesia, focusing particular attention to species invasions associated with vessels. We recommend that DoD also assume a lead role in developing and implementing these surveys. This is intended to examine geographic distribution of non- native species present in Guam (that resulted from transport by ships) and the extent of spread to other locations in the region. These data examine the efficacy of vector management to prevent the spread of invasions from Guam to other regions. Ideally, these surveys would be repeated over time, although perhaps at less frequent intervals than above (Recommendation #48). In addition to the broad-based surveys, a more focused and intensive approach could also be advanced for a few species, serving

as important model systems or indicators to understand spread dynamics (risk) in the region.

The above recommendations address the need to rigorously assess the pattern and rate of invasions to support vector management, including especially efficacy of current prevention measures, but do not provide a mechanism for early detection. New invasions may certainly be detected at an early stage in such surveys, but these are not designed explicitly for the purpose of early detection. To implement early detection capability, there are two general types of approaches that are used:

- First, field-based measures are explicitly designed and used to detect selected species of concern, focusing on sites where incursions are likely. These are usually focused efforts for known species, allowing tailored protocols (such as those implemented for brown tree snakes) at key points of entry; the goal here is intensive and efficient measures, instead of broadly trying to achieve early detection for many species at once.
- Second, a public outreach effort and reporting system is established to encourage any new or suspected non-native species to be detected. These can be either focused efforts (and complementary to the first method) for particular species of concern, or very broad-based efforts to include many species, taxonomic groups, and habitats. This approach obviously benefits from many potential observers who may encounter non-native species, either due to search or accident, and it is clear that many new marine invasions are first detected by the public (e.g., Chinese mitten crabs along the eastern U.S., Ruiz et al. 2006).

To be useful and effective at early detection, both approaches require personnel time and resources. This is most obvious in the first approach. For the second approach, the actual detection effort is distributed broadly, which has clear advantages and perhaps little direct cost, but it is also important to recognize that personnel are required for coordination (including communication and outreach) as well as verification and tracking of reported sightings.

To develop early-detection capacity for marine invasions, we recommend the following step:

50. Design and implement a public reporting system for new or suspected non-native marine species in Micronesia, as a component of education and outreach efforts in the region. This system could be designed for focus on particular species of concern (see next section) or provide broad-based early detection capability. This system should include a permanent hotline number and website, allowing the general public to report suspected non-native species and also provide a portal for additional information on non-native marine species, current policies, and actions throughout Micronesia. This contact information should be included in public outreach/education materials. A specific lead agency should be designated and provided sufficient trained personnel to respond to inquiries from the public, as part of the overall biosecurity program infrastructure for Micronesia (see Section 6.7.3). This reporting system, and overall program, must obviously be designed and implemented as a partnership between DoD and other agencies and jurisdictions throughout Micronesia. Some information is already shared within and among countries on an informal basis, and this reporting system would serve to (a) build upon current efforts, (b) establish a stronger framework, and (c) contribute to a regional database on non-native species records.

Focused early detection efforts, using the first approach above with field surveys to detect target species of concern, are considered further as possible responses in the next section.

6.6 Response to Marine Invasions: Recommendations

Throughout this chapter, a premium is placed on steps to prevent new invasions, as the highest priority for marine biosecurity, but we also recognize that there will be breaches of this security, occurring either as (a) the delivery of non-native organisms associated with a particular vector or (b) the establishment, colonization, or occurrence of non-native organisms in the natural environment. In each case, it is appropriate and desirable to consider a response plan to limit undesired impacts or outcomes associated with a breach or incursion. Part of this plan is a clear decision process about when and how to respond, as well as who should respond.

In Section 6.4 on vector management, specific recommendations were outlined for assessing and detecting breaches in biosecurity, during the transfer (vector) stage. For a breach at the vector stage, such as the arrival of a vessel that exceeds an acceptable level of biofouling, these previous recommendations included the development of a response plan; this is intended to define specific response actions, how and when to implement them, who would implement them, and the necessary resources to implement them.

A similar response plan is needed for a new incursion and breach at the invasion (colonization) stage, serving to define first if a response is triggered and then the nature of the response. The decision of whether to respond to a new invasion is a complex one, as it depends upon many factors, including: (1) the potential consequences or impacts of the invasion; (2) the chances of success or feasibility of achieving a desired outcome; and (3) the capacity and available resources needed for action.

In recent years, several non-native marine species have been the focus of successful eradications, demonstrating the feasibility of such efforts to achieve the desired outcome (Culver and Kuris 2000; Bax et al. 2002; Miller et al. 2004; Anderson 2005; Hopkins et al. 2011). However, not all invasions are conducive to eradication (or control and containment), as the effort and likelihood of success depends greatly upon the organism, its areal extent and abundance, and particular treatment options (Myers et al. 2000; Crombie et al. 2008; Edwards and Leung 2009). Furthermore, the consequences of invasions will differ among species and locations, reflecting the type and magnitude of effects as well as the social values in a region (see Appendix A).

Ideally, a response plan for new incursions would begin with an analysis of costs, benefits, and feasibility of achieving a particular outcome or objective, before proceeding to implement specific actions. The initial part of this two-step process is important for setting priorities, because (a) it is simply not possible to implement actions for all invasions with limited resources and (b) only a subset of non-native species will have high impacts. Unfortunately, the initial analysis step often requires data on the impacts of a species and the value assigned to those consequences (in addition to feasibility), which may not yet exist. Furthermore, where data on potential impacts are available, it is important to consider the level of uncertainty about how robust or relevant the data are for the region (Micronesia). Evaluating this information is thus central to establish an efficient response capability, and may guide the design of detection efforts (see Recommendation #50).

To develop a response plan for marine invasions, we recommend the following steps be taken:

51. Evaluate social, cultural, economic, and ecological values in Micronesian countries that may be impacted by invasions by non-native marine species. This follows and expands directly upon the pilot project (Appendix A) to adequately characterize core values at risk to invasions in the region, for inclusion broadly in decisions about management and response. The new survey must be statistically adequate, in order to begin to answer some of the questions raised in Appendix A.

52. Establish a watchlist of high-risk non-native marine species that are known or thought to pose significant ecological, economic, social, or cultural impacts to Micronesia, focusing on species that are not established or widely distributed in the region. This list should be developed by experts based upon evaluation of those species that (a) have known invasion histories (or unusual potential for invasion), (b) are thought to pose a high risk to core values, (c) are likely to survive regional environmental conditions, and (d) are likely to be transported by known vectors in operation in Micronesia. We recognize various methods could be used to evaluate these four criteria, from quantitative to qualitative, and given existing data limitations for all criteria and species, this is not a precise process. The resulting list is not intended to be comprehensive but serves to identify a list of potential high-impact species for possible management action, including detection (see previous section) and response. Although there is no specific target number of species for this list, limiting this to a small and manageable number has clear advantages for some applications, such as detection.

53. Develop a detection program and response plan for new incursions by a few focal non-native marine species on the watchlist of high-risk non-native marine species for Micronesia (see Recommendation #52). Species should be selected from the watchlist, based upon detection ability (due to size, morphological uniqueness, habitat distribution) and perceived severity of invasion consequences. The goal of this recommendation is to establish a demonstration project, using a few high-impact species to develop this response capacity and experience, instead of a program with comprehensive coverage. Ideally, the detection program would include focused surveys and a public reporting system (Recommendations #49-50), using these focal species as model system to develop these capabilities.

6.7 Implementation and Capacity: Priorities and Recommendations

This chapter is intended to provide recommendations for marine biosecurity and best management practices in Micronesia, addressing current gaps that exist across all sectors of activity (military, commercial, and private). This is a large scope for even one country, let alone for many countries that span such a broad range of cultures, activities, and geography. While we have addressed key areas of marine biosecurity in the region, there are no doubt some omissions, due to the scope of the endeavor and available time.

The effort to implement all of the proposed recommendations for Micronesia is extensive and may appear daunting, requiring considerable capacity that does not now exist. Although development of these recommendations is linked to the Guam Buildup, it is important to recognize that (a) these are core elements and objectives for a regional biosecurity plan and (b) the timeline for implementation of each recommendation is not yet specified. As indicated elsewhere in this report, the specific timeline and extent of implementation is obviously contingent upon available

resources for this purpose. Defining the specific timeline, resources, and responsibilities for implementation is beyond the scope of this report, requiring a detailed implementation plan produced by DoD in partnership with other parties (i.e., agencies, jurisdictions, organizations, and groups) in Micronesia to address these elements.

From the onset of our analyses, an implementation plan was specified as the next stage in the process, for which this report would provide necessary background and recommendations. In an effort to help advance an implementation plan, however, we provide some priorities and also discuss possible approaches and structural aspects for implementation in the sections below.

6.7.1 Initial Priorities for Implementation

A clear priority is the prevention (reduction) of marine species transfers associated with the movement of vessels and in-water structures. This applies to any movements to Guam, other parts of Micronesia, and Hawai'i. This applies to DoD activities, including: (a) the movement of any vessels, whether owned by the DoD, operated by MSC, or operated by a contractor (either under MSC or for another purpose); and (b) the movement of any in-water structures such as dry-docks, piers, dredges, and platforms. This applies equally to movement of any vessels or in-water structures for commercial or private use.

This area is emphasized as a priority for multiple reasons. First, the movement of vessels and in-water structures is a dominant source of non-native species transfers and invasions on a global scale. Second, it is clear that there are critical gaps, and a lack of clarity, in biosecurity in Micronesia for management of these vectors, leaving the door open for species transfers to occur by such movements (Section 6.4; see also Chapter 2). Third, there is a high level of regional connectivity of vessel movements in Micronesia, creating the opportunity for spread of associated non-native organisms (Chapter 3). Fourth, some vessels are known to arrive to Guam with high levels of biofouling (Chapter 2). Fifth, increased movement of vessels into Guam is expected during the Buildup, including those types of vessels (e.g., barges) prone to high biofouling, creating an additional sense of urgency.

While many specific recommendations have been made in this chapter to establish a broad-based biosecurity approach surrounding movement of vessels and in-water structures (and materials), we also have underscored throughout the **critical need to address vessels and structures that have high levels of biofouling.** The movements of such in-water assets (with high biofouling) pose relatively high risks of invasion and spread of non-native marine species in Micronesia, but specific biosecurity requirements on acceptable levels (or management) of biofouling do not exist for movement of these assets, either within or outside DoD.

Thus, **one of the highest priorities for rapid implementation are the specific steps to identify, assess, and treat (if necessary) vessels or structures that have propensity for the highest biofouling accumulations.** Specifically relevant to DoD activities in this regard are steps outlined in Recommendations #14-19, 39, and 40; a parallel set of recommendations are provided for commercial and private activities. In addition, we recommend that any vessel or structure with a long residence time (weeks to months) in a location or uncertain hull husbandry should receive an explicit, high level of scrutiny before movement among locations. While long residence time can occur for any vessel, certain vessel types are particularly prone to experience long residence times,

including:

- Preposition ships operated under DoD;
- Mothballed or decommissioned vessels (either military or commercial);
- Barges and dredges (used in support of military or commercial activities);
- Any laid-up vessel.

The planned, predicted, or observed arrival of any vessel or structure with history of long residence times in a location should trigger an assessment and response, to achieve effective vector management. While establishment of a reporting (detection) system was recommended to identify vessels with potential high biofouling levels (see Section 6.4), a critical aspect is training for assessment and response. Thus, we emphasize the need to implement an education and training program in order to identify and respond to vessels (and structures) with high biofouling levels. Ideally, such training would be done as a single program, together for DoD and commercial activities, including the various countries and responsible agencies throughout Micronesia (see also next Section). This approach would serve to provide a consistent approach and avoid redundant efforts, and also address the full spectrum of commercial and military assets that may operate under the DoD, especially when considering activities by contractors.

The movement of vessels and in-water structures are identified as a high priority for rapid implementation, providing the rationale for this selection, but we do not imply that other recommendations are low priority. Movement of organisms with live trade (such as aquaculture) or other vectors also poses significant risks, which should be mitigated and reduced. Indeed, invasions that result from any vector have the potential to cause severe impacts, even if they occur at low frequency. Vessels and in-water structures were selected merely as a dominant vector and starting point to advance regional biosecurity in marine ecosystems.

6.7.2 Approaches to Implementation

We have attempted to provide a strong conceptual framework as the basis or set of organizing principles for our recommendations, which are presented and organized by vector in this chapter. As a result, many of these recommendations are closely related, with strong parallels (by design) across vectors. The intention in creating these separate recommendations (#1-53) was to identify explicit needs and steps for a marine biosecurity plan. However, implementation should be advanced as a coordinated and integrated approach, organizing according to the parallel themes and objectives.

An integrated approach would serve to streamline the overall effort and resources required for implementation. This is perhaps best exemplified by considering vector management for ballast water and biofouling of vessels, including both DoD and commercial vessels across Micronesia:

- First, approaching recommendations for the entire Micronesia region, with full participation of member countries, offers clear economy of scale. There are relatively few vessel visits in Micronesia overall, compared to some global regions. Most vessels visit

Guam, and many of these vessels visit multiple countries (instead of completely novel vessels to each country). This suggests that some data collection and assessment needs can be combined efficiently on a regional scale, rather than conducting completely separate programs.

- Second, there is strong overlap between activities recommended for DoD and commercial vessels, such that there is excellent opportunity to jointly develop and implement some activities, especially in establishing uniform methods, criteria, response plans, and outreach components.
- Third, although recommendations were developed for ballast water and hull fouling as separate vectors, some of the reporting, training, infrastructure, and legal framework components can be combined effectively.
- Fourth, a regional approach to implementation (with similar standards and approaches) also serves to simplify and create a consistent, uniform message for outreach and implementation by the diverse sectors involved in operating and managing vessels.

An integrated approach does not require any specific assumptions about authority or oversight for implementation of specific components, as no recommendations were made in this regard. Instead, an implementation planning process is suggested that seeks simply to integrate activities in order to enhance coordination, efficiency, and consistency.

One approach and a logical next step to advance an implementation plan would be to create a matrix (table) of recommendations that is used to characterize the scope and possible integration of specific actions. For each recommendation, the initial goal would be to develop a matrix that lists of the following information:

- 1) Specific vector (e.g., all cargo ships, barges, fishing vessels, live food, pet import).
- 2) Specific type of actions required by category (e.g., recording, inspection, treatment, outreach, training, protocol development, criteria for acceptable level of vector operation).
- 3) Current agency responsible for each type of action (if one exists) by each jurisdiction in Micronesia. [Note: this does not imply responsibility for funding or capacity to implement.]
- 4) Likely responsible agency in each type of action by jurisdiction in Micronesia. [Note: this does not imply responsibility for funding or capacity to implement.]
- 5) Estimated cost associated for each type of action, including that for each jurisdiction and for Micronesia overall.
- 6) Estimated time required to implement each type of action (assuming available resources exist), including that for each jurisdiction and for Micronesia overall.
- 7) Estimated recurring cost (if one exists) for each type of action, including that for each jurisdiction and for Micronesia overall.
- 8) Possible sources and amounts of funding to implement each action, including that for each jurisdiction and for Micronesia overall.
- 9) Priority for each action according to jurisdiction and overall.

This information serves to outline the operational details for implementation and could be used to evaluate feasibility, timeline, cost, responsibilities, coordination and integration for the specific

actions. It would be useful to consider various levels of effort for each of the cost estimates (e-g, above). This overall approach would provide a solid basis developing an implementation plan. By necessity, collecting this information would require involvement, participation, and partnership among the various jurisdictions in Micronesia.

Although this treatment is focused on biosecurity for marine habitats, coordination and integration of activities with those in terrestrial and freshwater environments should also be evaluated. This may be especially relevant and useful for overall program structure, communication, and outreach activities. In addition, we recognize that border control, customs, and other agencies within Micronesia likely operate across these boundaries already.

6.7.3 Structural Aspects of Implementation

Many of the specific recommendations made in this document cannot be put into place without some institutional and structural changes, which require the cooperation and coordination of agencies throughout Micronesia. There is also a need for increased communication and integration in activities, if the goal of implementing a truly regional plan is to be realized.

To provide some of the structural capacity of the Micronesian region to deal with marine invasive species, we recommend the following:

54. Create a single program, the Micronesian Marine Biosecurity Facility (MMBF), to serve as a focal point, coordinating body, communication and information center, and training resource for marine biosecurity activities throughout Micronesia. The MMBF would not replace the need for biosecurity activities within the individual countries but instead would serve as a resource center for the Micronesian countries, agencies, industry, and the public to (a) provide training and advice, (b) develop protocols and methods, (c) help establish detection and response capability, (d) implement education and outreach campaigns on a regional scale, (e) characterize current regulations and guidelines that exist, and (e) seek and coordinate regional funding. The MMBF could also serve as a central data center for reporting, analysis, screening, and maintaining records for vector activities or non-native species information (see Section 6.4). The MMBF should be formed as a formal partnership among the countries of Micronesia.

55. Establish a Memorandum of Understanding (MOU) among government agencies and the DoD departments establishing a response plan and command structure in cases where urgent action by multiple agencies is needed to respond to marine biosecurity. Responses to non-native species are often delayed when such a response plan and structure are not in place, especially when multiple agencies or jurisdictions are involved (Anderson 2005). Moreover, this MOU would allow joint action across countries within Micronesia, rather than requiring independent capacity be developed in each country. If it is not possible to have such a MOU across government and military jurisdictions, then we recommend the development of parallel command structures with an agreement to coordinate efforts through joint activities of the commanding officers.

56. Identify and establish a source of dedicated, long-term funding to implement marine biosecurity recommendations outlined in this chapter. While the type of analysis discussed in section 6.7.2 provides one approach to identify funding needs and possible sources, the most likely

outcome will be a combination of funding sources to achieve the desired objectives. Funding sources, amounts, and durations certainly will vary for the different activities recommended in this report. However, in addition to advancing individual objectives, there is a critical need to sustain marine biosecurity as a long-term and vital activity, just as customs and border security (for goods and people) is an ongoing activity. To sustain marine biosecurity and provide long-term continuity requires some core level of activities, personnel, and coordination, which will require dedicated funding.

57. Define management and oversight for implementation of regional marine biosecurity activities in Micronesia. Defining management and oversight is a critical part of implementation planning and the overall function of biosecurity efforts in Micronesia. The MMBF could serve or assist in a management and oversight role. However, if this is not done, another administrative structure should be arrived upon to provide necessary oversight, evaluation, and management. In particular, the current capacity that exists in Micronesia is dispersed across countries, and it is possible that a broad range of people and organizations around the globe may participate in various aspects of implementation. Thus, management and oversight is required to assure that work and directed research addresses specific objectives, and also to provide continuity among countries and over time.

Finally, education and outreach are considered an integral tool for marine biosecurity and for implementation of a programmatic approach to fall under the umbrella of the MMBF. Moreover, we note that many of our recommendations include specific and targeted outreach or training components, in order to advance specific objectives in vector management.

6.8 Summary

The overall goals of this report were to (a) evaluate current activities that pose a risk of marine invasions to Micronesia and (b) provide recommendations for management practices to minimize the likelihood of invasions and associated negative impacts. We have identified specific gaps in marine biosecurity, resulting from current practices, critical information gaps, and lack of capacity (which includes infrastructure, people, and resources). To address these gaps, we have presented 58 separate recommendations, which outline particular steps that could be taken. This analysis and information is intended as input for development of a detailed implementation plan, as the next step to be undertaken. Importantly, some recommendations and approaches were identified as high priorities for implementation. It is also evident that implementation planning also requires evaluation of available resources (which determine the scale or rate of implementation) and involvement of agencies and jurisdictions in Micronesia (i.e., those engaged and affected by implementation activities), which are beyond the scope of this report.

Although the Guam Buildup was the primary for advancing this analysis and a biosecurity plan, the approach undertaken is visionary in its scope. Guam is clearly a hub for military and commercial activities and therefore the potential transfer of non-native species into Micronesia. The analysis and recommendations for biosecurity were funded due to proposed DoD activities in the Mariana Islands but extend throughout Micronesia and include linkages (indirect effects) for Hawai'i. The spatial scale examined is very broad. Moreover, similar analyses have been undertaken for marine, freshwater, and terrestrial components at this scale. The overall approach is unusual for its broad geographic and taxonomic scope, as well as including many countries and

cultures.

In many respects, advancing the regional biosecurity plan for Micronesia provides an important model for many reasons:

- First, the approach explicitly considers multiple vectors and environments (marine, freshwater, and terrestrial systems) together, using an appropriate spatial scale at which invasions operate.
- Second, implementing a large-scale, integrative, and cross-cutting plan should result in improved biosecurity protection, efficiency, and consistency, compared to advancing many individual activities in isolation.
- Third, this plan seeks to establish a coordinated and consistent strategy that operates internationally, across many different countries and cultures.
- Fourth, most understanding and management of marine invasions come from temperate latitudes and continents, and this plan aims to address invasions on tropical islands ecosystems, having high relevance on a global scale.

Even though Micronesia is a large area and spans many countries, current levels of trade and the number of points of entry are small relative to many other global regions. This suggests that understanding transfers of vessels and goods is more feasible here than many areas, even for Guam, and should make biosecurity more feasible than in many regions. In short, this underscores the value of Micronesia as a model. It is important to recognize that current capacity and resources limit current biosecurity activities in Guam, and Micronesia more broadly, and this must be considered a major focus of any implementation plan for the region.

By implementing a cohesive regional plan and key protocols to address marine invasions, DoD and its partners across Micronesia would become world leaders in advancing marine biosecurity, especially in tropical ecosystems. Such a program could effectively become a global model and training center, providing benefits to Micronesia and many other regions.

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Appendix A: Perceptions of Impact of Non-Native Marine Species

By Marnie Campbell & Chad Hewitt

A.1 Background

This research forms a component of a risk assessment undertaken for the U.S. Defense forces transfer of U.S. troops (and associated infrastructure) from Okinawa, Japan, to Guam. It is expected that this relocation to Guam will inadvertently result in a transfer of non-native species to Guam that may subsequently spread throughout Micronesia. A component of this work was to determine the risk (the combination of likelihood that a species will be transferred to Guam and other Micronesian countries and the consequence [impacts of these transferred species]) to the marine environment of Guam and Micronesia.

This research targets Guam, Palau and Saipan, using questionnaires and interviews to collect information about environment, economic, social and cultural core values that people in these locations hold and how they perceive that non-native species will affect these values. It was planned initially that this information would be used as a component of the consequence analysis for the overall risk assessment (see Chapter 5). However, the risk assessment used a quarantine end point and hence all consequences were considered significant. As such, this Appendix now represents a measure of the values that would be affected and provides a values mapping for a risk assessment that would have an impact end point. Typically, environmental risk assessments ignore social and cultural impacts and thus we are ensuring that this aspect is not lost, to provide a voice to the local and indigenous people in this region.

The importance of recognizing valid risk perceptions has been identified and studied for a number of years with the main insight for this study being the ability to understand and anticipate people's responses to a hazard [non-native marine species] (Slovic 1987, 2000; Sheeran and Orbell 1999) and hence managing this response within a holistic risk management framework.

By ascertaining people's motivations, actions and beliefs the driving factors associated with intentional and unintentional introductions and further spread (secondary transfers) can be effectively managed. This is pertinent for this risk assessment, as the public are potentially hostile to changes that they are seeing as being foisted upon them (such as the increase in military presence in Guam and subsequent exposure to shipping).

A.2 Aims

This research had two specific aims:

1. Identify known and perceived values that may be impacted by non-native marine species and
2. Assess the perception of changed values if non-native species occur in the region.

This research is preliminary (a pilot study), focusing on Guam as the primary site of impact, with a further assessment of two trading partners within Micronesia (Palau and Saipan). The results and trends seen are country relevant and cannot be extrapolated to other countries within or across Micronesia.

A.3 Determining Consequence – Values

Within this appendix, the use of the terminology “value” refers to things and/or notions/beliefs that people feel are important to them. Although the inclusion of economic, social and cultural values is beyond the initial scope of the project, the research team was approached by the NISC project coordinator to include this aspect within this report. This has occurred, but the report is limited due to the methods that could be utilized. Thus, what is presented in this appendix is a very preliminary assessment of all values (the assessment is limited in its scope) that provides some insights, and there are a number of important caveats (see next section). It is recommended that further investigation of these preliminary findings is necessary to truly elucidate the social, economic and cultural aspects.

A.4 Caveats

A number of caveats are important to note for this aspect of the consequence data:

1. This work was not a component of the original tender and thus it was not budgeted for.

Instead, it was fit into the study as possible while undertaking the major component of work (as presented in Chapters 1-6). But this meant that data was collected in a manner that is acceptable in western style questionnaire surveys (i.e., responses were elicited via an electronic survey by emailing the survey to people that were able to send the email onto others [referred to as snowballing]) but is of less use for studies wishing to collect data from cultural or social groups. Thus the data presented for the values has limited scope. An improved collection method (such as a temporal ethnographic study that incorporates participant observation and immersion in local culture) would see a better outcome for this data.

2. When working with cultural and social groups a better technique to collect data is via a series of meetings, informal chats, focus group interviews, and observations via immersion within difficult cultural contexts. This type of work is more field intensive and unfortunately could not be undertaken in this situation. The research presented in this chapter has identified a number of values through our initial face-to-face interviews and meetings and further reading, but often these values may have represented a miniscule aspect of cultural identity, which is difficult to ascertain and to value as a whole.

3. Values are based on a person’s heuristics, which are influenced by aspects such as their cultural background and identity, age, gender, and income level. Because of the manner in which the questionnaires were administered (see caveat 1), it was unlikely that indigenous cultural or social groups would respond. Thus, the data received is more likely to be influenced by ‘outsider’ opinions and under-represents Chamorro and Carolinian culture. This is particularly true for the analysis of change in value.

4. It is recognized that respondents may potentially overvalue aspects of their culture as a sense of cultural pride, when in reality that particular aspect is neither practiced or has been forgotten by most of the population. The same can be said for activities that respondents may be involved with or an area that they may wish not to have affected. The researchers do not judge these aspects and

believe that all aspects are worth consideration and assessment. Thus, the research as used all data as presented on face-value.

The response rates for our electronic questionnaires were relatively low and typically limited to expatriate American citizens, with few indigenous respondents.

What was achieved was a number of meetings (interviews) that elucidated values based on face-to-face interviews (see Table B.1) and the identification and support of values via reading the published literature, informal discussions, and visiting museums. This information was used to develop a questionnaire to ascertain the validity of these values, to collect further values that may have been missed and to see if people felt that a value would change if a non-native marine species entered a region. This means that the results under-represent the indigenous population and the general public.

A.5 Methods

A.5.1 Data Collection

A three-staged approach was used to collect values and then to investigate whether respondents perceived if values would change once a non-native marine species arrived in their region (Guam, Palau and Saipan). Ethics approval was provided for this research (H11233) by the Tasmanian Social Science Human Research Ethics Committee. In all instances researchers followed the ethics approved sampling methods and met the Australian National Statement standards. Data was collected using interviews and three questionnaires that were distinct for Guam, Palau and Saipan. Non-random purposive sampling (e.g., Babbie 2007; Walter 2010), with additional snowballing, was used given that this was a preliminary assessment. The sampling frame was restricted to scientists, environmental managers, industry (shipping and tourism related), government officials, and the public that had declared an interest in non-native marine species risk associated with the potential alterations in Guam vessel traffic associated with the U.S. Defense Force redeployment of troops to Guam. The sampling frame⁶ was restricted in that other participants were identified as sampling progressed and hence the frame could not be fully identified. As such, snowballing (the description of this method is provided below) was also used.

Stage 1: Identification of values. A triangulation process (e.g., Esterberg 2002) was used to identify and clarify values. The initial step in the triangulation was to hold face-to-face meetings

⁶ “Sampling frame: the listing of all units in the population from which the sample will be selected” (Bryman 2012).

and focus group interviews. These occurred from 31st March 2010 until 24th April 2010. These meetings and interviews elucidated people's values and served to direct us to further individuals to meet/interview. The second step of the triangulation involved researching the literature and/or materials that could help substantiate the values that were identified. A bibliography of the literature that was reviewed is provided (see References) to give insight into the literature that was assessed with regards to this study. The outcomes of this were the creation of a draft list of values that were relevant to Guam, Palau and Saipan.

Interviews occurred in Guam (31 March – 9th April 2010), Palau (10 April – 18th April 2010) and Saipan (19th April – 24 April 2010) and occurred on an individual basis or via group discussions. Discussions (in the form of semi-informal interviews) were held by introducing the topic and providing a background on the research that was occurring. Participants were encouraged to express their opinions and ideas related to the research topic. As such, the participants were involved in the construction of meaningful results related to the topic (i.e., they could drive the interview direction within the bounds of the research topic). Although the agenda for discussions/interviews was restricted to the research topic, the direction of the discussions was guided by the participants and hence participants were able to articulate what was important to them, to have more 'power' in the discussions and subsequently influence the results by choosing what they would and would not discuss.

Stage 2: Alteration of values. Based on the values identified at stage 1, a questionnaire was developed that asked respondents to: (a) rate each provided value on a scale of worth (1 = low, 5 = high); (b) add additional values that may have been missed; and (c) rate these new values on the same scale of worth.

Stage 3: Change in value. Based on the values identified at stages 1 and 2, respondents were asked if a non-native species arrived in their region could they state whether this would change their view on the value. If they answered "yes" then they were asked to rate how the value had changed (i.e., a decrease in value is now worth less or an increase results in the value being worth more). Please note that "worth" does not have a dollar value, but instead its used to infer an importance to someone – this importance can be intrinsic (i.e. hold importance merely for being) or utilitarian (i.e. holds an importance because it can be used by humans [provides a service]), or a combination.

A.5.2 Bias in Data Collection

A non-random purposive sampling method was used with a restricted sampling frame (scientists, environmental managers, industry, government officials and the public that had stated an interest in non-native marine species risk associated with the potential alterations in Guam vessel traffic), which under-represents the actual population. Thus, the results do not reflect the population in each country but rather reflects people that might be affected by the changing vessels movements into and out of Guam or have to manage these altered vessel movements or potential increases in non-native marine species. In this situation, under-representation of the sample is not a major concern because this is a preliminary study that is highlighting trends (Walters 2010). In essence, the sampling was guided by a theoretical sampling plan that would enable the problem of non- native marine species to be explored.

A snowballing technique was implemented (e.g., Bryman 2012). This method targeted people that work in areas relevant to non-native marine species and marine species and then used these people to establish contacts with others. This technique was used as the ability to establish a sampling frame given the short time frame for the research, was not possible.

To overcome recall bias (Szklo and Nieto 2007), each participant in meetings, interviews and questionnaires were briefed on the issues being investigated prior to beginning the questionnaire. Briefing all participants ensured that everyone involved was exposed to the same data pertaining to non-native marine species and the redeployment of U.S. Defense Forces.

To ensure that leading questions were not used and to identify any wording issues within the questionnaire, a pilot group of individuals was used as a trial. Two interviewers were used, with each having been trained to standard protocols (to ensure replicability; Stewart and Cash 2008), and one interviewer being in charge of quality control and quality assurance of interview techniques.

A.5.3 Data Analysis

Due to the preliminary nature of this research quantitative analyses are not possible. Instead descriptive statistics were used to describe the trends, with value network maps being used to explore the strength of linkages across and between values.

A.6 Results

A.6.1 Identified Values

A total of 337 values, from 61 participants, were identified across environment, economic, social, cultural values and combinations of these values (Figure A.1). We identified 140 values for Palau, 105 for Guam, and 92 for Saipan.

Guam identified the most environmental values, followed by Palau and then Saipan (Figure A.1). Palau, closely followed by Guam identified the highest amount of economic values, with a similar trend for the social values. Palau, followed by Saipan identified the most cultural values, with a large reduction in the identification of cultural values occurring in Guam.

In Saipan, the following additional values were identified:

- Coastal protection from reef
- Coastal protection provided by seagrasses
- Water quality improvement (filtering) provided by seagrasses

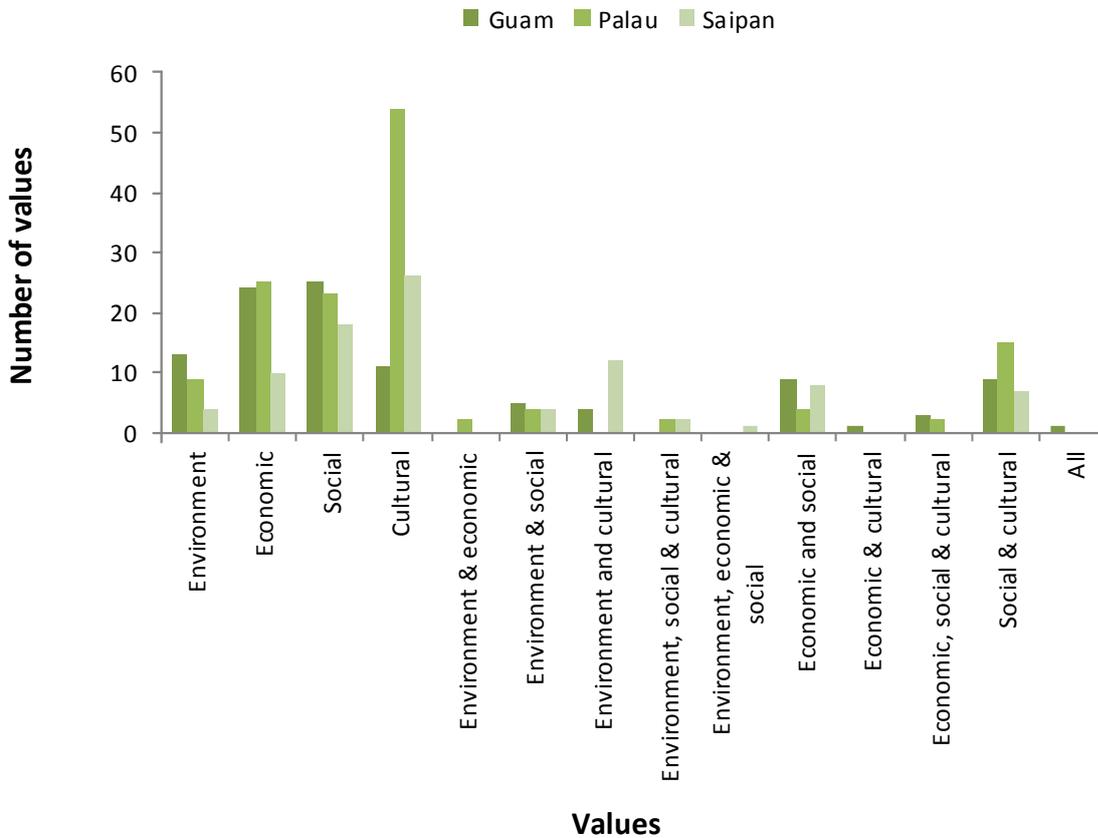


Figure A.1. Total numbers of values within each presented category for Guam, Palau and Saipan. The category “All” represents the identified value(s) that spanned across the environment, economic, social and cultural aspects.

A.6.2 Value Networks

Value networks (Figure A.2) were then used to illustrate the strength of connection across and between the core values (environment, economics, social and cultural). Each value had a number of identified ‘subcomponents’ (an element of a core value that with other subcomponents forms the entire core value) that represented a single core value (circles in Figure A.2), or could represent multiple values (lines connecting two, three, or four core values). Within Guam, there was minimal overlap or sharing of values, with most subcomponent values representing just one value and relatively little cross-over of values or participant perceptions that values crossed over (Figures A.1 and A.2). The values identified in Guam had a stronger social and economic focus compared to the other two regions. In Palau, there was a stronger network of subcomponents shared across core values, with social and cultural values sharing the strongest linkages (Figures A.1 and A.2). A similar trend was evident for Saipan (Figures A.1 and A.2).

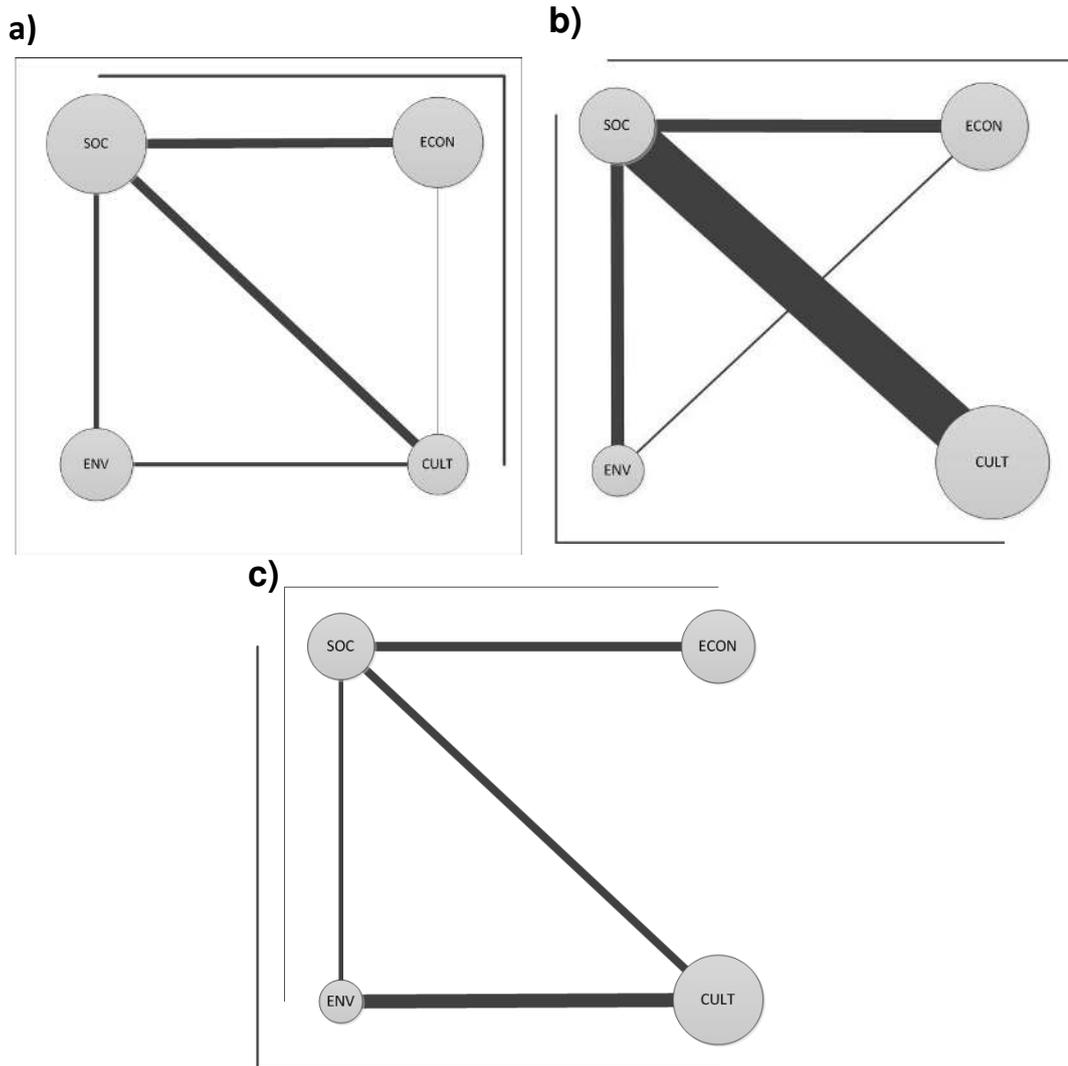


Figure A.2. Value networks illustrating the proportion of core values for each region and the strength of linkages between core values for: a) Guam; b) Palau; and c) Saipan. Core values are denoted by SOC = social; ECON = economic; ENV = environment; and CULT = cultural. The number of identified subcomponents in each category (one, two, three, four core values) is represented graphically by the size of the circle or thickness of the lines (networks).

A.6.3 Worth of Values

No responses were received from Palau and hence they are excluded from this portion of the analysis. It is recommended that further investigations are undertaken to elucidate the patterns and to better engage with the Palauan population to provide reliable outcomes concerning their perceptions about the identified values, the identified values worth and change in identified values worth.

The survey (questionnaire) results are preliminary, with low response rates; hence questionnaire findings discussed below need to be taken in the context that reliability is low. The data indicate some preliminary trends that need further investigation. In Guam, survey participants rated 63% of identified values as high value, with 21% having a neutral value (neither high nor low), and the remaining 16% having a low value. This differentiation between value worth can be further categorised based on each of the core values: 74% of the identified environmental values were rated as a high value, followed by 64% of social values, 57% of economic and 54% of cultural values (Figure A.3a).

In Saipan, 52% of the identified values were rated as having high value, with 44% having a neutral value and 4% having a low value. On a core value basis, 64% of environmental values were rated as high, with 59% of economic, 72% of social and 21% of cultural values being rated as high. Saipan participants rated the majority (73%) of cultural values as having a neutral value (Figure A.3b). This may reflect an inability to properly assess the value and hence a choice to select the middle option (i.e., to fence sit or to remain undecided).

A.6.4 Change in Value Worth

The participant's perceived change in worth of the core values due to a non-native species varied across the countries. Within Guam, 57% of the values remained unchanged, 39% of values would decrease in worth and 4% would increase in worth (Figure A.4a). A small number of social (Education – University of Guam, and education Schools) and cultural values (Seasonal fisheries: impediment to equipment; and food gathering) were perceived as potentially increasing in worth if an introduction occurred. The largest impact (decrease in core value worth) occurred for the cultural values (72% of values would decrease in worth), followed by social (44%), environment (43%) and economic (21%).

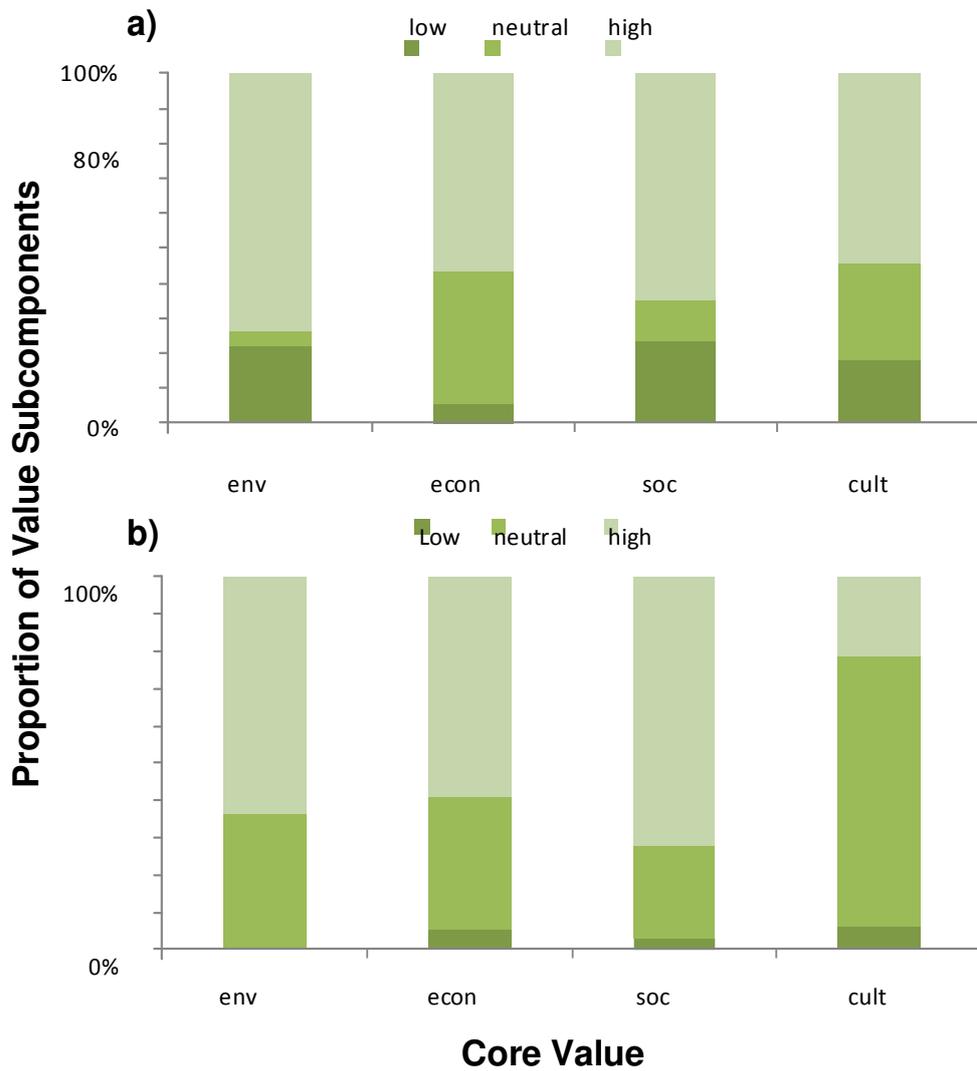


Figure A.3. Proportion of each core value subcomponent that was rated as having a high, neutral or low value by survey respondents for a) Guam; and b) Saipan. Where values are denoted as env = environment; econ = economic; soc = social; and cult = cultural.

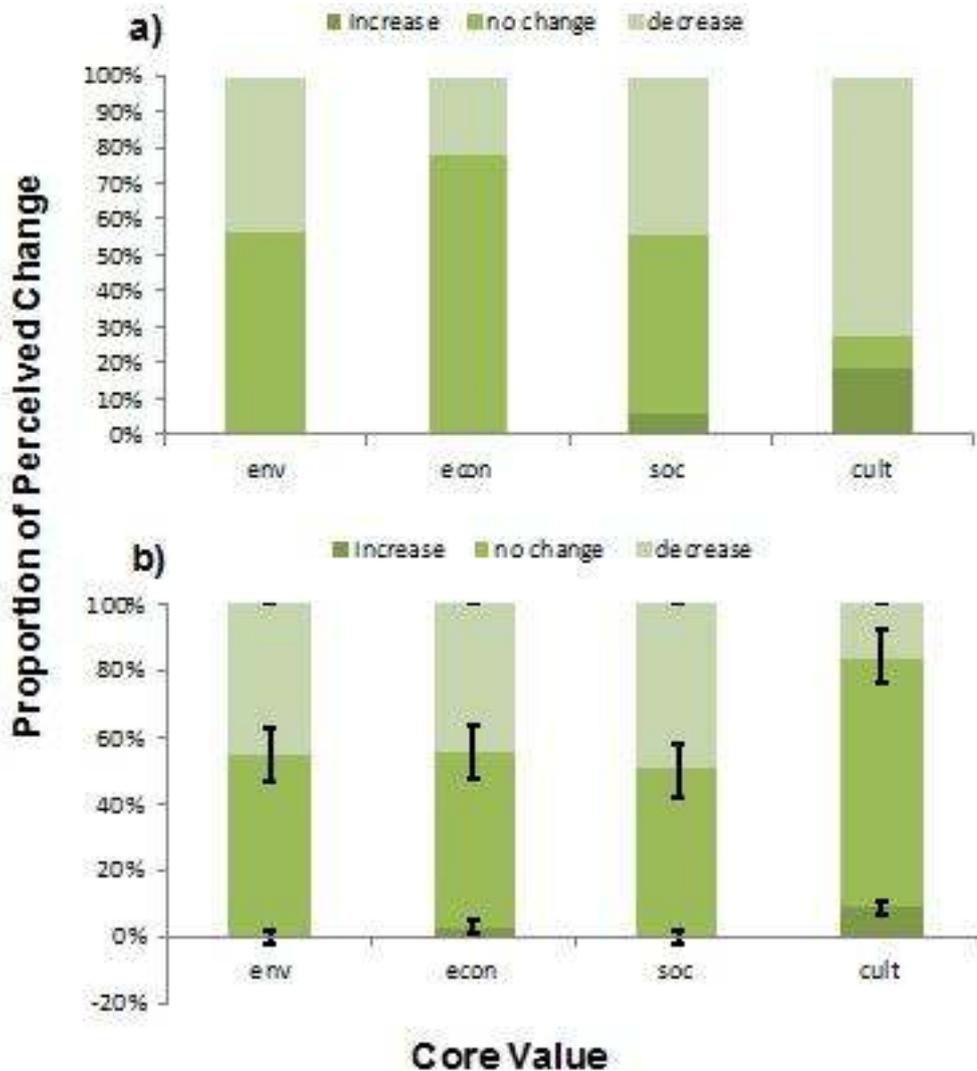


Figure A.4. Participant's perceived change in core value worth after an non-native species enters a countries water for: a) Guam; and b) Saipan (with standard error bars). Where values are denoted as env = environment; econ = economic; soc = social; and cult = cultural.

Within Saipan, the change in value was variable. Fifty-nine percent of the values did not change worth. Yet, there was a decrease in perceived value for 37.5% of the values with a small (3%) increase in value worth. At the scale of the core value, 54.5% of environmental values remained unchanged, and a further 45.5% of environmental values decreased in perceived worth (Figure A.4b). Economic values had a similar trend, with 53% remaining unchanged, 44% decreasing in perceived worth, and 3% increasing in worth. Social values were divided equally (50:50) between worth remaining unchanged or worth decreasing. Cultural values had the largest dichotomy, with 75% of values remaining unchanged, 16% decreasing in worth and 9% increasing in perceived worth.

A.6.5 Participant Feedback and Comments Received to Date

An opportunity for participants to provide feedback and make comments about the discussions and interviews and the questionnaires was provided. Further feedback will be collected after the report is released. Feedback and comments collected to date is summarized in Table A.1. A number of participants wished to remain anonymous and provided verbal information but requested that this information not be repeated within the report. The authors have respected these wishes and have used these data to inform the report in a manner that maintains anonymity (and these are not listed in Table A.1).

Table A.1. Participant’s initial feedback

Feedback and comments	Country relevance		
	Guam	Palau	Saipan
The marine environment is intrinsic to our life and lifestyle.	✓	✓	✓
We rely heavily on marine resources (food and tourism)		✓	
Loss or impacts on marine resources will increase poverty		✓	
Attempting to place a value on single aspects of cultural identity is difficult (if not impossible) because the real value, in many cases, is with the whole and not the individual parts. This could also be said for ecological systems	✓	✓	✓

Table A.1. Continued

Feedback and comments	Country relevance		
	Guam	Palau	Saipan
The assessed values may be dependent (auto-correlated) upon the cultural background of the recipient and their time spent in Micronesia (level of exposure to the culture and environment)	✓	✓	✓
Most of your respondents in the CNMI will most likely be outsiders. Consequently, their answers may reflect their impression of what others may have on certain issues or be biased by their own cultural identity.			✓
Indigenous respondents may overvalue aspects of their culture as a sense of cultural pride - when in reality, that particular cultural aspect is neither practiced or has been forgotten by most of the population.	✓	✓	✓
Some cultural values may be rooted in the marine environment but unaffected by change in this area.	✓	✓	✓
Biggest risk (from non-native species) is that we are not prepared.		✓	
Developing countries have a goal to support their economies and therefore sometimes things are lost	✓	✓	✓
An important part of our culture is the community projects that are organized by Chiefs.		✓	
Traditionally always people saved for tomorrow. This sustainability has been lost. A breakdown of traditions is occurring.	✓	✓	✓

Table A.1. Continued

Feedback and comments	Country relevance		
	Guam	Palau	Saipan
Buul (traditional management of resources in Palau) is managed by the Chiefs, with the community providing enforcement. Buul is now also used to manage behaviors. Fishing seasons and techniques were originally managed by Buul's, but now these are managed by legislation.		✓	
There needs to be an improved flow of information so the community knows what's happening with non-native marine species.		✓	
There is no important social/cultural importance of the sea, except when people want to use this resource			✓

A.7 Discussion and Conclusions

This research set out to identify known and perceived values that could be impacted by non- native marine species and to determine if perceptions of these values may be altered if a non- native marine species incursion occurred. The research successfully identified a large number of values (n = 337: Guam 105; Palau 140; and Saipan 92; Supplemental Tables 1-3) for the three different countries assessed. These values ranged across environment, economic, social, and cultural, with combinations thereof. Values vary from place to place, with place-culture being the greatest influence for the spatial and temporal patterns that can be detected (e.g., Williams 1981).

Although cultural and environmental values were kept as separate core values, it is noted that these values are often categorized together because philosophically environmental values themselves are considered to be embedded within culture (i.e., culture is a whole way of life), making it difficult to separate the two effectively. Thus, in some instances within this research, there was a downgrading of environment values (i.e., fewer environmental values may have been identified) that does not truly reflect the realized value or its worth. It is also noted that U.S. imperialism (i.e., Zimmerman 1998) has potentially influenced the values identified and reported for Guam and Saipan. Yet, the U.S. influence in Palau is less intense (Palau remains a Republic that was once a U.S. Protectorate but has now attained its own freedom), which is reflected in Palau by the higher number of identified cultural values and the strength of network connections between cultural and other values. This topic is discussed further below, noting however that the authors of this work are not sociologists and therefore the interpretation is limited and potentially naïve from a social science perspective.

A.7.1 Value Networks

A.7.1.1 Guam

Environmental and cultural values exist in Guam but were not valued as highly as economic and social values. Also, from a network perspective, Guam had little connection between core values (Figure A.2a). This lack of connection may be related to the history of this region. Guam has had a long history of being occupied by foreign nations, including occupation by the Spanish, Japanese and the U.S., which has resulted in the loss of the Chamorro culture (Jennison-Nolan et al. 1979a, 1979b; Diaz 1994; Rogers 1995; Zimmerman 1998).

The stronger social and economic focus of the identified values in this study may be related to the utilitarian societal norms witnessed in this region. Guam is heavily influenced by the U.S. (it is a U.S. Territory) and the resource conservation ethic (i.e., natural resources abound in nature and should be used, with conservation standing for development: "...the greatest good of the greatest number for the longest time...") (Pinchot 1947, 1968; Callicott 1990). The resource conservation ethic is strongly enshrined in the U.S. legislation and government management of resources (Callicott 1990; Groom et al. 2006). As a U.S. Territory in the Pacific Rim, a perception exists that local norms and beliefs are often diluted as the country is forced to adopt U.S. laws and practices (i.e., 'peripheralization'⁷; Wilson 2000a; Perez 2002).

Within this research, there was a strong indication that participants felt that Guam was disenfranchised, resulting in a loss of culture through 'Americanization' (e.g., Barusch and Spaulding 1989; Diaz 1994; Perez 2002). This was reinforced by participants indicating that they did not want more U.S. Defense Forces in Guam. This opinion was further reinforced by street protests that occurred during the survey work and subsequent protests that have occurred (e.g., <http://ww4report.com/node/8160>; <http://links.org.au/node/1547>; <http://reefrescue.wordpress.com/2010/02/26/guam-protests-navys-plan-to-dredge-coral-reef/>; http://www.horseopera.org/Insular_Empire_2010/?page_id=564).

There was also a general perception amongst some survey (Guam and Saipan) participants that cultural values are no longer authentic because they are not practiced by the majority of the population or that modernization of society has no room for these outdated concepts. However, typically these sentiments were provided by Caucasians expatriate Americans, not Chamorro or Carolinian participants.

⁷ Peripheralization refers to the "differential distribution of power, interest, labor, and capital across space, and the domination of local spaces and cultures by the mandates of military-industrial time" (Wilson 2000a).

A.7.1.2 Palau

Cultural values, followed by economic, social and then environmental values were identified in Palau (Figure A.2b). The strongest of connections occurred between social and cultural values, probably related to the strong community and cultural identity that still remains in this country. Palau also has a strong cultural law that governs usage of species (Buil 8-tiered system and fishing grounds; e.g., Johannes 1978, 2002) and influences lifestyles, including environmental goals aligned with conservation (D Olkeriil pers. comm.). The parliament is currently working on translating traditional stewardship into legislation that will simplify the three tiered system that currently exists (N Idechong and D Alexander pers. comm.). Marine protection has a strong focus within Palau (e.g., Gilman 1997a), especially within tourist focal areas such as the Rock Islands and Koror or on specific species that have a cultural value (e.g., Campbell 2003; I Olkeriil pers. comm.). This protection stance is often linked with customary management of marine resources (Gilman 1997a; Johannes 2002; D Olkeriil and I Olkeriil pers. comm.), which has been degraded in the past but is being rebuilt at present (N Idechong and D Alexander pers. comm.).

A.7.1.3 Saipan

The number of values identified for Saipan was similar to Palau, with a large number of cultural values, followed by an equal weighting of social and economic values, with fewer environmental values (Figure A.2c). Although, within Saipan, the importance of the sea turtle has been used to express and maintain Carolinian culture (Kolinski et al 2001). This value was identified, and its subsequent worth was identified as high, by survey participants. Much like Guam, the connections between values were relatively weak, with the strongest connection existing between the environment and culture. Again, the history of Saipan may have an influence on the identified values and assessed worth/changes in worth. Saipan has had five centuries of colonial rule, seen four empires and accommodates two indigenous cultures (Rios-Martinez 2000). Chamorros were forcibly removed from Saipan for a significant portion of the islands history, with the Carolinian culture becoming dominant during this period. When the Chamorro people returned to Saipan a disjunction in their Saipan culture had been created (R Hunter pers. comm.).

Saipan is within the U.S. CNMI (became a Commonwealth of the U.S. in 1986; Gilman 1997b; Rios-Martinez 2000) and is subsequently heavily influenced by the U.S. (Rios-Martinez 2000; Warheit 2010). Saipan constitutes part of the U.S. colonialism where a number of ‘insular areas’ are occupied by the U.S., where they are provided with some political willpower, but have fewer rights (King 1991; Rios-Martinez 2000; Warheit 2010). For example, a number of elements of sovereignty were surrendered when Saipan and the U.S. formed the Commonwealth (King 1991; Rios-Martinez 2000; Warheit 2010), with a major issue being the loss of the Islands rights to self-governance. This loss of power has caused some issues through time.

A.7.2 Worth and Changing Values

Although this information was collected, the low response rate to the survey tools leaves little that can be accurately stated about these data. In general, there are a multitude of ways to identify values (e.g., Corraliza and Berenguer 2000; Kalof and Satterfield 2005; Fraj and Martinez 2006)

and to determine a value's worth (e.g., Knetsch 1994; Satterfield 2001; Emerton and Bos 2004; IUCN/The Nature Conservancy/The World Bank 2004; Pagiola et al. 2004; The World Bank 2004; Kalof and Satterfield 2005). Recently there has been a move away from Willingness to Pay (WTP) and Willingness to Accept (WTA) style assessment of a value's worth, because of fundamental flaws in these processes (Kalof and Satterfield 2005). The result has seen the development (or further development) of axiomatic traditions that capture 'non-cost' and 'non-utilitarian' values. These methods are 'divorced' from the market and recognize that the environment (or at least many components of the environment) is a limited resource (Satterfield 2001; Kalof and Satterfield 2005).

The methods that were employed for this research, although in hindsight were not effective at collecting values from indigenous groups, did not use WTP/WTA style methods and did not rely on a dollar based system. Instead, the elicitation techniques attempted to use a narrative style (via interviews, group discussions, and surveys) to collect or identify values for each country and gauge worth and change in worth. The central question that was investigated was what were the values that would be impacted from an introduction of a marine species? This method was separated from the Guam Buildup research so that values, worth, and change in worth could be identified and driven by participants that are local to the countries being examined (i.e., not influenced by outside observer preferences). This method has been suggested as ideal for identifying and capturing the worth of values when non-market based values are explored (Satterfield 2001). Thus, the elicitation method was sound, but it required more time in country to fully explore the values in a face-to-face method that was more suitable to the countries sampled.

What this research has managed to achieve is some insight into the potential value worth and changes to worth that may be perceived of as occurring if a non-native marine species was to arrive in Guam or Saipan (Palau is excluded here due to a no response rate to the questionnaire). In general, participants from Guam and Saipan indicated that few values would benefit from a non-native marine species arriving in the country. A non-native marine species incursion would decrease the worth of a number of values, with more than 50% of values (summed across all core values) being negatively impacted (Figure A.4). Although the study needs further validation, in a management context the 'no change in worth' values would be excluded from further assessment as the perception is that these values are not deleteriously impacted by an incursion. It is the values that have decreasing worth that have a high management potential. Again, the authors reiterate that our findings are preliminary and hence no action should be taken until further exploration of these values is conducted.

One obvious missing link in the data that was collected is the 0% (i.e., no response) questionnaire response rate from Palau. This poor buy-in of participants to the questionnaire was not reflected within the interviews and discussions that had elicited keen interest, with people expressing a desire for inclusion. The poor survey response rate in Palau might be due to the cultural implication where freedom of enquiry is restricted in some instances. For example, Kesolei (1977) discusses the concept that Palauans believe that there is a hierarchy to data availability. Full information disclosure to the public is rare. In a social context, the more you know in Palauan society the more credibility that person is afforded, with information flow (or the right to know) being based on an individual's social status, age, or lineage (Gilman 1997b).

A.7.3 Future Research Needs and Recommendations

The preliminary research indicates that there is some concern over the impacts that non-native marine species will have in Guam, Palau and Saipan. Hence, it is strongly recommended that a full-scale perceptions study be undertaken in the Micronesian region to determine the perceptions of impact (involving the identification of values, identifying each value's worth and identifying potential changes in value). The collection of information needs to be done in a format that would feed into a non-native marine species risk assessment framework to enable social and cultural values to be assessed equally with economic and biological values.

The authors note however, that because of the preliminary (pilot) nature of this research it is necessary to re-iterate that the outcomes are descriptive, they under represent the population (small and non-random sample size), and hence have a low reliability. Further exploration of the perceived worth and impacts (change in worth), especially to the core values assessed here, is required. The authors urge that this further research follow an ethnographic design that enables the researchers to spend more time with the populations within Micronesia, to truly gauge the level of worth and potential change to values with the perceived potential introduction of marine species. To this effect, it will be valuable to include an expert with non-native marine species expertise and risk assessment to be involved in these studies to help guide the work to ensure that useful data for a risk assessment can be obtained.

Data collection methods need to be refined to meet each country's needs and cultural requirements and to allow face-to-face interviews with a greater sample size of people. Questionnaires were not an effective tool in this instance and the reliability of the data could easily be improved via the running of a number of stakeholder workshops, group interviews, and single interviews. In general, interviews (individual or group) provided the most valuable data, but workshops facilitated by local or a regional agency with expert input, may provide more effective to gauge, especially with regards to the social and cultural elements of impact from non-native species. In societies where information flow is select or restricted (e.g., Palau) the need to more fully engage with government agencies is required. This could be achieved via the use of more intensive one-on-one interviews that collected the questionnaire information directly.

Supplemental Data Tables for Appendix A

Table S.1 Guam values defined where grey shading denotes an identified value. Where -1 denotes a perceived decrease (loss) of worth for the identified value; 0 denotes a perception of no change in worth for the identified value; and 1 = a perceived increase in the worth of an identified value.

Value	Environment	Economic	Social	Cultural	Change in Value*
Catchment effects					0
Harmful algae blooms and nuisance species: health					0
Habitat forming areas: mangroves					-1
Habitat forming areas: coral					-1
Disease					0
Natural authenticity					-1
Water: quality					-1
Water: potability					-1
Water: disease & parasites					-1
Endangered species (sea turtles)					0
Water: flocculants					0
Integrity of Preserves (protected areas)					-1
Biodiversity					-1
Protected species (mammals, sea birds)					0
Ecological functions					0
Blooms and nuisance species: oxygen deprivation					0
Blooms and nuisance species: pH impacts					0
Trophic interactions					0
Maintaining resiliency					-1
Habitat loss: mangroves in Apra harbor					-1
Offshore dredge disposal					0

Table S.1: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Pollutants disposal (PCB's, WWII equipment, etc.)					0
Joint defense force exercises: impacts					0
Loss of natural space					0
Reduction in access to natural space					0
Use restrictions: port					0
Access restrictions					0
Public health: mortality					0
Public health: morbidity					0
Tourism: tropical experience (beaches)					0
Tourism: relaxation					0
Tourism: WWII experience (not common anymore)					-1
Iconic International significance: blue holes					0
Iconic International significance: crevice					0
Iconic international significance: water visibility (diving)					0
Seasonal fisheries: artisanal					0
Cost of maintenance: boats					0
Cost of maintenance: infrastructure					0
Cost of access					0
Maintenance of ecotourism					0
Industry seawater intakes: power plants (Piti and eastern)					0
Industry seawater intakes: marine lab (UOG)					0
Industry seawater intakes: Underwater world (tourism)					0
Industry seawater intakes: aquaculture hatchery					0
Industry: effluent discharge					0

Table S.1: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Ocean Thermal Energy Conversion (OTEC)					0
Aquaculture: Disease free image					-1
Aquaculture: market access					-1
Aquaculture: health of product					-1
Live rock culture					-1
Hotel trade					0
Tourism: divers					0
Tourism: fishing					0
Tourism: submarine – sightseeing					0
Loss of tourism business					0
Loss of business					0
Tourism infrastructure					0
Port traffic flow (added time and hold-ups)					-1
Effluent discharge: sewerage					-1
Tuna fleet					-1
Seasonal fisheries: subsistence					-1
Food gathering: subsistence					-1
Pacific Island Culture					-1
Family beaches: harvest					-1
Family beaches: tradition					-1
Restricted access: public access to beaches (total)					-1
Restricted access: public access to beaches (time limited)					-1
Food gathering: Mangrove crabs					-1
Food gathering: other fishing					-1
Sailing					0
Access restrictions: boat launching					0

Table S.1: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Deployment (DOD)					-1
Spearfishing: subsistence					0
Spearfishing: competition/tournament					0
Boat racing: derbies (Micronesia wide)					-1
Boat racing: local events					-1
Social events: Beach going (outing)					0
Social events: picnics					0
Social events: parties, weddings, funerals/wakes					0
Aesthetics: beauty of the ocean					-1
Private owned beaches: locals					0
Private owned beaches: hotels					0
Private owned beaches: other					0
Family beaches: picnics and BBQ's					0
Family beaches: swimming					0
Yacht moorings					-1
Vessel moorings					-1
Loss of access: 6 mile danger zones					0
Loss of access: 12 mile possession/domain					0
Education: University of Guam					1
Education: Schools (rare)					1
Fishing derbies: international					0
Use restrictions: firing range					0
Use restrictions: Navy in port					0
Seasonal fisheries: impediment to equipment (difficulty in throwing nets)					1
Food gathering: Eels and shrimp					1

Table S.1: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Exposed water-land sites (freshwater seeps and caves)					0
Wetlands: dry season grazing (Caribou)					-1
Caribou raising					-1
Prestige: Food gathering					-1
Prestige: Food preparation					-1
Rites of passage (fishing)					-1
Prestige: food (green turtle)					-1
Loss of habitat: turtle grass (food for turtles)					-1
Loss of habitat: sponge gardens (food for turtles)					-1

Table S.2 Palau values defined where grey shading denotes an identified value. Where “NA” denotes that no data on change in an identified value was collected.

Values	Environment	Economic	Social	Cultural	Change in Value
Water quality: issue of increased waste water outfall (sewerage)					NA
Coral quality (environmental appreciation): diver interactions quality					NA
Protected species: Dugong (local name Mesekiu)					NA
Important species: green turtle (local name Melob)					NA
Marine Protected Areas: tourism and recreational activities					NA
Protected species: shark					NA
Important species: mangroves					NA
Water quality: issue of increased marine debris					NA
Marine Protected Areas: conserve fish and other seafood					NA
Marine Protected Areas: conserve fish and seafood habitats					NA
Marine Protected Areas: conserve turtle populations					NA
Marine Protected Areas: protected endangered dugong					NA
Marine Protected Areas quality: boating impacts					NA
Marine Protected Areas quality: invasive species					NA
Water quality: pollution from oily water					NA

Table S.2: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Ecosystem quality: pollution from anchorage damage					NA
Rock Islands: Potential World Heritage site					NA
Commercial fishery: tuna					NA
Traditional knowledge: control fishing seasons					NA
Food items: commercial					NA
Access: increased attraction for yacht cruisers					NA
Social species: mandarin fish (aquarium species)					NA
Social species: game fish (blue marlin, black marlin, sailfish)					NA
Marine Protected Areas: infrastructure					NA
Beach development (creation)					NA
Industry: water intakes (PICR)					NA
Industry: waste water discharge					NA
Industry: Bureau Marine Resources - mariculture					NA
Industry: Bureau Marine Resources - hatchery					NA
Industry: aquaculture (milk fish, rabbit fish and groupers)					NA
Commercial fisheries: subsistence					NA
Aquarium trade (export)					NA
Tourism: diving					NA
Tourism: kayaking					NA
Tourism: snorkeling					NA
Tourism: surfing (new)					NA

Table S.2: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Myth: sunken villages (magic breadfruit tree)					NA
Tourism species: shark (main) (tiger shark - Mochelas; ocean white-tip - Melkaki; great hammerhead - Ulach; white-tep reef shark - Ulebsuchel; silver tip reef - Besachel; grey reef shark - Mederart; black tip reef shark - Matukeoll)					NA
Tourism species: manta rays (local name Ouklemedao)					NA
Tourism species: turtles					NA
Tourism species: Whale sharks (Pelilou)					NA
Tourism species: reef fish (barracouta, unicorn fish etc.)					NA
Tourism habitats: coral reef					NA
Tourism habitats: pelagic environment					NA
Tourism habitats: wrecks (few)					NA
Tourism/local interactions: unwelcome behaviors ('shark city')					NA
Tourism/local interactions: unwelcome behaviors (military)					NA
Tourism: dive reputation					NA
Cultural species: giant clam					NA
Cultural species: coral reef					NA
Cultural species: seaweed (lesser extent)					NA
Food items: customary					NA
Fish weirs: ancient Palau					NA
Important species: trochus (Japanese)					NA

Table S.2: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Community action: keeping environment clean and safe (chief led)					NA
Community actions: mangroves					NA
Community actions: rock islands					NA
Traditions: maintenance of traditions					NA
Cultural management: females - clam, trochus and sea cucumbers					NA
Cultural management: males - triton and fish					NA
Village sacred sites					NA
Village protector species					NA
Social species: napoleon wrasse (local name Maml)					NA
Access: natural space					NA
Access: open access					NA
Access to fishing locations					NA
Access to certain fish stocks					NA
Rock islands: birthdays					NA
Rock islands: family get-togethers					NA
Rock islands: camping					NA
Rock islands: visits					NA
Rock Islands: fishing					NA
Aesthetics					NA
Family group dynamics altered by immigrants					NA
Information flow: maintenance					NA

Table S.2: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Social species: fluted clam (tourist item)					NA
Social species: cuttlefish (local name Milngoll)					NA
Social species: octopus (local name Bikutang)					NA
Social species: nautilus (local name Kedarm)					NA
Social species: sea cucumbers (local names teatfish, Bakelungal, Oas) - food, toxin, booties					NA
Social species: shrimp (local name Cherchur)					NA
Social species: hermit crabs (local name Chum)					NA
Social species: coconut crab (local name Ketat) - food					NA
Social species: moray eel (local name Kesebeku)					NA
Social species: damsel fish (local name Mud/Cheremelamerand)					NA
Social species: triggerfish (local name Dukl)					NA
Myths: giant clam					NA
Myths: shrimp					NA
Myths: rock islands					NA
Myths: crocodile (local name Ius)					NA
Traditional fishing rights					NA
Ceremonies: funeral food (eg Napoleon fish)					NA
Ceremonies: engagement food (eg Pohnpei parrotfish)					NA
Ceremonies: tiger shark for funerals/festivities (in the north)					NA
Cultural tools: clam shells for carving					NA
Important species: sea cucumbers					NA

Table S.2: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Important species: mangrove crabs					NA
Myths: rabbit fish and Imelik God					NA
Myths/Customs: banded sea crate (protector, God) (local name Mengerenger)					NA
Myths/Customs: manta ray (protector)					NA
Sacred species					NA
Buul: turtle					NA
Buul: turtle shell					NA
Cultural sites: underwater heritage sites unknown					NA
Myths: village specific					NA
Ocean: life					NA
Ocean: stories					NA
Ocean: legends (myths)					NA
Cultural items: dugong bracelets (Olecholl)					NA
Myths: origin/creation (giant clam and shrimp)					NA
Cultural food items: dugong for installation ceremonies substituted by nuts)					NA
Cultural items: turtle (Hawksbill; local name Ngasech) shell					NA
Cultural items: clam shell (food and tools)					NA
Cultural items: trochus shell (bracelets, buttons)					NA
Cultural items: triton shell (horn)					NA
Traditional harvest: turtle					NA
Myths: Uleb and island creation					NA
Myths: turtle breeding season					NA

Table S.2.: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Cultural management: males - fish weirs/traps (rare, ancient)					NA
Cultural species Black lip pearl oyster (tools, jewelry, inlays in woodcarvings)					NA
Cultural species: Golden cowrie (decoration on war and sailing canoes)					NA
Cultural species: Cone shells (bracelets)					NA
Cultural myths: rays (related to Gods)					NA
Fishing regulated species: Groupers					NA
Fishing regulated species: Rabbitfish					NA
Fishing regulated species: Humphead parrotfish					NA
Fishing regulated species: Napoleon wrasse					NA
Fishing regulated species: Aquarium species					NA
Fishing regulated species: Rock lobster					NA
Fishing regulated species: Mangrove crab					NA
Fishing regulated species: Coconut crab					NA
Fishing regulated species: Turtles					NA
Fishing regulated species: Giant clams					NA
Fishing regulated species: Blacklip pearl oyster					NA
Fishing regulated species: Trochus					NA
Fishing regulated species: Sea cucumbers					NA
Fishing regulated species: Rock lobster					NA
Fishing regulated species: Dugongs					NA
Fishing regulated species: Sponges, hard corals and marine rock					NA
Cultural items: giant clam (pestles, tools and weapons)					NA

Table S.3 Saipan values defined where grey shading denotes an identified value. A range of values for worth reflects differing perceptions (uncertainty). Where -1 denotes a perceived decrease (loss) of worth for the identified value; 0 denotes a perception of no change in worth for the identified value; and 1 = a perceived increase in the worth of an identified value.

Value	Environment	Economic	Social	Cultural	Change in Value
Corals: attracts divers					-1, 0
Cultural species: Tellimis (food)					0
Cultural species: Strombids (food, tools)					0
Social species: seaweed (Japanese - food)					-1, 0
Protected habitats: seagrass					-1, 0
Protected habitats: mangroves					-1, 0
Protected habitats: wetlands					-1, 0
Cultural species: coconut crab					-1, 0
Cultural species: turtle					-1, 0
Cultural species: sea urchins (food)					-1, 0
Cultural species: clams					-1, 0
Cultural species: napoleon wrasse					-1, 0
Historic artifacts: tridacnids (clams)					-1, 0
Historic artifacts: spongylus (tools)					-1, 0
Cultural species: lobster					-1, 0
Cultural species: sea cucumber (food)					-1, 0
Cultural species (Carolinians): Sea birds (frigate bird) associated with navigation					-1, 0
Cultural species (Coralinians): black trochus					-1, 0
Cultural species (Coralinians): cowrie (presents)					-1, 0

Table S.3: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Habitat forming areas: mangroves					-1, 0
Habitat forming areas: coral					-1, 0
Habitat forming areas: seagrass					-1, 0
Marine Parks: protecting natural resources					-1, 0
Maintenance of historical sites (removal of pest species)					0, 1
Industry seawater intakes (firefighting)					0
Tourism: WWII artifacts/shipwrecks					-1, 0
Tourism: yacht race					-1, 0
Tourism: Saipan international fishing tournament					-1, 0
Tourism: Rota international fishing derby					-1, 0
Tourism: getting to paradise					-1, 0
Tourism: relaxation					-1, 0
Vessel maintenance					-1, 0
Wharf/marina structure maintenance					-1, 0
Tourism: diving					-1, 0
Tourism: Japanese memorials					-1, 0
Commercial fish species: rabbit fish					-1, 0
Commercial fish species: parrot fish					-1, 0
Commercial fish species: unicorn fish					-1, 0
Commercial fish species: nozzle flatfish					-1, 0
Aquaculture					-1, 0
Maintenance of ecotourism					-1, 0

Table S.3: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Fish traps: wooden					-1, 0
Eminent domain					-1, 0
School mascots (sacred species): octopus					-1, 0
School mascots (sacred species): turtle					-1, 0
School mascots (sacred species): unicorn fish					-1, 0
School mascots (sacred species): dolphin					-1, 0
Fishing - offshore (Chamorro)					-1, 0
Fishing - inshore (Carolinian)					-1, 0
Recreational activities: spearfishing					-1, 0
Recreational fishing					-1, 0
Subsistence fishing					-1, 0
Pace of life (island style)					-1, 0
Aesthetics: natural beauty					-1, 0
Recreation: beaches					-1, 0
Tourism: beach access (includes dive site access)					-1, 0
Aesthetics: isolation					-1, 0
Social: Island life					-1, 0
Social: Tranquility					-1, 0
Beach activities					-1, 0
Barbeques (beaches)					-1, 0
Swimming					-1, 0
Rod fishing					-1, 0
Outrigger - paddling					-1, 0
Commercial sport - competitions					-1, 0
Cultural artifacts: WWII shipwrecks					-1, 0
Cultural Carolinian: funeral traditions					0

Table S.3: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Cultural Carolinian: fishing traditions					-1, 0
Cultural Carolinian: ocean navigation					0
Cultural Chamorro's: fish weirs (ancient)					0
Kite fishing (ancient)					-1, 0
Achumaern fishery (bait fishes and bringing them up from deep)					-1, 0
Connectivity with the sea (Carolinians)					0
Historic artifacts: smaller clams (food and tools)					0
Historic artifacts: trochus (food)					0
Restrictions on Carolinian activities: cultural					0
Restrictions on Carolinian activities: fishing					0
Cultural species (Carolinian): green turtle (Wongemangusch Mool) - healing, cultural harvest and food					0
Cultural species (Carolinian): marine plants/algae (medicinal)					-1, 0
Sacred sites (Carolinians): beaches, cliffs (everything near the sea)					-1, 0
Sacred waters (Carolinians): provision of food					0
Sacred waters (Carolinians): provision of healing					0
Cultural species (Carolinians): trochus (food)					0
Cultural species (Carolinians): shore crabs (food)					0
Cultural species (Carolinians): clams (food)					0

Table S.3: Continued

Value	Environment	Economic	Social	Cultural	Change in Value*
Cultural species (Carolinians): reef and deep water fishes (fish names not specified)					0
Cultural species (Carolinians): seagrass for weaving					0
Carolinian Culture: ocean is the mother of the footstool of heaven					0
Carolinian culture: connectivity between people and ocean					0
Cultural species: blue spotted grouper					0
Cultural species (Carolinian): hawksbill turtle (Wongemaaw) - jewelry, funeral ceremonies					0
Marine Parks: protecting history, culture and recreational values					-1, 0

Supplement to the Regional Biosecurity Plan for Micronesia and Hawaii Marine Risk Assessment

**Based on comments received from various reviewers of the Micronesia Biosecurity
Plan Marine Risk Assessment**

**Edited by members of the University of Guam Micronesia Biosecurity Plan
Development Team**

August 2013

Critique of Chapter 5 of the Marine MBP

Many of the sections of the marine MBP report provided a solid and reliable overview of biosecurity issues in Micronesia, as well as offered useful implementing suggestions. Part I provides a good background on the history, mechanisms, and the impacts of marine invasions. In addition, the political, economic, and legal framework important to the development of risk assessment and biosecurity plans were outlined, and the vectors and human activities conducive to the introduction of non-native species in Micronesia were reviewed. Part III presented an exhaustive and thoughtful list of recommendations to develop a successful marine biosecurity plan tailor-made to the region. However, several of the marine experts contacted to review the draft marine MBP had serious concerns with the quality of Part II/Chapter 5 of the report (the Risk Assessment). A detailed critique of these sections follows, based on the reviewers' comments.

Chapter 5 suffers from erroneous assumptions, gross simplifications, wrong metrics, and a failure to include environmental and ecological data. This assessment should serve as a guideline to develop management strategies and assessment protocols specific to Micronesia. As presented, however, the risk assessment is not credible and does not provide any guidance for the implementation of a marine biosecurity plan because of:

- the non-transparent methodology employed (analyses based on a proprietary and incomplete database)
- the grouping of donor regions into unacceptably large geographical units
- the disregard of environmental and ecological data
- the lack of a thoughtful and informed review of taxonomic query results
- the masking of raw data which prevents an evaluation of the presented results, and
- the flawed likelihood-metric used to evaluate arrival/inoculation risks.

Many of these issues can be traced back to the proprietary database on which the risk analysis is based. This database consists of a limited number of potentially invasive species. Most of the analyzed species are considered to pose an invasion threat to Micronesia, as ship traffic to the region originates from many of the 18 large bioregions (apparently the basic units to document distribution ranges in the database). For this reason the taxon lists in tables 5.3 - 5.8 are almost exact copies of each other. Therefore, the risk assessment is not tailor-made to Micronesia but is in fact a generic one. If – for example – this risk assessment approach was applied to a location in the Arctic that received vessels from some of the 18 large IUCN bioregions, most of medium to high risk invasive species listed for Micronesia would also appear in the "risk assessment analysis" of this Arctic locality because these species (i) are absent from the Arctic and (ii) have a broad distribution range (overlapping with many of the vast bioregions ships originate from). This underscores the necessity to include environmental and ecological variables in the analysis. Furthermore, the taxonomic identity of many of the listed invasive species is questionable. As a result, many of the medium to high risk invasive species listed for Micronesia can be rejected because:

- (i) they already occur in the region (many being natives)
- (ii) many are temperate (to subtropical) species that are highly unlikely to survive in tropical waters, and
- (iii) many are bulk container taxa that from a practical perspective represent a large proportion of the species diversity in their respective genera.

It is difficult to imagine the utility of the Chapter 5 Risk Assessment given that the so-called "invasive species watch lists" (a) fail to list many of the important potentially invasive species, (b) are riddled by species that pose no threat (native species and non-natives restricted to other climate regions), and (c) list a number of species for which correct identifications are next to impossible.

To expand on point (c), although difficult to include in the risk assessment, one must keep in mind that cryptic diversity abounds in many groups of marine organisms (as is alluded to in part 3 of the report). Therefore simple "species watch lists" fail to capture the true extent of the potential marine invasive species in the region.

The most vocal critic among the marine experts ends with the following statement: "Lastly, please realize that you are writing a very important document that will steer future development, management, and conservation efforts in a highly biodiverse region, which is often considered to be one of the last strongholds of relatively pristine tropical reef systems. To do justice to the people and the natural heritage of the region, I sincerely hope that the authors consider improving the risk assessment analysis specifically focusing on non-native species (not just "databased" invasive species) that can realistically invade the tropical waters of Micronesia."

More specific criticisms of Chapter 5 have been grouped into 5 categories:

1. On the accessibility of the species dataset:

The Risk Assessment depends on a listing of non-native marine and estuarine species that have "demonstrated or inferred potential to cause impact". Species listed in this database were compiled from many literature sources (over 1,000 data sources, according to the report) from both peer reviewed publications and grey literature. The authors of Chapter 5 did not see fit to release the full database they used, nor did they list their literature sources. This is very unfortunate as it precludes independent analysis of the adequacy of the available data. For instance, were there species of potentially high concern that were missed in the risk analysis? How were the species lists compiled? Are newest reports of invasive species included in the listings? Are there taxonomic issues with any of the listed species? Aside from allowing independent review of the Chapter 5 risk analysis, access to this database would be particularly useful to develop and optimize management strategies concerning invasive species in the region (that is, be able to rank which taxa are of highest priority for invasive species managers).

It is assumed that the database is based on research supported by public funds, and that the development of the species database itself was likewise supported by public funds. Therefore it seems reasonable to suppose that the species database should be available to the public. It seems, however, that this database is proprietary. A clarification seems necessary – is the database indeed proprietary? If so, what are the reasons for protecting it?

2. On the species included in the likelihood/watch lists:

As mentioned above, there are five main problems with the list of non-native marine species used in the risk analysis:

a. Assumption that only species known to be invasive pose any risk:

The literature is loaded with new records of hitherto unknown invasive species, which certainly does not support the hypothesis that a complete compilation of all invasive species is possible at this stage nor that all currently known invasive species have been archived. Moreover, little work on invasive species in the tropics has been done in comparison to the less species-rich temperate regions. Therefore the species lists are biased towards temperate species (many of which might not be able to establish populations in the tropics), and fail to take into account emergent invasive species from the tropics. It is important to acknowledge the possibility that a species which is not catalogued in the database and which does not occur in Guam can be introduced (for example, any species that belongs to a genus of which invasive representatives are known).

b. Problems with geographic range designations:

There seem to be numerous errors in the listed geographic ranges of species. Many species presumed native to Guam are nonetheless listed as having medium or high likelihood of arrival. Among the marine macroalgae, *Bryopsis pennata*, *Caulerpa mexicana*, *C. racemosa* var. *lamourouxii*, *Dictyosphaeria cavernosa*, *Neomeris annulata*, *Ulva clathrata*, *Valonia fastigiata*, *Chnoospora minima*, *Padina boryana*, *Acanthophora spicifera*, *Asparagopsis taxiformis*, *Centroceras clavulatum*, and *Hypnea spinella* already occur in (are native to?) Guam.

The red alga *Acanthophora spicifera*, a very aggressive tropical invasive, is listed as a "Medium" likelihood of arrival for Guam, the CNMI, and FSM (see table 5.11) – yet it is actually believed to be native in these areas. However, it has been reported that this species successfully invaded the RMI and UMI (Line Islands) (Tsuda et al. 2008, Knapp et al. 2011). Table 5.11 fails to list *A. spicifera* invasion likelihood risk for either RMI or UMI. *Acanthophora spicifera* might be the best-documented and fiercest "red algal invader" in the region and is recorded as such in the following publications:

Tsuda R.T., Coles S.L., Guinther E.B., Finlay A.O. & Harriss F.L. 2008. *Acanthophora spicifera* (Rhodophyta: Rhodomelaceae) in the Marshall Islands. *Micronesica* 40: 245-252.

Knapp I.S., Godwin L.S., Smith J.E., Williams C.J. & Bell J.J. 2011. Records of non-indigenous marine species at Palmyra Atoll in the US Line Islands. *Marine Biodiversity Records* 4: e30.

c. Known invasive species omitted from database:

Several known invasive species that should be included in the watch lists are inexplicably not listed in the database. These include the macroalga *Spyridia*, and 3 species of marine fish reported from Apra Harbor (Smith et al. 2009). Given the methodology used in the risk analysis, one would expect to see the infamous invasive strain of *Caulerpa taxifolia* to be listed in the tables, but it is not listed. It is unclear why this species did not make the watch list. Perhaps it is considered by the authors to be the same taxon as the native *C. taxifolia*? However, from a biological perspective, the reviewer who raised this concern is fine with it not being listed on the watch list. This brings up the next point (d).

Based on the fact that many of the listed species (natively) occur in the recipient region, it seems that this analysis does not focus on non-native species but all species that are likely to be transported (which differs from the methodology description). Are the authors concerned with genetic exchange between donor and recipient regions even if the (morpho-)species already occurs in the recipient region? If so, this should be clearly stated in the report.

Smith, B.D., T.J. Donaldson, T. Schils, A. Reyes, K. Chop, and K. Dugger. 2009. Marine Biological Survey of Inner Apra Harbor, Guam. University of Guam Technical Report No. 126.

d. Inclusion of species from temperate and colder waters (non-consideration of environmental parameters and ecology):

Plenty of temperate species are considered to have a medium or high risk to be introduced, despite biologically low likelihood for establishment. Case in point: the giant kelp *Macrocystis pyrifera* almost certainly would not survive in the tropics. In fact, a recent post on the algae-I list inquired about intentional introductions of this species in France and China, where it apparently wasn't able to survive. Here it is listed as a medium risk invader in the tropics. On p. 312, the chapter authors cite Graham et al. (2007) in support of their inclusion of *Macrocystis* in their species list. However, Graham et al. (2007) mention that the alga occurs over a wide temperature gradient from boreal to warm temperate waters. Why would you then consider this species to be an invasive outside of this wide temperature range (i.e., in tropical Micronesian waters)?

Other temperate algal species that are deemed unlikely to be established in Micronesia and Hawaii include *Sargassum muticum*, *Pylaiella*, *Bangia*, *Caulacanthus*, and *Corallina officinalis*.

Graham, M. H., J. A. Vásquez, and A. H. Buschmann. 2007. Global ecology of the giant kelp *Macrocystis*: From ecotypes to ecosystems. *Oceanography and Marine Biology* 45: 39-88.

e. Problems with cryptic species:

A large proportion of some of the groups included in this report are in fact cryptic species (currently lumped in species complexes). The marine MBP categorizes them as cryptogenetic species (=species of uncertain geographic origin), but this is not exactly correct. Many of these species can reasonably be assumed to be native to Micronesia, but their identification to species-level is dependent on a molecular-assisted alpha taxonomy approach and has not been conducted on most of the considered taxa. Some of these groups in which cryptic diversity abound include textbook examples of invasive species in the region.

For example, the *Ulva* species listed in the tables are bulk container taxa that include a diversity of species throughout their distribution range. The listed names have often been used out of convenience because morphological characteristics to identify *Ulva* species are limited. Indicating that "just" these *Ulva* "species" have a high likelihood to spread shows the shortcomings of the methodology based on a preconceived list of invasive species. The same is basically true for all the other listed green algae in this and subsequent tables. Among the red algae, *Laurencia brongniartii* (an often misapplied name) and *Hildenbrandia rubra* also stand out. Inclusion of *Hildenbrandia rubra* shows that the data was analyzed without much knowledge about phycology. Records for *Hildenbrandia* are scarce in the region & this particular species identification has often been one of convenience – it is unlikely that this is the same species throughout its huge distribution range. The type locality of this species is in Norway. It's unrealistic to assume that this species can grow in Micronesian waters.

3. On the bioregions used in the risk assessments:

Geographic distributions of the species used in the Chapter 5 risk assessments were delineated based on 18 large scale IUCN marine bioregions (see figure 5.3). These bioregions are too broad to be useful for risk assessments. The entire area covered by the Micronesian Biosecurity Plan falls within one vast bioregion (bioregion #14) that stretches from the Marianas in the west to Hawai'i and the Tuamotus in the east (N.B., the placement of Palau is not clear from figure 5.3 – it could be in bioregion #14 or #13). Bioregion #14 straddles a large portion of the well known “mega-transect” of declining marine biodiversity from the western to the central Pacific (driven largely by processes such as isolation and dispersal limitation). For example, there are marine species native to the Solomon Islands that are not present in Guam, and there are native species in Guam that are not found in Fiji, much less Hawai'i (which is very depauperate and has proportionally higher marine endemism than other areas of the Western Pacific). Therefore, placing a species of interest as belonging to bioregion 14 is not at all useful, as it will tend to erroneously designate introduced species as native. Consider the impact of the assumed size of bioregion 14 on Hawai'i: the assumption used in this analysis disregards risks of exchanging invasive species between Micronesia and Hawai'i. This doesn't seem logical and it invalidates the risk assessment. The prime objective of the MBP is to prevent arrival and establishment of invasive species in Micronesia and Hawai'i, and Micronesia is undoubtedly a major source of invasive species for Hawai'i (and vice versa).

The authors of Chapter 5 imply that they do not only rely on the 18 regions designated by IUCN. They state that the IUCN bioregions have overlapping boundaries, resulting in a sequence of ‘core’ and ‘transitional’ areas that are roughly equivalent to a newer, finer-scale, and more widely-accepted biogeographic analysis by Spalding et al. (2007). However, it is difficult to comprehend how the bioregion overlaps can be equivalent to Spalding et al.'s approach, given that Spalding et al. (2007) identified a total of 62 marine provinces and 232 ecoregions. Logically, some of this geographic detail must be lost in an analysis based on only 18 bioregions.

The ‘conservative approach’ to estimating species distributions favored by the chapter authors simply does not result in a useful risk assessment, when the geographic scale employed is so large that there is virtually no difference between a region-specific risk assessment (what the authors set out to do) and a global analysis (what actually resulted from their work). While it is true that fine-scale geographic distribution data are not available for many taxonomic groups, there are some better studied groups for which such data are readily available (e.g., marine macroalgae, fish, etc.). Why not work on a finer geographical scale when possible? A finer geographic grain could have been applied for those taxa for which data are available, and a coarser-grained analysis could still have been done for taxa that lack such resolution.

Spalding, M. D., H. E. Fox, G. R. Allen, N. Davidson, Z. A. Ferdana, M. Finlayson, B. S. Halpern, M. A. Jorge, A. Lombana, S. A. Lourie, K.D. Martin, E. McManus, J. Molnar, C. A. Recchia, and J. Robertson. 2007. www.nature.org/MEOW. Accessed May 2008.

4. On environmental & ecological parameters, and niche modeling:

This has already been referred to in point 2, but it is important to stress that the inclusion of ecological data and environmental parameters (especially temperature data) is essential to produce a tailor-made invasive risk assessment plan for a specific region, i.e. the goal of this

report. Given that that very little biological information was included in the risk analysis, this chapter is essentially an extension of chapter 3, and should be included there as a subsection.

On page 311 of the original document, the chapter authors reject the use of “environmental matching” studies (more popularly known as environmental niche modeling), which is employed to model species distributions (including predicting potential species invasions). They cite Hewitt and Hayes (2002) in support of their arguments; however their 2002 paper does not represent the current state-of-the-art of remote sensing products. It is suggested that they have a look at Verbruggen et al. (2009) and Tyberghein et al. (2012) on niche modeling of marine species using environmental data. The reviewer in this case disagrees with the rejection of environmental matching/niche modeling, arguing that this is currently the only realistic method to conduct a risk analysis of a large suite of invasive taxa incorporating environmental conditions. If the distribution ranges of the taxa of interest are of high resolution, most of the environmental data will be too. Also, with the availability of increasingly better satellite imagery products, this is the only option if one wants to include the temporal variability in environmental variables (seasonality) to model invasive risks on a global scale (consistent use of a single product of the same resolution and similar error margins). This approach is the norm and - although not perfect - a great improvement on analyses that ignore environmental parameters completely (like the here-presented analysis).

Also (still on p. 311), the environmental match between the Port of Sydney and the Port of Hobart based on an IUCN bioregion approach indicates the weakness of the methodology used in this report. If the authors opt for a very coarse-scale biogeographic concept (as commented on before), indeed little environmental variability is to be expected. If, however, they used the widely accepted and most current biogeographic concept of Spalding et al. (2007), the authors would have noticed that both ports are two ecoregions apart (Sydney: marine ecoregion 203; Hobart: marine ecoregion 205). Furthermore since the authors are from Australia they should be aware that the IMCRA bioregion model is at an even finer scale than Spalding's marine ecoregion model and is completely compatible with the latter. So, if one conducts an invasive species risk analysis confined to a specific region, why not use the best biogeographic concept available for that region? Both harbors are 4 meso-scale IMCRA bioregions apart, which clearly indicates that these regions differ environmentally. The reason for the failure of niche modeling to accurately predict the species distribution of *Asterias amurensis* is not because of a fundamental flaw with niche modeling studies, but rather because the biogeographic region used in the analysis was too large. Inaccurate prediction of the range of the seastar does not justify the exclusion of environmental data in the marine MBP risk assessment.

Spalding, M. D., H. E. Fox, G. R. Allen, N. Davidson, Z. A. Ferdana, M. Finlayson, B. S. Halpern, M. A. Jorge, A. Lombana, S. A. Lourie, K.D. Martin, E. McManus, J. Molnar, C. A. Recchia, and J. Robertson. 2007. www.nature.org/MEOW. Accessed May 2008.

Tyberghein L., Verbruggen H., Pauly K., Troupin C., Mineur F. & De Clerck O. 2012. Bio-ORACLE: a global environmental dataset for marine species distribution modeling. *Global Ecology & Biogeography* 21: 272-281.

Verbruggen H., Tyberghein L., Pauly K., Vlaeminck C., van Nieuwenhuyze K., Kooistra, W.H.C.F., Leliaert F. De Clerck O. 2009. Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed *Halimeda*. *Global Ecology & Biogeography* 18: 393-405.

5. On assumptions in the analyses:

To determine the risk of introduction of a potentially invasive species, Chapter 5 authors equated likelihood of introduction with the proportion of vessel arrivals originating from different global bioregions. Given the acknowledged incompleteness and inaccuracy in the available vessel traffic data, it would have been better to concentrate on environmental/ecological factors that determine the establishment, survival, and spread of potentially invasive species in tropical waters. An inoculation only needs to occur once to be successful, probabilities of how many times such introductions can occur are rather irrelevant for a good biosecurity plan. If species X has the physiological capability to invade Micronesia (for instance, if it is a habitat generalist and only occurs in a geographically confined tropical location), then the inoculation only has to happen once for a successful establishment. On the other hand if species X only occurs in temperate waters then the likelihood of inoculation in Micronesia is practically zero (contradicting the unrealistic likelihoods calculated in the risk assessment). Chapter 5 does not assess the risk of species invasions; rather it estimates the probability of an invasion from a generic representative of a bioregional fauna/flora.

Table 5.2 presents a likelihood matrix that defines probability of inoculations based on proportion of vessel traffic from different bioregions. There are two major problems with this likelihood matrix:

- a) the levels are arbitrarily defined (e.g., what is the real-life difference between 1-10% probability – “extremely low” – and 10-25% probability – very low? And as mentioned above, wouldn't a single successful inoculation be sufficient to establish a species in a new locality?
- b) flawed use of the *proportion* of vessel traffic, rather than the actual number of vessels. The problem with this method is illustrated in the following example:

Say, you have two regions for which you do a risk assessment (R1 and R2).

For R1 you have 500 ship arrivals from Bioregion A, 100 from Bioregion B, and 50 from Bioregion C.

For R2 you have 5 ship arrivals from Bioregion A, 10 from Bioregion B, and 50 from Bioregion C.

This translates into the following percentages of total arrivals:

R1: 77% from A, 15% from B, and 8% from C

R2: 8% from A, 15% from B, and 77% from C

So, you conclude that the risk of an invasion in R1 is highest from A (once again incorrectly ignoring environmental/ecological variables), then B, and then C.

For R2 you find the reverse.

However, when you look at the real risk, you see that both regions are similarly connected to

bioregion C (equal risk, both have 50 ship arrivals from this region). Yet, in your risk analysis you conclude that the likelihood of a non-native species arrival from Bioregion C at R1 (based on 50 ship arrivals) is "extremely low" whereas this likelihood is regarded to be high at R2 (based on the same number of ship arrivals: 50). Similarly, you find an equal risk (77%) of a species from Bioregion A arriving at R1 as one from Bioregion C arriving at R2, whereas R1 receives 500 ship arrivals from Bioregion A and R2 "only" 50 from Bioregion C.

It could be argued that you could conduct this likelihood for the two regions combined (which is not done in this report), but the essence remains the same: where do these proportional cut-off margins come from and how were they arbitrarily defined? The arrival of a single heavily fouled barge from an unlikely tropical donor region is a much greater risk than hundreds of clean Navy vessels from San Diego.

The errors of this approach are well illustrated in the results of the risk analyses for the FSM and RMI. For the FSM, the total number of vessel arrivals was 811 while for the Marshall Islands, there were 1170 arrivals. So, if a non-native species X could be "imported" on 615 vessel entries in the FSM, this would be regarded as a high risk likelihood (76%). The same number of potential arrivals of this species (bioregion in fact) in the Marshall Islands (615), would suddenly become a medium (almost a low risk: 53%) for the Marshall Islands. This "proportional" risk assessment approach is wrong, in the above scenario species X poses an equal invasion threat to the FSM and the Marshall Islands.

Because the total number of arrivals is higher and because of the limited number of "predetermined" potentially invasive species in the data set, it is mathematically obvious that the Marshall Islands have a lower number of species that meet the proportional thresholds that determines the "high risk category" when compared to the FSM.

Recommendations:

The inclusion of an analysis that pinpoints/ranks the last ports of call that pose the greatest threat to import viable non-native species to Micronesia would be of great benefit to the development of a biosecurity plan.

Also, on p. 318 there is mention of ranking ports of inoculation into high-risk, medium-risk, and low-risk – such a ranking would be extremely useful for invasive species managers.

Likewise, a ranking of species from those of negligible concern to species of serious concern (=high likelihood of introduction coupled with large potential ecological impacts) would be a very important contribution to the risk assessment and biosecurity plan. This would require consideration of environmental parameters (of the receiving environment) and ecological data (of the potential invasive species) to derive better predictions of which species are physiologically capable of establishing themselves in Micronesia and Hawai'i (i.e., environmental niche modeling).

A comprehensive marine risk assessment would not focus solely on biofoulers on commercial and MSC vessels, but also consider:

- (a) biofouling communities brought in by recreational vessels and barges (both are less maintained than commercial vessels, therefore have higher risks of transporting invasive species), and
- (b) other vectors, most importantly introductions from the live trade and from ballast water.

Consider expanding risk analyses beyond the known invasive species, by including species that are likely to exhibit invasive characteristics – for instance, including all species in genera that include invasive representatives.

Consider gathering new (primary) data on tropical marine invasive species in Micronesia. Chapter 6 of the marine MBP already recommends baseline surveys and periodic monitoring of port areas, and the development of a coordinated database on information on species, vessel traffic, and ballast water (section 6.2.1, p. 318). To these very timely recommendations, one could add alpha-taxonomic studies on species complexes that include invasive members. Such studies should include a molecular/ DNA barcoding component, which would provide rapid and inexpensive determinations of taxa.

Lastly, to improve the quality of the existing analyses as they stand, the following are recommended:

- release of the full species database, including references used, mention of availability of ecological, environmental, and distributional data (or lack thereof), and an assessment of the reliability / accuracy of the data provided
- assembly of more data (and better data) on the distribution of species
- improvement of species lists (acknowledgement of cryptic species/ species complexes, known invasive species not currently in database)
- geographically finer-scale analyses for those groups where available data permits more detailed analyses (e.g., marine macroalgae, which have a good database on species' biology and geographic distributions).

4 Volume IV - Terrestrial Systems

**Regional
Biosecurity Plan
for Micronesia and
Hawaii**

Volume IV

Prepared by:

University of Guam and the Secretariat of the Pacific Community 2014

This plan was prepared in conjunction with representatives from various countries at various levels including federal/national, state/territory/commonwealth, industry, and non-governmental organizations and was generously funded and supported by the Commander, Navy Installations Command (CNIC) and Headquarters, Marine Corps.

Terrestrial Risk Assessment of Alien Invasive Species for Micronesia and Hawai'i

**Edited version of an original document
produced by USDA**

2013

The original document, from which this edited version was produced, was prepared by United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). A team from the USDA APHIS Plant Protection and Quarantine (PPQ), Plant Health Programs–Quarantine Policy Analysis and Support staff and Veterinary Regulatory Support staff compiled this document from Terrestrial Risk Assessments that were prepared by risk assessment teams from the USDA-APHIS Plant Protection and Quarantine, Center for Plant Health and Technology, Raleigh, North Carolina, the USDA-APHIS Wildlife Services, National Wildlife Research Center, Hilo, Hawai'i, the USDA-APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado, the USDA-APHIS Veterinary Services Centers for Epidemiology and Animal Health, Fort Collins, Colorado, and the USDA-APHIS Veterinary Services, National Center for Import and Export, Raleigh, North Carolina. Chapter 8, Terrestrial Vertebrate Species was prepared separately by the USDA-APHIS Wildlife Services, National Wildlife Research Center, Hilo, Hawai'i. The final document was edited by Kenneth Werner, USDA APHIS PPQ, Honolulu, Hawai'i.

The compilers of that original document would like to express their appreciation to the many federal, state and local officials in the Micronesia Region and the United States for their help and assistance throughout this project. The compilers wish to express their appreciation for the contributions to the Terrestrial Risk Assessment from the risk assessment teams from the USDA-APHIS Plant Protection and Quarantine, Center for Plant Health and Technology, Raleigh, North Carolina, the USDA-APHIS Wildlife Services, National Wildlife Research Center, Hilo, Hawai'i, the USDA-APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado, the USDA-APHIS Veterinary Services Centers for Epidemiology and Animal Health, Fort Collins, Colorado, and the USDA-APHIS Veterinary Services, National Center for Import and Export, Raleigh, North Carolina.

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EXECUTIVE SUMMARY

As a result of the Defense Policy Review Initiative conducted by the United States (U.S.) Secretary of State, the Secretary of Defense, the Japanese Minister of Foreign Affairs, and the Minister of Defense, the U.S. Department of Defense (DoD) has proposed relocation of U.S. military forces to the U.S. Territory of Guam and the island of Tinian within the U.S. Commonwealth of the Northern Mariana Islands (CNMI). The purpose of the relocation is to meet international agreement (Alliance Transformation and Realignment Agreement) and treaty (*U.S.-Japan Roadmap for Realignment Implementation*) requirements, and to fulfill U.S. national security policy requirements in the Western Pacific Region. Proposed actions include components of the U.S. Marine Corps, the U.S. Navy, and the U.S. Army.

To comply with the National Environmental Policy Act of 1969, 42 United States Code §§ 4321 et seq., as amended, DoD and other federal agencies must examine the environmental effects of the DoD's proposed actions for the relocation process. Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations (CFR) §§ 1502.09 and 1502.20) govern supplemental and tiered environmental impact analyses. On behalf of DoD, the Department of the Navy prepared an Environmental Impact Statement (EIS) (Final EIS [FEIS] delivered July 2010) to inform decision makers of potential environmental consequences of the proposed Guam and CNMI military relocation actions so all parties can take measures to protect, restore, and enhance the environment.

According to the DoD FEIS, the military relocation beginning in 2011 and expected to peak by 2014¹ will have substantial impact on the population, economy, and environment on Guam. Other Micronesia Region islands and the state of Hawai'i will be impacted as well. DoD expects as many as 79,000 new residents on Guam by the peak year of the military relocation. Imports are expected to increase substantially with the increase in population during the military relocation and build-up, and may increase the risk of pests and diseases entering the Micronesia Region. Areas of U.S. jurisdiction under United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) regulations 7 CFR § 318.13-1 and 9 CFR § 1-146 (under the Definitions subsection) include Guam, Hawai'i and CNMI (Saipan, Tinian, and Rota). These areas are defined the same as states (along with Puerto Rico, the U.S. Virgin Islands, and the District of Columbia) in regards to APHIS jurisdiction.

The primary objective of this terrestrial risk assessment is to propose detailed recommendations sufficient to prevent and mitigate risks to human health and safety, animal and plant health, the economy, and the ecology of the Micronesia Region from the intentional or unintentional introduction, spread, or establishment of terrestrial alien and potentially invasive animal, plants, and diseases. These recommendations are based on risk assessments by APHIS, APHIS regulations, and established policies

¹The National Defense Authorization Act (NDAA) for Fiscal Year 2012 (FY 2012), signed into U.S. law on December 31, 2011, by President Barack Obama, imposed restrictions on the Secretary of Defense's usage of funds to develop infrastructure associated with the USMC relocation to Guam. Additionally, Congress did not authorize or appropriate funding for the Guam realignment in FY 2012. As the pace of construction is subject to the availability of funds, it is anticipated that the realignment will proceed at a slower rate than originally anticipated (NDAA for FY2012).

to determine the risks of introduction of invasive species or pathogens from the transport of passengers, baggage, cargo, commodities, and construction materials to Guam.

The recommendations are based on the risk assessments of APHIS-Plant Protection and Quarantine (PPQ) personnel with extensive on-the-ground experience. These recommendations and suggested best management practices should help prevent invasive species damage to the region from the military relocation on Guam and the CNMI. While the recommendations vary in specificity, they do not provide a comprehensive blueprint for implementation. How these recommendations are implemented will determine their effectiveness.

In determining biosecurity recommendations, risk assessors identified pathways which could be carriers for the introduction of invasive species and pathogens. Risk assessors evaluated current literature, visited sites, and conferred with local subject matter experts to evaluate potential risks for the introduction of invasive species and studied these risks as predicted impacts from the military relocation and build-up on Guam.

Each group of APHIS risk assessors developed a specific methodology to determine risks and recommendations for biosecurity enhancements. For many pathways and species, information for making determinative rankings for risks was limited; therefore, risk rankings for most pathways and species in the APHIS risk assessments are qualitative.

Risks were determined for a wide range of animal and plant species and pathogens. Plant propagative material may present phytosanitary risks in the Micronesia Region as either a pathway for introduction of exotic plant pests or as propagated invasive species. The introduction of many livestock, poultry, and wildlife diseases could have severe consequences to animal and human health throughout the Micronesia Region and far-reaching impacts on trade for the rest of the United States. More smuggling could mean more health and ecological risks from exotic pets and recreational animals. The potential for importation of zoonoses that pose a major public health threat warrants increased surveillance for imported wildlife.

To determine biosecurity recommendations, the assessors reviewed U.S. and Guam statutes, regulations, and procedures for prevention and mitigation of biosecurity risks for general mitigation practices for all pathways (commercial, military, and private).

While federal, territorial, and military regulations may prevent and mitigate the introduction of invasive species and pathogens, the estimated increase in population and goods with the military relocation will strain current capacity for inspection and interdiction of illegal goods, and increase the likelihood of invasive species transported throughout the region. Already mitigation resources are stretched at air- and seaports in the Micronesia Region. Ports and diagnostic laboratories do not have sufficient detection and identification equipment. Surveillance for the detection of plant pests and the brown treesnake (*Boiga irregularis*) (BTS) is routine. Rapid response capabilities are limited to BTS and lacking for even BTS in many areas.

With its broad scope and complex risks, the challenge of protecting Hawai'i and the Micronesia Region from the multitude of threats requires an overarching framework for a successfully sustained biosecurity process. This Micronesian Biosecurity Plan includes components designed to reduce biosecurity risks through prevention with educational outreach programs and through risk mitigation measures including inspection, quarantine, monitoring, surveillance, rapid response, control, and eradication.

A comprehensive biosecurity plan requires an integrated process for regular reassessment and improvement as situations change and new risks become known. An improvement planning approach from the Department of Homeland Security (DHS), *Homeland Security Exercise Evaluation Plan*, will serve as an informative reference for continual improvement in biosecurity planning. Templates are available for scheduling and conducting improvement planning events and building successful prevention and mitigation programs and can be found at https://hseep.dhs.gov/pages/1002_Exerc0.aspx.

The challenges, risks, and costs of long-term control and eradication of an established invasive species are significant. The most cost-effective approach to protecting regional human health and agricultural resources is prevention and early detection. Success in preventing the transport, introduction, and establishment of invasive species in the region will require a coordinated and comprehensive approach based on information-sharing, funding of well-planned resources, and coordinated prevention and protection programs among all biosecurity partners and stakeholders. A regionally inclusive process will engage appropriate experts and decision makers fully, build consensus and commitments, and take advantage of expertise and resources within Micronesia.

1 INTRODUCTION

In compliance with EO 12114 and according to proposed events and anticipated impacts described in the FEIS, USDA-APHIS has developed this regional terrestrial risk assessment (RA) to assist in the protection of Guam, Hawai'i, CNMI, Federated States of Micronesia (FSM), Palau and the Republic of the Marshall Islands (RMI) as well as the broader Pacific from invasion by unwanted pests and disease agents during the increased U.S. military activity (EO 12114).

The terrestrial RA provides recommendations for protecting Hawai'i, Guam and other Micronesian Region locations based on USDA-APHIS Pest Risk Assessments (PRA), USDA-APHIS regulations, and established USDA mitigation procedures. Species life histories and current biosecurity practices have identified potential means of transport of invasive species into the Micronesia Region and Hawai'i. While the primary geographic focus is Guam, the terrestrial RA considered the CNMI, the Republic of Palau, FSM, RMI, and Hawai'i with particular focus on CNMI due to proposed military training activities with trans-shipment of relocation cargo through CNMI.

The APHIS assessment task was divided among four APHIS teams based on program expertise. The Plant Health Programs of APHIS-Plant Protection and Quarantine (PPQ) provided regulatory and risk mitigation guidance. APHIS-Veterinary Services (VS) analyzed risks to livestock from disease vectors. APHIS-Wildlife Services (WS) analyzed risks to wild terrestrial vertebrate animals from wildlife disease vectors and wildlife. The Center for Plant Health Science and Technology (CPHST) of APHIS-PPQ analyzed risks from invasive plants, plant pests, and plant diseases.

1.1 ASSESSMENT DESIGN

Chapter 1: Introduction, provides an overview of the objectives, scope, design, and caveats of the terrestrial RA.

Chapter 2: Military Relocation to the Mariana Islands.

Chapter 3: Existing Mitigations, describes current policies, requirements, and methods developed by Guam, APHIS, DoD, and other authorities for phytosanitary and general sanitary practices at all Guam ports. Ports for other jurisdictions were not detailed here and therefore will be covered in the implementation plan component of the Micronesia Biosecurity Plan.

Chapter 4: Recommendations, lists APHIS recommendations for enhancing biosecurity measures and programs during and after the military relocation.

Chapter 5: Outreach Plan, describes an approach to educate local populations and organizations about potential risks from invasive species and methods to prevent, report, and control their introduction.

Chapter 6: Monitoring and Surveillance, describes strategies and methods for a coordinated monitoring and surveillance process to detect and report high-risk species rapidly.

Chapter 7: Rapid Response, describes strategies, methods, and organizations involved with control and eradication of invasive species.

Chapter 8: Terrestrial Vertebrate Species, describes the unique biosecurity requirements for terrestrial vertebrate species.

The remaining chapters include compilations of APHIS risk assessments, pathway risk analyses, quality assurance measures, and references.

1.2 OBJECTIVES OF THE TERRESTRIAL RA

- Prevention of the introduction and spread of IAS to the jurisdictions of Micronesia and Hawai'i.
- Evaluation and integration of APHIS PRA information, risk ratings, and recommendations along with appropriate APHIS regulations and policies into a comprehensive strategy for biosecurity protection and response during and after the military relocation to Guam.
- Development of an outreach and education plan to increase awareness of risks from invasive species, encourage the adoption of practices to prevent the transport of invasive species, and describe mechanisms for reporting suspected introductions.
- Development of monitoring and surveillance risk-mitigation strategies for rapid detection of high-risk species and diseases.

1.3 CURRENT RISK ASSESSMENTS

This terrestrial RA integrates the APHIS risk assessments and recommendations developed by the CPHST, PPQ, VS, and WS risk assessment teams showing potential impacts to agriculture, ecosystems, and economies throughout the Micronesia Region from the introduction of invasive species during the planned military relocation on Guam and Tinian. For the purposes of this RA, references to “invasive species” include live animal and plant species, animal pests, vectors, and infectious agents. APHIS Terrestrial Risk Assessments are included in Appendix A.

1.4 SCOPE

This RA is framed by a closely defined scope on three levels: geographic, temporal, and operational. The geographic scope describes the locations of Micronesia Region islands and Hawai'i as well as foreign ports from which personnel and supplies originate. The temporal scope describes timing and duration of all plan requirements to be completed.

The basis for understanding risks of the military relocation phase is the evaluation of all military relocation activities as described in the FEIS issued in July 2010 (U.S. Navy 2010a); identification of all potential enhanced risk due to the unintentional introduction of invasive species associated with the relocation; and the integration of the risk profile and required protection enhancements into this RA. Any changes to the military relocation plan after delivery of the final draft of this RA may not be considered in the RA document.

The operational scope analyzes potential direct and indirect impacts from military relocation activities in movement of personnel and belongings, construction, commercial development, shipping and service industries, tourism, resource utilization, resource planning, etc. The operational scope also includes prevention and protection programs; education; awareness training on Guam and throughout Micronesia for military and civilian populations; and mitigation programs of inspections, monitoring, surveillance, and emergency response.

1.5 CAVEATS

The development of risk assessments and biosecurity planning recommendations for the military relocation to Guam and Tinian and potential impacts throughout the Micronesia Region depends on processes outside the control of RA developers, and therefore, certain caveats apply. The RA presents recommendations based on methodology for assessing mitigation capabilities and determining potential impacts. The caveats are addressed in Chapter 5: USDA-APHIS Risk Assessments.

2 MILITARY RELOCATION TO THE MARIANA ISLANDS

2.1 MEASURING IMPACTS FROM THE MILITARY RELOCATION

The proposed complex military relocation includes components of the Marine Corps, Navy, and Army as well as Air Force assets already on Guam. To accommodate the three major elements of the proposed actions, a substantial increase in construction and improvements (Marine and Army base residence, aviation maintenance facilities, etc.) as well as more frequent ship berthing would be necessary. According to the DoD FEIS (U.S. Navy 2010a), implementation of the proposed military actions would result in:

- Temporarily increased population related to the construction work force
- Permanently increased number of military and civilian personnel and dependents on Guam
- Increased transient presence on Guam and Tinian
- Increased numbers and types of major equipment assets to support military personnel and operations (e.g., aircraft, ships, amphibious watercraft)
- Increased numbers and types of training activities
- Construction of new facilities
- Improvements to existing facilities
- Improvements to infrastructure (including roads and utilities)
- Acquisition of additional land (required for three of the Marine Corps Relocation-Guam actions)

The risks from invasive species to Hawai'i, Guam and other Micronesia Region islands are linked most closely with the conveyance pathways that could transport the plant and animal species. Pathways are any means that allow the entry or spread of pests. A pathway risk assessment systematically evaluates the likely ways by which exotic pests or pathogens might enter an area and become established. A number of physical animal and plant pathways may move invasive species and diseases; however, most introductions to Hawai'i, Guam and other Micronesia Region locations are likely to be by commercial and military aircraft and maritime vessels.

Military relocation activities can impact multiple pathways in diverse ways. While data may be limited, interrelationships uncertain, and future events unpredictable, estimated numbers of personnel and contract workers are available and can be used to estimate potential impacts and necessary protections required to mitigate these impacts. Estimates are also available for the increase in construction materials needed to add or improve new military and residential housing, roads, and other infrastructure.

Planning and the allocation of funds will need to be part of any military relocation to the Mariana Islands. Even a scaled back version of the build up will be overwhelming in terms of the impacts it will have on the limited infrastructure, especially inspection capabilities for contraband and invasive species.

Military relocation will increase air transportation volume to and from Guam. Most military personnel and temporary workers will travel to Guam by commercial aircraft, increasing passenger volume on air transports substantially. Related pathways to this conveyance:

- Military and civilian passengers capable of transporting infectious diseases, disease vectors, and hitchhikers (species unintentionally transported in cargo, packing material, or containers)
- Baggage of passengers and all potential risk species that could be transported therein
- Commercial air cargo
- Garbage on board aircraft and from items confiscated at port
- Imported plants, plant products, animals, and animal products
- Smuggled biological items
- Unintentional transport of terrestrial vertebrates

New Guam residents and increased military activity on Guam and Tinian will require transport of equipment and materials and other cargo by maritime vessels for infrastructure and services.

- Construction equipment and materials shipped to Guam as containerized, break bulk, and bulk cargo
- Additional homes and buildings constructed to meet the demands of new residents and businesses
- Expansion of commercial and military port infrastructure
- Garbage generated on vessels
- Imported plants, plant products, animals, and animal products

New Guam and Tinian residents will conduct activities for business or pleasure, which could impact biosecurity.

- Mail and shipments to new residents on Guam and Tinian
- Landscaping
- Cultural activities (food preferences, religious ceremonies, aesthetic pursuits, hunting, fishing, boating, and other water water and terrestrial based activities)
- Scientific activities (zoological exhibitions and scientific research)

Leisure and business travel throughout the region and beyond by new residence and/or by visitors to residents

Military Impact Estimates

According to the DoD FEIS, Guam's current population of 177,718 (World Bank, World Development Indicators 2009) will increase by about 79,178 new residents, approximately 45%, at the peak of the military relocation. The post-relocation steady state will result in 33,608 new residents, an approximately 19% increase (U.S. Navy 2010a). DoD planning as of 2013 anticipates these numbers to be lower.

The DoD FEIS estimates shipments of containerized cargo to increase and then stabilize to a post-military relocation steady state (U.S. Navy 2010a).

It should be clear that these estimates are based on information which was current in 2010 but is no longer likely to occur. Changes will take place in regards to the buildup but exactly what these changes and associated impacts will be and at what levels was still undetermined as of August 2013.

2.2 PATHWAYS AND RISK SPECIES

Invasive species and disease agents threatening biosecurity on Hawai'i, Guam and other Micronesian Region islands are linked through their life cycles to specific pathways of transport. In most cases, these animals, plants, pests, and diseases move through more than one pathway. APHIS risk assessments have evaluated each of these relationships. Table 5-1 illustrates the range of mitigation measures employed at airport and maritime port facilities. Each of the following mitigations may be applied at both the air- and seaports: 1) inspection, 2) commodity identification, 3) control, 4) quarantine, 5) treatment or disinfection, 6) review of documents (permits, health or phytosanitary certificates, etc.), 7) training, and 8) approval to handle regulated garbage.

The pathway and risk profiles described in this section are designed as snapshots of the primary risk types, risk levels, mitigation measures, and recommended mitigation upgrades based upon APHIS risk assessments. Greater detail for biosecurity mitigation measures is in Chapter 6, *Existing Mitigation*. A more detailed, comprehensive description of the biosecurity recommendations for plants and plant products, livestock and poultry, and wildlife diseases is in Chapter 7, *Recommendations*. Specific recommendations for terrestrial vertebrates are in Chapter 11, *Terrestrial Vertebrates Biosecurity Plan*.

Table 5-1: Mitigation Measures for Risk Pathways

Pathway	Pre-test/certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
Cargo	X	X		X	X	X	X
Wood Packing Material	X			X	X	X	X
Construction		X		X		X	X
Mail				X ^a			
Regulated garbage	X	X	X	X		X	X
Plant propagative materials	X	X		X		X	X ^b
Plant products	X	X ^c					X
Soil		X		X			X
Livestock	X	X		X	X	X ^d	X ^e
Poultry	X ^f	X		X		X	
Pet birds	X	X		X	X	X	
Dogs and cats	X ^g			X		X	X ^h
Other animals	X	X		X	X	X	
Animal products	X	X		X			X

^a Only international mail may be inspected without a warrant.

^b Plants from Hawai'i.

^c Fruits and vegetables.

^d All foreign livestock destined to Guam and associated territories would be quarantined on Hawai'i or in the continental United States.

^e Domesticated livestock imported to the United States is subject to inspection or treatment procedures; an inspector may require disinfection of livestock and equipment as a precaution against the introduction of animal diseases.

^f All imported hatching eggs from Exotic Newcastle's Disease-free regions must be accompanied by a veterinary health certificate as well as a USDA import permit.

^g Dogs imported to the United States, with limited exceptions, must be accompanied by a certificate for rabies vaccination; the entry of pets from areas affected by screwworms requires a health certificate; dogs must have a rabies vaccination certificate (Guam Administrative Rules and Regulations or GARR); cats must have a certificate of immunization (GARR).

^h Administration of two doses of rabies vaccine (GARR).

2.2.1 Aircraft

A.B. Won Pat International Airport manages hundreds of flights weekly of national and international cargo and passenger transport, with numerous flights originating or passing through major Asian and Pacific metropolitan areas. All flights are considered "foreign" for agricultural inspection purposes. During FY 2008-2009, flights into the international airport averaged 1,610/month (approximately 400/week) (Guam Airport 2009).

All aircraft pathways are considered high-risk due to their ability to transport Brown Treesnakes (BTS) and other IAS in stores, baggage, or cargo.

For military aircraft, risks were higher for conveyances departing on urgent missions, which are not delayed for BTS (or other terrestrial vertebrate) inspections.

Other factors mitigate the risk of introductions through the air transportation pathway. Most of the military personnel relocating to Guam probably will move from the United States including Hawai'i, origins with greater enforcement resources for intercepting potentially invasive species in transport. Much of Micronesia appears to be free from many high-consequence animal pathogens that affect other regions of the world (APHIS Terrestrial Risk Assessment, Appendix A), although it is difficult to substantiate this appearance without sufficient veterinary infrastructure and surveillance.

Risks from livestock are mitigated by a lack of exposure to suitable agricultural hosts. For example, mosquitoes carrying agricultural disease agents are commonly transported in conveyances, but inspection procedures and lack of susceptible hosts near ports make release of the vectors less likely. Air cargo inspection at the airline facility at the airport allows for better inspection conditions. Ticks often found in luggage or carried by humans are from countries of origin not of high risk for tick-borne exotic livestock disease to Guam.

2.2.1.1 ***Impact of the Military Relocation:*** it should be noted that the estimates expressed in this section are basic on 2010 planning projects which are no longer current.

The military relocation will cause a substantial increase in conveyance and passenger traffic to Hawai'i and the Micronesia Region. Passengers will be military personnel, temporary contract workers from foreign ports in the Philippines and China, and military and construction worker families. An estimated 9,000 permanent military personnel with 10,000 dependents will be transported to Guam by 2014 (U.S. Navy 2010a).² Approximately 20,000 construction workers will arrive in Guam, resulting in about 17,000 direct or induced jobs for needed services. Approximately 20,000 dependents will relocate to Guam, at least temporarily. Military families will transport baggage, household items, vehicles, and outdoor equipment. Each family is permitted up to 8,164 kg (18,000) pounds of household goods depending on rank (U.S. Navy 2010a).

The influx of the 59,000 workers and their families is likely to increase the demand for specialty ethnic items and impact the amount of plants and plant pests smuggled into the Micronesia Region.

Airport phytosanitary and general sanitary mitigation measures include inspection, permit review, control, quarantine, treatment, disinfection, and personnel training. According to military estimates, demand for airport services may increase as much as 51% during the peak of the military relocation (U.S. Navy 2010a). Therefore, these mitigation capacities may need to be evaluated to determine whether they can meet the increased demand or will require appropriate enhancements in resources and funding.

Current mitigation measures are not sufficient to protect Guam from invasive species introduction, and therefore also do not protect the rest of Micronesia nor the state of Hawai'i adequately. Recommendations that follow for improving mitigation practices should provide a suitable baseline of protection. The increased air traffic will stress the already strained inspection process on Guam. Additional resources and infrastructure improvements should be made to permit inspectors to protect

² Ibid, p. 2-1.

ports adequately from species introduction. Infrastructure and resources for inspection of arriving and departing aircraft should be increased to meet the expected increase in conveyance traffic to manage the influx.

2.2.2 Maritime Vessels

2.2.2.1 Pathways and Risk Species

Historically both commercial and military vessels have transported invasive species to new locations. Invasive species can be found in vessel passenger and crew cabins, food and garbage storage areas, and cargo holds. Cruise ships and smaller vessels like fishing and recreational craft are also potential pathways.

2.2.2.1.1 Hitchhikers

Maritime vessels often transport invasive species in ship interior cabins, food and garbage storage areas, and cargo holds. Passengers and crew can carry invasive species on their clothing and in baggage. High-risk species transported as hitchhikers include live plants and propagative materials, arthropods (ants, mosquitoes, ticks, bees, Khapra beetles), plant pests and diseases, small mammals (rodents and bats), reptiles (snakes), and amphibians. Historically rodents have presented substantial risks in their high populations in port cities, access to ships through mooring lines and cargo, and viability during long transports (WSTV PRA 2010).

2.2.2.2 Garbage

Disease-causing vectors for plants and animals could be transported in garbage stores aboard ships. Large stores of garbage also attract invasive wildlife and birds (MARPOL 2006). Vessels need to have SOPs for safe keeping of garbage and vessels when calling to port need to be inspected by biosecurity officers to make sure garbage is in an enclosed bin and secured. How garbage is handled when removed from vessels also needs to be described in SOPs to insure that disposal methods are adequate to prevent introductions.

2.2.2.3 Current Mitigation Measures

Ships entering Guam waters are inspected at Guam ports; GCQA, and the GDOA Biosecurity Division and Division of Aquatic and Wildlife Resources seize products, hold animals in quarantine, and prevent illegal imports.

Vessels may need decontamination if a source of contamination or infection is found or suspected on board. Vessels may require disinfection if restricted items were not transported in leak-proof containers. Decontamination of ships may also include de-ratting under Centers for Disease Control and Prevention (CDC) regulations.

The Defense Transportation Regulation 4500.9-R, Part V (DTR 5) establishes requirements for agricultural cleaning and inspection for the military.

Current mitigation measures are not sufficient to protect Guam from invasive species. Likewise, the planning for upgrading Guam capabilities has not been adequate.

2.2.2.4 Risk Rationale

Contraband items, drugs, and weapons may be much higher inspection priorities for GCQA. Limited time and insufficient staffing levels prevent GCQA from inspecting all ships adequately. Most maritime cargo is allowed to proceed for inspection from the seaport to the importer's premises. This practice increases the risk of pest dissemination.

Ship rodent protections may not prevent rodent infestation adequately, and therefore ships may depart from a port with rodents aboard. Inspection for rodents and other pest species needs to be conducted for all ship arrivals.

2.2.3 Cargo

2.2.3.1 Pathway and Risk Species

Invasive plant propagules, seeds, plant pests, insects, amphibians, reptiles, and small mammals may be spread in cargo through inadvertent transport of contaminated or infested household items, handicrafts, or agricultural products. Other invasive species incursions occur at shipping staging and loading areas (Frank and McCoy 1995; Hawley et al. 2006; Norman and Strandberg 1997; Smith and Moore 2008; USDA-APHIS-PPQ 2010a; Whinam et al. 2005).

Invasive species can be moved in shipping containers which may be infested prior to or during loading. Movement of pest species within containers is probably less common than with break bulk items which are open to the environment throughout the loading and transportation process..

Deliberate or accidental release of imported caged birds exposes livestock and poultry to disease agent hazards and disseminates vector hazards for establishment in suitable habitats.

2.2.3.2 Steady State Mitigation Measures

GDAWR and the GDOA PPQ Division identify confiscated products, hold animals in quarantine, and prevent illegal imports. Any importer or exporter of wildlife must obtain a permit from the USFWS and in some instances a permit from USDA-APHIS.

Chapter 511 of the DTR 5 requires GCQA inspection of all military cargo entering Guam, regardless of origin (DTR 4500.9-R, Part V, Chapter 511). The APHIS-PPQ Manual for Agricultural Clearance (USDA-APHIS-PPQ 2013) instructs inspectors to inspect cargo of agricultural interest. Cargo inspections are conducted at designated ports unless otherwise authorized by the Director of GCQA; however, inadequate maritime port inspection facilities often cause cargo to be moved off port for inspection at the importer's premises.

GCQA requires that all DoD cargo be available for inspection upon entry to prevent the introduction of plant and animal pests or diseases. DTR 5 establishes requirements for agricultural cleaning and inspection for all military cargoes. The U.S. military is responsible for meeting all regulations for foreign

host nations. Micronesian sovereign governments can insist on military compliance with appropriate regulations.

2.2.3.3 Risk Rationale

Because of the volume of traffic, not all containers are selected for inspection. The limited military training in invasive species can be particularly consequential for the cargo pathway. Smuggling may also become a bigger issue as the population of the region grows.

2.2.3.4 Impact of the Military Relocation

The risks from the re-deployment of military personnel are mitigated by the fact that most military personnel relocating to Guam probably will move from the United States, including Hawai'i. However, a large number of personal shipments of household goods would be transported.

2.2.4 Wood Packing Material

2.2.4.1 Pathway and Risk Species

Wood packing material (WPM) has been implicated in significant plant pest introductions worldwide. Historical interceptions include 80 families of insects from seven different orders, seven families of mollusks, and seeds of 27 plant families. Particular risks may be the introductions of ants, terrestrial mollusks, wood-boring beetles, nematodes, and fungi. Wood may contain plant propagules, seeds, soil, or a range of hitchhiking organisms (USDA-APHIS-PPQ 2010a).

2.2.4.2 Current Mitigation Measures

U.S. regulations and International Standard of Phytosanitary Measures (ISPM) No. 15 require either fumigation with methyl bromide or heat treatment according to specific schedules for all WPM entering the United States. Treated WPM must display a specified ISPM No. 15 stamp in a visible location to facilitate compliance checks at ports of entry. These regulations apply to WPM imported from foreign origins into Guam, Hawai'i, and the CNMI (ISPM). Movement of WPM between these U.S. jurisdictions is domestic and thus not subject to these regulations (ISPM No. 15 2009).

The USDA-APHIS MAC (USDA-APHIS-PPQ 2013) directs inspectors to check whether regulated WPM is compliant. The APHIS Miscellaneous and Processed Products Manual instructs inspectors to look specifically for timber pests, other insects, and unspecified hitchhikers (USDA-APHIS-PPQ 2012). This guidance is used by U.S. territories but may also serve as standards for other countries in the Micronesia Region.

DoD stipulates that all new WPM under DoD contracts or acquired by DoD must meet ISPM No.15 requirements for shipments both inside and outside of the United States (DSCC 2008).

2.2.4.3 Risk Rationale

Many species associated with WPM, if introduced, could cause severe damage to Micronesian native flora and agricultural production.

There are many challenges to measuring the risk from WPM. The diverse range of species limits the ability to predict the species that may be found on WPM.

Pests may be present in the WPM because the prescribed treatments are not completely effective against all pests, especially plant pathogens, and because WPM may be re-infested after treatment (Haack 2006; Biosecurity Australia 2006). Treatments may be applied incorrectly, and the ISPM No. 15 seal may be administered fraudulently.

Very little information is available to estimate the amount of WPM moved in trade. The quantity of WPM entering Guam and the Micronesia Region or what quantity will enter during the military relocation cannot be determined. Estimates range between 50 to 75% of maritime cargo and up to 33% of air cargo (NZ MAF 2003; Meissner et al. 2009). No data are available on the average amount of WPM present per shipment because not all containers are inspected.

Because WPM is a circulating product and routinely re-imported, its origin is not always the same as the origin of the commodity with which it is moved. Palau and the RMI are not signatories of ISPM No. 15. A percentage of military and commercial shipments containing WPM will always bypass existing regulations and guidelines (random USDA inspections revealed that about 1% of maritime shipment WPM and about 5% of the air shipment WPM arrive without the required stamp).

2.2.4.4 *Impact of the Military Relocation*

The lack of adequate inspection is expected to worsen during the military relocation. Unavailable data on the volume of WPM in cargo shipments make estimates of the increase due to the military relocation guided only by the increased volume of cargo shipments.

2.2.5 Construction Equipment and Materials

2.2.5.1 *Pathway and Risk Species*

Construction materials presenting a common pathway for the introduction of invasive species could consist of trucks, tractors, cranes, earthmovers, forklifts, and barriers, as well as packaged items and loose timber, gravel, sand, and soil. Many of the risks and recommendations for construction equipment are described in Section 5.2.3, *Cargo*. Imported construction materials are likely to be shipped in containerized, break bulk, or bulk cargo.

The source for the majority of construction materials will be the U.S. mainland, although significant portions will originate in China and Japan (Berthoud, personal communication). Some materials will be imported from the Philippines and Indonesia (Jimenez et al. 2009). Palau has been a source for wood imports (GovGuam 1995), and blocks of cement and concrete have originated in FSM (Berthoud, personal communication).

Significant introductions of invasive species may have occurred through the import of construction material. Construction projects in Micronesian island nations have been implicated as pathways of introduction for invasive snails, plants, coconut rhinoceros beetles, cogon grass seeds, and highly invasive giant African snails (Hawley et al. 2006; USDA-APHIS-PPQ 2010a).

More than 130 different species were found at U.S. ports in 394 total interceptions on quarry products and steel shipments from Asia between 2003 and 2009 (USDA-APHIS-PPQ 2010a). More than 271 interceptions occurred on general equipment, machinery, and vehicles arriving at U.S. ports of entry from 2003 through 2009 from Asia. Many of these interceptions were reportable pests, including insects, mollusks, beetles, weeds, and grasses (USDA-APHIS-PPQ 2010a).

Some invasive species may colonize environments more easily when altered by construction activities (e.g., invasive plants giant foxtail [*Setaria faberi*], redroot pigweed [*Amaranthus retroflexus*], and the highly invasive Argentine ant [*Linepithema humile*]) (Mulugeta and Stoltenberg 1997; Kennedy 1998).

2.2.5.2 Current Mitigation Measures

Following inspection by the GDOA PPQ Division, imports of construction equipment to Guam found to be contaminated with soil must be washed in designated areas. Those contaminated with pests must be treated or re-exported.

Saw logs with bark are prohibited from entering Guam, and debarked saw logs and lumber must be determined through inspection to be free of termites and wood-boring insects. Foreign timber must have an import permit detailing required treatment. Other Guam regulations apply to all commodities, allowing the GDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude any commodities infested with pests (GARR Title 8, Food and Agriculture).

All regulations and requirements listed for cargo apply to the import of construction material.

2.2.5.3 Risk Rationale

Similar to WPM, it is difficult to quantify the risk of hitchhiker pests by construction pathway. Precise information on the types and amounts of construction material and equipment entering or expected to enter Guam in the future is not available. Construction at Andersen Air Force Base (AFB) alone is estimated to require more than 1,361 metric tons (3 million pounds) of steel (PB International 2008). Overall, it is clear that imports of construction material and equipment will increase significantly as a result of the relocation and then level off after construction is complete. At this time, there is no information on whether materials will be imported from additional countries during the relocation.

On Guam, it remains unclear how consistently mitigation measures for timber, sand, and gravel are applied and how efficaciously they prevent pest entry. There are no entry requirements for other construction materials. In general, Guam inspections for construction material cargo may be inconsistent, ineffective, or non-existent. Timber may be particularly problematic for invasive species. Detection of hidden insects inside large volumes of timber is difficult, and prescribed quarantine treatments are not completely effective against all pests. These challenges and the diversity of pests with timber cause a significant risk of pest introduction to Guam through this pathway.

Because construction materials may be imported from other nations, biosecurity in those origins is important. No processes are in place for educating off-island workers about biosecurity and the potential impacts of introducing plant pests.

Construction activities disturb environments, making them more susceptible to establishment of exotic pests. Some pests preferentially invade disturbed sites (Mulugeta and Stoltenberg 1997; Kennedy 1998).

2.2.5.4 *Impact of the Military Relocation*

New housing, new utilities, municipal buildings, and roads will be constructed on Guam, and port infrastructure will be enhanced.

2.2.6 Mail

2.2.6.1 *Pathway and Risk Species*

Invasive species have been transported in domestic and international mail. Historical interceptions of mail packages sent from the Micronesia Region to Hawai'i demonstrate the possibility that pests introduced into the Micronesia Region could make their way to Hawai'i via the mail pathway (USDA-APHIS-PPQ 2010a). APHIS-PPQ has reported interceptions of various plants, high risk animal products and by-products, insects, and other invertebrate species from mail at U.S. ports, including seeds, fresh fruits and vegetables, propagative plant parts, nuts, live insects, and soil. Specific pests include a wasp parasite, bee and bumblebee colonies, nonnative nematodes, mites, disease agents, parasites, larvae of the Mediterranean fruit fly, the melon fly, the Oriental fruit fly, and the Malaysian fruit fly. Seeds are the most common type of intercepted material, demonstrating the potential for invasive plant species to be mailed into the Micronesia Region from anywhere in the world. Mailed propagative material carries the risk of introducing Huanglongbing, a serious citrus disease that has not yet reached the Micronesia Region (Gottwald et al. 2007). The impact on subsistence farmers may be significant if Huanglongbing is introduced. Betel nut pests may be of special concern, as betel nuts are frequently sent by mail.

Huanglongbing (CGD) is not currently present on Guam, Saipan, Tinian or Rota although its vector, the Asian citrus psyllid has recently been collected from Guam, Saipan and Tinian. Rota appears to be psyllid free at the moment. Most citrus in the Mariana islands is grown in residential areas, with relatively little grown by farmers. The impact of CGD would be the destruction of myriad backyard citrus trees, and the gradual decline of the few citrus orchards there are and of course the increased threat to the rest of the region. Betel nut in the Marianas is currently beset by pathogens that restrict its transport, hence the booming betel nut trade from disease free areas such as Yap to the Mariana islands.

All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i. Guam's Main Post Office in Barrigada processes domestic and international mail for the Micronesia Region (Murphy 1983; Jimenez et al. 2009). CNMI, RMI, Palau, and FSM receive mail processed on Guam.

2.2.6.2 *Current Mitigation Measures*

All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i. These parcels enter Guam as parts of the U.S. domestic first-class mail system. First-class mail in Guam and CNMI cannot be delayed or opened without either a search warrant or permission from the addressee.

While GCQA has a designated x-ray inspection area inside the post office, it is not fully functional, and the local postmaster does not always grant GCQA officers permission to access this area. Foreign origin mail cannot be opened and inspected by GCQA unless the addressee is present.

The Guam Post Office displays educational posters describing prohibited mail items, and post office clerks ask customers whether outgoing packages contain perishable items. Arriving packages stamped "perishable" are inspected by GCQA officers and sent to the Guam Plant Inspection Station when additional information or diagnostic assistance is necessary.

Military mail is handled by the Military Postal Service Agency (MPSA), the single DoD point of contact with the U.S. Postal Service (USPS), and is required to adhere to USPS rules, federal laws, and various international laws and agreements for movement of military mail. The MPSA also instructs military personnel about items prohibited in mailed packages.

2.2.6.3 *Risk Rationale*

Using interception data and mail approach rates, it is estimated that 300 plant quarantine materials along with an unknown number of animal products and byproducts arrive on Guam each week through public mail. However, specific information about the significance of the mail pathway in Guam and the Micronesia Region is scarce.

The lack of information may be due partially to the protection of mail by the U.S. Constitution (Fourth Amendment), which makes it illegal to delay mail or open it without either a search warrant or permission from the addressee (DoD 2002; USPS 2007). These protections apply in Guam and the CNMI. GCQA officers open and inspect the mail, but the addressee must be present in the facility for the parcel to be opened and inspected. The postal facility is not permitted to slow down the flow of domestic mail (USPS regulation). This restriction limits the number of packages that can be inspected with the available workforce.

Detector dogs have proved successful in establishing probable cause to obtain a search warrant for inspecting domestic mail. The USPS allows GCQA to use detector dogs in the facility after official permission has been granted to enter the facilities with canines. The permission to enter the premises for inspections is not based on processing schedules, but is granted only on a case-by-case basis. Requests from GCQA must be submitted every time canine officers want to enter the postal facilities. Many times the requests are denied. The lack of cooperation between agencies inhibits canine use in the postal facility and is recognized as a weakness in the safeguarding structure.

The increase in mail order purchases over the last several decades increases the risk of introduction by mail. Consumers are generally not aware of this risk.

All domestic mail for Micronesia is received and processed first in Hawai'i, then again in Guam, so biosecurity at Hawai'i mail processing centers is important for Guam and the entire Micronesia Region, and biosecurity at Guam's mail processing facility is important for the rest of Micronesia. It is unclear to what degree domestic mail entering Hawai'i is inspected in Honolulu because the Hawai'i Department of Agriculture recently experienced a drastic decrease in agricultural inspectors due to budget cuts.

2.2.6.4 *Impact of the Military Relocation*

The pathway traffic volume in mail cargo is expected to increase as a result of the military relocation due to demands for consumer goods by a larger population.

After the military relocation, an additional 207 plant quarantine materials are estimated to arrive in Guam through public mail each week. This is in addition to the estimated 300 plant quarantine materials arriving on Guam each week through public mail.

2.2.7 Regulated Garbage

2.2.7.1 *Pathway and Risk Species*

Garbage of agricultural concern is waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material. Any other refuse associated with such materials is also garbage. Garbage is regulated if it has been aboard a conveyance that has been outside the United States and Canada within the previous 2-year period or if the means of conveyance has traveled within the previous 1 year between the continental United States and a U.S. territory, U.S. possession, or Hawai'i, or either directly or indirectly, to any U.S. territory or U.S. possession from any other U.S. territory or U.S. possession or from Hawai'i, or to Hawai'i from any U.S. territory or U.S. possession. Non-regulated garbage comingled with regulated garbage is also regulated. Regulated garbage must be either destroyed by incineration to ash, ground, and discharged into an approved sewage system or sterilized (heated to an internal temperature of 212 degrees Fahrenheit [°F] for 30 minutes) (7 CFR § 330.440-330.403; 9 CFR § 94.5).

Garbage as a pathway can carry diverse populations of plants, animals, and insects and other invertebrate species. Military, commercial, fishing vessels, and cruise ships generate refuse. Rejected cargo and prohibited items removed from passenger baggage at commercial and military airports and maritime ports of entry are treated as regulated garbage. Cargo shipments of garbage are common throughout Micronesia, although the importation of garbage into Guam and the CNMI is prohibited (9 CFR § 95 and 7 CFR § 330.400-403).

A wide range of potentially invasive insects, reptiles, amphibians, plant materials for plant propagation, and human and animal pathogens can be transported in garbage. Agricultural disease agents African swine fever (ASF), classical swine fever (CSF), foot and mouth disease (FMD), and swine vesicular disease

(SVD) viruses spread to swine readily through ingestion of contaminated meat, typically through garbage feeding (VS PRA 2010).

The food source and shelter of garbage attract a variety of invasive species, particularly rats and mice that could carry human and animal diseases throughout the Micronesia Region. How long disease agents remain infectious varies by agent and environmental conditions but many remain viable for weeks to months under the right conditions (e.g., *Brucella abortus*, avian influenza viruses, *Echinococcus* virus, and Exotic Newcastle's Disease [END]) (VS PRA 2010). Mice and rats are also prey items for predators such as Brown Treesnakes and the presence of such prey items in and around garbage likely increases the potential for accidentally transportation of these predators.

2.2.7.2 Current Mitigation Measures

APHIS-PPQ and its cooperators have responsibility for monitoring regulated garbage handling at airports, caterers, cleaners, cruise ships, fixed-base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and transfer stations. There are insufficient governmental resources to monitor regulated garbage activities on Guam and CNMI. Adequate on-island disposal methods for garbage, either regulated and non-regulated, do not currently exist on Tinian, the proposed site for increased military training.

The APHIS-PPQ MAC (USDA-APHIS-PPQ 2013) guides monitoring of the handling of foreign regulated garbage within U.S. territory. Entities that handle regulated garbage must be approved by USDA-APHIS and either have a compliance agreement with or be supervised directly by APHIS or APHIS cooperators. Regulated garbage must be moved by entities approved by USDA-APHIS to handle regulated garbage under the direction of an inspector to an approved garbage-handling facility. There are nine companies on Guam and Saipan authorized to handle regulated garbage under compliance agreements with USDA-APHIS. Regulated garbage is monitored to prevent the movement and dissemination of pests and plant and animal diseases. Tightly covered, leak-proof containers must be used to store regulated garbage while inside U.S. territory, which includes Guam and other locations in Micronesia. This territory extends 12 nm off the coast. Regulated garbage must be stored in the proper container to move it from a conveyance for disposal.

Regulated garbage from commercial and military aircraft must be unloaded at an airport or military base approved to handle regulated garbage. On Guam, NAVFAC Marianas at the Apra Harbor Naval Station and Pacific Environmental Resources Incorporated at Andersen AFB are approved to handle garbage. Private companies handle the off-loading of regulated garbage at A.B. Won Pat International Airport including rejected cargo from maritime vessels.

2.2.7.3 Risk Rationale

Non-compliant (non-containerized) regulated garbage makes this pathway prone to incursion by numerous invasive species. There is a risk of regulated garbage entering at the airport or seaport without transport to an approved processor. Private aircraft arriving at A.B. Won Pat International

Airport, military aircraft entering at Andersen AFB, and private/commercial vessels arriving at commercial seaports represent the greatest risks because of the lack of oversight.

2.2.7.4 Impact of the Military Relocation

The relocation is expected to bring additional people, aircraft, cargo, and commercial and military ships from foreign countries (U.S. Navy 2010a). Therefore, the military relocation is expected to increase volume of all imports proportional to the population increase, including rejected cargo and prohibited items seized from passenger baggage.

2.2.7.5 Additional Mitigation Measures Recommended for the Military Relocation

To mitigate the risk presented by regulated garbage, it must undergo one of three processes: 1) incineration, defined as reducing garbage to ash by burning (with policy exemptions for glass and metal); 2) sterilization, cooking at an internal temperature of 212°F for 30 minutes; or 3) grinding and discharge into an EPA- and APHIS-approved sewage system.

To handle the immediate increase in garbage generated and regulated garbage off-loaded in Guam, building a waste-to-energy processing facility to reduce the amount of debris transported to a landfill and to increase the electrical capacity of the island should be considered. Tinian government and the U.S. military should collaborate to ensure adequate facilities and resources are available to properly dispose of regulated, as well as non-regulated, garbage on-island prior to the commencement of military training. Refer to Section 6.3.10, *Garbage*, for additional information.

2.2.8 Plant Propagative Material

2.2.8.1 Pathway and Risk Species

Whole plants, buds, bulbs, tubers, seeds and other propagative parts present phytosanitary risks in the Micronesia Region either as pathways for the introduction of exotic plant pests or as invaders.

The movement of plant propagative material is a primary means by which plant pests and small animals invade new areas. Plant propagative material can be transported in the baggage and cargo of planes and maritime vessels, in WPM and construction materials, in soil attached to military and construction equipment, and in garbage.

Plant material hitchhikers include insects, mollusks (snails, slugs), mites, and weeds; pathogens include viruses, fungi, bacteria, and nematodes. Potential hitchhikers include the Red palm mite, *Raoiella indica* (Acari: Tenuipalpidae). At U.S. ports of entry from March 2009 to March 2010, there were 5,600 interceptions of more than 16,000 pest specimens including insects (86 families), mollusks (16 families), mites (5 families), weeds (13 families) as well as viruses, fungi, bacteria, and nematodes (USDA-APHIS-PPQ 2010a). Potential plant pathogens include banana bunchy top virus, a disease of *Musa* (banana plants) for which there is no effective treatment (Thomas et al. 1994), and the bacterium *Candidatus Liberibacter*, which causes Huanglongbing in *Citrus* species (Wang 2009). It is worth noting that banana

bunchy top virus is already present in the region, specifically on Guam since at least the 1970s and was first detected in Hawai'i by University of Guam extension agent Frank Cruz.

The deliberate or accidental introduction of invasive plant propagative material may present phytosanitary risks in the Micronesia Region and Hawai'i. Examples are noxious weeds that pose ecological and economic threats, exhibit aggressive growth, and interfere with watershed functions. For example, *Miconia calvescens* (Melastomataceae), introduced to Hawai'i as an ornamental tree, is listed as a noxious weed (Loope 1997).

2.2.8.2 Current Mitigation Measures

For Guam the regulations for the import of foreign and domestic materials rest with APHIS and GDOA, respectively. All propagative plant materials imported into Guam, including trans-shipments to the CNMI, Palau, and FSM, are inspected at the GDOA Plant Inspection Station under agreement with USDA-APHIS-PPQ. Flowers and cut flowers are examined intensively for import violations. GDOA requires all plants entering Guam from Hawai'i to be treated with a hot water or citric acid solution drench prior to shipment and to be inspected for pests of concern to Guam.

Guam prohibits the entry of specific propagative plant materials from specified locations to prevent the introduction of pests of concern: citrus, coconut, banana, taro, and sweet potato planting materials are prohibited. Certain plants from areas infested with the European Corn Borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae) are restricted. However, the number of regulated pests is a small percentage of all pest organisms from propagative materials. Imports of plant material for landscaping on Guam are imported mainly from the United States, but other sources include Thailand, Taiwan, Philippines, Costa Rica, Ecuador, and Puerto Rico (McConnell 2010; Campbell personal communication).

2.2.8.3 Risk Rationale

Several factors influence risks from plant propagative materials as either hosts or carriers in Guam and the Micronesia Region. The DoD does not place restrictions on military personnel moving plants into Guam, increasing the risk of the unintentional introduction of invasive species. The current DoD landscape plan may facilitate the spread of potentially invasive plants; therefore, plants known to be invasive or to have a high invasive potential are common in Guam landscapes.

Some plant pests carried by plant propagative materials are unlikely to be detected by visual inspection because of their small size (e.g. mites). There is evidence that these pests often go undetected. Improper disposal of plants often increases the spread of plant pests from propagative materials.

There are no appropriate diagnostic tools for most plant disease pathogens feasible for plant quarantine purposes; thus, plant pathogens often are not detected unless the infected plant material expresses noticeable symptoms, often not the case. As an example, *Candidatus Liberibacter*, causative agent of Huanglongbing in *Citrus* species, can spread through infected propagative material without symptoms (Wang 2009).

No treatment requirements are in place for plants from the Caribbean and Florida, heightening the risk of introduction of plant pests from these locations.

The invasive potential of the propagative material itself is not considered in any regulation.

2.2.8.4 *Impact of the Military Relocation*

The military construction and the relocation of commerce will increase imports of plant propagative material, particularly landscape species, and may increase the risk of pests entering the Micronesia Region. These increases may well be in both volume and range of species imported.

Additionally, garden centers may increase their supply of ornamental plants to meet demands from a larger consumer base (homeowners, hotels, and commercial businesses). Garden centers may increase their supply of ornamentals, including plants that could become invasive.

Residents could demand imported home furnishings. Some plant propagative materials may also be intended as ethnic food products for foreign temporary workers on Guam.

2.2.9 Plant Products

2.2.9.1 *Pathway and Risk Species*

Plant products are commodities, foods, or other articles moved for trade or other purposes. Cut flowers and branches are fresh parts of plants intended for decorative use and not for planting. A variety of plant pests, plant disease vectors, and small exotic animals can be carried in plant products. Plant products can be transported by import in the baggage and cargo of planes and maritime vessels and through smuggling.

Christmas trees are of significant concern as potential vectors for non-native pests species. There are numerous records of non-native organisms hitchhiking to Guam and other ports as accidental passengers in Christmas tree shipments. Anticipated increases in U.S. mainland residence moving to the region will likely only increase the interest in shipping Christmas Trees and hence will also likely increase the potential for accident transport of pest species unless appropriate measures are installed throughout the region to address this pathway for invasive species.

Plant products can carry hitchhiking insects and mites and can be infected hosts for plant pathogens. Two potential plant pathogens include banana bunchy top virus, a nontreatable disease of *Musa*, and the bacterium *Candidatus Liberibacter*, which causes Huanglongbing in *Citrus* species (Thomas et al. 1994, Wang 2009).

2.2.9.2 *Current Mitigation Measures*

For Guam U.S. Federal regulations require an APHIS permit for the importation of fruits and vegetables. The APHIS-PPQ Fruits and Vegetables Import Manual guides PPQ and APHIS cooperators on fresh fruit and vegetable shipments (USDA-APHIS-PPQ 2010b). Chapter 5 of the APHIS-PPQ Treatment Manual

shows the treatment schedule for fruit, nuts, and vegetables (USDA-APHIS-PPQ Treatment Manual 2008).

Cargo manifests are reviewed to determine whether cargo contains fruits and vegetables of agricultural interest. Cargo of agricultural interest must be held until cleared by PPQ or its cooperators. Clearance of fruits and vegetables may be done by an inspection of the paperwork, an inspection of the commodities, or both. Inspections may be random, routine, or targeted. Guidance for inspections is from the APHIS–PPQ Fruits and Vegetables Import Manual (APHIS Manuals).

USDA-APHIS-PPQ regulations require phytosanitary certificates for the importation of plants and certain plant products from foreign sources. GDOA may require such certificates from other parts of the United States. Risk Rationale

Of particular concern are exotic plant products imported by temporary workers relocating from origins with plant pests and diseases not found on Guam. Often these products are marketed by roadside stands outside the realm of inspection and compliance.

2.2.9.3 *Impact of the Military Relocation*

The military construction and the relocation of commerce will increase imports for plant products.

2.2.10 Soil

Movement of soil, whether intentional or unintentional, is a well-known pathway for a wide variety of potentially dangerous organisms. Soil imported for landscaping and plant propagation can be moved unintentionally on construction equipment, military equipment, other construction materials, cargo, and shoe soles.

2.2.10.1 *Current Mitigation Measures*

For U.S. jurisdictions APHIS regulations (7 CFR § 318 State of Hawai'i and Territories, Quarantine Notice, Sub-Part-Sand, Soil, or Earth, with Plants from Territories and Districts; 7 CFR § 318.60 Notice of Quarantine) describe requirements for inspecting and, if necessary, treating imported soil (7 CFR § 318, 318.60).

Guam law prohibits importation of raw soil except in small quantities for research or testing at certified soil testing laboratories (Guam Administrative Rules and Regulations 1986, USDA-APHIS-PPQ Rules and Regulations). Guam's

hardware stores and plant nurseries import large quantities of packaged potting soil and soil amendments including compost, mulch, manure, peat, and sphagnum moss from the mainland U.S. These

imported packages are a potential pathway for invasive species entering Guam. Most imported potting soil and other processed soil amendments from the U.S. Mainland are currently not inspected on arrival in Guam.

2.2.10.2 Risk Rationale

Movement of soil (e.g. landscaping, plant propagation, construction, military equipment, construction materials, cargo, and shoe soles) is a common pathway for a wide variety of invasive organisms.

2.2.10.3 Impact of the Military Relocation

Military construction and increased commerce may increase the need for plant propagative materials, particularly of landscape species. Increased sales of commercial potting soil may introduce and facilitate the spread of pests on Guam (Berringer 2010). In general, each of these increases represents an increased risk from this pathway.

2.2.11 Livestock Imports

2.2.11.1 Pathway and Risk Species

The livestock pathway is determined by the risk assessment to be primarily legal import of domesticated equids (horses, mules, and asses). Domestic equids can be infected hosts, contaminated with disease agents, or serve as hosts to tick vectors of disease agents. Infected domesticated equids are primary sources for the etiologic agents of African horse sickness (AHS), contagious equine metritis (CEM), dourine, equine infectious anemia (EIA), equine piroplasmiasis (EP), and glanders. Through infection or as an infected host, fomite, or host to vectors, equids can transport nipah, rabies, VEE, Vesicular Stomatitis (VS) viruses, screwworms, *Echinococcus* spp., *Leishmania* spp. parasites, *M. bovis*, eastern equine encephalitis (EEE), Japanese encephalitis (JE), western equine encephalitis (WEE), West Nile viruses, ASF, CSF, and FMD viruses. Domesticated equids are hosts frequently for tick species as competent vectors for EP and less frequently for tick species as competent vectors for heartwater (VS PRA 2010; Estrada-Peña et al. 2004).

2.2.11.2 Current Mitigation Measures

Horses for import to Guam first must enter through ports in the continental United States for quarantine until negative results to specified tests, depending upon the country of origin, are obtained, and the horses are certified by the port veterinarian to be free from clinical evidence of disease.

Domesticated equids for import to the United States from regions affected by screwworm, CEM, and VEE are subject to inspection or treatment. Imported domesticated equids, with limited exceptions for those originating in certain countries, cannot enter the United States until they have been tested for EIA, EP, dourine, and glanders by an official test with negative results. Before a horse imported from any part of the world is released from the U.S. port of entry an inspector may require the horse and its equipment to be disinfected as a precautionary measure against the introduction of FMD or any other disease dangerous to livestock (9 CFR § 93.314).

According to GARR Title 9, Division 1, Chapter 1, no animals affected with or exposed to an infectious, contagious, or communicable disease or ectoparasite or originating in an area under state or federal

quarantine shall be introduced into Guam. Horses are subject to specific mitigations to prevent the entry of EIA, EEE, WEE, and VEE viruses.

2.2.11.3 *Risk Rationale*

Risk to livestock as a result of the introduction of invasive species to Guam and the Micronesia Region is limited for several reasons. Guam has a relatively small livestock population with minimal movement of livestock on the island. No livestock have been imported in the last 5 years. This fact reduces the likelihood that any disease agent has come into contact with Guam livestock. Ticks may be carried on invasive mammals, but pre-importation and inspection procedures reduce the probability of vector release and exposure to livestock.

Imports of domesticated equids to Guam might increase as a result of the military relocation, but the steady-state import of livestock is very small. Any domesticated equids imported probably will originate in the U.S. mainland due to federal regulations on importation of livestock. The United States is free of AHS, African animal trypanosomiasis, dourine, FMD, glanders, heartwater, JE, nipah virus encephalitis, screwworm, surra, and VEE (U.S. Animal Health Report 2008). The greatest risks might be from CEM, EP, and VS due to recent outbreaks in the United States.

There has been no evidence of smuggling of livestock to Guam. Illegal transport of large agricultural animals is not feasible, and this infeasibility is not expected to change during the military relocation.

2.2.11.4 *Impact of the Military Relocation*

Traffic volume in domesticated equids to Guam might increase slightly as an indirect result of the military relocation (increased demand for recreational activities). Federal regulations governing the importation of livestock make domesticated equids for importation to Guam highly likely to originate in the continental United States, which is free of most of the hazards for which domesticated equids are primary sources. The risk of importation or interstate movement of hazards for which domesticated equids might play significant roles in transporting them to Guam is mitigated by APHIS and Guam territorial regulations.

2.2.12 Poultry Imports

2.2.12.1 *Pathway and Risk Species*

Poultry are chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching. Poultry can transport hazards in three roles: 1) they can be infected hosts, 2) they can be contaminated with disease agents and serve as fomites, or 3) they can serve as hosts to tick vectors of disease agents.

Infected or contaminated poultry can facilitate the transmission of many etiologic agents, including avian metapneumovirus, duck virus hepatitis, fowl typhoid, pullorum, EEE, END, highly pathogenic avian influenza (HPAI), WEE, VEE, West Nile viruses, screwworms, ASF, CSF, and FMD viruses (VS PRA 2010). Game fowl, pet, and exhibition poultry may have encounters with disease-carrying ticks.

Infected bird feces and secretions spread primarily through direct contact. People, other animals, vehicles, and equipment can become contaminated with poultry feces or secretions and can carry disease agents from one location to another; END, for example, is transmitted readily on fomites.

END and HPAI are some of the most severe poultry diseases throughout the world. Animal health consequences are significant. For both diseases, morbidity and mortality rates may approach 100%, 90% in susceptible chickens (VS PRA 2010). Introduction of END, HPAI, or other high -mortality avian diseases could have a catastrophic effect, perhaps local extinction, on the very small populations of the Micronesia Region's endangered bird species.

The World Health Organization (WHO) has reported rare cases of H5N1 HPAI in humans in Asia, Africa, the Pacific, Europe, and the Near East. Indonesia and Vietnam have reported the highest number of human H5N1 cases with mortalities of up to 60%, especially in cases hospitalized late in the course of the illness (WHO 2005).

2.2.12.2 *Current Mitigation Measures*

Importation of live poultry, poultry products, and hatching eggs is restricted from regions affected by END or HPAI; several of these regions are Asia-Pacific countries. Live poultry permitted to enter the United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a quarantine facility on the U.S. mainland (9 CFR §§ 93.201, 209, and 94.6).

Birds not of U.S. origin must be accompanied by an import permit issued by APHIS. All imported hatching eggs from END-free regions must be accompanied by a veterinary health certificate as well as a USDA import permit.

Interstate commerce of a bird for the purpose of participation in a fighting venture is illegal regardless of the law in the destination state, including Guam.

Guam territorial regulations require all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian (9 GARR 1 §1110). The health certificate must be issued within 10 days prior to shipment attesting that the bird has been found free of ectoparasites and symptoms of transmissible disease. Any animal found to be clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites is returned to the point of origin or destroyed.

Guam import requirements for poultry include: 1) origin from flocks and hatcheries free from pullorum disease or with a pullorum-controlled status; in the latter case birds must test to be serologically negative for pullorum disease within 30 days of entry; 2) vaccination for Newcastle disease virus (NDV) between 30 to 60 days prior to shipment; 3) no symptoms of NDV or other communicable diseases at the time of shipment; and 4) a health certificate issued by an accredited veterinarian (9 GARR 1 §1110). Requirements 2, 3, and 4 do not apply to hatching eggs and day-old poultry with an affidavit from the shipper stating that the flock of origin has not been exposed to and has been free of NDV for 60 days

prior to shipment. All poultry and hatching eggs must be shipped in new (unused) containers and inspected by the territorial veterinarian or deputy prior to entry.

The USPS allows adult and hatchling poultry to be mailed with restrictions. Postal regulations prohibit mailing of hatchling (day-old) poultry vaccinated for NDV. Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to the addressee within 72 hours after hatching.

2.2.12.3 Risk Rationale

Illegal imports of poultry could increase temporarily as a result of the military relocation due to the popularity of cockfighting among foreign temporary workers from the Philippines. Historically, temporary construction immigration from the Philippines has increased fight attendance.

Similar to other islands in the Micronesia Region, a sizeable population of feral chickens roams freely on Guam. This feral population could facilitate the spread of poultry disease among domestic flocks.

Due to import regulations, most poultry breeding stock probably will continue to be imported from the continental United States and Hawai'i. The United States is free of ASF, CSF, END, FMD, HPAI, screwworms, and VEE; therefore, imported live poultry are unlikely to have contact with these agents and to serve as fomites for exposure of livestock to them (USDA-APHIS 2009a). Illegal traffic in live poultry, including hatching eggs, is known to occur.

The increased traffic volume that might be an indirect result of the military relocation cannot be quantified. Any significant influence on the number of imported poultry would be related most likely to the influx of foreign temporary workers.

2.2.12.4 Impact of the Military Relocation

The illegal import of poultry may increase temporarily from the influx of temporary workers from the Philippines. The number of live poultry legally imported to Guam or the rest of the Micronesia Region is unlikely to change as a result of the military relocation. The risk of hazard release through legal entry of live poultry to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations.

2.2.13 Pet Bird Imports

2.2.13.1 Pathway and Risk Species

Import of pet birds for pets or for commercial trade is a common practice. Smuggling of pet birds is also common. Pet birds can be invasive species or transmit infectious diseases directly or through infected vectors. Infected bird feces or secretions spread primarily through direct contact. People, other animals, vehicles, and equipment can become contaminated with bird feces or secretions and can carry disease agents from one location to another (VS PRA 2010).

Like poultry, other birds can be infected by and serve as reservoirs for equine encephalomyelitis, END, HPAI, and West Nile viruses. Infected birds can be sources for etiologic agents of fowl typhoid and

pullorum. Reports of infestation of birds with screwworms are rare. Birds that have been in contact with affected premises can spread ASF, CSF, and FMD viruses mechanically (VS PRA 2010).

Psittacines (parrots, cockatiels, parakeets, budgerigars, and other parrot-like pet birds), the most popular pet birds in the United States, are uncommon hosts for vector hazards. A variety of buntings, sparrows, finches, and weavers (families Emberizidae, Passeridae, and Ploceidae), songbirds transported in the caged bird trade, are frequent hosts for European, Asian, or African ticks (VS PRA 2010).

2.2.13.2 Current Mitigation Measures

For Guam birds not of U.S. origin must be accompanied by an import permit and be received and inspected by USDA personnel at an approved port of entry with quarantine facilities. Approved bird quarantine facilities are located in New York, Miami, and Los Angeles. Birds are quarantined for 30 days, during which they are tested for certain communicable diseases. USDA maintains trade restrictions on the importation of live birds from certain countries in Africa, Europe, and Asia affected by HPAI (USDA-APHIS 2009a).

Importation of exotic birds into the United States must comply with APHIS and USFWS requirements. Certain exotic birds are protected by the Convention on International Trade in Endangered Species (CITES) (www.cites.org) and the WBCA (<http://www.fws.gov/international/laws-treaties-agreements/us-conservation-laws/wild-bird-conservation-act.html>). U.S. Customs and USFWS enforce the international trade regulations for exotic birds. USFWS requires an importation permit, and the WBCA has set a limit of two birds per year per person, who must have resided continuously outside the continental United States for at least 1 year.

All birds entering the territory of Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian issued within 10 days prior to shipment attesting that each bird has been found free of ectoparasites and symptoms of transmissible diseases. A leg band number should identify the scientific name of the animal. Any animal found clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites must be returned to the point of origin or destroyed (GARR Title 9, Division 1, Chapter 1).

Under 9 GARR §§ 2101-2102 pet shops and importers are required to keep a record of each sale for at least 90 days and to make the record available to the GDOA if a quarantine is placed on the premises by the territorial veterinarian (GARR Title 9, Division 1, Chapter 1).

Guam has introduced additional quarantine requirements for the importation of all birds (poultry and non-poultry) from the continental United States to prevent the introduction of West Nile Virus. All birds must be quarantined a minimum of 7 days in an approved quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage (Poole 2009).

Under USPS regulations, non-poultry birds cannot be mailed (USPS 2009).

2.2.13.3 Risk Rationale

The small number of live non-poultry birds imported to Guam may increase as a result of the military relocation due to demand in the pet trade. At least 7% of military families reported keeping a pet bird (Anderson 1985). Residents of military base housing are not prohibited from keeping non-poultry pet birds.

Most live birds moved legally to Guam during the military relocation are likely to originate from the U.S. mainland due to federal regulations on importation of live birds addressed under mitigations. The United States is free of ASF, CSF, END, FMD, heartwater, HPAI, JE, screwworms, and VEE (U.S. Animal Health Report 2008).

The risk of hazardous release through legal entry of live non-poultry birds to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations. Quarantine takes place off-island as there are no APHIS-certified quarantine facilities on Guam, and import regulations are strict.

Smuggling of pet birds may increase to meet a potentially higher demand from the increased population caused by the military relocation. An increase may also occur as a result of Guam becoming a more achievable pathway to other U.S. states and territories as a result of greater flight availability into Guam from Asia. The increase is not likely to be significant due to existing regulations, but enforcement can be difficult. Most smuggled live birds seized by U.S. officials between 2004 and 2008 originated from Mexico, Central America, and South America, but smuggled birds also come from Japan, Hong Kong, and Indonesia (USDA-APHIS 2006; USDA-APHIS-PPQ 2010a). The United States is one of the largest markets for the illicit global commerce in wildlife with wild birds as major commodities, mostly for exotic pets or tourist souvenirs.

2.2.13.4 Impact of the Military Relocation

The small number of live non-poultry birds imported to Guam may increase along with the anticipated human population increase on Guam as a result of the military relocation. The number of birds brought to Guam through legal means should remain relatively small compared to some U.S. mainland areas but increase more than proportionally if the 7% estimate is achieved (in recent years, fewer than 12 birds annually) (VS PRA 2010).

While no reliable estimates of illegal traffic volume of live birds for the pet trade are publicly available, the demand for illegal wildlife in the United States is likely to parallel U.S. demand for legal wildlife. Illegally imported live non-poultry birds bypass mitigations intended to reduce the likelihood of release of hazards.

2.2.14 Importation of Dogs and Cats

2.2.14.1 Pathway and Risk Species

Domesticated dogs and cats can be infected by and serve as reservoirs for rabies and can harbor screwworms, *Echinococcus* spp., and *Leishmania* spp., and *Trypanosoma* spp. parasites. Cats and dogs

are susceptible to HPAI virus and Salmonella pullorum infections. Dogs can be infected by AHS and VEE viruses, ASF, classical swine fever, or FMD. Viruses can spread mechanically by domestic dogs and cats in contact with affected premises (VS PRA 2010).

Dogs are common hosts for several tick species as competent vectors of EP and heartwater. In a few instances, hazardous ticks, specifically *Amblyomma* spp., have been found on dogs imported to the United States (VS PRA 2010).

2.2.14.2 Current Mitigation Measures

All pet dogs and cats arriving in Guam are subject to local quarantine requirements. The quarantine period is 120 days post-arrival for domestic dogs and cats (reduced to 30 days or less than 5 days for certain provisions made for dogs, cats, and other carnivores).

Cats and dogs imported to the United States are subject to inspection at ports of entry and may be denied entry for evidence of an infectious disease that can be transmitted to humans. Dogs imported to the United States, with limited exceptions, must be accompanied by a certificate for rabies vaccination; imported cats are not required to be vaccinated for rabies. The entry of pets from areas affected by screwworms is subject to APHIS regulations (9 CFR § 93), which require a health certificate stating that the pet was found to be free of screwworm infestation within 5 days of export (USDA 2000; USDA-APHIS 2009b).

Guam restrictions and prohibitions for the importation of cats and dogs are stricter than federal requirements, including quarantines. Cats and dogs must enter Guam through the A.B. Won Pat International Airport or the Apra Harbor maritime port. Every cat and dog must be accompanied by an entry permit, a health certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine kennel reservation. Dogs must have a rabies vaccination certificate dated between 30 days and 1 year prior to shipment and a certificate of immunization against distemper, hepatitis, leptospirosis, parainfluenza, parvovirus, coronavirus, and bordetella. Cats must have a certificate of immunization for feline distemper, feline viral rhinotracheitis, calicivirus, panleukopenia and chlamydia (GARR Title 9, Division 1, Chapter 1). Regulations for the importation of cats and dogs into Guam require animal identification, quarantine procedures, and rabies vaccination and testing prior to arrival (GARR Title 9, Division 1, Chapter 1).

GDOA (5 GCA § 60108) regulates dog and cat imports. Title 10 Guam Code Annotated Chapter 34 Article 3 states that animals imported must complete a maximum 120 days of confinement in a commercial quarantine facility, 30 days of quarantine if they meet pre- and post-arrival requirements: administration of two doses of rabies vaccine, presence of adequate protective antibody titer, and a properly implanted identification microchip. A 5-day quarantine program is available for pets with a Fluorescent Antibody-Virus Neutralization test conducted by an eligible laboratory between 120 days and 12 months prior to entry (Guam Public 29-112). Some pets may qualify for the home quarantine option.

Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for counties on the Mexican border) can be quarantined on Guam. Animals originating from elsewhere must be quarantined in Hawai'i prior to entry. Cats and dogs originating from rabies-free areas, Hawai'i, New Zealand, Australia, and the United Kingdom, are exempted from quarantine if they comply with all other requirements.

All cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) must have a certificate from the national chief livestock sanitation officer stating that the animals originated in a state, country, or political subdivision officially declared free of surra, animal African trypanosomiasis, and leishmaniasis.

Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the custody of the carriers at a designated inspection area at the port of entry until sent back.

2.2.14.3 *Risk Rationale*

Most pet dogs and cats will be imported through legal channels. Total imports of dogs and cats may be limited due to import restrictions and costs. Most imported pets will come from the United States and Hawai'i with a few animals imported from Japan and the CNMI (VS PRA 2010). Temporary workers and tourists are unlikely to bring pets due to their nonpermanent status on Guam and the regulatory requirements of import.

Because Chagas disease is endemic in parts of the continental United States and the majority of pet dogs and cats will come from the United States, this disease agent must be considered a risk. Leishmania presents a similar concern.

2.2.14.4 *Impact of the Military Relocation*

Traffic volume (10 to 100 annually in domestic cats and dogs to Guam is likely to increase as result of the military relocation). Most domesticated cats and dogs intended for importation to Guam are likely to originate in the continental United States, which is free of most of the hazards for which domesticated cats and dogs are epidemiologically significant sources.

The risk of importation or interstate movement of hazards for which domesticated cats and dogs might play significant roles in transporting them to Guam is mitigated by U.S. military and Guam territorial regulations.

2.2.15 Importation of Exotic Animals

2.2.15.1 *Pathway and Risk Species*

Exotic species of animals are often imported for pets, cultural or scientific purposes, or zoological exhibition. These animals can be invasive species and can transport disease agents or vectors for native species. Worldwide, illegal trade in these animals is substantial and profitable, and the U.S. is the leading import market. There may be an increase in breeding of socially popular species which could have impact on Guam's environment.

Members of the genera *Amblyomma*, *Dermacentor*, *Haemaphysalis*, *Hyalomma*, and *Ornithodoros* frequently parasitize reptiles, particularly terrestrial chelonians, snakes, and lizards, in tropical regions (VS PRA 2010). Numerous ticks, primarily exotic species of *Amblyomma* and *Hyalomma*, have been found on reptiles imported to the United States. Exotic ticks introduced with imported reptiles could be infected with organisms pathogenic to domestic livestock populations; *E. ruminantium*, the causative agent of heartwater, was detected in *Amblyomma sparsum* ticks collected from imported tortoises (Burridge et al. 2002).

2.2.15.2 *Current Mitigation Measures*

Importation of zoo, fur-bearing, and other wild animals to Guam requires a permit in advance from the Director of Agriculture of Guam. USFWS designates Agana, Guam, as a special port for importing certain kinds of wildlife (including animal parts and products with a final destination of Guam). The GDAWR and the GDOA PPQ Division identify and hold animals in quarantine. Any importers or exporters of wildlife must obtain a license from USFWS.

2.2.15.3 *Risk Rationale*

The U.S. live animal trade in small mammals, reptiles, and amphibians has grown significantly since the 1990s, driven in part by the increasing popularity of exotic pets and demand for traditional foods and medicines. Worldwide, illegal trade in these animals is substantial and profitable, and the United States is the leading import market.

2.2.15.4 *Impact of the Military Relocation*

The larger human population resulting from the military relocation will increase demand for exotic pets and for traditional foods and medicines, and therefore, increase pathway traffic volume in small mammal, reptile, and amphibian species.

2.2.16 Animal Product Importation

2.2.16.1 *Pathway and Risk Species*

Animal products are defined as of animal origin, including meat, milk, blood and their products, skins, feathers, wool, hair, and animal feed containing products of animal origin.

Milk, eggs, meat, blood, and other tissues can serve as disease agent sources. While the probability of transmission through animal products is low, several high-risk disease agents may be transmitted, including FMD, bovine spongiform encephalopathy, END, classical swine fever, ASF, HPAI, and swine vesicular disease.

2.2.16.2 *Current Mitigation Measures*

GCQA is responsible for the inspection, of the import of animal products and by-products. GDOA monitors animal products found on wholesale and retail shelves.

2.2.16.3 Risk Rationale

Although many disease agents have demonstrated the capability to survive in animal products for months to years and under a variety of environmental conditions (e.g., ASF, CSF, FMD, SVD, and Bacillus anthracis spores) (WS Diseases PRA 2010), there is a low probability of transport of disease agents to the Micronesia Region through this pathway, i.e., the legal importation (many of the potential disease agents are spread primarily through routes other than direct exposure to contaminated animal products).

Most animal product imports originate in the continental United States (75 to 98%), a low-risk area for diseases of concern, and there are strict regulations for the importation of animal products and by-products (VS PRA 2010). Other foreign imports originate from New Zealand and Australia. Limited veterinary services and lack of slaughter facilities throughout Micronesia limit commercial trade in locally produced meat, eggs, and milk.

The increase in foreign temporary workers may result in smuggling of animal products from their home countries, or Guam retailers may carry products to meet the demand. Preventive regulations are in place, but enforcement can be difficult.

2.2.16.4 Impact of the Military Relocation

Pathway traffic volume in animal products will increase as a result of the military relocation due to demands for animal products by a larger population.

2.2.17 Other Activities on Guam

2.2.17.1 Pathway and Risk Species

Imported or smuggled materials for animal fighting, game hunting, religious ceremonies, research, or aesthetic pursuits may increase proportionally according to the population increase, especially for cultural preferences of temporary foreign workers.

Species can include the full range of biological commodities and exotic animals. High-probability items are poultry (animal fighting); amphibians, reptiles, birds and insects (pets, religious ceremonies); animal and plant products (foods, furnishings); and feral animals (game). Various animals could be for biocontrols and scientific research.

2.2.17.2 Current Mitigation Measures

Legal imports to Guam must follow all APHIS and Guam regulations for permits, inspections, quarantine, etc. for each plant and animal type (see above pathways or Chapter 6, *Existing Mitigations*).

2.2.17.3 Impact of the Military Relocation

Imports of plants and animals and their products are likely to increase proportionally to the increase of population, particularly that of foreign temporary workers and their families.

2.3 APHIS RISK RATINGS

Tables 5-2 to 5-4 list qualitative risk ratings for the various potential pathways for introduction of invasive species to Hawai'i, Guam and other Micronesian Islands. Each risk rating is specific to an APHIS risk assessment team, and each team developed a risk rating methodology suited to the types of risks evaluated. Additional information on the rating methodology and risk ratings justification is in each APHIS Terrestrial Risk Assessment report (Appendix A).

Table 5-2: APHIS-VS Risk Ratings

Pathway	APHIS Risk Ratings				
	Release Assessment Legal	Release Assessment Illegal	Exposure Assessment	Consequence Assessment	Overall Risk
Conveyance–Aircraft	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low
Conveyance–Maritime vessels	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low
People	Negligible	Negligible	N/A	N/A	Negligible
Livestock	Negligible	Negligible	N/A	Guam and Micronesia: N/A United States: N/A	Negligible
Poultry	Negligible	Very low	Medium	Guam and Micronesia: Low United States: Medium	Low
Non-poultry birds	Negligible	Very low	Medium	Guam and Micronesia: Very low United States: Very low	Very low
Cats and dogs	Negligible	Negligible	N/A	Guam and Micronesia: N/A United States N/A	Negligible
Animal products	Negligible	Low	Medium	Guam and Micronesia: Low United States: Medium	Low

Pathway	APHIS Risk Ratings				
	Release Assessment Legal	Release Assessment Illegal	Exposure Assessment	Consequence Assessment	Overall Risk
Garbage	Negligible	Very low	Medium	Guam and Micronesia: Low United States: Medium	Low
Other cargo	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low

Table 5-3: USDA-APHIS-WS Terrestrial Vertebrates Risk Ratings

Pathway	APHIS Risk Ratings			
Conveyance–Aircraft	HIGH RISK			
Conveyance–Maritime vessels	HIGH RISK			
Cargo	HIGH RISK			
Construction	HIGH RISK			
Plant products	HIGH RISK			
WPM	HIGH RISK			
Garbage	HIGH RISK			
INTENTIONAL	Importation	Establishment	Hazard	Total Risk
Pet trade	3	3	3	9 HIGH
Aesthetic releases	3	2	3	8 HIGH
Food use	3	3	3	9 HIGH
Animals for entertainment	2	2	3	7 MODERATE
Game hunting	1	2	3	6 MODERATE
Biocontrol	1	3	2	6 MODERATE
Scientific research	1	3	3	7 MODERATE
Religious ceremonies	1	1	2	4 LOW
Bioterrorism	1	1	3	5 LOW

Table 5-4: USDA-APHIS-WS Wildlife Diseases Risk Ratings

Pathway	APHIS Risk Ratings			
	Probability of Infection	Alternate Probability	Impact of Infection	Alternate Impact
Hantavirus	Moderate	-	Low	-
Rabies virus	Minimal	-	Low	-
West Nile Virus	Minimal	-	High	-
HPAI	High	-	Moderate	Moderate

Japanese Encephalitis Virus	High	-	Minimal	Low
Avian Malaria Parasites	High	Minimal	Moderate	Moderate
Henipaviruses	Minimal	High	Moderate	Moderate
NDV	Minimal	High	Moderate	Moderate
Yersinia pestis	Minimal	-	Low	-
Tick-Borne Encephalitis	High	-	Low	Moderate

2.4 HIGH-RISK SPECIES AND VULNERABLE MICRONESIAN LOCATIONS

Guam receives visitors and imports of commodities from multiple countries. Guam is also served by multiple shipping lanes; east/northeast waterways connect with Hawai'i, and the continental United States waterways running north and west connect to CNMI and Asian ports.

In 2002, Guam imported agricultural commodities primarily from Australia, Asia (China, Korea, Hong Kong, Japan, Malaysia, the Philippines, Singapore, Taiwan, and Thailand), the rest of Micronesia (Chuuk, CNMI, Palau, Pohnpei, and Yap), New Zealand, and the United States. Most visitors travel by air from Japan or Korea (WS Diseases PRA 2010). Most arrivals to CNMI in 2002 and Palau in 2007 demonstrated a similar trend. Most visitors to FSM arrived by air from the United States followed by Japan and Europe (WS Diseases PRA 2010). It should be noted that information from 2002 and perhaps from 2007 may well be outdated. More updated information should be considered.

Of particular concern is the introduction of invasive species from China, Korea, Hong Kong, Thailand, Malaysia, and the Philippines. The USDA-APHIS publication *Combined Animal and Plant Health Risk Ratings for Countries*, October 2010, lists each of these in the top 25 countries presenting the highest combined risk for animal and plant diseases and pests (USDA-APHIS-PPQ 2010c). China ranks as the highest risk country, and Thailand is third highest. Countries linked to Guam by trade include Japan (ranked 7th), Republic of South Korea (ranked 15th), and Indonesia (ranked 22nd). (See APHIS-Terrestrial Risk Assessments in Appendix A for more detail.)

International airports are located in the State of Hawai'i and the U.S. territory of Guam, the CNMI islands of Saipan (71% commuter, 18% commercial), Tinian (99% commuter, 1% commercial), and Rota (72% commuter, 27% commercial), the Republic of Palau, the FSM, and the RMI (CPA 2007a, b, c). Commercial air transportation traffic may increase among these islands, evidenced by the scope of improvements underway at airports on Saipan, Tinian, and Rota.

The complete list of invasive species presenting potential biosecurity threats to Hawai'i, Guam and other Micronesian Region islands is far too large for detailed descriptions in this plan. Greater detail on risk species is in the APHIS Terrestrial Risk Assessments (Appendix A). These species could produce significant impacts if introduced to Hawai'i, Guam and other Micronesian Region locations.

Chapter 7, *Recommendations*, recommends enhanced mitigations for Hawai'i, Guam and other Micronesian Region locations based upon risk assessments by PPQ-Center for Plant Health Science and Technology (plants, plant products, and plant pests), VS (livestock, poultry and pets), and WS (wildlife

diseases). Recommendations for Terrestrial Vertebrates are in Chapter 11, *Terrestrial Vertebrates Biosecurity Plan*.

3 EXISTING MITIGATION

3.1 INTRODUCTION TO MITIGATION AND PREVENTION STRATEGY

Biosecurity measures prevent and mitigate risks posed by invasive species and incorporate a wide range of preventive activities including public awareness, training, inspection, monitoring, detection, and eradication. Some of these measures may take place before conveyances arrive at the border. Determination of entry status, inspection, and treatment are usually conducted at the border. Post-border activities include control and eradication efforts for introduced species, public awareness programs, agreements with local businesses, and habitat improvement projects.

3.2 ORGANIZATIONS INVOLVED IN PHYTOSANITARY AND SANITARY PROTECTIONS FOR GUAM

Numerous organizations contribute to phytosanitary and general sanitary protections on Hawai'i, Guam and other Micronesia Region locations.

Each organization may have responsibility for a portion of the mitigation processes as described in Table 6-1. The following entities play significant roles in Guam mitigation activities:

Table 6-1: Biosecurity Organizations

Organization	Description
Aquatic Nuisance Species Task Force	The Aquatic Nuisance Species Task Force collaborates with the NISC Prevention Committee as the Pathways Work Team in support of the NISC Management Plan (NISC 2008).
CEQ	Coordinates federal environmental efforts with agencies and other White House offices in the development of environmental policies and initiatives (40 CFR §§ 1502.09 and 1502.20)
GCQA	GCQA clears aircraft, passengers, baggage, and cargo at airport and maritime ports, both civilian and military. Responsible for border inspections and monitoring regulated garbage handling at the ports of entry.
GDOA	<p>A Biosecurity Task Force has been approved legislatively to unify GCQA and GDOA activities conducted under the direction of USDA-APHIS-PPQ and GCQA. Members will be available to respond to of invasive species reports.</p> <p>Foreign agricultural import inspections are overseen by USDA-APHIS-PPQ and GDOA. GDOA also permits the importation of certain animal products and live animals including zoo, fur-bearing, and other wild animals. GDOA works with the University of Guam, USDA-APHIS-WS, and USFWS to manage invasive species. GDOA and PPQ identify confiscated agricultural products, hold animals in quarantine, and prevent illegal imports.</p> <p>A Biosecurity Task Force has been approved legislatively to help coordinate GCQA and GDOA activities conducted in cooperation with USDA-APHIS-PPQ. Members will be available to respond to invasive species reports and incursions.</p> <p>Foreign agricultural import inspections are overseen by USDA-APHIS-PPQ while domestic imports are under the jurisdiction of GDOA's Biosecurity Division. GDOA also permits the importation of</p>

Organization	Description
	certain animal products and live animals including zoo, fur-bearing, and other wild animals. GDOA works with the University of Guam, USDA-APHIS-WS, and USFWS to manage invasive species. GDOA and PPQ identify confiscated agricultural products, hold animals in quarantine, and prevent illegal imports.
GDAWR	A division of the GDOA, GDAWR identifies confiscated aquatic, marine, and wildlife products, holds animals in quarantine, and helps prevent illegal imports of such items.
Guam Invasive Species Council	Aligned with the Western Micronesia Regional Invasive Species Council, provides guidance when invasive species are detected, liaises to coordinate activities of Guam government agencies.
Guam Invasive Species Advisory Committee	Provides specialists to identify invasive species and determine distribution, identifies mitigation options, prepares cost/benefit analysis for mitigation options, and recommends emergency response actions to Guam Invasive Species Council.
JGPO	Serves as the NEPA proponent of proposed actions. The JGPO coordinates federal agencies having either jurisdiction over or technical expertise for certain components of proposed actions or a potentially affected resource.
NISC	The NISC Prevention Committee and Aquatic Nuisance Species Task Force collaborate as the Pathways Work Team in support of the NISC Management Plan (NISC 2008).
Quarantine Policy, Analysis and Support (QPAS)	An APHIS-PPQ program unit providing assistance on regulatory issues related to port inspection requirements and quarantine events. QPAS works closely with the PPQ Veterinary Regulatory Support (VRS) unit, which is dedicated to performing the same functions for animal products and by-products and regulated garbage.
University of Guam	The University of Guam conducts research and survey activities on invasive species, including plant disease and botanical identification in collaboration with GDOA and USDA-APHIS-PPQ.
USDA-APHIS-PPQ	PPQ oversees foreign agricultural import inspections as well as regulated garbage handling activities and handles invasive species events. PPQ Plant Inspection Station identifies plant products and plant pests seized in port inspections.
USDA-APHIS-WS	Conducts all BTS canine inspections, undertakes extensive BTS management efforts (trapping, fence line searches, and rapid response) and provides public outreach.
USFWS	Enforces international trade regulations on exotic birds and other wildlife. Any importers or exporters of wildlife must obtain a license from USFWS. USFWS designates the Agana, Guam port for importing certain kinds of wildlife (including animal parts and products with a Guam final destination).

Organization	Description
USGS BTS Rapid Response Team	USGS has a coordination office in the region which supports management agencies and NGOs involved in invasive species throughout all the jurisdictions covered by the MBP as well as the US Mainland. Support includes training courses for ED and RR, capacity building activities, community outreach, and coordinating ED and RR actions throughout the region. The RRT is manned by team members from all jurisdictions covered by the MBP as well as the US Mainland. Team members generally work for local, territorial, state, federal and private agencies and groups and in exchange for training are available to support field actions throughout Micronesia and Hawai'i as needed. The coordination office works with the governments throughout the region and supports their request for assistance. The USGS response coordination office also mans a 24/7 regional alien snake reporting hotline (671-777-HISS). The USGS response coordination office also supports other biosecurity and invasive species issues within the region when feasible, including servicing as a clearing house for information, facilitating linkages between locations, agencies, and experts and assist when possible with other taxa (other than snakes) response efforts.USGS has a BTS rapid response team capability on Guam. As of March 2013 the USGS coordination office has been vacant but capacity within the region for ED and RR still exists.
U.S. Marines	Relocation of force to Guam and training on Tinian.
U.S. Navy/NAVFAC PAC	Relocation of force to Guam.
U.S. Transportation Command	Oversees the movement of military personnel and equipment. The U.S. Air Force Air Mobility Command supports strategic and tactical military operations by airlifting personnel and cargo. Military cargo not consigned to commercial carriers would be transported by Air Mobility Command aircraft.
Veterinary Regulatory Support (VRS)	An APHIS-PPQ program unit providing assistance on regulatory issues related to port inspection requirements and quarantine events related to animal diseases. PPQ, Agricultural Quarantine Inspection (PPQ-VRS-AQI) provides regional support for animal product/by-product import inspections as well as regulated garbage handling activities
VS/National Center for Import and Export Technical Trade Services Staff	A program unit within APHIS-VS which is responsible for the import regulations and policy with respect to live animals and animal products. Provides import permits for imported and transiting commodities.

3.3 PROCEDURES

3.3.1 Safeguarding Standard Operating Procedures

Government agencies with safeguarding authority have developed SOPs for protecting pathways, ports, and mainland areas within the Micronesia Region and for mitigating the accidental or intentional introduction of infective or invasive species. SOPs for Guam and CMNI, developed in harmony with U.S. and international standards, are for monitoring, surveillance, and rapid response functions for plant pests. ERPs exist for all jurisdictions covered by the MBP (except Guam) for alien snake incursions.

These were created by each jurisdiction in coordination rapid response team coordination office (Stanford, personal communication). The FSM, RMI, and Palau all have ERPs for bird flu which SPC helped develop. Yap has an ERP for coconut rhinoceros beetles which was developed by RISC and their technical supporters. Other ERPs which generally include SOP language may also exist for other organisms and/or situations through the region and the state of Hawai'i. .

3.3.2 Port Infrastructure

Biosecurity planners evaluate the types of infrastructure required to monitor pathways so resources are available to detect and mitigate the introduction of plant and animal health risks on arrival. These facilities include having sufficient equipment and personnel at all ports and designated cargo handling stations during surge conditions as anticipated for the military relocation to Guam. While Guam has the best-equipped airport and maritime port locations in the Micronesia Region, certain deficiencies in the ports' infrastructure require the following improvements:

- Port staging areas
- X-ray equipment, detector dogs, and other inspection resources
- On-site decontamination/treatment areas
- On-site quarantine facilities
- Dedicated inspection facilities within the port environs
- Barriers to separate potentially invasive from native species
- Regulated garbage disposal equipment/facilities
- Information technology and necessary equipment

3.3.3 Port Operations (inspection, permit/certificate enforcement, and treatment)

Essential biosecurity components are capabilities for inspection, enforcement of regulatory requirements, and operable equipment and materials. In conjunction with their own policies and procedures, Guam and CNMI authorities utilize procedures from the APHIS MAC and individual animal product and plant port of entry manuals (USDA-APHIS-PPQ 2013). USDA-APHIS-WS is responsible for BTS inspections upon port departure (export) from Guam. It should be clearly understood that BTS inspections conducted by USDA on Guam for departing cargo and planes are not required by law but rather are conducted on a volunteer basis. Additionally, it should also be clear that these inspections are conducted only for BTS and are only conducted on Guam (no other jurisdiction has this type of program and the volunteer departure program on Guam is only for BTS detection, no other organisms are specifically searched for). Shipments from other areas of Micronesia are inspected upon arrival according to local regulations and policies. GDOA issues import permits for various commodities including eggs for consumption, live animals, and various plant materials.

3.3.4 Interdiction Procedures

3.3.4.1 *Guam*

GCQA clears aircraft, passengers, and cargo at the airport, seaport, and mail facility. There are approximately 120 GCQA inspectors stationed at these locations (based on 2009 figures). There are currently four trained agriculture detector dogs stationed on Guam primarily for air passenger clearance. The airport has three shifts for clearing international flights.

USDA-APHIS-PPQ and GDOA oversee propagative plant inspections at the Plant Inspection Station. The University of Guam (UOG), GDOA, USDA-APHIS-WS, and USFWS are tasked with handling invasive species issues.

A Biosecurity Task Force has been legislated, coordinating GCQA and GDOA activities in cooperation with USDA-APHIS-PPQ. Members would be available to respond to invasive species reports and incursions. Guam also has the Guam Invasive Species Council, which includes the Guam Invasive Species Advisory Committee to provide it with scientific recommendations. USDA-APHIS-WS has an active BTS trapping, hand capture, and dog detection program on Guam available at all times.

GDAWR and the GDOA Biosecurity Division identify confiscated products and pests, hold animals in quarantine, and prevent illegal imports. Any importer or exporter of wildlife must obtain a license from USFWS and in some instances a permit from USDA-APHIS.

All pet dogs and cats arriving at Guam are subject to local quarantine requirements. The quarantine period is 120 days post-arrival for domestic dogs and cats (reduced to 30 days or less than 5 days if certain provisions are made for dogs, cats, and other carnivores).

Importation of zoo, fur-bearing, and other wild animals requires a permit in advance from the Guam Director of Agriculture. USFWS has designated Agana, Guam, as a special port for importing certain wildlife (including animal parts and products with a Guam final destination).

BTS presents a unique biosecurity circumstance, especially to Guam and CNMI (Saipan, Tinian, Rota), due to the military impact on these islands. Accidental transport of BTS from Guam is also a significant concern to all of Guam's trade partners, which include the islands of the CNMI, the U.S. State of Hawai'i, the Republic of Palau, The Republic of the Marshall Islands, and the Federated States of Micronesia including the four states: Chuuk, Kosrae, Pohnpei, and Yap. Whereas most customs and quarantine inspections occur upon arrival and importation of goods, BTS inspections take place upon departure and export of goods, cargoes (e.g., vehicles, military field gear) and aircraft (i.e., military, commercial, private) as well as in staging areas. For most purposes, these pre-departure inspections are voluntary in nature.

3.3.4.2 *Commonwealth of the Northern Mariana Islands*

The CNMI is funded through the Office of Insular Affairs to conduct BTS interdiction work in Saipan, Rota, and Tinian. BTS interdiction efforts on Guam are conducted by USDA-WS. These inspections are a

critical step in preventing off-island dispersal of BTS. Work done at the receiving ports in the CNMI or elsewhere is typically a second-line of defense but is considered equally important and in fact at times primary inspections are only conducted at receiver ports for items which miss the voluntary inspections conducted on Guam by USDA-WS .

3.3.4.3 Saipan

Airport operations are 7 days a week and run from 0300 hours to 2200 hours. On October 1, 2011, austerity measures (32-hour work week) were implemented resulting in an inspection rate of 40%, which is well below the 90% measure of effectiveness. Also, overtime was not authorized. As of mid-April 2012, the BTS program has been given approval to work up to 40 hours and limited overtime on a weekly basis to provide the program with the flexibility to cover most arrivals (about 70%); however, most flights are done visually instead of with canines. A new canine handler is awaiting Airport Operations Area certification and can then start clearing arrivals at Saipan International Airport, which may further boost inspection percentages.

About 46 BTS traps are currently deployed at the airport with an additional 40 at the seaport. The CNMI has an on-going public relations campaign "28-SNAKE, Don't give snakes a break" to raise awareness of the BTS threat and includes a central reporting system for snake sightings. Saipan currently has five employees working on BTS intervention, including one canine trainer; three canine handlers (one undergoing training, with previous canine handling experience with USDA-WS in Guam); and one trapper with no canine experience. The intent is to have this person trained as a handler.

3.3.4.4 Rota

Inspections for BTS are currently conducted by a single individual who has been trained for visual inspections, trap lining, and early detection and rapid response capacities. This individual has a canine to assist with BTS inspection work. CNMI Quarantine officers also may assist at times with the clearance of arrivals from Guam for BTS, but it is not their priority.

3.3.4.5 Tinian

Inspections for BTS are currently conducted by a single individual who has been trained for visual inspections, trap lining, and early detection and rapid response capacities. This individual has a canine to assist with BTS inspection work. Tinian has a BTS quarantine area at the seaport where suspect cargo can be held until appropriately inspected. The BTS inspector is stationed at the seaport. Aircraft Inspection

GCQA officers collaborating with USDA-APHIS to enforce federal animal and plant health regulations have the authority to board all military aircraft and maritime vessels. USDA-APHIS provides guidance, information, and training to DoD for pre-clearance inspections. However, because GCQA has not authorized the DoD to conduct inspections on its behalf, pre-cleared DoD shipments are still subject to routine inspection upon arrival. The USDA-PPQ MAC contains information on the inspection of aircraft and maritime vessels for plant and animal health concerns by APHIS collaborators (USDA-APHIS-PPQ 2013). Military regulations (OPNAVINST 6210.2 06) designed to prevent the introduction and spread of

disease agents (human, animal, and plant), arthropod vectors, and pests of health or agricultural importance comply with regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, DHS, Interior, and Commerce (OPNAVINST 6210.1; OPNAVINST 6210.2).

Current biosecurity inspections are the same for military and commercial aircraft upon arrival. Military aircraft are subject to agricultural quarantine inspections for animal and plant pests as well as invasive species, but are exempt from customs regulatory enforcement; however, passengers, cargo, and equipment are subject to both. Military aircraft departing Andersen AFB typically undergo canine inspection by APHIS-WS personnel for BTS to “the maximum extent possible,” with some exceptions for medical emergency missions (U.S. Navy 2005a; b). Since inspections of any aircraft departing Guam, commercial or military, are primarily to detect BTS (BTSCC 1996; U.S. Air Force 2007), other species not specifically targeted may be missed or overlooked. Arriving aircraft, military or commercial, are not usually inspected by APHIS-WS or GCQA for terrestrial vertebrates but are subject to inspections for other agricultural purposes.

APHIS-WS inspects the exteriors of planes that are not “quick turns” (on the ground for less than 3 hours) using both canine teams and visual inspections by personnel. Cargo contents are inspected generally within 2 hours of loading. Contents vary, and chartered planes not on regular commercial flight schedules require much more ongoing inspection coordination. APHIS-WS and GCQA very rarely inspects planes internally for BTS or for animal and plant health concerns. If a plane is down for extended service and its hatches, doors, or exterior compartments are open for extended periods, an internal inspection for BTS may be done. Military aircraft are exempt from inspection if the process could jeopardize national security.

3.3.5 Maritime Vessel Inspection

For maritime transportation, CFR Title 7 regulates articles from Hawai’i and the territories, Title 9 regulates movement of animals and animal parts, and Title 42 governs public health. Title 7 regulates plants and plant products (Subtitle B, Volume 5, Chapter 3, Parts 318.13-9 and 330.111) and requires notification to inspectors prior to ship departures or arrivals on Guam. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) permits inspection of any ship from foreign locations without a warrant to determine whether it carries any animal or animal part subject to safeguard or disposal to prevent the spread of disease. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) requires disinfection of ships transporting restricted items not in leak-proof containers.

Titles 7 and 9 permit the inspection of any ship for agricultural risk of animal diseases, plant pests or diseases, and animal or plant products, including ship infrastructure, stores, cabins, and equipment.

Information in the USDA-APHIS MAC on the inspection of ships details procedures for ship infrastructure, stores, and cargo (USDA-APHIS-PPQ 2013).

Agricultural clearance of commercial ships includes inspection of deck areas, ship stores, and crew quarters and may include cargo. Pets of crew members transported must be quarantined on board.

Hitchhiking pests or animals of agricultural risk must be removed or destroyed. If pests are found on fruits and vegetables in ship stores, the products are either sealed on board while in port or removed for destruction.

U.S. military ships are subject to inspection for agricultural concerns. In the United States, military personnel are trained to assist and expedite in completing ship inspection forms and spot-inspecting ship stores. GCQA and DoD are responsible for developing local policies to maintain these requirements for incoming vessels.

The Armed Forces Pest Management Board published Technical Guide Number 31 (AFPMB 2004) to describe cleaning and inspection procedures for retrograde washdowns.

NAVMED P-5010-8, *Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology*, covers the use of preventive measures and bait station anticoagulants for rodent control. NAVMED P-5052-26, *U.S. Navy Shipboard Pest Control Manual*, explains inspection and de-ratting procedures for ships. MIL-STD-904B guides detection and prevention of pest infestations (MIL-STD-904B).

3.3.6 Passengers and Baggage

Civilian and military passengers and their baggage arriving in Guam are subject to inspection by GCQA regardless of conveyance. Passengers are interviewed upon arrival to determine whether they have prohibited or restricted commodities. Limited time, inadequate inspection facilities, inoperable or absent x-ray equipment, and insufficient staffing levels prevent GCQA from inspecting all incoming passengers and their baggage. Four trained agriculture detector dogs are available, but current resources are far below what is needed to staff air arrivals fully. All arriving passengers are considered “foreign” and subject to the same agricultural restrictions regardless of their travel origins. For example, passengers arriving from Hawai’i undergo the same inspection procedures as those from Japan. Passengers transiting to other countries, including those in the Micronesia Region, are not inspected by GCQA.

3.3.7 Cargo

Container shippers are responsible for keeping containers and loading areas free of vectors, reservoirs of disease and contamination, and invasive pest species during the packing process. This type of shipping is a risk for the transport of insect pests and other wildlife as hitchhikers and in WPM for the cargo.

Air cargo shipments are of particular risk due to the speed of shipping. Fruits and vegetables for consumption, flowers and decorative plants, and propagative plants may present a greater risk in the introduction and establishment of plant pests and diseases.

While the movement of cargo from the United States to Guam is interstate, under CFR Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 318.13-8 and 318.13-10) cargo moving between Guam, CNMI, Hawai’i, and

the continental United States is subject to agricultural inspection for plant pests and diseases. There are no such restrictions on cargo containing animal products moving between Guam, CNMI, Hawai'i, and the continental United States. All cargo originating in foreign countries is subject to inspection by GCQA. Cargo and passengers entering Hawai'i and the continental United States are inspected by DHS-CBP. The GOA authorizes GCQA to inspect cargo from the continental United States.

Parcels shipped through private mail (express courier operations) are regulated and inspected as cargo. GCQA has authority to inspect these packages without a search warrant. Privately shipped mail by commercial express courier operations (except diplomatic parcels) is inspected by GCQA through visual evaluation of the parcel and the declaration label. No x-ray equipment is available at the express courier operations and the inspection area is lacking equipment and lighting.

3.3.7.1 *Construction Equipment and Materials*

Following inspection, imports of construction equipment contaminated with pests or soil must undergo approved remedial treatment (if available) or re-export is required. The vast majority of problems with construction equipment are contamination with soil that can be washed away in areas designated for approved collection or drainage of the effluent, as into a system that treats sewage. There may be a plan for improvements, including additional inspection of imported construction materials and a military inspection site. On Guam, it is unclear how consistently mitigation measures for timber, sand, and gravel are applied and how well they prevent pest entry. There are no entry requirements for other construction materials.

Safeguarding measures prevent the spread of pests by timber. Saw logs with bark may not enter Guam, and de-barked saw logs and lumber must be inspected for termites and wood-boring insects. Foreign timber must have an import permit detailing required treatment. Other regulations authorizing the GDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude any commodities infested with pests are found in GARR Title 8-Food and Agriculture, Division 2-Plant Industry, Chapter 10, Importation of Plants and Plant Products.

3.3.7.2 *Propagative Material*

Guam inspectors employ extensive phytosanitary measures inspecting propagative plant shipments and cut flowers for plant pests and diseases and for import permit violations. Plants imported into CNMI arrive via Guam from California or Hawai'i for entry clearance by PPQ. Because of concerns about smuggling, every large bag or box brought into CNMI by foreign passengers is inspected visually.

Plant material for landscaping on Guam is imported primarily from the U.S., but Thailand, Taiwan, the Philippines, Costa Rica, Ecuador, and Puerto Rico are other sources. All imported propagative plant material, including transshipments to the CNMI, Palau, and FSM, is inspected at the GDOA/USDA Plant Inspection Facility.

GDOA requires treatment prior to shipment of all plants entering Guam from Hawai'i with a hot water or citric acid solution drench and inspection for pests of concern (by GCQA), primarily the coqui frog.

Guam prohibits entry of citrus, coconut, banana, and taro propagative plant materials from specified locations to prevent the introduction of specific pests of concern, and sweet potato planting materials are highly restricted. Importation of certain plants from areas infested with the European Corn Borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae) is also restricted (GDOA). Parts of this Guam regulation have been superseded by the Federal Plant Protection Act of 2000 (R. Campbell, Personal Communication).

3.3.8 Plant Products

GCQA conducts extensive inspections of incoming fruits and vegetables at several designated facilities on the island. Because these items are for consumption, they are of high priority for clearance. These very large shipments (consisting of many containers) necessary to supply the population of Guam occur very regularly via both air and maritime transport.

The APHIS-PPQ Fruits and Vegetables Import Manual guides PPQ inspectors and cooperators on shipments of fresh fruits and vegetables (USDA-APHIS-PPQ 2010b). Chapter 5 of the APHIS-PPQ Treatment Manual shows the treatment schedule for fruit, nuts, and vegetables (USDA-APHIS-PPQ 2008).

Clearance of fruits and vegetables may be by inspection of both the paperwork and the commodities if indicated. Inspections may be random, routine, or targeted.

Title 7 Part 319 of the CFR governs the importation of fruits and vegetables. All must have an APHIS import permit.

GARR Title 8, Division 2, Chapter 10 governs the importation of plants and plant products (GDOA 1997). Import permits and phytosanitary certificates are required to ship regulated articles into Guam.

3.3.9 Garbage

Garbage has been implicated in various animal disease outbreaks around the world (CRS Report 2001). Regulated garbage is monitored to prevent the movement and dissemination of pests and plant and livestock diseases. Sections in Titles 7 and 9 of the CFR state requirements for the handling and movement of regulated garbage (7 CFR, 9 CFR). Garbage is defined in 7 CFR § 330.400-330.403 and 9 CFR § 94.5 as waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material. Any other refuse associated with such materials is also garbage. For purposes of this plan, trash is any waste material not in contact or associated with garbage and unregulated by APHIS for animal and plant disease concerns. Both trash and garbage are subject to EPA and local Micronesian regulations and restrictions (EPA 2013).

APHIS regulates garbage if the conveyance moving it has been outside the U.S. and Canada within the previous 2 years. Garbage on or removed from a means of conveyance is also regulated garbage, if at the time the garbage is on or removed from the means of conveyance, the means of conveyance has moved during the previous 1-year period, either directly or indirectly, to the continental United States from any territory or possession or from Hawai'i, to any territory or possession from any other territory

or possession or from Hawai'i, or to Hawai'i from any territory or possession. These regulations apply to Guam and CMNI. Regulated garbage may not be moved between the continental United States and U.S. territories, U.S. possessions or Hawai'i nor may regulated garbage be imported or discharged in any form into U.S. territorial waters (within 12 nm of the coastline).

Tightly covered, leak-proof containers must store regulated garbage within U.S. territorial waters. Garbage must be stored properly to move it from a conveyance for disposal. Regulated garbage can be moved under the direct supervision of a USDA-APHIS-designated inspector (e.g., GCQA or CMNI quarantine personnel) or by an entity operating under a compliance agreement with APHIS to an approved garbage handling facility. There are seven compliance agreements for regulated garbage handlers in Guam and five in Saipan. Approximately, 680,389 kg (1.5 million pounds) of regulated garbage was destroyed from 1 February 2009 to 1 February 2010 (Brown 2010). Ports without the capability to handle and process regulated garbage may not allow its removal from conveyances.

To mitigate the risk presented by regulated garbage, it must undergo one of three processes: 1) incineration, defined as reducing garbage to ash by burning (with policy exemptions for glass and metal); 2) sterilization, cooking at an internal temperature of 212°F for 30 minutes; or 3) grinding and discharge into an EPA- and APHIS-approved sewage system.

Garbage from commercial and military aircraft must be unloaded at an airport or military base approved to handle it. On Guam, NAVFAC marinas at the Apra Harbor Naval Station and Pacific Environmental Resources Incorporated at Andersen AFB are both approved to handle garbage. Regulated garbage from A.B. Won Pat International Airport is processed at the local aircraft catering company. Saipan International Airport has an incinerator owned and operated by the Commonwealth Ports Authority to handle regulated garbage. Site visits to Guam and Saipan noted multiple deficiencies on the premises of some compliance agreement holders (Jimenez et al. 2009).

Tinian has no functional equipment for the disposal of regulated garbage. The local landfill has been cited for multiple violations by the Saipan Division of Environmental Quality, and the EPA and the military's plan to move garbage generated on Tinian during training operations to Saipan or Guam for disposal until that time when and if a new landfill is complete violates APHIS regulations. Tinian has not repaired the equipment for processing regulated garbage and, according to the Saipan Tribune, the new Tinian landfill will be built within the area leased by the U.S. military (as of 2013 information on this remains vague), but will be closed during construction and training exercises. A transfer station will be built to store garbage generated by civilians during training exercises (Saipan Tribune 2010).

APHIS-PPQ has responsibility for monitoring garbage handling activities of airports, caterers, cleaners, cruise ships, fixed-base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and transfer stations in U.S. locations; however, there are only two PPQ officers for Guam and CNMI. In Guam, GCQA assists with this effort.

The APHIS-PPQ MAC guides handling of regulated garbage. The APHIS-PPQ MAC also instructs inspectors to monitor regulated garbage handling on aircraft and ships in port as well as at land-based facilities

(USDA-APHIS-PPQ 2013). The Quarantine Regulations of the U.S. Navy require garbage handling in compliance with APHIS regulations (OPNAVINST 6210.2).

Other practices related to garbage present additional risks. Garbage not on a conveyance outside of U.S. locales and Canada may be regulated if fed to swine. Some local pigs are fed garbage collected in restaurants and perhaps from boats; however, pig owners are not licensed to feed this type of garbage (Poole 2009). CFR Title 9 § 166.1–166.2 states that only personal household garbage may be fed to pigs and that the farmers must be licensed to feed them other types of garbage.

3.3.10 Mail

Mail is a high-risk pathway for the movement of agricultural commodities and invasive species. GCQA monitors mail and seizes items of phytosanitary concern. Both GCQA and the local postmaster recognize domestic and foreign mail as a pathway for smuggling all types of commodities (Jimenez et al. 2009). Foreign mail may be inspected without a warrant only at the first port of arrival, after which it is considered domestic mail. Approximately 95% of the mail arriving on Guam comes directly from the U.S. or is international mail processed in Hawai'i. All (100%) of the international mail entering Honolulu destined for Guam is inspected by CBP.

The remaining 5% of mail arrives directly from foreign countries, primarily Japan and the Philippines. In 2008, 1.9 million parcels/pieces of mail came through the Guam Post office (Jimenez et al. 2009). Mail arriving in Guam destined to the CNMI is inspected in Guam.

First-class mail sent via the USPS is legally protected under the Fourth Amendment to the U.S. Constitution, making it illegal to delay or open such mail without either a search warrant or permission from the addressee. These protections apply also in Guam and the CNMI. GCQA officers open and inspect the mail, but the postal inspector and the consignee must be present. The postal facility legally may not slow down the flow of domestic mail, which limits the number of packages that can be inspected with the available workforce. The facilities are inadequate, and the x-ray machine is not fully functional (Jimenez et al. 2009). In addition, the present postmaster makes the use of detector dogs inside the postal facility very difficult. Using detector dogs inside the postal facility would facilitate the inspection process and reduce risks.

The USPS allows adult and hatchling (day-old) poultry to be mailed with restrictions. Postal regulations prohibit mailing of hatchlings vaccinated for NDV. Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to the addressee within 72 hours after hatching. Per USPS regulations, non-poultry birds may not be mailed (USPS 2009). Poultry from Hawai'i are transported on United Airlines as domestic mail (Jimenez et al. 2009).

The Guam Post Office displays educational posters describing prohibited mail items, and while currently not occurring as a common practice, post office clerks are encouraged to ask customers whether outgoing packages contain perishable items. When packages stamped "perishable" arrive on Guam,

GCQA officers inspect them and, when necessary, forward them to the Guam Plant Inspection Station for additional inspections or diagnostic assistance.

Military mail is handled by the MPSA, the single DoD point of contact with the USPS, which is required by military regulation to adhere to USPS rules, federal laws, and various international laws and agreements for movement of military mail. The MPSA also educates military personnel about items prohibited in mailed packages (Ericksen personal communication). Military mail may not be inspected by GCQA.

The USDA APHIS MAC provides direction for inspections at U.S. postal facilities receiving international mail (USDA-APHIS-PPQ 2013).

Information from GCQA and the USPS indicates that the mail flow will increase with the military relocation (Jimenez et al. 2009).

3.3.11 Wood Packing Materials

U.S. regulations and the ISPM No. 15 (ISPM No. 15 2009) require either fumigation with methyl bromide or heat treatment according to specific schedules for all WPM entering the country for use in commerce. Treated WPM must display a specified ISPM No. 15 stamp in a visible location for compliance checks at ports of entry.

These regulations apply to WPM imported from foreign origins into Hawai'i, Guam, and CNMI. Movement of WPM between these same locations is domestic and not subject to these regulations. Because the majority of cargo entering Guam is from domestic locations, this fact represents a potentially significant safeguard gap. FSM, Palau and RMI have no existing regulations to mitigate the pest risk from the importation of WPM. It is likely that a certain percentage of WPM always bypasses mitigation and sometimes live pests are found in properly marked WPM. In these cases for U.S. locations when an issue is detected, APHIS-PPQ determines either that the shipment was treated improperly or that ISPM No. 15 stamps were applied fraudulently, without treatment. Inspections of WPM with its cargo for pests and the required marking have detected wood pests in both stamped and unstamped WPM. There are obvious gaps in this process .

The USDA MAC directs inspectors to check whether regulated WPM is compliant or non-compliant (APHIS MAC). Guidance from the APHIS Miscellaneous and Processed Products Manual on this topic applies to Hawai'i, Guam and the CNMI (USDA-APHIS-PPQ 2012). Inspectors are instructed to look specifically for timber pests, other insects, and unspecified hitchhikers.

3.3.12 Livestock, Poultry, and Non-poultry Birds

For purposes of this terrestrial risk assessment, livestock and poultry are defined per APHIS regulations:

- **Livestock**—Domesticated ruminants (cattle, carabaos, sheep, and goats), domesticated swine (including feral swine), and domesticated equids (horses, mules, and asses).

- **Poultry**—Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching (9 CFR § 93.100).
- **Non-poultry birds**—Birds other than those listed above susceptible to communicable poultry diseases or capable of carrying those diseases or their arthropod vectors (9 CFR § 92.1). This definition includes wildlife species.

APHIS regulations (9 CFR § 92) refer to all species of the animal kingdom except humans, including: cattle, sheep, goats, other ruminants, swine, horses, asses, mules, zebras, dogs, poultry, and birds susceptible to communicable livestock and poultry diseases or capable of carrying those diseases or their arthropod vectors. APHIS regulations governing the importation of domesticated livestock, poultry, and non-poultry birds in 9 CFR § 93 pertain to movement of cattle, sheep, goats, pigs, horses, mules, asses, other livestock species, poultry, and other non-poultry birds from foreign countries into any of the 50 U.S. states, the Commonwealth of Puerto Rico, the CNMI, the District of Columbia, and any territories and possessions of the United States. Domesticated livestock for importation into the United States from any part of the world must be shipped directly to an approved port and be quarantined there until negative results to specified tests, depending upon the country of origin, are obtained and the animals are certified by the port veterinarian to be free from clinical evidence of disease. In special cases the APHIS Administrator may designate unapproved ports as quarantine stations. No ports on Guam are approved for importation of livestock, poultry, or non-poultry species; therefore, at this time these species for import to Guam first must enter through ports in the continental United States.

APHIS regulations on the interstate movement of domesticated livestock, poultry, and non-poultry birds in 9 CFR § 71-89 generally prohibit animals, including domesticated livestock, affected with any communicable disease from interstate movement.

In 2002, an amendment to the AWA made the import or interstate commerce of a bird or animal for the purpose of participation in a fighting venture illegal regardless of the law in the destination state, including Guam (APHIS-VS 2003). This amendment does not restrict the possession of poultry or dogs for breeding or as show animals.

GARR import requirements for live animals, organisms, and vectors require any animal found to be clinically affected or recently exposed to any infectious, contagious, and/or communicable disease or infested with ectoparasites to be returned to its point of origin or destroyed (9 GARR 1 § 1100-1113).

3.3.12.1 ***Livestock***

U.S. and Guam territorial regulations impose livestock requirements for horses and other livestock moving interstate or imported into Guam. Horses are subject to specific mitigations to prevent the entry of EIA, EEE, WEE, and VEE viruses (9 CFR § 75 and 9 GARR 1 § 1104).

3.3.12.2 ***Poultry***

Federal regulations restrict importation of live poultry, poultry products, and hatching eggs from regions affected by END or HPAI; several of these regions are Asia-Pacific countries (9 CFR § 93.201, 9 CFR §

94.6, and 9 § CFR 95.30). Live poultry permitted to enter the United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a quarantine facility on the U.S. mainland (9 CFR § 93.209). The importation of hatching eggs is restricted from countries affected by END and HPAI, including the Philippines and several other Asia-Pacific countries (9 CFR § 93.201 and 9 CFR § 93.209).

In addition to applicable APHIS regulations, Guam territorial regulations require an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian as well as serological testing and vaccination for poultry diseases of concern (9 GARR 1 § 1110). Poultry must be identified individually with a numbered leg band with the number indicated on the health certificate. (9 GARR 1 § 1110). Hatching eggs and day-old poultry require only an affidavit from the shipper stating that the flock of origin is free of NDV and has not been exposed to it within 60 days prior to shipment for import. All poultry and hatching eggs must be shipped in new (unused) containers and inspected by the territorial veterinarian or deputy prior to entry into Guam.

3.3.12.3 *Non-poultry Birds*

Federal regulations state birds not of U.S. origin must be accompanied by an import permit and inspected by USDA personnel at an approved port of entry with avian quarantine facilities. USDA imposes trade restrictions on the importation of live birds from countries affected by HPAI, including certain countries in Africa and Asia (USDA-APHIS 2009a).

Importation of wild or exotic birds into the United States must comply with APHIS and USFWS requirements. Certain exotic birds are protected by the CITES and the WBCA.

All birds entering Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian. Birds must be identified individually with a numbered leg band with the number indicated on the health certificate (9 GARR 1 § 1110).

Regulations for the importation of pet birds (all birds except poultry) under 9 GARR §§ 2101-2102 require pet shops and importers to keep a record of each sale made for at least 90 days and to make the record available to the GDOA if a quarantine is placed on the premises by the territorial veterinarian (9 GARR §§ 2101-2102).

Guam has introduced additional quarantine requirements for all birds (poultry and non-poultry) arriving from the continental United States to prevent the introduction of West Nile Virus requiring a 7-day quarantine in an approved facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage.

3.3.12.4 *Dogs and Cats*

Under CDC regulations, 42 CFR § 71.51, dogs imported to the United States, with limited exceptions, must be accompanied by a certificate of rabies vaccination; imported cats are not required to be vaccinated for rabies (42 CFR § 71). The entry of pets from areas affected by screwworms is subject to

APHIS regulations (9 CFR § 93), which require a health certificate stating that the pet was examined and found to be free of screwworm infestation within 5 days of export (USDA 2000; USDA-APHIS 2009b).

The GDOA regulates importation of pets to Guam (5 GCA § 60108). Guam restrictions and prohibitions for the importation of cats and dogs are stricter than federal requirements. Cats and dogs must enter Guam through the A.B. Won Pat International Airport or the Apra Harbor maritime port. Every cat or dog must be accompanied by an entry permit, a health certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine kennel reservation. Dogs must have a rabies vaccination certificate dated between at least 30 days and 1 year prior to shipment and a certificate of immunization against various canine diseases. Cats must have a certificate of immunization for multiple feline diseases. Regulations for the importation of cats and dogs into Guam require animal identification, quarantine procedures, and rabies vaccination and testing prior to arrival.

Title 10 GCA Chapter 34 Article 3 states that animals imported must complete a maximum of 120-day confinement in a commercial quarantine facility. Animals may undergo shorter quarantines under specific testing schemes for rabies and some pets may qualify for the home quarantine option.

Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for counties on the Mexican border) can be quarantined on Guam. Animals originating elsewhere must be quarantined in Hawai'i prior to entrance into Guam. Cats and dogs originating from rabies-free areas, Hawai'i, New Zealand, Australia, and the United Kingdom, may be exempted.

Import regulations for cats and dogs in 9 GARR 1 § 1109 include additional requirements for cats and dogs from other countries. Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the custody of the carriers at a designated inspection area at the port of entry until sent back.

Military regulations for the import of dogs and cats published in the Quarantine Regulations of the Armed Forces (QRAF) comply with federal and state requirements. General requirements for the admission of cats and dogs include the following: 1) all animals arriving in the United States are subject to inspection by a public health or military quarantine officer; 2) animals will require testing and confinement when they appear to be not in good health or when they have been exposed during shipment to a sick or dead animal suspected to have a communicable disease; 3) unsanitary cat and dog containers arriving in the United States must be cleaned and disinfected before the animals can be admitted; and 4) a valid rabies certificate is required for dogs. The military requires dogs to be vaccinated for rabies and inspected at the port under quarantine regulations. All pets belonging to military personnel must meet the requirements for importation into Guam.

One of at least four private veterinary clinics on Guam maintains a quarantine facility for imported cats and dogs. The military has one veterinary clinic and a boarding and quarantine facility at Andersen AFB and another veterinary treatment facility at the Navy base. The Andersen facility maintains 14 canine kennels and six feline quarantine kennels. The Navy will construct a new facility with space for 10 military working dogs, a veterinary examination area, an outdoor dog wash, and four quarantine runs.

In recent years, effective mitigations have drastically reduced the risk of infectious disease in military dogs stationed overseas.

3.3.13 Wildlife

Importers or exporters of wildlife, wildlife parts, or products must obtain a license from USFWS and importers may be required to secure an import permit from APHIS or the CDC and subjected to additional APHIS and CDC regulations depending on the species (9 CFR § 93, 9 CFR § 95, 42 CFR § 71.52-71.56). Guam also requires permits for the import of zoological or menagerie animals, inspection by the territorial veterinarian, and any necessary quarantine conditions.

GCQA must notify the territorial veterinarian of the arrival of live wildlife. GDAWR assists GCQA in identifying confiscated animal products.

Routine activities to monitor the movement of vertebrate wildlife are limited to BTS. APHIS-WS is responsible for surveillance and monitoring.

3.3.14 Military Mitigation

DoD maintains customs and border clearance policies and procedures for wildlife, agricultural and animal products, pets, plants, and plant products. By mandate of the Military Customs Inspection (MCI), all passengers, crew members, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the Customs territory of the United States (CTUS) must meet all U.S. entry requirements. All personnel on military aircraft must complete a U.S. Customs Accompanied Baggage Declaration (DD Form 1854), and civilian crew members must complete Customs Form 5129. The MCI program does not extend to Guam because GCQA has not authorized inspections by DoD personnel on its behalf.

A DoD memorandum designates Navy personnel with authority to inspect and to issue ship sanitation certificates for Navy, Army, Military Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels. This memo requires adherence to standard procedures and policy—IAW Article 39 of the International Health Regulations 2005—certificate (valid for 6 months) (WHO 2005).

AFJI 48-104, Quarantine Regulations of the Armed Forces, incorporates regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movements of vessels, aircraft, and other Armed Forces transport arriving at or leaving U.S. and foreign ports, installations, or other facilities where arthropod vector-borne diseases exist. This requirement is included in the Military Entomology Operational Handbook.

3.3.14.1 *Military Aircraft*

Military aircraft departing Guam should be screened by USDA-APHIS-WS canine inspection teams prior to departure. Military aircraft that arrive at Guam from Asian ports in Japan, China, and Korea should be inspected for insects, mice, birds, and amphibian and reptile species trapped within cabin and cargo compartments or hitchhiking externally in wheel-well compartments.

3.3.14.2 *Vessels*

DoD rodent control on ships to guard or separate gangways from the shore extend to cargo nets and other devices in port and fit connecting lines with rat guards. Cargo found free or treated for rats must be loaded. Ships must be inspected for rats and fleas prior to departure.

3.3.14.3 *Military Personnel*

The DoD relies on individual military personnel to clean and inspect their clothing and personal property to prevent the introduction of plant pests. Military personnel undergo limited training in biosecurity for agriculture. They are not trained in pest detection and receive no comparable information about the risks of moving plant pests into Guam and around the Micronesia Region. Military personnel are informed about the risks of spreading BTS from Guam. No oversight, compliance checks, or quality control processes are in place to ensure that biosecurity procedures for personnel are effective.

3.3.14.4 *Cargo*

All DoD cargo must be available for inspection by CBP upon entry into the United States except for areas outside CTUS, such as the Micronesia region. GCQA and CMNI Quarantine are responsible for agricultural inspections on behalf of APHIS in their respective territories. DTR 4500.9, Part V includes agricultural cleaning and inspection requirements and indicates that DoD personnel will be assigned as agricultural and customs inspectors for pre-clearance programs (DTR 4500.9). USDA-APHIS provides DoD with guidance, information, and training for pre-clearance inspections. According to the agricultural cleaning and inspection requirements (Part 5, Chapter 505), no cargo may be loaded in a foreign country unless free from plant and animal contamination or pest infestations.

Chapter 511 of DTR 5 states that all cargo entering Guam, regardless of origin, is subject to inspection by GCQA. OPNAVINST 6210.2 authorizes USDA-APHIS-PPQ personnel to inspect cargo to prevent the introduction of plant and animal pests or diseases.

3.3.14.5 *WPM*

DoD stipulates that all new WPM under DoD contracts or acquired by the DoD must meet ISPM No. 15 requirements. Companies supplying WPM to DoD must comply with a quality control program administered by the American Lumber Standard Committee (ALSC) through an agreement with APHIS auditing for proper treatment and record-keeping practices. However, DoD may use old WPM not compliant with ISPM No. 15. Whether any of this noncompliant WPM is shipped to Guam is not known.

3.3.14.6 *Propagative Material*

The DoD Personal Property Consignment Instruction Guide Online system, which provides guidance to military and DoD civilian personnel assigned to foreign duty stations, states incorrectly that there are “No restrictions identified” for plant movement into Guam.

3.3.14.7 Mitigation Regulations and Requirements

Table 6-2 presents pertinent regulations for Guam inspections, quarantine, and treatment. Tables 6-3 and 6-4 detail other biosecurity guidance and the military regulations and requirements for biosecurity.

Table 6-2: Biosecurity Regulations and Requirements

Statute, Regulation or Requirement	Description
Animal Health Protection Act (AHPA)	The AHPA purpose is to prevent, detect, control, and eradicate diseases and pests of animals to protect animal health, the health and welfare of the people of the U.S., the economic interests of U.S. livestock and related industries, the U.S. environment, and U.S. interstate and foreign commerce in animals and other articles.
Animal Welfare Act (AWA)	A modification to the AWA, the Animal Fighting Enforcement Act of 2007, made interstate commerce of a bird for the purpose of participation in a fighting venture illegal regardless of the law in the destination state, including Guam.
National Defense Authorization Act, Public Law 110–181, Section 314	Requires prohibition on the transport and spread of BTS via aircraft.
National Environmental Policy Act (NEPA)	NEPA, 42 U.S. C. § 4321 as amended, of 1969.
Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990	Authorizes a cooperative program to control BTS outside its historic range.
Plant Protection Act (PPA)	The PPA consolidates all or parts of 10 USDA plant health laws into one comprehensive law, including the authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests.
Title 8 Guam Administrative Rules and Regulations (GARR)	Division 2–Plant Industry, Chapter 10 regulates Food and Agriculture, Importation of Plants and Plant Products.
Title 9 GARR 1997	Division 1, Chapter 1 of the GARR regulates the importation of live animals.
	Section 2 of § 1103 (GARR) states that under no circumstances shall any animal be turned loose at the port and that hogs and sheep may be confined in temporary pens or crates, cattle and horses may be tied, and dogs and cats shall be confined in crates.
	Title 9 GARR, Division 1, Chapter 1, § 1109 requires that all cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) have a certificate from the national chief livestock sanitation officer stating that the animals originated in a state, country, or other political subdivision officially declared free of surra, animal African trypanosomiasis, and leishmaniasis.
	Title 9 GARR 1 § 1110 requires all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian.

Statute, Regulation or Requirement	Description
	Subchapters §§ 2101 and 2102 regulate the importation of pet birds (all birds except poultry).
Title 10 GDOA 5 GCA § 60108	The GDOA regulates the importation of pets to Guam. Title 10 Guam Code Annotated Chapter 34 Article 3 states that animals imported must complete a maximum of 120-day confinement in a commercial quarantine facility.
Wild Bird Conservation Act (WBCA)	Certain exotic birds are protected by the CITES and the WBCA. Importation of exotic birds into the U.S. must comply with APHIS and USFW requirements.

Table 6-3: Other Biosecurity Guidance

Other Guidance	Description
Animal Product Manual	Guidelines based upon the regulation governing the importation of specific animal products and by-products.
Combined Animal And Plant Health Risk Ratings for Countries	USDA-APHIS analysis of relative risks presented from other countries as a result of animal and plant diseases inside their borders (CPHST, VS Center for Epidemiology and Animal Health, October 2010).
Fruits and Vegetables Import Requirements (FAVIR) Online Reference	www.aphis.usda.gov/favir/
Manual of Agricultural Clearance	The APHIS MAC provides comprehensive guidance for practices required for safeguarding imported products and articles and handling regulated garbage. Safeguarding is a preventive action for handling, maintaining, or disposing of prohibited or restricted products and articles to maintain cargo control and eliminate the risk of plant and animal pest and disease dissemination. Nursery Stock Restrictions (M319.37–A & B)
USDA-APHIS-PPQ Manuals	Guidelines for regulating the importation and interstate movement of specific plants and plant products.

Table 6-4: Military Biosecurity Regulations and Requirements

Regulation or Requirement	Description
AFJI 48-104, Quarantine Regulations of the Armed Forces	Incorporates regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other Armed Forces transport arriving at or leaving U.S. and foreign ports, installations, or other facilities.
AFPMB Tech. No. 31 (2004).	Delineation of responsibilities for the military meeting USDA-APHIS requirements for internal and external inspections for terrestrial vertebrate species, insects, and plant species.
COMNAVMAR INST 5090.10a	Navy instruction for BTS training for military personnel.
DoD Memorandum	DoD Memorandum designates Navy personnel with authority to inspect and to issue ship sanitation certificates (ship sanitation control exemption certificate and ship sanitation control certificate) for Navy, Army, Military

Regulation or Requirement	Description
	Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels to adhere to standard procedures and policy—IAW Article 39 of the International Health Regulations (WHO 2005)—certificate (good for 6 months) with section for observed rodent infestations.
DoD SDDC PPCIG 2010 Personal Property Consignment	The DoD Personal Property Consignment Instruction Guide Online system, which provides guidance to military and DoD civilian personnel being assigned to foreign duty stations, states that there are “No restrictions identified” for plant movement into Guam.
Guam and CNMI Military Relocation EIS/OEIS	The Guam and CNMI Military Relocation EIS/OEIS describes military relocation plans, schedules, impacts, and mitigations.
Naval Supplemental Publication Number 486, Volume 1	Naval policy contains information regarding APHIS requirements for foreign garbage.
NAVMED P-5010-8	Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology: Navy procedures for the eradication of animals.
OMNAVMARIANA SINST 5090.10A	Requirements for setting barriers for BTS.
OPNAVINST 6210.2	USDA-APHIS-PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases.
Quarantine Regulations of the Armed Forces	The Quarantine Regulations of the Armed Forces state that cargo is subject to inspection by a USDA representative to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is part of the U.S. DoD maintains customs and border clearance policies and procedures for wildlife, agricultural and animal products, pets, plants, plant products, and regulated garbage.
SECNAVINST 6210.2A AFR 161-4, DoD, 1992, Section 9	Outlines procedures for the use of rat guards at ports with known rodent infestations.
Subsistence Manual COMDTINST M4061.3C	Waste Disposal Requirements.

4 RECOMMENDATIONS

APHIS risk assessment teams from PPQ-CPHST, VS-Center for Epidemiology and Animal Health, and WS have developed phytosanitary and general sanitary recommendations for enhanced biosecurity necessary to protect Hawai'i and the Micronesia Region during and after the military relocation to Guam and Tinian. Recommendations are based on the specific pest risk assessments of each APHIS team and observed deficiencies in mitigation capabilities.

The primary focus of the MBP is to describe recommendations for additional biosecurity measures for Guam, Hawai'i, CNMI, FSM, RMI,, and Palau. Each of these jurisdictions has reason to be concerned about many of the same challenges related to the introduction of invasive species and the lack of resources for sanitary and phytosanitary protections. In general these islands have limited staffing, funding, infrastructure, and/or capabilities for airport and seaport border inspections; agricultural quarantine inspection programs; plant and animal pest and disease surveillance; control and eradication; and early detection and rapid response programs.

Several biosecurity infrastructure needs are common at each Micronesian location. Adequate x-ray capability for baggage screening and inspection must be improved at each commercial port, either by ensuring operability or adding additional equipment. The CNMI, FSM, RMI, Guam, Hawai'i, and Palau should expand their inspection capabilities for air and sea containers. Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be constructed and maintained, especially for construction vehicles arriving via water to Guam, Saipan, Tinian, and Rota.

In addition, a Micronesian Region monitoring and surveillance program for the occurrence of foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs. Special surveillance programs should be established for plant pests and diseases; exotic fruit flies, Khapra beetle, Rhinoceros beetle, and tropical wood pests should be trapped. All Micronesian Region islands and Hawai'i should improve early detection and rapid response capabilities.

Other biosecurity measures are recommended for specific Micronesian Region islands and Hawai'i, including additional inspectors, legislatively approved user fees, electronic systems for tracking manifests, container scanners, and a training and outreach program (see Appendix A for more detail).

4.1 GENERAL RECOMMENDATIONS: It is worthwhile to note that many of the recommendations within this risk assessment refer directly to Guam but that many of these same concepts can be applied to the other jurisdictions covered by the MBP. Additional recommendations and details will be provided in the SIP.

4.1.1 Infrastructure

4.1.1.1 *Funding*

Increase funding for regional biosecurity so necessary efforts to prevent, control, and eradicate animal and plant pests and diseases throughout the region are effective. A centralized regional group with

representatives from each country within the Micronesia Region should develop sustainable funding streams for efforts to manage interrelated risks that cross political boundaries. There should be sufficient funds to conduct routine surveillance, implement response plans, and provide outreach and education, in addition to port of entry exclusion activities and training for inspectors.

Ensure sufficient funding for agriculture and wildlife disease and pest exclusion activities by developing legislation to create a user fee structure similar to that employed by the DHS and USDA. Review penalty assessment structure for noncompliance with regulations covering animal and plant health as a source of additional funding. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly inadequate for the magnitude of the existing and emerging challenges posed by the military relocation to the current exclusion and control systems. In particular, a main challenge to an agency with the all-inclusive mission of GCQA is sustainable financial support and subsequent accountability. A reasonable solution would be user fees. User fees are assessed by the government to recover the costs of goods or services. USDA-APHIS levies user fees through statutory authority 7 CFR § 354.3 and 9 CFR § 130. In 2010, GCQA levied a \$6.36 per passenger combined Customs and Agriculture user fee to cover passenger and baggage inspections compared to \$10.50 per passenger fee for international arrivals to the rest of the U.S. (\$5.50 for Customs inspection collected by the CBP and \$5.00 for agricultural inspection services by CBP on behalf of USDA). There is an additional fee for immigration services. User fees are not charged for military passengers or conveyances. User fees cover inspection of commercial aircraft and maritime vessels as well as commercial maritime vessels or aircraft carrying military cargo. If passenger arrival totals remain at current levels, increasing the user fee to the same as that of USDA/CBP would represent an approximate 40% increase in revenues.

Ensure adequate long-term military funding is available for biosecurity efforts. The military must participate in regional biosecurity efforts.

Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts

Ensure adequate long-term funding is available for equipment and infrastructure.

4.1.1.2 *Staffing and Resources*

Ensure sufficient staffing (inspectors, plant health safeguarding specialists, and surveyors) to accomplish all necessary inspection and quarantine activities in the Micronesia Region. Develop a staffing model that addresses all activities for inspection and quarantine. Already insufficient staffing levels will be strained further by the military relocation as the workload at airports, maritime ports, the mail facility, and the Plant Inspection Station increases. Quarantine officers with agriculture expertise should be on duty to clear cargo and conveyances whenever aircraft or maritime vessels arrive. Quarantine officers must be trained adequately in all aspects of their work and should receive periodic refresher training.

Activate the Guam Biosecurity Task Force. The Biosecurity Task Force has been approved by the Guam Legislature as a way to increase effective prevention of the importation of IAS. The source of funding is undetermined. This task force will have a total of 30 officers; 15 from GCQA and 15 from GDOA. The task force, a major step towards increased agriculture quarantine inspections and early detection efforts, should be funded fully for the success of the program.

Establish an MCI-excepted program on Guam. The program would include USDA-APHIS-trained military personnel to augment, conduct, and coordinate with GCQA agricultural inspections of foreign military arrivals. This program would augment and improve the import process to inspect all military maritime vessels in compliance with USDA and Guam statutory regulations and authorities. These MCI personnel could receive instruction from WS to recognize invasive species. The MCI program should be initiated on Saipan and Tinian as well.

Ensure availability of necessary equipment. Equipment necessary for effective safeguarding, hand lenses, microscopes, and computers, etc., must be available to quarantine officers. X-ray machines and other appropriate scanning technology and cleaning equipment must be provided where needed. A sufficient number of cranes must be available for sea cargo container inspections. All equipment must be maintained in working order over the long term. APHIS manuals provide detailed guidance for necessary equipment.

Ensure facilities for incoming passenger and cargo inspection are adequate for necessary inspections.

- Ensure that passengers arriving at A.B. Won Pat International Airport to transit Guam cannot move restricted or prohibited agricultural or wildlife products to other jurisdictions. GCQA personnel should be stationed with DHS, Transportation Security Administration (TSA) personnel for expertise in screening transiting passengers for restricted or prohibited materials or all transiting passengers should be routed through GCQA inspection before they move to the departure area.
- Build physically secure facilities at the Port of Guam with ample warehouse space and equipment and resources required to unload cargo and conduct agricultural inspections to centralize inspection of maritime cargo. Current import practices allow imported maritime shipments to proceed to destination for inspection. There are insufficient areas within the maritime Port of Guam to offload cargo and inspect contents of sea containers. These inspection facilities must have sufficient lighting, inspection tables, and dedicated areas as specified by APHIS–PPQ to detect and identify intercepted pests on foreign cargo, and confirm the integrity of animal product and byproduct shipments. Appropriate facilities will allow agriculture inspectors to increase their skills and abilities in pest detection.
- Maintain secure areas for storage of vehicles and cargo at the air and sea facilities to prevent the dissemination of plant pests and reduce risks of cross contamination of other cargo items. Sterile staging facilities for incoming and outgoing vehicles and other cargo must be maintained at military and commercial locations.

- Build out the foreign inspection area for passenger clearance in the main terminal at Andersen AFB to a sufficient size for physical inspections of passenger baggage. The facility lacks space, lighting, and equipment (e.g., x-ray equipment, tables, and materials for collecting samples) sufficient to enable GCQA to complete all aspects of inspection.
- Ensure there are sufficient inspection facilities for express courier operations at the airport.
- Replace the garbage grinder drainage pipes with pipes sufficient in diameter (minimum of 4 inches) for effective drainage and disposal of ground-regulated materials in the new GCQA cargo inspection facility at the A.B. Won Pat International Airport.

Develop/enhance the tracking system for all cargo with unique identifiers for cargo shipments.

Include an electronic system for tracking, identifying, and collecting data from manifests for containerized commercial cargo arrivals to Guam and Saipan to streamline the import process while maintaining biosecurity.

This recommendation is especially necessary for cargo that originates in areas affected with significant plant and animal pests and diseases. Implement a data collection system and incorporate it into a centralized, secure system that could be modeled on the one used by CBP. Though all arriving cargo is subject to inspection, selection of containerized cargo is based on the shipping company's paper manifest that itemizes container contents (Merfalen, personal communication). The paper-based system of recording, identifying, and tracking these manifests is vulnerable to missing or lost documentation, unregulated and recurring biosecurity breaches, and omission from integration with electronic tracking. Develop MOUs with other entities to share shipping information across the region.

Ensure an adequate number of canine inspection teams to detect animals, plant materials, plant pests, and animal products and by-products. Teams should be scheduled routinely at airports, maritime ports, and the USPS mail facility for screening baggage, express mail carrier packages, and other cargo or incoming mail.

Establish decontamination sites for cleaning military and civilian equipment. Such sites must be available at all locations where military training exercises will take place and at both military and commercial maritime ports and airports. The importer bears the costs of remedial cleaning. Procedures should meet USDA-APHIS standards for soil-contaminated vehicles and equipment. Wash racks planned for the naval facility are not available at the commercial port. They should have sufficient water supply with high-pressure cleaning capability and lifts or ramps for access to undercarriage areas. Remedial cleaning must include the interior and exterior, engine compartments, and trunk areas with special attention to undercarriage, wheel wells, etc., as sites for soil, plant materials, and invasive species. Decontamination sites should have a quarantine area for storing contaminated equipment prior to cleaning. Precautions must prevent contaminated water from running off into the soil. All wash sites and decontamination systems must be effective. At a minimum follow Technical Guide No. 31, *Armed Forces Pest Management Board, Retrograde Washdowns: Cleaning and Inspection Procedures (AFPMB)*.

4.1.2 Offshore Mitigations

Establish an agricultural pre-clearance program in Okinawa, Japan, for all military equipment and other assets transferred to Guam and throughout Micronesia. The Pacific Command does not participate in any voluntary military agriculture pre-clearance program for containers, retrograde cargo, vehicles, or other assets. USDA-APHIS trains military personnel to conduct pre-clearance inspections. Shipments then would be selected randomly for inspections to monitor program efficacy. Large amounts of military assets will be moved from the closed facilities in Okinawa. Military shipments noncompliant with agriculture regulations or in need of cleaning will be refused entry or required to undergo remedial cleaning for entry requirements, leading to massive bottlenecks at the seaport. The military should support and fund this regional program similar to other Commands.

Include requirements and provisions in military and civilian contracts for the relocation to reduce the risk of introduction of animal and plant pests and diseases. Along with increased containerized cargo and vehicles, there will be substantially increased bulk shipments entering through the Port of Guam for construction and infrastructure upgrades. In addition to U.S.-origin workers and materials, other sources will include China, Japan, Korea, the Philippines, Malaysia, and Indonesia (Guam Contractors Association, personal communication). Provisions should include: 1) contractor-provided education for employees on import requirements (educational materials should include penalties [firing, pay-docking, etc.] for workers violating import regulations and should be developed collaboratively by officials who will have the greatest direct impact from the relocation [DoD, USDA-APHIS, Guam, and CNMI]; 2) contractor compliance with all import requirements [import permits, procedures at port of entry and beyond, etc.]; and 3) company-driven pre-inspection of their own materials for plant pests.

Require weed risk assessment for the importation of exotic plant species. Prohibit the importation of all plant species exotic to and not yet naturalized on Guam unless deemed unlikely to become invasive by a weed risk assessment with exceptions for plants historically imported without becoming invasive.

Require treatment of all WPM according to ISPM No. 15. All domestic and foreign, military and non-military WPM entering the Micronesia Region should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.

Require phytosanitary treatment of all imported timber, including timber from domestic locations to mitigate the risk of pest entry on this pathway. Required treatments should be effective in removing pests.

4.1.3 Point-of-entry Activities

Conduct agricultural inspection of arriving conveyances, military and non-military, for plant pests and animal contamination. Inspection must include a thorough search of the exterior and the interior of the conveyance for plant and animal pests and wildlife of concern. GCQA officers must be allowed to inspect military vessels as USDA-APHIS cooperators. Other jurisdictions must also have the ability to inspect U.S. DoD craft that enter their ports.

Minimize pest contamination of containers and WPM by:

- Minimizing outdoor storage
- Sealing storage site surfaces
- Keeping storage sites clean
- Controlling pests around storage sites
- Limiting use of nighttime lighting around storage sites

Treat storage areas with molluscicides or install barriers to prevent mollusks from infesting WPM and shipping containers. Remove weeds and other contaminants from container and WPM storage areas. Storage areas should be hard surface or gravel.

Conduct phytosanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign, military and non-military WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.

Clean containers and conveyances that arrive in the Micronesia Region contaminated with soil or exotic plant pests. Follow all APHIS policies and guidelines as applicable. Evaluate the effectiveness of current cleaning methods, and improve as appropriate.

Conduct phytosanitary inspection for contaminating pests of all incoming construction materials including materials previously treated or cleaned (for recontamination after treatment) and construction material from the United States.

Properly clean all equipment (construction and military) according to APHIS guidelines prior to entry into any part of the Micronesia Region to remove hitchhiker pests and soil contaminations. Equipment must be cleaned before moving within the Micronesia Region (between countries or islands of the same country, and, where appropriate, between areas of the same island).

Adopt a local DoD-GCQA MOU to codify agreements, clarify collaborator roles, and establish protocols and procedures for military vessel and cargo inspections. GCQA must be allowed to monitor military ships to fulfill responsibilities under USDA regulations and authorities agreed upon with USDA-APHIS.

Improve detection methods for rodents and other wildlife on vessels and in cargo. Rodents and other wildlife have been implicated in the transmission of zoonotic diseases. Methods may include trapping, monitoring for signs, etc. Rodent detection methods are not well developed and other wildlife detection methods have not been well documented. NAVMED P-5010-8, the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) outlines preventive measures for rodent control on ships, including proper sanitation, pier side inspections, rat

guards, illumination and movement restrictions, glue boards, snap traps, and limitations on vessel access points.

Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods similar to the APHIS-PPQ Agriculture Quarantine Inspection Monitoring Program are needed for random container searches regardless of documentation, type of shipment, or country of origin. Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened and for new avenues for implementing pre-clearance procedures.

Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging processes prior to arrival as imported cargo or after arrival when staged for loading for inland transport. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for labeling, packing, and transport prior to arrival and for eventual staging and loading for inland transport after arrival. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places, especially for BTS detection by canine inspection teams.

Enhance collaboration between USFWS and GCQA. GCQA and other agencies with port-of-entry inspection responsibilities should work with USFWS to increase the effectiveness of interdiction capabilities and inspections for wildlife and their products at the ports of entry to prevent the introduction of animal and zoonotic diseases.

4.2 CARGO

Agencies responsible for enforcing USDA-APHIS regulations should have access to the APHIS ePermits system for assistance in clearance of restricted agricultural materials. APHIS import permits may be required, in conjunction with local import permits, for various agricultural commodities imported into Guam and CNMI. All officers acting under an MOU with APHIS inspecting for agricultural commodities need access to the ePermits system to validate APHIS import permits presented with incoming shipments.

Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods similar to those of the APHIS-PPQ Agriculture Quarantine Inspection Monitoring program are needed for random container searches regardless of documentation, type of shipment, or country of origin. Allocate funding to increase the number of containerized and crated air

cargo shipments to be inspected. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened.

Construction and other commercial equipment must be inspected, cleaned, and washed down at the port of entry, and military aircraft and other military vehicles arriving as maritime cargo must be inspected, cleaned, and washed down at a retrograde wash facility before entry. Washdown procedures for military vehicles should target soil, plants, insects, and other wildlife. Tracked vehicles can be cleaned on shore only if they can be reloaded without recontamination of the treads; otherwise they must be cleaned on the ship's well-deck. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to shipment from the port of departure. Vehicles may be cleaned at the port of entry provided wastewater soil is collected and drained fully into an approved collection system.

4.2.1 Live Animals

All health certificates and necessary permits should accompany imported livestock, poultry, and other animals. Make sure the animals are subject to health inspection by the territorial veterinarian and quarantined as required.

4.2.2 Animal Products and By-products

Require the use of USDA or GDOA VS import permits or for restricted animal products.

4.2.3 Plant Products

Standardize methods and implement the random inspection of air cargo containers regardless of documentation, type of shipment, and country of origin. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened, and for new avenues for implementing pre-clearance procedures.

4.2.4 Propagative Plants

There should be sufficient equipment and supplies at the Plant Inspection Station for the full range of necessary inspections. Processes and equipment should provide for intensive inspections for insect, plant pathogen, foreign weed seed, and invasive plant detection in propagative plant shipments.

4.2.5 Wood Packing Material

Re-export or treat infested or noncompliant WPM. Non-compliant and infested WPM should be treated as regulated garbage; if not re-exported it should be incinerated or sterilized. Chipped WPM may present a pest risk when the chips are re-used or improperly disposed.

4.3 MAIL

Follow a model similar to that established in Hawai'i by utilizing detector dogs for establishing probable cause for inspection of first-class (domestic) USPS packages.

Use appropriate x-ray technology for all foreign-origin mail. Ensure that all x-ray equipment is in working order and operable.

PPQ should work with CBP and the Hawai'i Department of Agriculture for an adequate level of inspection in Hawai'i.

Establish effective working relationships between customs officials, agricultural officials, and USPS personnel in Guam so safeguarding personnel can carry out their responsibilities. Guam safeguarding personnel must have sufficient access to the postal facility to conduct appropriate biosecurity screening at all times. This could be modeled after the USPS policies in Hawai'i. The USPS in Hawai'i granted U.S. Customs officers and canine full access to the facilities to perform all inspection activities while international mail is being processed or is in the facility. While domestic mail is being processed or is in the facility in Hawai'i, USDA PPQ officers and canine have full access to the mail to perform all inspection activities.

Develop secure procedures for opening international mail without customer witnesses.

Record and analyze data on pest interceptions in mail. Analysis should improve targeting of phytosanitary and general sanitary hazards.

4.4 REGULATED GARBAGE

Consider construction of a waste-to-energy facility on Guam. The current landfill is not EPA-compliant. The future landfill will have only an estimated 30-year capacity with the increased military presence (Cruz 2010). A waste-to-energy facility will incinerate garbage, reduce the need for landfills, reduce the exposure of the environment to agriculture diseases and pests, and provide electricity to a significant number of households. Such a facility would serve as back-up processor of regulated garbage if other equipment is inoperable.

Appropriate disposal mechanisms should be in place before training on Tinian and other locations begins. Each location should have mechanisms to dispose of garbage generated on-island as well as regulated garbage from other locations. The Tinian incinerator should be repaired ASAP since periodic DoD training has already started there. The incinerator owned by the Tinian government is currently inoperable, the overfilled local dump was ordered closed previously, and the military is not authorized to use facilities approved by EPA. Transporting garbage generated during DoD training events violate APHIS regulations over movement of regulated garbage between U.S. possessions (9 CFR § 94.5, 7 CFR § 330.400-403).

DoD should consult with PPQ or local governments so they institute appropriate mitigations for handling regulated garbage in compliance with APHIS and local regulations. Collaboration with appropriate officials of Tinian or of any U.S.-affiliated country should ensure that proper (land-filled, sterilized, or incinerated) on-island disposal can be achieved. Military activities are currently not compliant with appropriate measures for handling regulated garbage. Some of the known issues which need to be addressed include:

- The use of sterilizing equipment without automatic temperature/time recording devices.
- Failing to use appropriate containers to move regulated garbage.
- Authorizing dumping of pulped-food waste within 12 nm of the coast of Guam and other U.S. territories and affiliates.
- Planning to move garbage generated during training on Tinian to Guam or Saipan.

begins.

Unannounced monitoring of APHIS-regulated garbage compliance agreement holders should be conducted at least quarterly. Appropriate agency representatives must be trained to conduct enforcement visits to compliance agreement holders to monitor whether they follow required procedures.

Include specific information in the Port Authority of Guam Master Port Plan to address equipment and other resources needed to handle regulated international garbage properly. There is nothing in the Guam Master Port Plan addressing resources and equipment required to handle regulated international garbage.

Enforce current swine health protection regulations requiring cooking of certain types of food waste (heating to an internal temperature of 212°F for 30 minutes) before feeding to pigs. The proper cooking of food waste will prevent the dissemination of foreign animal diseases of concern (9 CFR § 166).

Consider all garbage within the passenger sterile area for incoming and transiting passengers at the A.B. Won Pat International Airport to be regulated garbage. Food, food materials, and other prohibited and restricted agricultural and wildlife materials discarded in sterile area receptacles and bathrooms are handled as routine trash. These materials go to the local dump without mitigation and can present a significant risk with increased numbers of temporary workers on Guam. This garbage should be removed and processed under USDA compliance agreements.

4.5 EXPORT

Preferentially load conveyances in a way that minimizes pest entry whenever possible. For example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times.

Provide a pre-clearance staging area for all military vessels requiring immediate departure from Guam.

Coordinate USDA-APHIS agreements with commercial air cargo shipping agencies to prevent invasive species transportation. Despite high levels of cooperation by most cargo export entities, APHIS-WS still makes regular discoveries of previously unknown cargo handling processes or companies, and there are several private companies on Guam that refuse to provide information on or access to outbound cargo for inspection purposes. Coordinate agreements and procedures with air cargo shipping agencies for

handling cargo, including packing, over-land transport, cargo-staging, palletizing, canine inspection, and final loading.

4.6 REGULATIONS, GUIDELINES, AND COMPLIANCE

Systematically review all guidelines and SOPs of agricultural relevance so they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Develop guidelines or SOPs where lacking.

Put appropriate local and federal regulations in place to carry out biosecurity measures to prevent the introduction of plant and animal pests and diseases. Regulations should support the issuance of penalties and fines to enforce compliance.

Utilize the APHIS-PPQ port manuals as guidance in locations with APHIS cooperators as appropriate. The manuals contain information on port operations and commodity regulatory decision making designed to enhance biosecurity at the ports of entry.

Revise and update all military guidelines and SOPs for compliance with APHIS regulations where appropriate. In some cases, the military uses outdated guidance with inaccurate information. For example, the OPNAVINST 6210.2 lists only the States, District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands as the U.S., notably excluding the CNMI and American Samoa (7 CFR § 330.400[a] and 9 CFR § 94.5[a]). The NAVFAC Guam Program Management Office/PSC 15 Jan 2010 *Summary of Navy Pollution Control Discharges Restrictions* authorizes the discharge of garbage containing pulped or comminuted food within 3 to 12 nm of the coasts of Guam and the CNMI. This instruction is accurate in only very specific situations; much of this garbage is regulated by USDA for agricultural issues.

The military should execute an MOU with all Micronesian countries and develop appropriate agricultural disease exclusion and invasive species SOPs for compliance when conducting activities in their respective countries. The U.S. Navy has a Seabee unit stationed in the Republic of Palau. How much this unit will participate, if at all, in the military relocation is unknown. Military officials do not inform Palau quarantine officials when aircraft arrive, leave trash for government officials to destroy, and drop cargo and supplies for Palau construction projects. Equipment is washed on the tarmac without proper drainage facilities.

Develop BMPs for contractors and construction sites. Work with industry to gain support preventing the introduction and spread of exotic plant pests. Implement “clean” practices at construction sites to minimize land disturbance that spreads plant pests.

Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of native and noninvasive plants. This code of conduct should encourage businesses:

- To make their staff knowledgeable about invasive plants.
- To inform their customers about invasive plants.

- To report immediately any likely exotic pest organisms found on their premises.
- To use native or noninvasive plants locally sourced.

Revise the DoD landscape plan by removing plant species with the potential to be invasive in the Micronesia Region or Hawai'i. Request technical support from the University of Guam as appropriate.

4.7 TRAINING

Provide adequate information about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread. Provide a list of enterable and prohibited materials. Create awareness of the potential legal consequences of violations. Inform people how they can contribute to exotic species-prevention efforts. Alert the following groups: 1) military personnel and dependents; 2) nonmilitary workforces; 3) tourists; 4) the general public; and 5) private industry.

Provide training to increase inspection and identification expertise. Safeguarding inspectors (both civilian and military) should receive regular adequate training in proper techniques for detecting, collecting, recognizing, and identifying pests. A communication network for continuous sharing of new information is recommended.

Provide specific and detailed guidance to military personnel on how to inspect clothing and personal effects for plant pests.

Enhance training for military personnel and their dependents about phytosanitary and general sanitary regulations and the risks of sending or receiving agricultural and wildlife materials in the mail.

Train inspectors specifically on livestock, wildlife, and poultry diseases and pests.

Train appropriate agency representatives to conduct enforcement visits to APHIS Compliance Agreement holders handling regulated garbage. The number of personnel trained to monitor compliance agreement holders for functional equipment and appropriate procedures in handling regulated garbage is insufficient.

Develop a wildlife reference collection (i.e., taxidermy mounts or computer photo files with APHIS-WS) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.

4.8 EDUCATION AND OUTREACH

Develop education and outreach programs to inform the public and the military about the potential harmful effects of animal and plant pests and diseases with emphasis on consequences of smuggling animals and agricultural products. Provide adequate information on ways to prevent the spread of plant and animal pests and diseases. Provide reports and newsletters to educators, journalists, lawmakers, and business and community leaders; develop curricula for local schools; provide lists of

enterable and prohibited materials; place posters in private and public mail facilities; and conduct a pre-education survey of residents and other stakeholders to gauge their understanding of animal and plant pests/diseases introductions/invasions and subsequent impacts. Create awareness of the potential legal consequences of violations. The following groups should be included: 1) military personnel and dependents; 2) nonmilitary workforces; 3) tourists; 4) the general public; and 5) private industry.

Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials in the Micronesia Region, including the potential loss of business if invasive species are introduced to Guam and other Micronesia Region locations.

Develop voluntary agreements between Guam government officials and pet stores and other businesses in the pet trade industry to curtail smuggling and create safe avenues for import (i.e. no imports or sales of prohibited animals or plant pests).

4.9 MONITORING, SURVEILLANCE, AND ADDITIONAL SAFEGUARDING PRACTICES

Conduct background surveys as soon as possible to establish baselines for plant pests and livestock and wildlife populations and diseases. Initial measures to prevent introduction of livestock, poultry, and wildlife diseases should be implemented with a surveillance and monitoring strategy to determine whether measures perform adequately. These measures then should adjust to improve biosecurity.

Develop a biosecurity surveillance system for improved data collecting, reporting, and information sharing. A paucity of information is available to fully assess risks from intentional and unintentional movements of animal and plant pests and diseases posing significant risks to biosecurity efforts in the Micronesia Region and Hawai'i. A biosecurity surveillance system could serve as an early detection program for plant, animal, and zoonotic pests and pathogens emerging in Pacific Rim countries. Sustained surveillance and record keeping of interceptions will facilitate tweeking biosecurity mechanisms to reduce future incursions ultimately decreasing risks from varying threats and changes in the ways cargo and people are moved in the future.

- A well-documented process of pest and disease prioritization, surveillance, data collection, and record keeping must be followed. The system should include routine surveillance for wildlife, livestock, and poultry diseases and vectors as well as plant pests.
- Specific surveillance methodology should be appropriate for target species, (i.e. modifying sampling programs to account for behavioral differences in diurnal and nocturnal lifestyles). Utilize systematic surveillance for plant pests following the model of the Cooperative Agriculture Pest Survey (CAPS), and include both military and civilian properties as appropriate.
- Such a system should improve communications of survey results among all island mitigation programs. The communications plan will allow GCQA and other responsible biosecurity

authorities to react to changing risks posed by travelers and cargo based on countries of embarkation or origin.

Encourage and participate in actions to preserve biodiversity.

Include actions taken by joint agency collaborations like the Micronesia Challenge and the Micronesia Regional Invasive Species Council.

Conduct periodic surveys of ethnic markets, pet stores, and grocery stores to identify and intercept prohibited animals and animal and plant products following the model of the USDA-APHIS-PPQ Smuggling, Interdiction and Trade Compliance program.

4.10 OVERSIGHT

Centralize biosecurity efforts for maximum effectiveness. A central group acting as a liaison can bridge gaps between formal and informal and military and civilian communications. A central group would outline the current network of biosecurity communications in the Micronesia Region; find communication gaps; publish information in appropriate formats for public, private, and military sectors; and issue media and news releases on biosecurity.

Establish a Pest Risk Committee with participants from various agencies and organizations responsible for managing exclusion and control efforts at the ports of entry. This group could function as the operational arm of the larger regional biosecurity group.

4.11 EMERGENCY RESPONSE

Develop a hazard response plan for animal and plant pests with all entities responsible for these activities. Include military and civilian public health authorities for diseases with serious animal health and zoonotic potential.

Improve rapid response capabilities at military and commercial airports on Guam and the CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent establishment of introduced pest species. Rapid response takes place at and within the border at levels ranging from federal to local community involvement. Review the current process for rapid response to border and post-border detections and unconfirmed reports or sightings.

Improve rapid response capabilities at military and commercial airports on Guam and the CNMI Islands of Saipan, Tinian, and Rota.

Conduct practice drills to hone response skills and test communications.

4.12 CONCLUSIONS

The scope of the MBP is to describe mitigation recommendations sufficient to prevent and mitigate risks posed to human health, animal and plant health, economies, and ecologies of the Micronesia Region from the intentional or accidental spread, introduction, or establishment of terrestrial animal and plant

invasive species and diseases as a result of proposed military activities. Guam must be emphasized because the proposed military activities are focused there. Prevention of both the introduction of invasive species to Guam and the transport and spread of BTS from that island are the broad objectives and priority concerns. Guam is a transportation gateway for the rest of the Micronesia Region, facilitating the wide-spread movement of species.

Risks of the introduction of invasive species and diseases to Guam and the Micronesia Region are diverse. Plant propagative material may present phytosanitary risks as either a pathway for introduction of exotic plant pests or as an invasive species. Increased importation of plant propagative material during the military relocation may increase the risk of pests entering the Micronesia Region. The current DoD landscape plan may facilitate the spread of potentially invasive plants. Increases in plant propagative imports as a result of the military relocation will place increased demands on customs staff and infrastructure resources and may allow more pests to enter the Micronesia Region.

The introduction of many of the livestock and poultry diseases considered in this risk assessment could have major consequences to animal and human health throughout the Micronesia Region and far-reaching impacts on trade in the rest of the U.S. With the arrival of increased numbers of pet dogs and cats, current resources for inspection and follow-up could be overwhelmed. There is no ongoing surveillance for livestock and poultry disease on Guam; therefore, it is difficult to know what disease agents are already in the region and to detect the introduction of an exotic disease agent. Lack of a diagnostic laboratory in the region also diminishes the ability to detect disease agents. Rapid detection is critical to timely responses to new disease introductions, especially with the highly transmissible exotic diseases considered in this assessment. The potential for importation of zoonoses that pose major public health threats warrants increased surveillance for imported wildlife in the United States and Micronesia.

Safeguarding Guam and the Micronesia Region during the military relocation is challenging with the number of pests continuously approaching their shores. While federal, territorial, and military regulations aim to mitigate effects of the introduction of hazards, the estimated increase in population and goods from the military relocation will strain current capacity for inspection and interdiction of illegal goods, and increase the likelihood of invasive species throughout the region. There is reason to believe that Guam's biosecurity protection systems and resources may be overburdened and underfunded and therefore not sufficient to inspect cargo, passenger baggage, and conveyances appropriately during the military relocation.

The challenges, risks, and costs of long-term control and eradication of an established invasive species could be significant. The most cost-effective approach to protecting natural and agricultural resources on Guam and throughout the Micronesia Region is prevention and early detection.

5 OUTREACH

To reduce the demand on protection program resources, an outreach program should increase awareness of risks from the introduction of invasive species, pests, and plant and animal diseases throughout the Micronesia Region. In support of outreach, a comprehensive training program should be developed to increase awareness of risks and consequences to agriculture, human health and safety, the environment, and the economy from the transport of potentially invasive plant and animal pests, diseases, and species to Guam and the other Micronesia Region islands.

5.1.1 General Outreach Program

The outreach program should include awareness and prevention training in sources, activities and conveyances (pathways). Knowledge of certain high-consequence or high-probability animal and plant types or species is essential to reduce the frequency of personnel, equipment, and cargo transport of infective or invasive species on conveyances within the Micronesia Region.

5.1.2 Strategic Plan

A strategic plan should be developed to set objectives, design components, assign roles, determine costs, and integrate outreach planning with the biosecurity plan leadership.

5.1.3 Target Groups

The outreach program should target the following audiences:

- Military personnel and dependents relocating to the Micronesia Region
- Local government entities
- NGOs
- Guam and other Micronesia Region residents
- Foreign contractors and temporary workers
- Agents of commercial airlines
- Owners of shipping, fishing, and recreational craft
- Local businesses (e.g. pet stores and purveyors of specialty foods)
- Community associations
- Schools and universities
- Visitors to the region

5.1.4 Program Components

All components of the outreach plan should be well-defined, including:

- Publishing a regular schedule of outreach events.
- Scheduling locations or venues for outreach events that are convenient for the target audiences.
- Formalizing a message development process for high-risk species and their pathways.
- Developing information delivery systems for print media (newspapers, periodicals, posters, handouts, etc.), television, radio, and the Internet.
- Developing a mechanism for outreach communications to military personnel.

5.1.5 Measures of Program Efficacy

A method of measurement should gauge the effectiveness of the outreach program. This metric could be determined in many ways specific to outreach program objectives. Each outreach event should keep a record, tracking participating organizations, venues, topics covered, and any lessons learned. This information should be analyzed to re-evaluate and re-target the outreach program content, format, venues, and audience as needed.

Suggestions for general metrics to measure program effectiveness:

- Number of outreach events
- Number of individuals or organizations reached
- Number of individuals or organizations participating in program events
- Number of reports from outreach targets of suspicious animals or plants
- Number of ancillary education or outreach programs developed by governments, businesses, schools, community organizations, and citizens

5.2 ORGANIZATIONS AND ROLES

A planning and coordinating body for each jurisdiction of Micronesia and Hawai'i should be designated to direct and manage outreach activities. Every organization with a stake in the biosecurity of the Micronesia Region and Hawai'i should engage in the outreach planning process. Existing programs should be leveraged wherever feasible. For example, the Office of Economic Adjustment and the Military Integration Management Committee conduct community outreach dialogue sessions on Guam, the CNMI, and other locations to hear citizen concerns. Such organizations could expand their charters to formal outreach and awareness programs using established educational materials. Another good example is that of the regional response team which has been conducting outreach on IAS in all jurisdictions (except Hawai'i) for 10 years. RISC as a regional IAS council for Micronesia should also be involved in this development process.

5.3 FUNDING RESOURCES

In accordance with planning, managing, and reporting outreach activities, a contracting officer and an oversight committee are necessary to develop a source of funding. The primary stakeholders, such as

the U.S. military, Guam, and other Micronesia Region islands, should determine appropriate funding sources for a comprehensive outreach program. Potential increases in current user fees or new fees could be imposed on permitted imports. Legislatively appropriated funds could be utilized for these activities. The justification for this legislation is that outreach efforts would be effective long-term prevention campaigns.

5.4 MICRONESIAN REGION AWARENESS TRAINING AND OUTREACH:

The outreach program should involve biosecurity partners throughout Micronesia. A representative body should coordinate outreach programs among sovereign nations for each of these programs.

A comprehensive and continued information program on identification and potential impacts of invasive plant and animal species in Guam should be developed. The information in this program should target: residents, visitors, military personnel, businesses, governments, and associations throughout the Micronesia Region.

The program should provide information through the distribution of printed materials that show examples of how various released species can become economic, ecologic, or human-health threats. Schools should be target audiences to educate children on the importance of preserving natural ecosystems.

A person or organization should be designated as responsible to the Government of Guam (GovGuam) for developing high-priority outreach messages about invasive species and their pathways. GCQA, GDOA, and the Guam Invasive Species Advisory Committee are candidate organizations.

Topics should be highest-rated risks as determined by probability of introduction and level of impact. Suggested biosecurity topics include:

- Import and export requirements
- Precautions in traveling to Guam and other Micronesia Region islands
- Recognition and reporting of BTS and other invasive species
- Risks from domestic and international mail
- Proper handling and disposal of regulated garbage
- Pre-inspection of cargo for shipment
- Procedures for reporting sudden deaths in wildlife
- Personal sanitary precautions—washing shoes, cleaning vehicle tires, and checking for invasive species and wildlife of concern
- Reports of illegal movement of restricted agricultural commodities or invasive species
- Reports of observed incidents of invasive species on Guam and other Micronesia Region islands

5.5 OUTREACH METHODS

5.5.1 Training

Official sponsors who assist with relocation of military personnel should be designated and trained per regulations on the movement of animal and plant products. Designated sponsors should work with contractors and temporary workers to identify potential introduction pathways and reduce risks of transporting invasive species wherever possible.

5.5.2 Educational Materials

Educational materials for the outreach program could include reports and newsletters to educators, journalists, lawmakers, and business and community leaders; curricula for schools; and a pre-campaign poll of island residents to gauge levels of awareness of species introductions/invasions and subsequent impacts. Educational materials should portray the hazards of the import of illegal animals and plants and their products and by-products. Information should be posted in public locations in USPS mail and express courier facilities to inform customers of the potential economic and environmental impacts of exotic plants and pests.

The education program should focus on the dangers of maintaining populations of invasive species for food or sport with examples of potentially invasive species (e.g., rabbits, banteng, water buffalo, Polynesian rat, spotted turtledove, water frogs, African snails).

5.5.3 Outlets and Media

The following outlets and media should disseminate essential outreach information and answer questions and concerns about the risks of invasive species:

- Meetings in local communities
- Radio and television public service announcements
- Newspaper articles
- Websites (e.g., military, local governments, and federal government) that address restrictions and regulations on movements of animals and plant materials

5.5.4 Monitoring

A response network should be developed for community members to report incidents of illegal sales (independent or retail), illegal releases of plants or animals, and invasive species sightings. Community monitoring efforts should be aligned with those of local governments in a formal monitoring and surveillance plan (see Chapter 9, *Monitoring and Surveillance Plan*) to enhance biosecurity efforts.

5.5.5 Incentives

Incentives to participate in an outreach program should be explored. For example, state or local governments could offer tax incentives or preference points for municipal projects, trade agreements,

or monetary awards. These measures would be codified in public proposals that solicit Micronesian projects, reducing the burden on other funding sources.

Nonprofit organizations and higher-learning institutions promoting outreach programs could receive direct grants. Private industries that initiate an awareness and education program could receive tax advantages or preferential consideration for government contracts. Outreach to trading countries could be on the terms of trading or shipping agreements. Local governments could receive direct grants or reductions in financial obligations to the state government.

6 MONITORING AND SURVEILLANCE

6.1 INTRODUCTION TO MONITORING AND SURVEILLANCE

A Micronesia Region monitoring and surveillance program is important to improve efficacy in detecting the occurrence of foreign animal and zoonotic disease and plant pest introduction on Guam and other Micronesia Region locations. The RA recommends establishment of specific baseline monitoring for each program.

The monitoring plan should select specific locations and conveyances of potential introduction of high-risk or high-probability invasive species. A surveillance plan should present methodologies to collect and analyze data leading to action taken to prevent and control the introduction and establishment of invasive species. The plan should describe the strategies, resources, and methodologies that should be developed and applied to manage a monitoring and surveillance program for high-consequence or high-probability risk pathways and species.

USDA-APHIS-PPQ promulgates standards for plant pest and disease monitoring. For current information on survey protocol for specific pests, please consult the USDA-APHIS-PPQ Domestic program manuals at: http://www.aphis.usda.gov/import_export/plants/manuals/domestic/index.shtml.

6.2 OBJECTIVES

Objectives for a Guam and Micronesia Region monitoring and surveillance program include the following:

- Develop a comprehensive biosecurity surveillance system for an improved data collection, reporting, and sharing network.
- Conduct periodical surveys of markets and pet shops to intercept prohibited animals and plants and their products.
- Implement pest survey programs for the early detection of pests from imported fruits and vegetables, WPM, garbage, and construction materials.
- Augment surveillance measures and equipment at military and commercial airport and harbor ports-of-entry.
- Inspect imports randomly (e.g., cargo containers) for plants, plant pests, insects, disease agents, and wildlife.
- Develop a system of routine systematic surveillance for livestock and bird and poultry diseases and vectors.
- Work with the military for access to military sites and activities to monitor for pest conditions.
- Establish standards for surveillance reports and systems to manage surveillance data.

6.3 COMMUNICATIONS SYSTEM

All organizations and offices associated with Guam and Micronesia Region monitoring and surveillance programs should establish a communication system for pest surveys, outreach programs, port inspections, and pest identifications. A SOP should be developed for communication with rapid response teams (Chapter 10, *Rapid Response Plan*). The communications plan should allow PPQ, GCQA, GDOA, and other authorities responsible for inspection and identification to react to changing risks based on countries of origin of arriving travelers.

6.4 MONITORING AND SURVEILLANCE PLAN

6.4.1 Regulations

APHIS and Guam regulations justifying a monitoring and surveillance program include:

- AHPA
- PPA
- NEPA, 42 U.S.C. § 4321 et seq.
- AWA
- WBCA
- GARR Titles 8, 9, and 10
- GDOA, 5 GCA § 60108
- APHIS plant health regulations (7 CFR)
- APHIS animal health regulations (9 CFR)

6.4.2 Scope

The plan objectives should determine the scope of monitoring and surveillance activities. Ideally, a regional monitoring and surveillance program should be integrated closely with each location's biosecurity program. The regional monitoring and surveillance organization should serve as a communication network, rapid response resource, and information source for identifying and reporting potential invasive species incidents.

6.4.3 Organization/Roles and Responsibilities

A coordinating body should be designated to plan and direct all monitoring and surveillance activities on Micronesia Region locations and this body should coordinate closely with similar authorities in Hawai'i (as well as other locations which are linked to Micronesia by trade and/or human transport). Roles and responsibilities for the Micronesia Region monitoring and surveillance program should be identified and described and responsible parties designated according to program expertise. Individuals from across the biosecurity spectrum should participate in the monitoring program. At a minimum, each organization should reach out to the public. RISC, jurisdictional ISC, and a regional ISC would be the

most likely components of this regional coordination body. Most jurisdictions already have IS councils which could feed information via their ISC to the RISC which in turn would support and guide the regional ISC who could then serve as the main point of contact with Hawai'i and other locations regarding IAS issues for Micronesia.

6.4.4 Identification of Target Species and Pathways

High-risk species and pathways should be priority targets for monitoring and surveillance. The APHIS Terrestrial Risk Assessments in Appendix A identify these pathways and targets.

6.4.5 Monitoring Methods

Local governments should determine monitoring methods including SOPs, according to the threat and in conjunction with each technical program area such as plant (APHIS-PPQ), agricultural animal (APHIS-VS), and wild animal (APHIS-WS). These methods should be integrated into a comprehensive monitoring program that leverages resources and aligns strategies across risk groups.

6.4.6 Locations/Schedules

Appropriate governmental entities should select high-priority surveillance locations. Monitoring activities should be based on current APHIS risk assessment data and recommendations associated with special-risk military operations and training events.

6.4.7 Resources

Sources for critical funding, personnel, equipment, and materials should be ascertained. Offices to determine resource needs, coordinate resource requests, and manage resource allocation should be established. A monitoring and surveillance coordinating body should take the lead in requesting needed resources.

6.4.8 Reporting

Reporting procedures for detections of invasive species through monitoring or surveillance programs are unique to each program area. See Chapter 10, *Rapid Response Plan*, for details.

6.5 CURRENT APHIS AND GUAM MONITORING AND SURVEILLANCE PROGRAMS

A monitoring and surveillance program should leverage existing programs of this type wherever possible. On Guam and in the CNMI, current ongoing monitoring activities are limited to BTS and plant pests. These programs can serve as foundations for a more extensive and far-reaching monitoring program for Guam and other Micronesian Region locations.

All current monitoring and surveillance programs should be enhanced. At this time, there is no ongoing systematic surveillance of livestock and poultry on Guam, an inadequacy that may hinder early detection of any introduced agricultural hazard.

APHIS-WS conducts the following disease monitoring programs in the United States:

Feral Swine Diseases. The National Wildlife Disease Program (NWDP) operates in management, research, surveillance, emergency response, education, and outreach for feral swine diseases. NWDP considers these animals, weighing up to 181 kg (400 pounds), non-native to the United States and invasive. They can be reservoirs of disease and can be hosts to a number of parasites threatening the U.S. domestic swine economy.

H5N1. Avian influenza is a Type A influenza virus found in some species of waterfowl and shorebirds. A particularly dangerous set of subtypes of this virus, called H5N1, is of particular concern for its potential impact on wild birds, domestic poultry, and human health if introduced into the United States.

Plague. Plague is a disease of concern to human, wildlife, and domestic animal populations within the United States.

Tularemia. Tularemia is a disease of concern to human, wildlife, and domestic animal populations within the United States.

6.6 NATIONAL MONITORING PROGRAMS

No national animal monitoring programs are current on Guam or other Micronesia Region islands. There are several programs that could serve as models for surveillance. The National Animal Health Monitoring System Program Unit conducts studies on health management of U.S. domestic livestock and poultry. Reports are available for aquaculture, beef cow-calf, beef feedlot, dairy, equine, food safety, goat, poultry, sheep, and swine. The National Animal Health Surveillance System is a program for animal health surveillance through ongoing systematic collection, collation, analysis, and interpretation of data and dissemination of information about animal health risks.

If opportunities such as on-island slaughterhouse operations arise, passive surveillance (e.g., sampling animals at slaughter for foreign and domestic animal diseases) should be conducted.

CAPS is a USDA-funded program that operates through cooperative agreements with state agriculture departments and universities. The CAPS program manages a plant pest list derived from a national survey committee through input from regional and state committees with support from leading scientific and regulatory specialists. CAPS uses a scientific system for prioritizing pests of significance to U.S. agriculture and the environment. The Global Pest and Disease Database system contains information for pest risk assessments. CAPS produces federally funded domestic surveys conducted by cooperators from National CAPS for plant pests, biological control agents, and weeds and provides a means of detection, documentation, and rapid dissemination of this information. Survey information is available from the National Agricultural Pest Information System database.

Domestic pest detection and survey activities traditionally have trapped exotic fruit flies and tracked occurrences of imported fire ants, gypsy moths, Japanese beetles, and witchweed. Other activities have been national surveys on various exotic plant pests, diseases, and weeds and some pest detection activities to help meet various export requirements of foreign countries.

The systems, methods, and resources of these programs could be applied to monitoring and surveillance on Micronesian Region islands. The monitoring and surveillance coordinating body should consult with APHIS experts to determine the feasibility and value of including Micronesian Region islands in these programs.

7 RAPID RESPONSE

A rapid response plan describes a formal process recommended for responses to reports of invasive species or animal disease outbreaks on Micronesian Region islands and the state of Hawai'i. This plan should identify authorities, policies, roles, resources, and procedures required for effective management of all plan components. A rapid response plan gives detailed guidance for awareness of potential invasive species and pathways; detection and identification of species or disease; deployment and management of resources; and reports to appropriate APHIS, Guam, and Micronesian Region authorities. The response plan should direct personnel in how to eradicate invasive populations when discovered through port inspection, reported through monitoring or surveillance programs, or established in a new Micronesian Region location.

Each plant or animal program should develop its own rapid response plan based on existing program policies, response structures, and procedures. Chapter 10, sections 10.9, 10.10, and 10.11, present information on emergency management and response processes developed for PPQ, VS, and WS, respectively. The plans, programs, systems, and resources described in these sections are included in this section as models and resources for invasive species emergencies on Micronesian Region islands and the state of Hawai'i.

APHIS has described emergency management structure and process in its Agricultural Health and Homeland Security Emergency Response Integration Plan (Volume 1, January 2007) developed by the APHIS Emergency Management Leadership Council, which provides guidance for rapid response plan development

(http://www.aphis.usda.gov/emergency_response/downloads/APHIS%20Emergency%20Integration%20plan%20final%202-1-07.pdf).

All Guam and Micronesian Region rapid response organizations and offices should establish a communication system and an SOP for incident reporting and rapid response.

7.1 RAPID RESPONSE OBJECTIVES

The primary objectives of the Micronesian Region Rapid Response Plan include the following.

- Community outreach and education is the most important part of any ED/RR effort. Without community engagement and education there will be nothing to respond to. The local communities are the eyes and need to be the reporters for potential invasive species incursions.
- Develop an emergency response plan or ERP in collaboration with appropriate stakeholders to mitigate, contain, and/or eradicate significant animal or plant pest and disease outbreaks with appropriate coordination. ERPs already exist in all jurisdictions for alien snakes and some jurisdiction have additional ERPs for other species, for example Yap has an ERP for Rhinoceros Beetles. These existing ERPs can be utilized to develop more generic ERPs for each jurisdiction.
- Support local rapid response teams for pest issues (most jurisdictions already have at least some staff which are trained and/or on standby for response actions).

- Improve rapid response capabilities at military and commercial ports on Guam, the CNMI, Hawai'i, Palau, Yap, Chuuk, Kosrae, Pohnpei, and the Marshall Islands.
- Expand the communication network system among responding agencies and groups for detection and reporting of suspected invasive plant, animal, and insect species and diseases of concern.
- Coordinate monitoring and surveillance programs with rapid response capability through community-watch groups and a pest species hotline to report sightings immediately. Most jurisdictions already have hotline such as the Pest hotlines for Guam and Hawai'i, and the BTS hotline for the CNMI. Jurisdictions which do not yet have dedicated hotlines often you a combination of key individual office and cell numbers and general emergency hotlines such as 911 for back-up. Ideally each jurisdiction will eventually have a dedicated pest hotline with trained staff answering, recording information from incoming calls and alerting proper authorities as needed.
- Leverage the BTS Rapid Response Team capability and utilize this existing framework as a partial model for development of truly regional early detection and rapid response capacities. The RRT team, although only a loose affiliation is in some respects regional and in the past has developed outreach programs across the MBP region, supported ERP development for each of the jurisdictions and has been involved in determining the credibility of potential IAS reports and response field actions for more than just BTS.

7.2 REGULATIONS

The development of a rapid response plan is justified in the following regulations:

- AHPA
- PPA
- Public Health Security and Bioterrorism Preparedness and Response Act
- DHS Presidential Directive 5

7.3 INCIDENT COMMAND

The National Incident Management System (NIMS)-Incident Command System (ICS) should be a framework to manage the response needs for single- or multiple-incident emergency situations. Upon evaluation of an incident, the lead program unit will determine if an Incident Commander (IC) is needed to manage it. If established, the IC or the unified command (for multiple-agency response) is responsible for all aspects of the response, including incident objectives and all incident response operations.

The IC includes the command staff and general staff. Command staff positions may include a public information officer, safety officer, and liaison officer as required and assigned by the IC. General staff includes operations, planning, logistics, and finance/administrative responsibility. If requirements for

these responsibilities warrant, they may be established as separate functions under the IC and managed by section chiefs. They may be supported by other functional units.

Personnel should be designated to fill key ICS roles in the rapid response plan:

- IC
- Planning Chief
- Operations Chief
- Logistics Chief
- Administrative/Finance Chief

Responsibilities of the incident command and its general staff:

- Providing response direction
- Coordinating effective communication
- Coordinating resources
- Establishing incident priorities
- Developing incident objectives and approving response strategies
- Assigning objectives to response managers
- Reviewing and approving incident action plans
- Integrating response organizations into the ICS
- Establishing protocols
- Safeguarding worker/public health and safety
- Informing the media

7.4 RESOURCES

Micronesian regional governments and the state of Hawai'i should find funding sources for rapid response. The APHIS Emergency Mobilization Guide, available at: www.aphis.usda.gov/emergency_response/downloads/APHIS%20Emergency%20Mobilization%20Guide.pdf, facilitates cost-effective, timely coordination of resources needed for successful responses to agricultural health and homeland security emergencies by standard procedures guiding operations.

7.5 EXISTING MICRONESIAN REGION RESPONSE PROGRAMS

Several rapid response programs are in operation on the Micronesian Islands. These programs can be foundations for a comprehensive regional emergency rapid response program network. Examples are listed below.

- A regional response team has been developed for alien snake incursions. This team has trained members in each jurisdiction covered by the MBP. Until recently this team was coordinated by a US federal office on Guam. Currently that office is vacant.
- USDA-APHIS-WS, USGS and DAWR on Guam, CNMI DFW on Saipan, Tinian and Rota, the Hawai'i DOA and DLNR (as well as the various ISCs), Palau Agriculture, FSM Quarantine, Yap Agriculture, Pohnpei Agriculture and EPA, Kosrae Agriculture, and the RMI R&D all have resources for alien snake detection work, albeit no agency nor group has extensive resources and most groups (other than WS and USGS) have general capacity for IAS response work instead of focusing specifically on snakes.

7.6 RAPID RESPONSE TEAM

Rapid response teams should respond to suspected or confirmed introductions of invasive species and to disease outbreaks. Rapid response team members and contact information for specific emergencies depend on whether the emergency is a threat to plant, agricultural, animal, or wild animal populations. Rapid response teams direct the overall response to the emergency.

7.7 DETECTION-ERADICATION TEAM

Detection-eradication teams respond to specific introductions of invasive species and to disease outbreaks. Detection-eradication team members are subject matter experts skilled in identification and eradication procedures for specific plant and animal risks.

7.8 LEAD APHIS PROGRAM UNIT

For each emergency, hypothetically an APHIS program unit could lead the response under established APHIS authorities where they apply. For incidents related to U.S. agriculture, PPQ serves as the lead program unit for plant health incidents (Section 10.9) and VS for animal health incidents (Section 10.10).

The introduction of invasive species and emergent agricultural incidents in U.S. territories and possessions should be reported to the APHIS Emergency Management Response System (EMRS) and APHIS program emergency response managers. Each program has specific reporting requirements in their individual emergency management guidelines (see Sections 10.9, 10.10, and 10.11 and the APHIS website).

In some instances, WS, Animal Care, or Biotechnical Regulatory Services may serve as the lead program unit for incidents in their mission areas (Section 10.11). For example, Biotechnical Regulatory Services responds to incidents involving genetically modified organisms.

For Micronesia which includes both US and non-US jurisdictions, a non-US Federal agency approach to regional response support may be the most appropriate approach.

Additionally agencies such as the USGS have supported development of regional response capacity to IAS and there are numerous groups and agencies already established within the region that have some

capacity in this regard. These varied efforts and groups should all be considered when ultimately determining how best to further regional capacity in regards to early detection and response to IAS.

7.9 PLANT EMERGENCY RESPONSE—PLANT, PROTECTION AND QUARANTINE

The APHIS-PPQ program safeguards U.S. agriculture and natural resources from the introduction, establishment, and spread of plant pests and noxious weeds. PPQ's Emergency and Domestic Programs unit provides national leadership and coordination in plant pest programs and emergency management. As the lead federal agency for plant health emergencies, PPQ cooperates with national and international plant protection organizations; federal, state, and local agencies; Native American tribes; universities; industries, and private entities in developing and implementing scientific frameworks for optimum protection against invasive pests and diseases.

APHIS uses offshore information and pre-clearance programs, port inspections, and extensive domestic surveillance to prevent, detect, and respond to plant health emergencies. The PPQ emergency management framework consists of four key elements: 1) prevention, 2) preparedness, 3) response, and 4) recovery.

Prevention. PPQ works with trading partners and international plant protection organizations to develop and implement offshore pre-clearance, inspection, early detection, and control strategies to prevent the entry of invasive pests and diseases into the United States. PPQ works with the U.S. DHS-CBP and other cooperators to continue the success of agricultural inspection operations at all U.S. ports of entry. PPQ regulates plant imports, effects international safeguards, and operates domestic pest detection programs.

The first line of defense against the entry of harmful plant pests and weeds into the United States and U.S. territories is through the inspection of commodities, conveyances, and passenger baggage by APHIS cooperators at seaports and airports outside of CTUS. PPQ trains these cooperators to detect and identify these pests.

Preparedness. PPQ works with federal, state, tribal, and local governments and with industries to prepare, build, and sustain operational capacity and capability for early detection, timely diagnostics, and effective control strategies against plant health threats.

Response. PPQ works with federal, state, tribal, and local governments and with industries to coordinate actions to contain, control, or eradicate plant pests and diseases. PPQ uses ICS, which helps agencies and entities with a unified strategy for working together in response to plant health emergencies.

Recovery. After an emergency response is complete, PPQ works with federal, state, tribal, and local governments and the private sector to develop and implement systems for long-term stability and protection from the pest or disease that caused the emergency. Recovery includes plant health regulations, eradication, BMPs, and restoration plans.

Table 10-1 identifies key PPQ Offices.

Table 10-1: Key PPQ Offices and U.S. Plant Health Non-Government Organizations

Office	Location
PPQ Emergency and Domestic Programs	Riverdale, Maryland
PPQ Western Region	Fort Collins, Colorado
PPQ Hawai'i State Plant Health Director	Honolulu, Hawai'i
PPQ Port Director	Guam

7.9.1 National Identification Services

APHIS' National Identification Services (NIS) coordinates the identification of plant pests to support USDA's regulatory programs and quarantine actions. NIS collaborates with scientists specializing in plant pest groups, weeds, insects, mites, snails, and plant diseases. These scientists are stationed around the country in federal research laboratories, plant inspection stations, land-grant universities, and natural history museums.

NIS supports the use of alternative diagnostic methods to enhance the speed and precision of the identification process. The Remote Pest Identification Program utilizes digital imaging of suspected pests and transmits them electronically to qualified specialists for identification. The Molecular Diagnostics Laboratory is responsible for biochemical testing services supporting the agency's pest monitoring programs.

7.9.2 National Plant Diagnostic Network

With support from USDA's National Institute of Food and Agriculture, from land-grant universities, federal agencies, state departments of agriculture, and other stakeholders, the National Plant Diagnostic Network (NPDN) is a consortium of plant diagnostic laboratories developing a nationwide network of public agricultural institutions with a cohesive distributive system that quickly detects high-consequence pests and pathogens introduced into agricultural ecosystems, identifies them, and immediately reports them to appropriate responders and decision makers. The NPDN has invested in plant diagnostic laboratory infrastructure and training, developed an extensive network of first detectors through education and outreach, and improved communication among agencies and stakeholders that respond to outbreaks and mitigate them.

Guam is served by the Western Plant Diagnostic Network, a regional member of the NPDN. The network is a consortium of land-grant institutions and state departments of agriculture throughout the western United States and Pacific U.S. territories with services for plant disease diagnosis, plant identification, and insect or pest identification. The Western Plant Diagnostic Network uses a common software interface to process diagnostic requests and to share information among diagnostic laboratories.

7.9.3 APHIS-PPQ Incident Command System

APHIS-PPQ emergency planners have developed the 2004 *USDA-APHIS-PPQ Incident Command System Guide* for development of an ICS during a plant health emergency. The guide offers the following information:

- Report requirements
- Notification procedures
- Exotic pest identification
- Pest status assessment
- Financial support
- Incident management teams
- Legislative and public affairs

7.9.4 Standards for Plant Health Emergency Management Systems

APHIS-PPQ emergency planners have developed *Standards for Plant Health Emergency Management Systems* to help state and federal plant health officials and state emergency managers determine their needs in mounting successful responses to plant health emergencies. Information includes:

- Emergency plans
- Written agreements
- Authorities and policies
- Plant pest survey, containment, control, and eradication
- Communications
- Training and education
- Funding and resources
- Standards for state plant health emergency management systems

7.9.5 Specific Plant Emergency Programs

APHIS-PPQ emergency planners have specific response programs for multiple plant disease and plant pest emergencies. APHIS-PPQ prepares new pest response guidelines for anticipated arrivals of new pests into the United States and for detected new pests already arrived. These guidelines are for many insect, mollusk, and virus pests that attack crops, wood, grain, nursery stock, and other resources.

Additional information is available at http://www.aphis.usda.gov/plant_health/index.shtml.

7.10 ANIMAL EMERGENCY RESPONSE—VETERINARY SERVICES

APHIS-VS safeguards U.S. poultry and livestock from the introduction, establishment, and spread of foreign animal diseases by regular surveillance of domestic animal herds and flocks and monitoring animal disease outbreaks around the world. APHIS-VS personnel also work with other federal agencies at airports and maritime ports to inspect and approve incoming shipments of animals and animal products.

APHIS-VS is responsible for detecting and responding to animal disease incidents that occur within the United States. The APHIS-VS National Center for Animal Health Emergency Management (NCAHEM) manages the agency's animal health emergency activities. The center develops strategies and policies for effective incident management and helps coordinate incident responses. As liaison to outside emergency management groups, NCAHEM keeps the agency's animal health emergency management policies, strategies, and responses current with national and international standards.

NCAHEM and VS programs are valuable resources in animal disease emergencies from invasive species on Micronesian Region islands.

7.10.1 National Veterinary Stockpile

The National Veterinary Stockpile (NVS) provides the veterinary countermeasures—supplies, equipment, field tests, vaccines, response support services—that states need to respond to large-scale, catastrophic animal disease outbreaks that terrorists or nature may create.

NVS provides USDA-APHIS expertise for responding to animal diseases by:

- Deploying countermeasures against the worst animal diseases: HPAI, FMD, Rift Valley Fever, END, and CSF.
- Helping states plan for, train, and exercise the rapid acquisition, receipt, processing, and distribution of countermeasures during an event.
- Focusing exclusively on NVS and state logistics of disease response.
- Coordinating logistics planning especially for large-scale, catastrophic outbreaks.
- Preparing states to acquire, receive, process, and deliver NVS countermeasures as well as those from other sources rapidly.
- Managing delivery time of countermeasures.

Countermeasures and response capabilities:

- Vaccines as alternatives to destroying animals
- High-speed vaccination equipment
- Personal protective equipment

- Animal handling and depopulation equipment
- Field diagnostic tests for rapid, presumptive identification of disease
- Decontamination supplies to eliminate disease agents
- Emergency transport of supplies, equipment, vaccines, reagents, samples, and trained personnel equipped to support state response

NVS outreach and exercise programs help states, tribes, and territories plan, train, and respond logistically to large-scale disease outbreaks. NVS personnel assist states in developing test exercises conforming to DHS Exercise Evaluation Program guidelines.

Additional Information about the NVS program and resources is available at:

http://www.aphis.usda.gov/animal_health/emergency_management/nvs.shtml

Emergency Management Response System

EMRS supports management of animal disease outbreak data with state and tribal partners with a secure, accessible nationwide system for data collection, management, and analysis in a web-based, comprehensive investigation, task, and resource management suite on a universal information platform. Primary EMRS users are federal, state, and tribal veterinary medical officers, animal health officials and technicians, animal disease specialists, and epidemiologists. EMRS provides APHIS-VS and cooperators with a management system for:

- Responses to animal disease outbreaks
- Routine surveillance of foreign animal disease
- Emerging disease incidents
- All hazard animal incidents

Access to EMRS requires registration at EMRS_Registration_Approvers@aphis.usda.gov. EMRS technical assistance is available from the APHIS Technical Assistance Center via phone (877) 944-8457, or E-mail, atac@aphis.usda.gov.

Additional assistance is available from EMRSupport@aphis.usda.gov.

7.11 ANIMAL EMERGENCY RESPONSE—WS

NWDP does wildlife disease monitoring and surveillance in all regions of the United States. NWDP wildlife disease biologists act as first responders through NWDP's Surveillance and Emergency Response System (SERS). NWDP collaborates with NGOs and officials from other countries to promote development of wildlife disease monitoring programs worldwide.

7.11.1 Surveillance and Emergency Response System

SERS, an essential NWDP component, is the primary emergency response contact point within APHIS-WS. SERS has a cadre of wildlife disease biologists ready to mobilize within 24 to 48 hours of a request. NWDP-SERS biologists have extensive ICS training, medical clearances for personal protective equipment, and experience in emergency response scenario drills. Selections for requested incident response teams depend on the specifics of the request (e.g., immobilization and euthanasia-certified, shooter) and the number of people needed.

SERS will respond to requests for assistance from the following agencies and organizations:

- APHIS-VS
- APHIS Animal Care
- APHIS-PPQ
- Non-APHIS Emergency Support Function (all-hazards event)
- Federal Emergency Management Agency (all-hazards event)

Whether the request for emergency resources comes from within APHIS or from emergency support functions of the national response framework, the SERS national coordinator immediately develops an incident response team of SERS biologists whose skills and training meet the needs of the request. Once the team is formed and dispatched, SERS tracks it for the duration of the emergency response.

8 TERRESTRIAL VERTEBRATE SPECIES³

8.1 EXECUTIVE SUMMARY

This RA is based on the USDA-APHIS-WS Micronesia Region Risk Assessment, provides recommendations for preventing and mitigating regional threats to human health and safety, the economy, and ecology of the Micronesia Region posed by intentional and accidental transport of terrestrial vertebrate invasive species resulting from three actions proposed by the DoD, namely the relocation of Marines from Okinawa, providing visiting aircraft carrier berthing, and establishing an Army AMDTF for Guam and the CNMI. The scope of this plan also covers the Republic of Palau, FSM, and the RMI, including Hawai'i and the continental United States, but focuses on Guam because a majority of proposed actions will occur there, it serves as a regional transportation hub thereby facilitating wide-spread species movement, and because preventing off-island transport of the BTS is a high priority.

Proposed military actions are expected to significantly increase the flow of transportation throughout the region, thereby increasing the likelihood of introducing species intentionally, both legally and illegally, and unintentionally as hitchhikers, in air and water conveyances, cargo and cargo conveyances, and on people and in their baggage. Biosecurity strategy emphasizes a holistic approach of sterilizing pathways by implementing measures pre-border, at-the-border, and post-border. Prevention is more effective and cheaper than eradication or long-term control of established species, and eradication is more effective and cheaper over time than permanent population control.

Five key issues pertain to all recommendations: funding, coordination and communication, education and training, control methods development, and enforcement (of regulatory drivers). General recommendations serve as a starting point for more formalized, pathway-specific recommendations. Several recommendations focus on preventing the BTS from leaving Guam because resulting impacts extend well beyond Guam's jurisdictional and physical boundaries. Funding issues are weak links for regional biosecurity, crippling law enforcement and inspection processes, decreasing the efficacy of control measures, and preventing new methods from being developed. Education, training, and awareness are key preventative measures in unintentional and intentional pathways. Biosecurity is compromised in military sectors because exemptions are often granted to personnel; deployment can be immediate at any time to any place; military transportation traffic in the region will increase over time; there is overlap between military and civilian/commercial pathways; and the multipurpose and technologically advanced aircraft, vessels, and equipment used by the military pose unique risks. Current agricultural inspections need to target terrestrial vertebrate species, and inspectors require added knowledge, equipment, and facilities for proper screening and reporting; improved detection; and safe handling of such species. Cargo pathways warrant particular attention, as they are most vulnerable to transporting species because of the diversity of goods moved, the wide array of exposure to various handling and packing procedures, and the multiple modes of transport used.

³ This chapter was prepared by USDA-APHIS-WS, compiled by: W.C. Pitt, C.V. Deringer, and J.M. Gaudioso. 6 November 2010.

The number of stowaways detected per inspection, in combination with the huge volume of transported products and expected increases in regional transportation traffic, implies a substantial number of species will go undetected. Regulations and enforcement need to be enacted and implemented to address illegal transport of species, which occurs insidiously, even via legal routes like the pet trade and food imports. Effective regional biosecurity requires a long-term commitment, adequate and sustainable funding, cooperation, and enforcement of regulatory drivers. This plan can be used in its entirety, or as individual pathway- or taxa-based sections for specific action plans.

8.2 INTRODUCTION

The Micronesia Region Biosecurity Plan for terrestrial vertebrate species focuses on threats posed by the intentional and unintentional transport and introduction of terrestrial vertebrate invasive pest species as a result of increased military activities in the region. The scope of this plan covers Guam, the CNMI, the Republic of Palau, the FSM, and the RMI, including Hawai'i and the continental United States.

Military relocation refers to three actions proposed by the DoD, 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and CNMI. The military relocation and post-relocation training and operations are expected to significantly increase the flow of cargo, people, and transportation conveyances into and out of Guam and the CNMI (Helber et al. 2006). The estimated increase of goods and people during and following military relocation increases the likelihood of transporting terrestrial vertebrate invasive pest species throughout the region.

This action plan provides background on biosecurity efforts in the Micronesia Region, reviews potential risks identified in a pathway-based risk assessment, and provides recommendations for developing a comprehensive operational biosecurity strategy to prevent or mitigate risks posed by terrestrial vertebrate invasive pest species. Risk assessment covers unintentional and intentional pathways, with unintentional pathways identified by mechanism of transport and intentional pathways identified by motive for transport. Risks and mitigating recommendations are general and specific, with general information being applicable to all pathways, both military and civilian sectors, and regardless of pest species and transport mode or motive.

We also incorporate applicable information from successful biosecurity strategies currently implemented by governments to safeguard their people, commerce, and environments against marine and terrestrial pest species and diseases. These jurisdictions include New Zealand (NZ MAF 2003), Australia (Australian Government 2009), Galapagos Islands (CDF and WWF 2002), Europe (EEA 2010), the Caribbean (Meissner et al. 2009), British Virgin Islands (Perry et al. 2006), the Pacific (Sherley and Lowe 2000; SPREP 2000), Hawai'i (Kraus and Duffy 2009), Fiji (FQD 2010), and Guam (BTSCC 1996). We also use information from reviews on policy and management at a global scale (SCBD 2001, Meyerson and Reaser 2002; Grotto and Tucker 2006; Reaser et al. 2007; Reaser and Waugh 2007; Hulme et al. 2008, Sheppard 2010) and at local/regional scales for Japan (Takahashi 2009), New Zealand (Pearson 2004; Takahashi 2005; 2006, NZ MAF 2008, 2009), Australia (VPC 2004, 2007a, b), Hawai'i (Beard and Pitt 2005; Kraus and Duffy 2009), and Europe (Pyšek et al. 2010).

8.3 BIOSECURITY STRATEGY FOR THE MICRONESIA REGION

8.3.1 Purpose

The goal is to provide a biosecurity action plan with a strategic approach to minimizing negative impacts to the region's human health and safety, economy, and ecology due to risks associated with the transport and introduction of terrestrial vertebrate species. Objectives are to summarize information on pathway transport and introduction of terrestrial vertebrate species based on the USDA-APHIS-WS Micronesia Region Risk Assessment of proposed DoD activities in the region, and recommend prevention and mitigation measures that safeguard against biosecurity threats.

8.3.2 Scope

The scope of this plan covers the relocation and post-relocation operational phases of military activity in the defined Micronesia Region. Biosecurity measures on Guam are unique in that efforts include screening and inspection of both arriving and departing people, cargo, and conveyances to prevent the transport and spread of the BTS from Guam to other locations. This plan summarizes pathways capable of transporting and introducing terrestrial vertebrate species, with an emphasis on BTS.

Issues and concerns regarding BTS extend well beyond Guam's jurisdictional and physical boundaries. Encounters with BTS outside of Guam (extralimital encounters) have occurred in a variety of place around the globe (Stanford and Rodda 2007). As a hub for commercial and military shipments in the Micronesia Region, transportation activity from Guam greatly increases the probability of BTS transport to new locations such as Saipan, Tinian, and Rota in the CNMI, and Oahu, Hawai'i.

Ecosystems on oceanic islands are particularly vulnerable to pest invasions (Loope et al. 1988), as evidenced by the history of BTS on Guam (Fritts and Leasman-Tanner 2001b). Numerous snake encounters have been reported for the island of Saipan with most of these encounters (but not all) being suggestive of BTS (Stanford, personal communication). The exact number of these encounters that is considered credible varies depending on the criterial one uses to define the term credible but what can be stated is that there have been numerous confirmed BTS captures on Saipan and that the number of credible encounters for Saipan is much higher than for any other island outside of the BTS's native range (other than Guam) (Stanford, personal communication). A variety of search efforts conducted on Saipan during the past 10 years has not confirmed the presence of an incipient BTS population there (Stanford, manuscript in preparation). Further, given that Saipan receives much of its cargo from Guam, and the other Mariana Islands receive most of their cargo from Saipan, BTS infestation of Saipan is possible and would be problematic if it did occur (Stanford and Rodda 2007). Similarly, a BTS infestation on Oahu increases the risk of introduction and spread throughout the main Hawai'ian Islands because of the amount of inter-island cargo traffic that occurs from Oahu (Stanford and Rodda 2007).

This plan allows for some flexibility in accommodating changes to the proposed military relocation, trainings, and operations, depending upon the types of changes proposed, the magnitude of change, and the timeframe for the change to be implemented.

8.3.3 Proposed Military Activity

This section provides a general description of the military relocation and post-relocation activities proposed in the Final EIS (FEIS), July 2010 (U.S. Navy 2010a). Military relocation includes three actions proposed by the DoD, 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and the CNMI.

The proposed relocation of Marines to Guam also includes development and construction of facilities for training and operations that would occur on Tinian. The MIRC FEIS includes training area/facilities on Guam, Rota, Tinian, Saipan, and Farrallon de Medinilla (FDM), and covers training on existing DoD land and on training areas in and around Guam and the CNMI; therefore, overlap exists between the two FEISs in the area of usage of existing DoD by Marine Corps units. The proposed Army AMDTF would be placed on Guam to defend U.S. interests on Guam; its defensive umbrella would ensure that local military assets are protected and remain available to meet their military missions.

All descriptions are based upon the “preferred alternatives” listed in the following documents, and are subject to change pending upon the final ROD:

- FEIS = FEIS/OEIS; Guam and CNMI military relocation; relocating Marines from Okinawa, visiting aircraft carrier berthing, and Army air and missile defense task force, July 2010 (U.S. Navy 2010a)
- IMP = Integrated Military Plan, July 2006 (Helber et al. 2006)
- MIRC = MIRC FEIS/OEIS, July 2010 (U.S. Navy 2010b)
- ROD = August 2010

8.4 MILITARY OPERATIONS, TRAININGS, MISSIONS

8.4.1 Military Relocation

As noted above, the three proposed actions of Guam military relocation include 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and CNMI. Proposed relocation of Marines includes the development, construction, and use of facilities for training and operations on Tinian because not all training can be accommodated on Guam. The concept for Tinian is to provide the next stage in the training progression, which includes development of ranges for tactical use of the basic weapons skills developed on Guam, skills that complement the elements of ground training (U.S. Navy 2010a, Vol. 3, pg. 2-1).

The Guam relocation of Marines includes four military elements:

1. Command Element, III (3rd) Marine Expeditionary Force (MEF). III MEF is the Marine Corps’ forward-deployed Marine Air-Ground Task Force (MAGTF); it has the ability to deploy rapidly and conduct operations ranging from humanitarian assistance and disaster relief to amphibious assault and high intensity combat. The MAGTF command element consists

primarily of headquarters (HQ) and supporting organizations. Collocation and communications connectivity is a primary facility citing requirement. Estimated personnel: 3,046.

2. Ground Combat Element (GCE), 3rd Marine Division Units. The GCE has the mission of locating, closing with, and destroying the enemy with fire, maneuver, and close combat. It supports MAGTF expeditionary operations with infantry, armor, artillery, reconnaissance, anti-tank, and other combat arms. It consists of Division HQ and subordinate organizations. Ground combat and combat support organizations require proximity to ranges and training areas as well as traditional base support facilities. Estimated personnel: 1,100.
3. Air Combat Element (ACE), 1st Aircraft Wing and subsidiary units. The ACE operates from a variety of sea- and shore-based facilities to support MAGTF expeditionary operations. The focus is to support the MAGTF during assault landings and subsequent operations ashore. The ACE includes the Marine Aircraft Wing HQ, expeditionary, and garrison supporting organizations. Unlike aircraft squadrons, aviation command and general supporting elements can be located close to the airfield and higher commands, and do not necessarily need to be located at the airfield. Estimated personnel: 1,856.
4. Logistics Combat Element (LCE), 3rd Marine Logistics Group (MLG). The LCE provides all support functions beyond the capabilities of the GCE and ACE units. Functions include: communications, engineering support, motor transport, medical, supply, maintenance, air delivery, and landing support. The LCE consists of MLG HQ and supporting organizations that provide a variety of direct logistics support to the rest of the MEF. The MLG HQ element would be sited in proximity to Command HQ and other HQs. Indirect and industrial support facilities of the LCE would be located in proximity to support activities and maximize efficiency, with efficient access to roads, ports and airfields. Estimated personnel: 2,550.

With the Marine relocation, training activities would be increased on Guam and in the CNMI to include training in major exercises that involve multiple strike groups and task forces. Major exercises provide multi-service and joint participation in realistic maritime and expeditionary training that replicates the types of events and challenges potentially faced during real-world contingency operations. Major exercises also include providing training to submarine, ship, aircraft, and special warfare forces in mission tactics, techniques, and procedures (U.S. Navy 2010b, Vol. 1, pg. ES-11).

Existing training capabilities on Tinian would be expanded to support company and battalion level live fire ranges; a battalion is a group of 5 companies, approximately 960 individuals. The main components of the proposed action are: 1) development and construction of live-fire training ranges: a platoon (42 Marines) battle course, 2) automated combat pistol range, 3) rifle known distance range, and 4) field firing range. These proposed training components complement the existing ground training practices undertaken at Tinian and in the CNMI as described in the MIRC (U.S. Navy 2010a, Vol. 3, pg. 2-1).

Operational training on Rota includes hostage crisis rescue operations, undercover operations or surveillance, fighting in urban areas, evacuating civilians during a war or natural disaster, preventing terrorist activities, and protecting troops while they are in combat situation. The training on Rota will be held at least twice a month, but frequency may increase depending on the kind of training that may be urgently needed (Todeno 2009).

Relocation activities would include aviation units and aviation support units that require runway and hangar space and maintenance, and supply and administrative facilities. There is also a need for air embarkation operations that are comparable to, compatible with, and co-located with, existing Andersen AFB operations on Guam. Air embarkation operations refer to loading and unloading cargo and passengers to and from aircraft, comparable to a civilian airport terminal (U.S. Navy 2010a, Vol. 2, Ch. 2).

Firing ranges are required for live and inert munitions practice by the Marine Corps, which generates the need for safety buffers called Surface Danger Zones, and special use airspace (SUA) on Guam for certain weapons [note: SUA not applicable to Tinian] (U.S. Navy 2010a, Vol. 3; U.S. Navy 2010a, Vol. 2, Ch. 2). Range Alternative A (preferred FEIS Alternative) would require the realignment of approximately 2.8 km (1.7 miles) of Route 15 to the interior of the existing Andersen South parcel. The total land area, not including submerged lands, is estimated at 441 hectares (1,090 acres) (ROD 2010).

Military Operations in Urban Terrain trains Marine Corps, Army, Air Force, Special Warfare, and Navy Expeditionary Combat Command personnel combat tactics appropriate for a small city environment inhabited by noncombatants but occupied by a hostile force to search out and capture or destroy the hostile force. Primary training area (PRI) is Guam: Andersen AFB South, Finegayan Communication Annex, Barrigada Housing, and Northwest Field. Secondary training area (SEC) is Tinian, Rota, Saipan (U.S. Navy 2010b, Vol. 1, Table 2-8, pg. 2-53). Non-fire maneuver ranges are required for vehicle and foot maneuver training by Marine Corps, including urban warfare training. Urban warfare training is conducted in buildings that simulate a city or town. These buildings would be arranged close together so that Marines can practice entering and maneuvering in tight spaces (U.S. Navy 2010a, Vol. 2, Ch. 2).

Maneuver training areas are used for training Marines in the variety of skills specified in the Infantry Training and Requirements Manual (NAVMC DIR 3500.87), as defined in the Required Capabilities Document. Generally, for company-level (200 Marines) training, a 3,108 hectare (12 square mile) maneuver space is optimal, but this amount of space is not available on Guam. Maneuver training can be conducted in smaller areas depending upon the size of the Marine units and the size and complexity of a training event. Proximity is an important characteristic for efficient-to-use training areas, as cost and difficulty of transportation directly diminish the amount of training that can be accomplished within a given budget (U.S. Navy 2010a, Vol. 9, Appendix M).

Proposed activities call for creating a U.S.-based forward operating port for modern littoral warfare ships, combat logistics force ships, submarines, surface combatants, and high-speed transport vessels by improving U.S. Navy's Naval Base Guam to serve as a forward operational and logistic support hub for a mix of platforms and joint operations (Helber et al. 2006). The development of a Navy Transient Aircraft

Capability on Guam: Polaris Point Preferred Alternative—this alternative would construct a new deep-draft wharf at Polaris Point with shore side infrastructure improvements:

- The existing Outer Apra Harbor Channel would be widened to 183 meters (600 feet) with minor adjustments to channel centerline and navigational aids. There is a sharp southward bend in the existing channel toward Inner Apra Harbor that would require widening to 183 meters (600 feet) and dredging to meet aircraft carrier requirements.
- A new ship turning basin would be established that would require dredging to -15.1 meters (-49.5 feet) Mean Lower Low Water plus 0.6 meters (2 feet) overdraft. The turning basin would be located near the wharf and north of the Inner Apra Harbor entrance channel. The eastern edge of the new wharf would not have the required full 183 meters (600 feet) of distance from the wharf face and care would be necessary to nudge the carrier into position. However, Commander, U.S. Pacific Fleet requirements show that ships can safely navigate the reduced clearance at this site. The aircraft carrier would be assisted by tug boats, pivoted within the minimum radius turning basin to be aligned starboard (i.e., right side when facing the front or “bow” of the ship) to the wharf and the bow would be facing east. On departure, the aircraft carrier would follow the same route.
- It is anticipated that a transient aircraft carrier and its escort ships would rely on shore side utility infrastructure for water, wastewater, and solid waste after 2015. Electric power would be provided in accordance with customer service agreements (CSA) between Guam Power Authority and the U.S. Navy. Any Guam Power Authority commitments for additional power to support the aircraft carrier and its escort ships will be determined by future CSA modifications. Any required changes in the shore side power infrastructure or their operations to meet the requirements for the aircraft carrier and its escort ships may require additional NEPA review.
- Pertaining to aircraft carriers arriving to Guam, a new Port Operations support building and various utility buildings would be constructed on a terrestrial vertebrate-proof staging area at the wharf. There would be an area established for morale, welfare, and recreation activities and vehicle parking (ROD 2010).

The Army AMDTF is a ground force and would not be accompanied by aircraft or ships. Components would include command and control, missile field teams, maintenance, and logistics/supplies support. Establishing an AMDTF includes developing facilities and infrastructure on Guam to support relocating approximately 600 military personnel and their dependents (U.S. Navy 2010a, Vol. 1, Ch. 2). The proposed Army AMDTF on Guam contains the following three missile components:

5. The Terminal High-Altitude Area Defense (THAAD) system is a long-range, land-based theater defense weapon that acts as the upper tier of defense against ballistic missiles. This system is designed to intercept missiles during late mid-course or final stage flight. The THAAD flies at high altitudes and provides broad area coverage against threats to critical assets such as population centers, industrial resources, and military forces.

6. Patriot Missiles target short-range ballistic missiles that threaten the THAAD or other civilian or military assets on Guam. This weapon system is a point defense option with limited range designed to strike ballistic missiles, aircraft, unmanned aerial vehicles, and cruise missiles just before impact. This system utilizes hit-to-kill technology.
7. A Surface-Launched Advanced Medium-Range Air-to-Air Missile (SLAMRAAM) engages targets to beyond line-of-sight and defends against the air threat from unmanned aerial vehicles and cruise missiles.

Two major categories of training would be required: individual/crew and collective. Individual/crew training would include basic rifle marksmanship and crew-served weapons training. Training ranges on Guam and in the CNMI are considered joint use (i.e., available to all U.S. forces). Consequently, the Army would utilize ranges within the MIRC for this type of training. Collective training would be required for the AMDTF. Regular crew training on all aspects leading up to and through a launch would be required for THADD, Patriot, and SLAMRAAM weapons systems. These training exercises would be conducted at the Army facilities and no training-specific facilities would be required. No live-fire missile launch training exercises would occur on Guam or in the CNMI (U.S. Navy 2010a, Vol. 5, Ch. 2).

Continue efforts to develop U.S. Air Force Global Intelligence, Surveillance, and Reconnaissance (ISR) and Strike hub. Aviation training areas used are either improved (paved runway) or unimproved (unpaved landing sites) used to practice landing/takeoff and air field support (including loading/unloading of fuel, munitions, cargo, and personnel). Aviation training includes use of both international airspace and U.S. controlled airspace within the MIRC area (U.S. Navy 2010a, Vol. 2, Ch. 2).

Waterfront functions serve transient (visiting) ships and assault crafts associated with the proposed Marine Corps relocation. The transient vessels support Marine Corps operations and transient forces that presently train on Guam and in the CNMI. These ships would continue to support Marine Corps requirements in the western Pacific after the proposed relocation, and would continue to require transient vessel support facilities on Guam. The planning criteria for harbors, regardless of usage, differ from those for land-based facilities (U.S. Navy 2010a, Vol. 2, Ch. 2).

Associated infrastructure, housing, quality of life improvements (IMP) (Preferred Alternative): This alternative would co-locate AMDTF support facilities with the proposed Marine Corps units at Finegayan. The Administration/HQ and Maintenance operations would be co-located in the eastern portion of NCTS Finegayan and would be compatible with adjacent proposed Marine Corps land uses. Housing facilities for unaccompanied personnel would be located within NCTS Finegayan. Accompanied personnel housing facilities would be co-located with the Main Cantonment housing areas in South Finegayan, while recreational and QOL facilities would be co-located within and adjacent to the housing areas (ROD 2010).

Munitions Storage Alternative 1 (Preferred Alternative): Munitions storage would be in three non-contiguous areas near the Habitat Management Unit (HMU) of the Andersen AFB Munitions Storage Area, the latter being Alternative 1 of candidate sites for ammunition storage. The proposed magazines

would be constructed at these two sites (requiring demolition) and at a third site located east of the HMU across an unnamed roadway. The area of ground disturbance including a buffer is estimated 2.5 hectares (6.2 acres). The existing Explosive Safety Quantity-Distance arc(s) at the Munitions Storage Area 1 would be expanded approximately 122 meters (400 feet) to the north to provide the required safety distances for the new munitions storage facilities (ROD 2010).

Combat Search and Rescue (CSAR) operations include fixed-winged aircraft, helicopters and submarines, and use tactical procedures to rescue military personnel within a hostile area of operation. The PRI is both Tinian (North Field), and Guam (Northwest Field), SEC is Orote Point Airfield, and Rota Airport (U.S. Navy 2010b, Vol. 1, Table 2-8).

ISR is conducted to evaluate the battlefield and enemy forces, and gather intelligence. For training of assault forces, "red cell" or "OPFOR" units may be positioned ahead of the assault force and permitted a period of time to conduct ISR and prepare defenses to the assaulting force. ISR training has occurred at urban training facilities at Finegayan and Barrigada on Guam, and both the EMUA and the LBA on Tinian. The PRI is Guam: Northwest Field, Barrigada Housing, Finegayan Comm. Annex, and Orote Pt. Airfield. The SEC is Tinian, Rota, and Saipan (U.S. Navy 2010b, Vol. 1, Table 2-8, pg. 2-56).

8.4.2 Post Relocation

8.4.2.1 *Speculative*

Speculative (notional) base loading (U.S. Navy 2010a, Vol. 7) includes:

- A brigade-sized portion of a MEF
- An Army Brigade Headquarters and Army Battalion (to be determined), and various U.S. Air Force mission support initiatives
- New forward support Littoral Combat Ships, High-Speed Vessels/Theater Support Vessels (HSV/TSV)
- Auxiliary Dry Cargo/Ammunition Ships (T-AKE) that will replace aging Auxiliary Ammunition Ships (T-AE) and Auxiliary Combat Stores Ships (T-AFS), in addition to existing homeport Nuclear Attack Submarines
- Berthing accommodations for a transient nuclear powered aircraft carrier (aircraft carrier, fixed wing, nuclear powered [CVN]) and support for the carrier air wing (CVW), infrastructure for transient ships that support Marine Corps embarkation activities, and various training and support elements
- Facilitate use of transient U.S. Navy Nuclear Aircraft Carrier CVN at Naval Base Guam
- Infrastructure improvements to fuel pumps and pipelines that extend from the Sasa Valley Fuel Farm to Andersen AFB. Project includes a new 25.3-km (15.7-mile) pipeline that is parallel and adjacent to existing pipeline and located within an existing 3.05-meter (10-foot) wide easement (PACAF A7P, Air Force and U.S. Navy). This action is scheduled for 2013 in Central Guam

- Amphibious assault vehicle training by the Marine Corps. Beach improvements: one concrete revetment at each beach, remove non-native vegetation, no inland water improvements. This action is scheduled for 2014 and beyond⁴
- One concrete boat ramp in southern end of Inner Apra Harbor, for one amphibious assault vehicle at a time, overland paved route to Tipalao includes steep descent to Tipalao Beach. Site improvements associated with amphibious training include a new ramp at the southernmost point of Inner Apra Harbor. Overland route would be along the wetland area between the inner harbor and Dadi Beach. This action, by the Marine Corps is scheduled for 2014 and beyond⁵
- Redevelopment of munition igloos at Andersen AFB

8.4.2.2 *Pertaining Specifically to Tinian*

All scheduled for 2014 and beyond⁶ for Marine Corps (FEIS Vol. 7 Ch. 4 Table 4.3-2):

- Additional construction to accommodate up to 3,000 personnel (housing, recreation, medical, etc.)
- Ammunition storage facility. Includes six igloo magazines, a segregation facility, operations building, security systems, and a road network
- Automated multipurpose range. Includes range support building, ammunitions storage, range observations tower, general instruction building, covered mess, covered bleachers, field range latrines, and 788 target emplacements
- 1.5 x 3 mile area for live-fire and maneuver training, including stationary and automated targets. Supports up to .50 caliber ammunition
- 2,000 x 4,000-foot area for live-fire and movement training. Supports up to 7.62-millimeter infantry weapons
- Areas for mortar and artillery firing points
- Paved area at North Field for helicopter landings, weekly aviation training. Includes fire protection and bermed area for fuel bladder
- Six pistol and rifle firing ranges, including stationary/automated targets, standard set of range support facilities
- 100 x 300-foot area for tank/fighting vehicle training. one firing point, central dubbed impact area
- Breakwater repair, pier face structures repair, loading ramp, holding yard for customs, storage/transfer area, harbor dredging. Includes demolishing the finger pier

⁴ Ibid, p. 2-1.

⁵ Ibid.

⁶ Ibid.

- Roadway improvements, electrical distribution changes, fire protection facilities, and access to Unai Dankulo on Tinian

8.5 PATHWAYS

8.5.1 Description

Overall biosecurity strategy emphasizes a holistic approach that focuses on sterilizing pathways capable of transporting terrestrial vertebrate pest species. Species are transported intentionally, both legally and illegally, and unintentionally as hitchhikers, moving to a different location in cargo, packing material, a shipping container used for transport, or on/in the conveyance of transport (Meissner et al. 2009).

Redundancy occurs among pathway recommendations where risks are similar and the same regulatory drivers apply. For implementation purposes recommendations are organized per pathway into stand-alone sections. For example, the Port of Guam would use those recommendations pertaining to water conveyances and vessel cargo pathways, as opposed to those in air transportation.

In general, terrestrial vertebrate species transport is via air transportation conveyances (hereafter aircraft) (e.g., airplanes, helicopters), water transportation conveyances (hereafter vessels) (e.g., ships, barges, fishing boats, amphibious landing crafts), cargo (i.e., types and associated packing materials) including cargo conveyances (e.g., containers, crates), and people and baggage.

8.5.2 Air Transportation

Recommendations in the air transportation pathways focus on the aircraft itself as the mode of species transport. The term ‘aircraft’ includes both fixed and rotary-wing aircraft in military, commercial, and private sectors. Different types of military, commercial, and private-owned aircraft currently visit, are home-based, or routinely operate on Guam, with air transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include training and field exercises conducted on the islands of Tinian, Rota, and Saipan, which involve aircraft operations from Guam and from aircraft carriers.

Aircraft pose several risks in transporting terrestrial vertebrate species. Aircraft are capable of rapid transit, equating to higher species survival during the short travel time. Global air transportation facilitates the widespread movement and dispersal of species. Aircraft are capable of harboring a variety of species, including birds such as Java finch (*Padda oryzivora*) and the Red-vented Bulbul (*Pycnonotus cafer*), snakes like BTS and rodents such as mice (*Mus musculus*). Aircraft are also capable of repeated introductions of species because of routine routes travelled and regularity of flight schedules. Further, aircraft cabins and cargo holds that are maintained at mild temperatures during transit, such as on passenger planes, offer hitchhikers in those craft recesses a thermal environment that is conducive to species survival during transport. All of these aspects increase the probability of successful species transport, including their myriad possible combinations.

Inspections of aircraft are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and only target one terrestrial vertebrate species, BTS, when aircraft are departing Guam. Inspections do not occur for BTS on aircraft that have been grounded less than 3 hours, operate during

daylight hours, or require immediate departure, such as for military aircraft that depart Guam on urgent missions; however, aircraft leaving repair facilities for operational use are not usually inspected (Vice 2010a). Military aircraft are not exempt from agricultural inspections due to a MOU between GCQA and PPQ, where PPQ has granted GCQA the acting authority to inspect aircraft. However, military aircraft have the option of operating out of commercial and military airports, and military airfields, complicating inspection procedures. Also, military aircraft may be granted exemption in the following three cases: the aircraft is engaged in warfare, the cargo of the aircraft is classified, or pre-clearance procedures have been granted to the aircraft. Aircraft come into direct contact with the ground, giving terrestrial vertebrate species direct access to the craft. Aircraft can be difficult to inspect externally, depending upon the type of aircraft and its undercarriage configuration, but also internally, because of the numerous recesses, compartments, and storage holds aboard a craft, and the physical size of the craft. Chartered, personal, and airfreight aircraft are difficult to inspect because flight activities are hard to monitor, hence transportation of species can occur any time, to numerous places without detection. Despite the difficulties, inspection procedures and control efforts are efficient for aircraft. For example, USDA-APHIS-WS use visual and canine team detection methods to prevent BTS from departing Guam aboard an aircraft, and flight crews should adhere to sanitation regulations and be observant to signs of rodents. Aircraft are usually kept clean, reducing the attraction by species seeking a food source. External hitchhikers, such as those in wheel wells, may not survive the cold temperatures at high altitudes flown by some aircraft (Perry and Vice 2009).

8.5.3 Water Transportation

Recommendations in the water transportation pathways focus on the vessel itself as the mode of species transport, and include military, commercial, and private sector vessels. Types of vessels are numerous, including but not limited to, rigid inflatable boats, long-line fishing boats, sailboats, amphibious landing crafts, high-speed catamarans, container ships, cargo ships (bulk, break-bulk, roll-on/roll-off), aircraft carriers, landing craft utility vessels, barges, inter-island ferries, cruise ships and shuttles, platforms, and hovercrafts. Different types of military, commercial, and private-owned vessels currently visit, are home-based, or routinely operate on Guam with water transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include the construction and use of training ranges for field exercises and activities on the islands of Tinian, Rota, and Saipan, which involves water transport of materials, equipment, and vehicles for range construction, operation, and field exercises.

Typically, vessel access is limited; terrestrial vertebrate species either board themselves, or are intentionally and unintentionally brought on by persons or loaded as cargo. Species can board via fenders, mooring lines, and gangways that come into contact with land when vessels are at port, a pier, or a wharf, thus providing species with direct access to the hull. Departure from craft may be by the same routes plus directly through the water. Military vessels are not exempted from agricultural inspections due to a MOU between GCQA and PPQ, where PPQ has granted GCQA the acting authority to inspect craft. However, the arrangement that grants the authority for GCQA to conduct these inspections has been questioned. Military vessels such as Landing Craft Utility Vessels with direct access to the hull from beachheads via a ramp, and Amphibious Landing Crafts that can transport and spread

terrestrial vertebrate hitchhikers over water and land complicate inspection procedures. Also, military vessels may be granted exemption in the following three cases: the vessel is engaged in warfare, the cargo of the vessel is classified, or pre-clearance procedures have been granted to the vessel. However, these inspections are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and do not target terrestrial vertebrate species specifically. Like military aircraft, vessels that depart Guam for urgent missions without inspection can harbor and transport terrestrial vertebrate species without notice. Vessel inspections can be difficult or easy to conduct, depending upon the type of vessel, its physical size, and the vessel configuration, both above and below deck (e.g., are there cabin areas, storage holds, bunk rooms, etc.). Chartered and privately-owned vessels and private, chartered, and commercial fishing vessels are difficult to inspect because boating activities are hard to monitor, hence transportation of species can occur any time, to numerous places without detection. Control efforts exist for safeguarding vessels from harboring unwanted species. Cargo exported from Guam via water transport is typically inspected by USDA-APHIS-WS canine teams prior to loading to detect BTS presence. Vessel captains have the option of using rodent guards on mooring lines to block mice and rats, the WHO's sanitation regulations for cleaning galleys and waste disposal reduce the probability of attracting and sustaining rodents and crews should be observant to signs of rodents.

8.5.4 Cargo

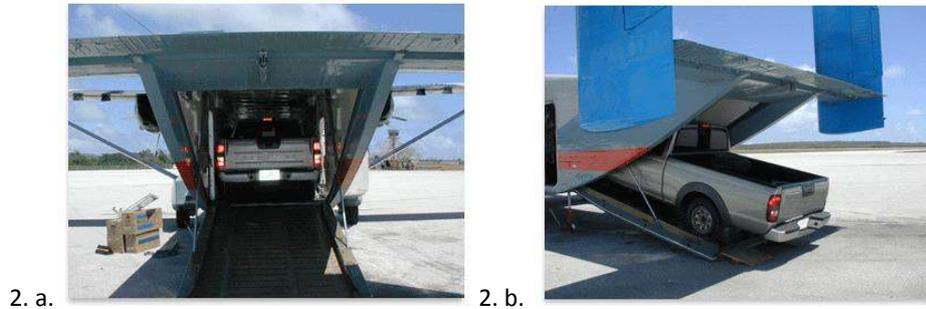
Recommendations in the cargo pathways focus on the cargo itself as a mode of species transport, including how cargo is packed and handled (e.g., crate, container, pallet, box, individual items); associated packing material; mode of transport (aircraft or vessel); shipping process, such as whether transport is via commercial or military-contracted commercial companies (e.g., Matson and Horizon vessels, passenger planes); military-owned transport systems (e.g., USTRANSCOM); or privately chartered shipping companies (Freedom Air 2010; Stratos 2010). Cargo is broadly defined as goods carried on a vessel or aircraft, or in a motorized vehicle. Cargo can be military, private, or commercial goods. Types of cargo vary and include both food and non-food goods. Types of cargo include, but are not limited to, personal checked airplane luggage; imported aquaculture (e.g., live fish or fish parts) and plants and plant parts (cut flowers, leis, nursery industry plants); animals imported legally and illegally (pet trade, personal pets, smuggling); vehicles such as cars, trucks, armored tanks, bulldozers, military vessels and aircraft (i.e., shipped aboard aircraft carriers, Landing Craft Utility vessels, Landing Craft Air Cushion vessels, hovercrafts); household goods; and empty shipping containers (for lease by shipping companies). Cargo can be handled and packed in a variety of ways. For example, household goods can be handled by private homeowners, commercial packers, or military personnel, with goods boxed and palletized for airfreight shipping, or further containerized for vessel transport, hence termed containerized cargo as opposed to palletized. Cargo like fuels, grains, and coal are termed bulk because the goods are transported unpackaged in large quantities and typically dropped or poured with a spout or shovel bucket as a liquid or as a mass of relatively small solids into a bulk carrier ship's hold. Break-bulk or general cargo must be loaded individually, as opposed to within intermodal containers or in bulk, and transport is via a cargo ship, whereas roll-on/roll-off cargo, such as vehicles, tanks, semi-trailers, and trailers which are driven on and off the vessels or aircraft on their own wheels. Different types and amounts of military, commercial, and private cargo is currently moved to, from, or through Guam and

the Micronesia Region, with cargo transports aboard aircraft and vessels in all three sectors expected to increase from military activities during and after relocation. Cargo pathways pose many risks in transporting terrestrial vertebrate species. Cargo originates from many sources, both within and outside the Micronesia Region, and species access can occur during the packing and handling process, or during transport, if contaminated from another source while en route, such as rodents moving from the vessel to the cargo shipment. Cargo is also transported to numerous destinations, making it difficult to track and monitor shipments while facilitating the widespread movement and dispersal of terrestrial vertebrate species. Cargo arriving to the region may be targeted for agricultural inspection of insects, plants, and plant pathogens if manifests declare it as coming from a country of concern, having agricultural goods, and using proper certification for packing materials, but such inspections do not target terrestrial vertebrate pests. Cargo departing Guam may receive USDA-APHIS-WS canine inspection for BTS, especially if deemed high-risk cargo or if originating from a location of high snake density; however, the probability of detecting snakes or any type of species is drastically reduced when cargo is sealed inside containers, or packed and staged in complex configurations that offer numerous hiding places and challenges for inspectors and canine teams. The type of cargo can influence the type of species being transported. Cargo such as nursery plants and associated growing mediums offer environments conducive for transporting amphibians; food shipments can attract and harbor rodents; equipment cargo can offer intricate hiding places for reptiles like snakes, anoles, and geckos; and outdoor household items, such as tubing from swing sets and barbecue grills, can transport BTS. Animals shipped live, including those for research, personal pets, the pet trade, work, or food, are a risk because escapees can contaminate other types of cargo, an aircraft, or a vessel. Illegal movement of species can occur through legal routes, such as frog eggs and tadpoles entering through the plant nursery trade and aquaculture industries, respectively. Further, transport durations and packing and shipping methods vary, thereby influencing species' survival probability differently.

Cargo inspections can occur on goods imported to and exported from the region. Arrival inspections are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and do not target terrestrial vertebrate species. Departure inspections are also agricultural in nature, and on Guam and Saipan, all departing cargo should be inspected for BTS. The volume of cargo being moved in the region is difficult to inspect thoroughly because of a lack of resources to meet current and military relocation demands, the myriad shipping companies that process and move cargo, and the need to avoid delays in loading and unloading cargo at air- and seaport facilities. Chartered and private airfreight cargo is difficult to inspect because unlike typical commercial airfreight services, flight activities can be unscheduled, hence transportation of species can occur any time, to numerous places without detection. For example, the private company Freedom Air carries various types of cargo, including personal vehicles, which can be transported from Guam without inspection for BTS (Freedom Air 2010) (Figures 11-2a-2b.). Cargo moved through private routes present a risk; visiting sailboats, private aviators, and long-line fishing boats can transport and disperse species. Military cargo presents additional risks, including classification and therefore exemption from inspections, and immediate shipping without advanced notice for medical emergencies. Military cargo such as personnel field gear and training equipment can be transported directly from the field via amphibious landing craft,

helicopters, or personnel, as well as via commercial and military airports, and military airfields, complicating inspection procedures.

Figures 11-2a and 11-2b: Vehicle Transported as Airfreight Cargo Through Chartered Service Company



Source: Freedom Air

8.5.5 People and Baggage

Recommendations concerning people and baggage pertain to the travelers and their carry-on items (hereafter referred to as baggage). People tend to opt for the quickest mode of travel, making travel duration short and species survival high in this pathway. Risks associated with the recommendations for this pathway are due to intentional and unintentional transport of vertebrates. Transport of people and their baggage can occur either by air or water, and can be private, commercially or military-operated, with each mode differing in the inspection process at the border. Commercial air transport of people and baggage includes commercial airlines or private charters, while commercial water transport consists of cruise ships or private charter boat passengers. On the other hand, military air transport of personnel may be involved in purely transportation from airfield to airfield, routine aviation training, or immediate departures of urgency (warfare, medical). Similarly, military water transport of personnel includes transport from one base to another, training missions, and immediate departures or urgency (warfare, rescue).

While inspection agencies are in place at commercial ports, the inspections do not target for detection of vertebrate species, but rather target for direct human health and safety threats and agricultural pests. Also, the equipment available for the inspection procedures (x-ray machines) of passengers may be inadequate both in number and sensitivity for the detection of vertebrate species. For example, while GCQA has two x-ray machines at the airport, they were inoperable at the time this was documented and are awaiting replacement RapidScan machines (Berringer, personal communication). Furthermore, while paper-based agricultural forms are used for arriving passengers, the forms may not be reviewed quickly enough by inspection agents in order to address breaches in regulations, or passengers may be dishonest with their entries or have difficulty completing the form due to a language barrier.

Military personnel that travel on a military-operated passenger aircraft (<http://www.baseops.net/spaceatravel/>) must describe their travel by category (i.e., emergency leave, ordinary leave, retiree or dependents leave). Like commercial air travel, personnel and passengers departing Andersen AFB are subject to security screenings and carry-on baggage clearance operated and regulated by the TSA. However, exceptions to the regular passenger screening process apply to personnel whether they are departing from a civilian or military airport. For example, personnel do not have to remove their boots during the screening process unless the walk-through alarm sounds. While these exemptions expedite the travel process for personnel that must travel quickly due to the nature of their service, the exemptions leave gaps in the inspection process for vertebrate species. Personnel transported by water will utilize military-operated vessels such as high-speed catamarans, amphibious vehicles, or hovercraft departing out of Navy Base Guam, Apra Harbor.

Under the authority of the MCI, passengers, crewmembers, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the CTUS must be inspected or examined prior to departure. All travelling personnel must complete U.S. Customs Accompanied Baggage Declaration, DD Form 1854 while civilian crewmembers must complete Customs Form 5129. The MCI should accomplish this inspection or examination immediately before departure of the ship or aircraft. Urgent departures such as medical emergencies are still subject to MCI inspection. The mandatory inspection includes opening and examining baggage carried on by personnel and a physical search of personnel for prohibited items (as outlined in DD Form 1854), and breaches are addressed by military enforcement officials. Unfortunately, MCI does not yet operate in Guam, although its role is currently being supported by PPQ. The Navy is advocating instituting MCI on Guam.

8.6 SPECIES OF CONCERN

The level of risk to biosecurity is heavily influenced by the type of species and pathway of potential transport (USDA-APHIS-WS 2010). Species of concern are those that exemplify serious biosecurity risks pre-border, at the border, and post-border due to distinct biological and behavioral attributes documented for each species.

Species-specific characteristics that pose risks to biosecurity include the conduciveness of the species to enter a pathway (e.g., physical size and conspicuousness, number of individuals), and survival probability (individual fitness and thermoregulatory abilities). In addition, shipping logistics introduce risk depending upon the duration and type of transport, food availability during transport, air temperature and ventilation during transport, type of cargo, cargo packing and shipping method used, type of commodity, and origin of the shipment (e.g., history of incidence, large pet trade industry).

At the border, the stringency (see Chapter 3, *Regulatory Drivers*) and technology available regarding the inspection process of vessels and cargo influences the potential for introduction at the destination. If introduction does occur, the establishment of a population is again subject to support of the species' distinct biological and behavioral attributes (invasiveness, habitat matching, diet type, release from predators, increase in natural resource availability, circadian rhythm type). Also, establishment can be facilitated by interactions with other species, both native (e.g., prey shift) and non-native (invasional

meltdown) (Simberloff and Von Holle 1999), and humans (human-facilitated dispersion). Emerging issues of modernity include climate change and genetic introgression (genetically engineered captive-only species), which introduce further uncertainty and complexity.

In application, the following section may be used for taxa-specific action plan purposes. Species of concern are organized by taxa, and the recommendations that apply to each group are found within each section. More attention was given to taxa of highest risk, such as BTS and species involved in the pet trade.

8.6.1 Reptiles

8.6.1.1 *Brown Treesnake*

BTS is venomous, posing a risk to human health and safety. Approximately one in every thousand hospital visits on Guam is due to a BTS biting incident, with victims including infants, agricultural workers, and BTS field staff (Fritts et al. 1990; Fritts and Leasman-Tanner 2001a). Accidentally introduced to Guam via imported military cargo presumably at Apra Harbor in the 1950s (USGS 2005), BTS has been a nuisance species that continues to pose risks to Guam's ecology, economy, and human health interests. The snake's native range includes portions of Indonesia, New Guinea, the Solomon Islands, and Australia (Colvin et al. 2005), but extralimital populations currently thrive on Guam where the species occurs in very high densities of up to 40 individuals per acre (Colvin et al. 2005) due to optimal environmental conditions like abundant prey, absence of predators, decreased competition for food, and favorable breeding habitat and climate, as well as life history characteristics like high reproductive rates. On Guam, BTS has extirpated 10 of the 12 native forest bird species and 2 of the 11 native lizard species. It is associated with frequent power outages, with economic impacts including the loss of power generation, damaged equipment, and time needed to conduct emergency repairs to restore electrical services. Loss of power equates to human health and safety concerns when facilities such as hospitals and airport control towers are involved. Further economic impact is caused to the tourism industry on Guam when power outages notably disrupt vacationers' activities (Fritts and Leasman-Tanner 2001a). BTS appears to have a trophic cascade effect that indirectly affects insect populations; some bird species extirpated by BTS were primarily insectivores. With avian predators extirpated, insect populations typically increase in abundance, with negative economic consequences to the agricultural industry on Guam (Kraus 2009a, Chapter 3).

Extralimital occurrences of BTS have been documented for Pacific Regions and in air and sea transportation pathways, for both commercial and military sectors. Incidences with military crafts include BTS found in the landing gear of military cargo planes (Kwajalein), in an Air Force B-52 bomber (Darwin, Australia, n=1, 1984) (USGS 2005), and possibly but not confirmed, disembarking and disappearing from a cargo plane (Hickam AFB, Honolulu, Hawai'i, n=1, 1997) (Claiborne 1997; USGS 2005). The snakes enter residential and commercial structures in search of food and cover, and they have been detected in household items such as appliances, vehicles, lawnmowers, swing-set tubing, barbecue grills, and outdoor recreational equipment, making this species of extreme concern for military relocating from Guam. there are also numerous BTS encounter and capture reports for a variety

of locations that are not specifically tied to military activities. More specific information on locations and number of encounters can be found in Stanford and Rodda (2007).

The abundance of snakes on Guam, coupled with the tendency of BTS to hide in cargo and aircraft, creates a significant threat to the biodiversity and economic security of the tropical Pacific, as well as military operations on Guam. BTS is the single greatest threat to terrestrial ecosystems in the CNMI and the rest of Micronesia and is one of the greatest ecological threats to Hawai'i, making it a prime species of concern.

While it is unlikely that established populations of BTS will be completely eliminated with current technology where high densities exist (e.g., Guam), it is possible to control this species on a smaller scale (Rodda et al. 1999). An effective program for BTS interdiction must involve wide-area population suppression, snake-proof barriers, visual searches, and canine detection and interdiction, but also requires effective ED and RR capabilities for all areas at risk such as the jurisdictions covered by the MBP.

8.6.1.2 *The Asian Beauty*

The Asian Beauty snake (*Elaphe taeniura*) is native to Southeast Asia and Taiwan, but has been found on Okinawa since 1985, including gravid females. Although non-poisonous, this species poses an ecological threat as a potential predator of native mammals and birds (Ota 1999c; Ota 1999a) via intentional and unintentional transport. Due to its presence in the Ryuku archipelago, there is a high risk for its introduction to Guam via air or water transport related to military relocation efforts from Okinawa to Guam. In fact, one of these snakes was discovered in a shipping container holding munitions on Guam that had been shipped from Okinawa and held in storage for approximately 2 months in 2004 (Vice et al. In preparation). There is little information on effective control methods specific to *E. taeniura*.

8.6.1.3 *Habu*

The habu (*Trimeresurus flavoviridis*), a venomous viper, is native to the high islands of Amami and Okinawa. In these islands, the habu is a common human health threat, with high incidence of extremely painful bites. The venom can cause hemorrhaging and necrosis, and may progress to unconsciousness and death (Mishima et al. 1999). The incidence of habu bites varies with region; about 80% occurs in agricultural and residential areas, and up to 5.8 bites per 1,000 people can occur (Ota 1999b). The habu is also an ecological threat because it preys upon native birds, especially on islands with little or no rodent populations (e.g., Minnajima). The presence of an additional venomous snake on Guam could alter the effectiveness of current BTS interdiction measures. Unlike BTS, the habu is relatively sedentary and an affective attractant for habu traps has not been found (Hattori 1999), but trapping and barrier fences are the best methods available for control of the habu in residential areas. Due to its presence in the Ryuku archipelago, there is a high risk for its introduction to Guam via air or water transport related to military relocation efforts from Okinawa to Guam.

Only three snake species are mentioned here but it is worth noting that there are numerous species which could become established either through accidental transport or via pet trade. Various species

other than those mentioned in this section have already been recorded for various island in Micronesia and for the state of Hawai'i, the number of species and encounter incidents is much higher. Snakes in general are highly efficient predators which if allowed to establish will cause tremendous negative impacts to any of the islands within the region.

8.6.1.4 *Geckos and Lizards*

The mutilating gecko (*Gehyra mutilata*), and green anole (*Anolis carolinensis*) are introduced species found within the region that have the potential to be spread (Kraus 2009a, Chapter 3), and pose ecological threats to native ecosystems. Although a single individual generally will not lead to an incipient population, many lizard species are capable of parthenogenesis, a form of asexual reproduction found in females, where growth and development of embryos occurs without fertilization by a male. The lizard species of most concern for the region is *Carlia ailanpalai*, a lizard species already established in parts of the FSM (Buden 2009), and a known aggressive predator of the Pacific Blue-tailed skink (*Emoia caeruleocauda*) on Guam (Wiles et al. 1989). It is therefore considered a possible causal factor in the decline in native scincid lizards in the Marianas (Case and Bolger 1991; Rodda et al. 1991; Rodda and Fritts 1992). Furthermore, this scincid lizard is a main diet item for BTS, helping support the large population of BTS on Guam (Rodda and Fritts 1992). *Anolis* species can be transported via cargo containers, and the swimming ability of some enables them to jump ship in favorable scenarios, such as when the vessels are close to shore (Perry et al. 2006). *Anolis carolinensis* are known habitat generalists and the feeding behavior of these animals caused insect populations to collapse on the Ogasawara Islands of Japan, resulting in this species being listed as an Invasive Alien Species in Japan since June 2005. Although the green anole population on Guam has not recently undergone rapid growth, its density could nevertheless approach hundreds to thousands of individuals per hectare (Toda et al. 2010) in the absence of predators like BTS. Green anole populations on some of the islands of the CNMI are found at high density levels. Preventing invasions of small reptilian species such as geckos is often difficult to manage, and once established there are no known methods of eradication (Cole et al. 2005). Even the mangrove monitor (*Varanus indicus*) is not ubiquitous within Micronesia and it is known as a predator of sea turtles, crabs and birds. It is hoped that island which do not currently have populations of mangrove monitors can in fact be kept free of this predatory species.

Green iguana (*Iguana iguana*) are also a concern. They are known as IAS in other areas, are common in the pet trade and individuals have been recovered previously in both Guam and Hawai'i. Green iguana are known to be established in Florida, Puerto Rica, and on at least several islands in the Fiji island group (Pers Comm. J. Stanford).

Additionally it might be worth mentioning that Brown Anoles, Day Geckos and a few other lizards not yet known to be established in Micronesia are established in Hawai'i. Again, there is also likely potential invasive lizard candidates in places like the Philippines which might make it to Guam give the anticipated increases in the flow of people and goods from southeast Asia to Guam. Another lizard which we should be concerned about is *Calotes versicolor*. One individual has been found on Saipan and this species is a known invasive in some areas of Asia and also on Diego Garcia (Pers. Comm. J. Stanford).

Most lizards which become established not only will likely compete for resources with native biota as well as consume native species but they are also a great food source for predators which might establish like snakes and feral cats.

8.6.2 Amphibians

Guam has no native anurans, yet 13 anuran species have been discovered in Guam since 1937 of which at least 6 have established populations (Christy et al. 2007a). The modes most involved in alien anuran introduction are biocontrol, cargo, on/in shipping containers, food imports, plant trade, pet trade, and aesthetic release (Perry et al. 2006; Kraus 2009a). Due to their physical size and broad physiological tolerance, anurans can hide and survive various transport conditions, resulting in unintentional introduction on arrival if they remain undetected. Furthermore, anurans are most successful in transport survival when they are stowaways associated with living industry (e.g., plant propagation materials, live plants, and aquaculture) cargo, as the environmental conditions during transport are more likely to be optimal for anuran survival.

8.6.2.1 Cane Toad

The cane toad (*Bufo marinus*), native to Latin America, has been intentionally introduced in the tropics for the purpose of biocontrol, and unintentionally through air- and water-transported cargo, especially cargo associated with the plant trade (Kraus 2009a). As a generalist, the cane toad has proven to be an extremely successful invader throughout the Caribbean and Pacific (Lever 2001). It is a human health threat because it secretes bufotenine toxin that can potentially lead to serious illness or even human fatalities, particularly in children (Lever 2001). In addition, cane toads carry extremely high levels of pathogenic *salmonella*, specifically *S. waycross*, a species that contributes to high human salmonellosis rates on Guam (Haddock et al. 1990). Cane toads also pose ecological threats to native species through depredation; they are known to destroy nest burrows and prey on eggs and young nestlings of rainbow bee-eaters (*Merops ornatus*) (Boland 2004) in Australia. Further, the expected influences of global climate change on the worldwide problem of species invasions (Zhang et al. 2006; Ward and Masters 2007; Sommer et al. 2010) is evident in cane toads introduced into Australia; the species is rapidly expanding its range in part because of changing environmental and habitat conditions (Urban et al. 2007; Kearney et al. 2008).

8.6.2.2 Frogs

Introductions to Guam of the coqui frog (*Eleutherodactylus coqui*), Guenther's frog (*Rana guentheri*), spot-legged tree frog (*Polypedates megacephalus*), greenhouse frog (*Eleutherodactylus planirostris*), crab-eating frog (*Fejervarya cancrivora*), cricket frog (*Fejervarya limnocharis*), banded bullfrog (*Kaloula pulchra*), Northern Pacific tree frog (*Pseudacris regillii*), and the Mantella (*Mantella pulchra*) have occurred either through aquaculture or plant trade imports (Christy et al. 2007b), all of which have become established with the exception of the coqui frog and banded bullfrog (Vice 2009). Guenther's frog (widely known locally as the barking frog) was introduced to Guam in 2001 from an aquaculture shipment most likely originating in China or Taiwan, and has since flourished throughout Guam. A more recently introduced species is the spot-legged tree frog (in 2004), which was introduced via an

aquaculture shipment originating in China. The greenhouse frog arrived in Guam in 2003 through horticultural shipments originating in Hawai'i. An active horticultural trade exists between Hawai'i and Guam, and the species was found on Guam either at or in the vicinity of active plant nurseries or recent plantings (Christy et al. 2007a). All three established frog species pose ecological threats on Guam because they potentially may provide an additional source of food for non-indigenous invasive populations of rats, mongooses, and BTS. In fact, the barking frog and the green house frog are now found throughout Guam and in some areas can be found in remarkably high densities. Gut content of BTS from areas with high green house frog densities over the past several years have suggested that as the frog populations increase, so does predation on the frogs by BTS (Per Comm. J. Stanford).

The coqui frog and banded bullfrog were detected on incoming cargo to Guam (Christy et al. 2007a), the former found on horticultural material, while the latter in military cargo on a U.S. Air Force cargo plane. The coqui frog was also detected on Guam near a plant nursery (Christy et al. 2007b) but is not believed to have successfully established on the island. It has also been detected and intercepted on bulk palletized cargo shipped from Hawai'i (Vice et al. In preparation). The coqui frog is a significant economic threat in Hawai'i where it has negatively impacted the real estate market, nursery trade, and tourism industry, primarily due to the frogs loud and incessant calling behavior (Beard and Pitt 2005; Kaiser and Burnett 2006). The coqui frog also poses an ecological threat; in Hawai'i it has the potential to reduce endemic invertebrates and increase nutrient cycling rates, which may confer a competitive advantage to invasive plants in an ecosystem where native species have evolved in nutrient-poor conditions (Sin et al. 2008). The Northern Pacific tree frog is annually detected in imported Christmas trees shipments (Vice, personal communication); repeated introductions are likely to lead to the establishment of this species.

Prevention of the introduction and spread of anurans are the most efficient type of biosecurity measures for the taxa as attempts to rapidly eradicate invasive anurans in general have been unsuccessful, but some exceptions do exist. For example, if eradication is undertaken at an early stage of development (tadpole stage), success increases dramatically, as seen in the case of *Limnodynastes dumerilii* in New Zealand where all egg masses and individuals detected were destroyed quickly (Kraus 2009a). On the contrary, removal of adults may actually increase survivorship of metamorphs due to the release from cannibalism inherent in some species such as *R. catesbeiana* (Govindarajulu et al. 2005). However, most cases of anuran invasion pose more complex challenges to eradication efforts. In Hawai'i, *E. coqui* requires long-term management, and eradication is unlikely due to high incidence of repeated introductions and invasions. Still, *E. coqui* management options include intensive surveys and monitoring of populations, clearing of optimal habitat, and spraying (ground and aerial) of citric acid and hydrated lime to kill individuals. Management efforts of cane toads in Australia include the forming of the Cane Toad Task Force and implementing various short- and long-term control measures such as large-area barriers and fencing to prevent further dispersal of cane toads (Taylor and Edwards 2005; Sawyer 2006).

8.6.3 Mammals

8.6.3.1 Rodents

Introduced rodents have historically posed significant economic, ecological, and human health threats worldwide. Rodent species of concern to Guam include house mice and black rats (*Rattus rattus*). Both are transported as hitchhikers by air and water transportation pathways. Larger rodent species, such as nutria (*Myocastor coypus*) imported for fur ranching, also pose a threat.

House mice can economically threaten the food industry, and are known to be associated with salmonella, rickettsial pox, and choriomeningitis (Long 2003b). Also, the gnawing behavior common to rodents may cause damage to electrical wiring within the aircraft electrical equipment or infrastructure, threatening human safety and causing economic impacts. They also prey and therefore are attractive to other invasive species like BTS. The potential ecological destruction of established rodents may be exemplified by the infestation of more than 700,000 house mice on Gough Island off South America; since their establishment, these mice have physically tripled in size because they prey on albatross chicks in lieu of their typical insect and seed diet (Vidal 2008). House mice have been found hitchhiking aboard commercial airplanes, both within the cabin (Bodry 2008) and in wheel well compartments (Vice 2010b).

Black rats have reached about 80% of the world's islands, and are among the most successful invasive mammals (Caut et al. 2008). Rat infestations can occur in port facilities due to improper garbage disposal and handling, in addition to inadequate eradication measures (USDA-APHIS-WS 2010). These rodents can cause economic threats to livestock and poultry operations, crops such as rice, sugarcane, coconut, and macadamia, and damage to buildings and electrical materials. Rats can be reservoirs of zoonotic diseases, including *leptospirosis*, *typhus*, and *trichinosis*; rat fleas are vectors for *pasteurella* and *murine typhus* and plague; these all pose threats to human health through bites, contamination of food and water, and air-borne transmission. Lastly, ecological threats include predation on and extinction of native mammals, reptiles, and birds (Stenseth et al. 2003), either directly or by sustaining higher risk predators (e.g., BTS) as prey themselves (Fritts and Rodda 1998).

Furthermore, rodents may be transported along with a food source, thereby increasing their chance of survival during transport, such as a shipment of rodent-infested grain (Baker 1994a). Hitchhikers aboard civilian pathways include rodent pups discovered in the rear wheel well of an aircraft that had landed on Guam in March 2010 (Vice 2010b). Management of invasive rodents most often utilizes rodenticide methods, primarily anticoagulants. These methods are implemented in and around buildings, together with practices of exclusion, sanitation, and habitat modification (Timm 1994a, b). Day and night shooting is used with some larger species (e.g., nutria) (LeBlanc 1994). Most island eradications of rodents have utilized anticoagulant rodenticides, hand broadcast, in bait stations, or aerially broadcast (Howald et al. 2007). Military implementation of rodent control can be found in NAVMED P-5010-8, the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004).

Established rodent and other small mammal populations provide excellent food sources which can support other non-native species, especially predators such as the BTS. There are a variety of rodent species already established in the region with some species overlapping and others not. More details on specific species can be found at the issg.org website.

8.6.3.2 Indian Mongoose

The Indian mongoose (*Herpestes javanicus*) is an example of an early attempt at biological control of an invasive pest species. It was introduced to the Hawai'ian Islands in an effort to control damage in the sugar cane industry caused by invasive rat populations that invaded the islands (Matthews and Turner 2009). The mongoose is established on some islands in Hawai'i but likely not all of them. A mongoose capture occurred recently on Kauai which prompted officials to set up a response system including interview formats based on those used by the alien snake team through the region (Pers. Comm. J. Stanford). Mongooses have also been introduced to control rats in Fiji, Mauritius, and to Amami-Oshima Island in Japan (Watari et al. 2008). Since their establishment, mongooses have contributed to the decline of populations of many native and endemic species of ground-nesting birds and reptiles, posing a serious ecological threat to Pacific islands. In addition, mongooses can also threaten mammalian health by their transmission of diseases such as *leptospirosis*, canine distemper, canine hepatitis, *toxoplasma*, *salmonella*, feline panleukopenia, *streptococcus*, and pulmonary virus.

Trapping and toxic baits placed in bait stations are the main methods used for control and eradication of mongoose, although success has usually been marginal (Roy et al. 2002; Quinn and Whisson 2004). Currently, National Wildlife Research Center scientists are working to identify attractants to better monitor and capture mongoose on Hawai'i. Additional methods development will further investigate effective, durable toxic baits and multiple-capture traps for mongoose. Where rabies exists, the development of an oral rabies vaccine for mongoose is also considered an important research goal due to the role of the mongoose as a vector for this virus (Quinn and Whisson 2004).

8.6.3.3 House Shrew

In high densities, the Asian house shrew (*Suncus murinus*), also known as the Musk shrew, poses ecological threats and impact on a wide range of other species, including plants, invertebrates, and vertebrates, either through predation or competition (ISSG 2005). This species can also act as a reservoir for the plague (Duplantiera et al. 2005), posing a serious human health threat. The house shrew is currently established on Guam, and due to their commensal nature, they are believed to be transported accidentally in cargo and personal effects (e.g., vehicles, cargo containers) (USDA-APHIS-WS 2010). The house shrew is thought to be anti-coagulant bait resistant and control measures rely on using baited snap traps (ISSG 2005). These shrews are also established on several other islands within Micronesia, including Saipan where they are found at much higher densities than on Guam (the reduced population on Guam is likely due to heavy predation by BTS).

6.3.4 Crab eating Macaque

Crab eating Macaques (*Macaca fascicularis*) are established on one island of Palau where they are produced tremendous negative impacts including reducing numbers of native bird species and impacting the human inhabitants by direct competition for food and destroying crops. While it is unlikely that macaques could “accidentally” stowaway and hitchhike to other islands, the fact that some humans consider the young to be valuable pets does make this a species of concern for the islands of Palau as well as the remainder of the region.

8.6.4 Birds

8.6.4.1 Wild Passerines

While there are several passerine species that have the potential to be introduced to Guam by air and water transportation pathways, wild passerine species of concern are those that are known agricultural pests of crops grown on Guam, possess highly invasive biological and behavioral characteristics, and exist along routes of frequent transport to and from Guam (Pacific Rim). The red-vented bulbul (*Pycnonotus cafer*) has been introduced to Australia, Fiji, French Polynesia, RMI, New Caledonia, New Zealand, Samoa, Tonga, and the United States via sea freight and more recently, Majuro (RMI) likely via the commercial air transport pathway. It is an agricultural pest (economic threat), an aggressive competitor of endangered native birds such as the Tahiti Flycatcher, a disperser of invasive plants like Lantana, and a prey source for BTS (ecological threat) (ISSG 2005). The black drongo (*Dicrurus macrocercus*), already introduced to Rota and Guam, continues to be an extremely aggressive species that harasses and displaces native bird species, a predator of bees, disperser of invasive plants, and prey source for BTS (ecological threat). The drongo also tends to nest on utility structures, in avoidance of BTS, meanwhile causing electrical damage (economic threat) (Fritts and Rodda 1998). Java sparrows (*Padda oryzivora*) are small passerine birds that are popular in the pet trade and have been introduced to many countries worldwide, including China, Myanmar, Thailand, Sri Lanka, Borneo, Sumatra, Ambon and Lesser Sundas, Fiji, Philippines, Taiwan, Japan, South Vietnam, Christmas Island, and Hawai’i. They feed on a variety of seeds in grasslands and are considered an agricultural pest of grain crops, especially rice (economic threat) (Koopman and Pitt 2007), and have a high reproductive rate with a modal clutch size of eight eggs (Islam 1997). While USDA Code of Federal Regulations prohibits the importation of this species into the United States and its territories, many states allow the possession and interstate traffic of captive-bred birds. Eurasian sparrows (*Passer montanus*) are well established on Guam and several other islands within Micronesia. These sparrows on Guam (as well as other bird species) are an additional food source for non-native predators such as the BTS. There also also a variety of other species including doves and pigeons spread throughout the region. Hawai’i has by far more non-native feral bird species established than any of the islands within Micronesia. Some of these feral population are from original pet stock.

8.6.4.2 Exotic Pet Birds

The pet industry is a well-organized and profitable industry in the United States (Ginsburg 2004). At least 94 species of introduced and invasive birds have become established in the United States, and most introductions originated from pets. Most of these are passerines (39 species), but many are psitticines (22 species), popular animals in the pet industry (Kraus 2003). The pet industry is a major pathway for

the introduction of vertebrates into the United States (Kraus 2003) because very few are prohibited from entry and can be imported legally with the proper permitting. Requirements of importation of exotic birds to the United States include a USDA import permit, 30-day quarantine at a USDA Quarantine Port Center, and veterinary certification of health from the country of origin (http://www.aphis.usda.gov/import_export/animals/nonus_pet_bird.shtml, accessed 9/14/10).

Once imported, release of caged birds may result in feral populations that can pose economic, ecological, and health threats, respectively to local industry (agriculture, electrical damage), native ecosystems (natural resource competition), and native bird species (host shift of ectoparasites). For example, the monk parakeet (*Myiopsitta monachus*), now established in the Midwest and Eastern United States, is a significant agricultural pest destroying up to 45% of some crops. In some regions, the monk parakeet utilizes native bird species' nest sites (introduced competition), or can cause electrical damage by nesting on utility structures. Currently, there are feral populations of pet bird species in Hawai'i and also likely within Micronesia. The continued importation of bird species for the pet trade sustains the potential risk of release of additional species and in new locations. Pet retailers on Guam are known to import exotic species such as Meyer's parrot, red-bellied parrot, green-cheeked conure, society finches, red-factor canaries, lovebirds, cockatiels, budgerigars, and ringneck doves (Guam pet retailer, personal communication). The non-native Java Sparrow (*Padda oryzivora*) has established at least one (if not more) small populations on Guam (Pers. Comm. J. Stanford).

Control methods for invasive bird species may include disrupting or destroying nests, targeted poisoning, trapping, and hunting. Farmers in Australia have shot more than 27 species of pest birds, but active control of invasive birds remains rather uncommon (Usher 1989). Characteristics inherent to birds such as ability to fly large-distances and high fitness, a commonality of invasive birds species, makes re-colonization a continuous issue, such that pest birds are very difficult to control.

8.7 BIOSECURITY RECOMMENDATIONS

8.7.1 Three-tiered Perspective

Biosecurity measures implemented to mitigate risks posed by terrestrial vertebrate species are necessary at three levels: pre-border, at-the-border, and post-border. Recommendations may be associated with one or more level and may overlap across levels, depending upon the mitigation measures. There are five key issues pertaining to all recommendations: funding, coordination and communication, education and training, early detection, rapid response, and enforcement (of regulatory drivers). For example, cooperative trade agreements, which would fall under coordination and communication, affect pre-border activities, while rapid response programs include at-the-border and post-border activities, and enforcement issues generally range across all levels. Prevention is more effective and cheaper than eradication or long-term control of established terrestrial vertebrate species, so exclusion of these species pre- and at-the-border should be the first line of defense. Eradication is more effective and cheaper in the long run than permanent control of a pest population, so eradication should be considered where feasible.

8.7.2 Key Issues Regarding General Recommendations

This section will discuss some overall, general recommendations for mitigating the risk of transporting vertebrate invasive species unintentionally. More specific recommendations are covered in other sections. These general recommendations should not be considered as the only, or the most important, recommendations. Rather, they should be viewed as a starting point for more formalized recommendations. Five key issues are central to successful implementation of the recommendations given here. These key issues are: funding, coordination and communication, education and training, control methods development, and regulatory drivers and enforcement.

8.7.2.1 Funding

Regardless of the biosecurity strategy developed, lack of sufficient and properly managed funds will be the weak link in any effort implemented. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly inadequate relative to the magnitude of the existing problems posed by invasive species, the emerging problems and associated risks to other islands, and the scope and magnitude of military activity in the region.

Short-term funding cycles hamper necessary methods development and interdiction activities and restrict the forward momentum needed for effective control programs. For example, because BTS efforts are currently underfunded, much higher costs are expected in the future to resolve expanding threats not addressed now. Cost-sharing among agencies and the transportation industry has advanced greatly, with more room for improvement. Although DoD supplies funding for interdiction on military facilities, the DOI Office of Insular Affairs (OIA) is carrying much of the funding responsibility at present for BTS. The Office of Insular Affairs is the primary entity supporting BTS rapid response. Both Interior and DoD support BTS research efforts. Greater and sustainable investment by DoD and other federal agencies is warranted as part of their efforts to reduce the comprehensive impact of military activities and their overall stewardship of natural resources on their lands.

8.7.2.2 Coordination and Communication

The multiple economic, ecological, and human health impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams 2007). NISC was established by EO 13112 to provide coordination and planning, and to facilitate cooperation among the diverse federal agencies and to take a more comprehensive approach to invasive species. NISC is co-chaired by the Secretaries of Agriculture, Commerce, and the Interior; and includes a total of 13 federal agencies and departments that have a role in invasive species (Williams 2007).

Federal agencies that must work in coordination to maintain a biosecurity plan include USDA-APHIS, USFWS, CBP, Interior, DoD, Department of Commerce, Department of Energy, DHS, and the Department of Transportation, among others. Interagency coordination is pertinent, as is frequent and comprehensive communications. The communication network that occurs between government agencies results in information that can be compiled, consolidated, and reproduced in a manner suitable

and clear to the general public and private industry (e.g., transportation, construction). Local capacity-building is needed to support research, operations, and program management, and to improve local recruitment pools. Efforts could include cooperative university and government programs, so that funding is utilized in a most resourceful manner (Colvin et al. 2005). For example, the public outreach program on Saipan is a model, particularly the partnership with private industry. This public outreach effort, fielded by the Office of Economic Adjustment and the Military Integration Management Committee, conducts community outreach dialogue sessions on Saipan to hear concerns of citizens. This and other demonstration projects illustrate attempts at achieving biological, social, and economic objectives through managing invasive species on islands (Saunders et al. 2007).

In addition there are various local and regional entities which can and should be involved in biosecurity and IAS work. An important or potential important regional body which already is involved with IAS for Micronesia is RISC. This group, if better supported could become a key mechanism for regional communication and coordination activities and in some regards it already is. Many of the jurisdictions also already have established invasive species tasks forces or councils/committees. Groups such as the Pacific Island Learning Network (PILN), the Pacific Invasives Partnership (PIP), and Pacific Invasives Initiative (PII) are also already involved in supporting regional IAS efforts. A few of the jurisdictions also have invasive species coordinators and it is hoped that in the near future each of the jurisdictions could have such a position to support communication and coordination throughout the region on IAS issues. SPC and SPREP, 2 Pacific region groups, are also already very involved in IAS issues within Micronesia and it is hoped that the roles of both of these groups can be expanded to further the support they can provide in this regard.

8.7.2.3 *Education and Training*

Gaps in invasive species management can be bridged by increased education and training, with an emphasis placed on public outreach. Public perception and lack of support have affected efforts to manage or eradicate vertebrate species in the United States, as elsewhere in the world (NISC 2001). Knowledge levels regarding invasive species and the harm they can cause are relatively low among the general public (NISC 2001, Conover 2002). For example, reports on invasive species management in Hawai'i (TNC and NRDC 1992) concluded an overall gap in public awareness of invasive species. This resulted in the formation of the Coordinating Group on Alien Pest Species (CGAPS), a voluntary government/non-government partnership, formed in 1995 to increase public awareness of invasive species. Following the formation of the partnership, CGAPS launched a campaign in 2006, with television and print media and a new toll-free hotline number regarding the dangers of BTS. Encouragingly, follow-up surveys confirmed a rising awareness about BTS (Martin 2007). Educating the public on preventative measures must be continual, especially given that, over time, the longer an invasive species is not discovered, the further it tends to slide from public concern.

Furthermore, staff involved in the enforcement aspect of invasive species (e.g., inspection agents) need to be educated on biological risks on which they act daily. Knowledge of the impacts of introduction is bound to increase staff motivation and efficiency in the workplace. Training should include the taxonomic identification of species, continued education on species status updates, changes to

regulations, and new pest species listings (e.g., White List). In conjunction, multimedia educational material will further facilitate proper identification of species, with written descriptions, physical attributes, and animal behavior, as well as immediate human health and safety concerns (see Distance Diagnostic and Identification System, [University of Florida 2010]).

Rapid response programs are designed to implement immediate action on the detection of invasive species. They are comprehensive programs that require the melding of coordination, communication, education, and training. Rapid response actions and sightings are documented in incident reports, and response times are substantially reduced by emphasizing training and public awareness, as shown in the CNMI in 2003 (Colvin et al. 2005). The BTS review by Colvin et al. (2005) found rapid response to be most successful when the following aspects are incorporated into the program: extensive training, public awareness and outreach, use of technological advances, centralized documentation (e.g., SOPs), and networking that allows the program to operate on a regional level. These aspects are central to the recommendations for rapid response programs outlined in the review. Currently, the most developed rapid response programs exist in Guam, Saipan, and Hawai'i, but training and organizational efforts in other archipelagoes in the Pacific Basin are underway. For example, the USGS Rapid Response program has conducted BTS trainings for quarantine officers throughout Micronesia, including the CNMI, Palau, Chuuk, Pohnpei, Kosrae, Kwajalein, Ebeye, and Majuro (Stanford and Rodda 2007). It should be clear that while the BTS response team has existed for more than 10 years, it is not well funded in regards to being able to address issues such as regional outreach and staff turnover at participating agencies has been higher than expected. It has been moderately successful with regional networking, supporting response actions and working within the FSM, RMI, Palau and the CNMI on outreach initiatives due in large part to support from OIA and local authorities. Not all local agencies (none) are well funded and most are extremely understaffed and have little equipment and few training opportunities. Building a high capacity response team on a shoe string budget across multiple countries in an area bigger than the continental US is not an easy task. The fact that RRT has a regional team with trained responders on all of the major islands of the region and the Hawai'ian islands, is to be applauded. So while funds have been appropriated, but given the extent of the situation, those funds and the ability to use them to address ED and RR activities across the region are insufficient.

8.7.2.4 *Control Methods Development*

Methods development is also needed to facilitate prevention measures occurring at the pre-border stage, but its largest application is in mitigation at the post-border stage of introduction of an invasive species. Methods development is most productive when closely coordinated and integrated with SOPs to maximize efficient use of funds and execution in the field (Colvin et al. 2005).

While extensive progress has been made on many aspects of BTS biology and control measures, additional research is needed to facilitate control and interdiction, including topics such as bait and attractants, application of control agents, logistics of control measures (Colvin et al. 2005). Unlike BTS, there remains a lack of methods development for particular invasive species, such as the Asian beauty snake, garter snakes, gecko species, mongoose, and house shrews. Certain species require integrative solutions for effective control methods; characteristics inherent in their biology and behavior may make

some species more difficult to control. For example, effective baited trapping of BTS is feasible due to their large movements, while bait and attractants are not as effective on the more sedentary Habu snake (Hattori 1999). Successful methods development relies heavily on sufficient funding to fuel the education, training, human resources, and facilities required to pursue a comprehensive, integrative approach to control and management of invasive species.

8.7.3 General Recommendations

Address funding issues necessary for regional biosecurity. Regardless of the biosecurity strategy developed, lack of sufficient, consistent, and properly managed funds will be the weak link in any effort implemented, allowing for biological invasions of terrestrial vertebrates to occur in the region.

Military funding for biosecurity efforts in the region must be sufficient, consistent, and properly managed. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds, as many risks to biosecurity are associated not only with the relocation, but with continual and growing military regional activities resulting from the relocation. Management of funds outside the military sector is necessary to curtail gaps in the biosecurity system that hamper success. For example, although sustained military funding to implement biosecurity measures are in place for some species, like BTS, allocation of those funds can be drastically delayed when new transfers of military personnel solely in charge of those funds reassess the BTS threat, as well as the amount and timing of funds that are allocated. Military funding should address current needs, which are grossly inadequate for even basic biosecurity in the region. Military funding solely for the relocation is disproportionate to the need being created over the long term, and therefore funding should extend to cover ongoing and cumulative impacts of the relocation. For example, funding for BTS management should extend beyond the 1-year limit being imposed currently in the final ROD (pg. 104) following military construction and the permanent relocation of non-transient Marine Corps military units to Guam.

Re-authorize the BTS Control and Eradication Act (2004-2009). The 5-year BTS Control and Eradication Act expired in 2009 and needs to be reauthorized. This is an important regulatory driver pertaining to prevention, mitigation, and management of BTS and pertinent for protecting areas exposed to BTS from trade, travel, and tourism. Once reauthorized, USDA and Interior should engage in rulemaking to develop regulations that further protect Micronesia from the spread of BTS.

A centralized group should be responsible for creating avenues for funding within the Micronesia Region. Regional funding is necessary because many of the risks are interrelated and require efforts that cross political boundaries, and sustained efforts are required to effectively minimize risks. Representatives from all pertinent parties could act as a panel to organize priorities, ensure timely and adequate allocation of funds, and implement adaptive management practices of consistently reviewing and refining the funding processes to adapt to changes needed to maintain efficacy. In addition, a centralized group could apply checks and balances to quickly detect problems or shortcomings in the system.

Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Because cargo originates and is destined for myriad locations increasing the potential for transporting unwanted terrestrial vertebrate species, the most cost-effective solution is to regulate the processes involved in cargo movement. Funding is required to adequately develop and enforce regulations for movement of cargo by military and civilian sources with an emphasis on terrestrial vertebrate species. Warehouse facilities that consent to and help facilitate inspections of cargo and cargo handling procedures, such as providing training to staff, and allowing inspections and control efforts to be implemented should be given incentives to maintain this proactive approach. Cargo staging area issues need to be addressed, for example, to reduce the cross-contamination between high- and low-risk cargo. Regulations need to be enforced to show that penalties not only apply, but are actively being implemented.

Centralize biosecurity efforts. The NISC was established by EO 13112 to provide coordination and planning, facilitate cooperation among the diverse federal agencies, and to take a more comprehensive approach to invasive species. However, the multiple economic, ecological, and human health impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams 2007), so that efforts must be centralized in order to operate cohesively and effectively. A central group acting as a liaison can bridge gaps between formal and informal, and military and civilian communications. A central group would outline the current network of the biosecurity communications in the Micronesia Region; identify communication gaps; provide information in the appropriate format for public, private, and military sectors; and be a representative for media and news releases concerning biosecurity.

Develop a biosecurity surveillance system for improved data collection, reporting, and information sharing network. There is a paucity of available information from the military to fully assess risks associated with the unintentional and accidental movement of terrestrial vertebrate species, posing significant risks and undermining biosecurity efforts in the Micronesia Region (USDA-APHIS-WS 2010). Sustained surveillance of biosecurity risks to lead an adaptive response would decrease the risk due to changing threats and changes in the way cargo and people are moved in the future. Further, information sharing would allow programs to be fully integrated into new projects, new cargo routes, or new air and sea shipping companies.

Encourage and participate in action to preserve biodiversity. Include actions taken by joint agency collaborations, such as the Micronesia Challenge (Micronesia Challenge 2009).

Create community funding sources for local programs. Promote local programs, such as “Environmental citizenship” (Barry and Knab 2005), for local training, education, eradication efforts.

Expand and manage University programs. The universities of the region can serve as local facilities for education and training to enhance biosecurity measures.

Comprehensive and continued education is needed. Educate everyone who can help or positively influence the campaign against invasive species. Elements can include disseminating reports and

newsletters to educators, journalists, lawmakers, and business and community leaders; establishing local reporting systems for rapid response teams; developing curricula for the schools; and conducting a pre-campaign poll of island residents to gauge levels of awareness regarding species introductions/invasions and subsequent impacts (Holt 1997). Include military and military-civilian personnel.

Implement biosecurity measures for detecting myriad terrestrial vertebrate species. Biosecurity activities need to account for several species of terrestrial vertebrates in the Micronesia Region, but hazards and regulations currently driving biosecurity efforts on Guam are aimed primarily at preventing the transport and spread of BTS. Detection methods for various terrestrial vertebrate species would involve an increase in awareness, adequate training, and proper equipment for dealing with inceptions and the capabilities to report all incidences, including incidental sightings. Such an integrative approach also permits assessment of the cumulative effects of terrestrial vertebrate species movement in the region.

Ensure the number of USDA-APHIS-WS canine inspection teams at military ports. To adequately prevent the movement of BTS on military and commercial boats, the number and capacity of USDA-APHIS-WS Canine Teams should be increased in response, if necessary, to adequately cover boats departing Guam.

Enhance canine inspection teams in the CNMI. Enhance the capabilities of canine teams in the CNMI by increasing the number of personnel and canine teams available, training opportunities, the ability to conduct random inspections, and the number of inspections and amount of materials that can be inspected.

Create a centralized canine inspection station for USDA-APHIS-WS canine teams on Guam for the commercial airport, port facilities, and commercial warehouses. Make the existing canine housing facility on Guam a central inspection headquarters that houses the majority of canine teams. This centralized station may also serve as a community collection point for vertebrate terrestrial species information, and awareness/training programs, and also be a place where the public can report observations and bring specimens.

Develop a labeling and tracking system for all cargo. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software. Provide funding to adequately manage and refine electronic tracking of cargo in the region. Implement adaptive management practices to continually refine the tracking abilities and the overall surveillance system.

Manage the grounds around ports to reduce populations of target invasive species. Unintentional transport of hitchhiking terrestrial vertebrate species may occur in a number of ways. Hitchhiking species may be initially attracted to certain physical or chemical conditions, such as rats nesting in

aircraft wheel wells (Vice 2010c), BTS sheltering inside shipping containers or packing material (Fritts et al. 1999), and mice feeding on grain and garbage shipments transported overseas (Baker 1994b). Use USDA-APHIS-WS-approved vertebrate-proof staging areas, spot-lighting checks at night, continual trapping, large area population suppression efforts, and sighting response capabilities.

Expand capacity and funding for control methods for BTS. While progress has been made on many aspects of BTS biology and control measures, additional or improvement of methods would facilitate control and interdiction procedures, including bait and attractants, repellents, large area suppression, additional interdiction techniques, and logistics of control measures (Colvin et al. 2005). Sustained funding to refine existing strategies and develop new methods would decrease the long-term costs of interdiction, improve efficacy, and reduce risk.

Expand capacity of barrier methods for BTS and other invasive species. Develop and use more cost-effective BTS barriers systems that may permanent or temporarily deployed. Develop cost-effective barrier technologies (both physical and chemical) that keep snakes from entering cargo and for use in large- and small-area control efforts.

Develop methods for reducing the risk of transporting amphibians and lizards. New technologies should be developed for detecting and preventing lizard and frog movement in cargo.

Improve detection methods for rodents on vessels and in cargo. Rodents are difficult to detect, whether aboard vessels, in aircraft, or within cargo. Preventing rodents from entering ports or cargo is the most cost-effective measure for reducing transport of rodent species. NAVMED P-5010-8 is the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) and outlines preventative measures for rodent control on ships. This includes proper sanitation, pier-side inspections, rat guards, increased illumination, craft/vessel movement restrictions, glue boards, snap traps, and efforts to limit access points to the vessel, aircraft, or cargo. The information available on rodent prevention measures is more extensive for vessels than that of aircraft or cargo. Current control methods for rodents in cargo consist of anti-coagulant bait, snap traps, and sticky traps. Most efforts regarding rodent presence on vessels and in cargo remain in the control realm, while methods on rodent detection are underdeveloped.

Assign trained, uniformed USFWS personnel to law enforcement at commercial and military ports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, provide permits, provide education, provide assistance in handling and processing terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border.

8.7.4 Unintentional Pathway Recommendations

8.7.4.1 *Air Transportation*

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances departing Guam in both military and civilian sectors. Comply with 100% BTS inspection of

military and commercial aircraft departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via aircraft, and the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 that authorizes a cooperative program to control BTS outside its historic range. Representatives of USDA, the Department Commerce, DoD, and Interior; the CNMI; the Territory of Guam; and the State of Hawai'i, who comprise the BTS Control Committee (formed in May 1993), all advocate for 100% BTS inspection of aircraft leaving Guam.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances departing Saipan in both military and civilian sectors. For military and commercial aircraft, the BTS Technical Working Group Plan (2009) specifies 100% BTS outbound interdiction on Saipan and other areas where incipient populations may be evident in the future, such as Tinian and Rota where Guam-based military actions are proposed.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial aircraft, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes aircraft arrivals to the Hawai'ian Islands of Oahu, Maui, and Hawai'i from Guam and Saipan. Interdiction measures include inter-agency coordination, such as expanded communication networks to notify Hawai'ian airports and airfields of craft arrivals from Guam and Saipan that missed BTS inspection, and funding to increase inspection capacity for U.S.-bound aircraft departing from Saipan and Guam.

Expand the capacity of USDA-APHIS-WS canine teams for aircraft inspections on Guam. Current demand for canine inspections of aircraft arriving and departing Guam needs to be expanded to meet 100% BTS inspection policy for departing aircraft, as well as account for expected increase in air transportation activity due to the military relocation.

Enhance the capacity of canine teams in the CNMI for BTS inspections of aircraft on Saipan, Tinian, and Rota. Implementation of inspection capabilities for Saipan are necessary because Saipan receives much of its cargo from Guam and the other Mariana Islands receive most of their cargo from Saipan, and because of expected increased activity from military training and deployment missions and commercial travel. USDA-APHIS-WS canine inspections of aircraft departing Saipan need to be implemented to meet 100% BTS inspection policy for departing aircraft, and to meet expected increase in the island's air transportation activity due to the military relocation. USDA-APHIS-WS canine inspections for BTS on aircraft arriving on Tinian and Rota from Guam and Saipan are necessary to keep the islands BTS-free, protect the native ecology and the agricultural interests of each island, and to account for expected increased activity from military and commercial travel. Military training on Rota is expected to increase aircraft traffic, hence increasing the probability of species transport. Current canine inspections of aircraft operating on Tinian and Rota need to be created to meet 100% BTS inspection policy for departing aircraft, to inspect aircraft arriving from Guam or Saipan that missed BTS inspection at departure point, and to account for expected increase in the island's air transportation activity (arrivals/departures) due to the military relocation.

Increase aircraft inspections for BTS and other terrestrial vertebrate species during seasonal peaks in military and commercial air transportation to and from Guam. More commercial flights depart Guam during the summer months, which may reflect peak tourist season, school summer recess, and summer holiday travel (Vice and Pitzler 2008). During these seasonal peaks, aircraft departing Guam, when inspected for BTS, should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Assign at least one USFWS personnel at military and commercial airports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, assist in the handling and processing of terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border should an aircraft-related incidence occur.

Conduct an internal and external inspection on military aircraft arriving to Guam. Military aircraft carrying classified cargo are exempt from inspection procedures by non-military entities and “enjoy sovereign immunity from interference by all other governmental authorities” including police, health, customs, and immigrations (U.S. Navy 2009b; Hart 2010), compromising biosecurity efforts undertaken to prevent further introductions of unwanted terrestrial vertebrate species to Guam. Certain military aircraft arrivals to Guam warrant internal and external inspections. Military aircraft arriving from locations with known IAS for which Guam is at high risk of receiving need to be inspected either before departing those locations (ideal situation) or immediately on arrive to Guam. Military aircraft that arrive to Guam from Asian ports such as those in Japan, China, and Korea should be inspected for species of mice, birds, and amphibian and reptile species trapped within cabin and cargo compartments or hitchhiking externally in wheel well compartments.

Improve rapid response capabilities at military and commercial airports on Guam, Hawai'i, Chuuk, Palau, Pohnpei, Yap, Kosrae, Marshall Islands and CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent the opportunity for introduced pest species to become established. Rapid response takes place at the border and post-border, at levels ranging from federal to local community involvement. Monies have already been appropriated for rapid response capabilities in the region, but the efforts implemented remain ineffective for dealing with terrestrial vertebrate species. Conduct a review of the current process for rapidly responding to border and post-border detections and casual sightings. Apply BMPs to refine and improve protocols and coordination of efforts. Conduct practice drills to hone response skills and test communications network. Expand the communication network system. Improve processes for notifying jurisdictions receiving high-risk aircraft from Guam (e.g., contains high risk cargo, missed BTS inspection before departure). Provide information on specific species like BTS to military and civilian residential communities adjacent to airports and military airfields, and allow the public to be part of rapid response programs, with involvement levels ranging from organized community watch-groups to individuals calling into a pest species hotline for immediate reporting of a sighting.

Perform internal inspections on all military aircraft during washdown procedures, both general and retrograde washdown, to detect and capture terrestrial vertebrate species located within the aircraft.

Military procedures for washing aircraft focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within an aircraft being washed go undetected. This includes aircraft involved in routine flight operations, aircraft transported as cargo items (via air or water transport), or those staged upon a departing aircraft carrier.

Minimize distance between washdown facilities (general and retrograde wash facilities) and airports of embarkation. Military aircraft departing from a washdown facility (general or retrograde) should cover a minimal distance to port of embarkation to prevent post-contamination prior to loading. For example, the final ROD (2010) states that after a training event on Guam is complete, “vehicles and equipment will return to the wharf or airfield” to be washed and inspected prior to being loaded on to the ships or flying off-island.” However, neither washdown facility locations, nor type (general or retrograde) at military airports and airfields like Andersen AFB, the NWF, and Orote Airfield are specified.

Implement measures to control terrestrial vertebrate species at and around washdown facilities. Terrestrial vertebrate species control efforts at washdown facilities are needed to prevent post-contamination of washed aircraft staged for loading, and to reduce populations of pest species in surrounding areas. Control efforts include constructing USDA-APHIS-WS-approved species-proof barriers around secured washing and staging areas, collection/screening of wastewater run-off, and implementation of trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species. Implementation of snake trapping and snake barriers will not assist in address issues with other vertebrate taxa such as flighted birds, amphibians, and some mammals and of course suggested measures to protect against vertebrates will also not reduce risk from other taxa groups such as invertebrates.

Military retrograde and general washdown procedures for aircraft departing Guam for the Hawai’ian Islands are not specifically for detecting hitchhiking terrestrial vertebrate pest species. Because BTS presence is likely missed by external washing and inspection procedures for aircraft departing Guam, transporting these aircraft does not comply with 100% BTS inspection of military and commercial aircraft departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via aircraft to other U.S. locations. Further, other terrestrial vertebrate pest species are not targeted, and they are likely missed during inspections.

Conduct inspections on commercial/private aircraft arriving to Guam, and those departing Guam that do not meet the BTS criteria for screening exemption. Currently, aircraft departing Guam are typically inspected externally for BTS, using visual and/or USDA-APHIS-WS canine Inspection techniques. Internal aircraft inspections (both arrivals and departures) do not typically occur, even when departing aircraft fail to meet criteria for exemption, for example, if the aircraft has been on the ground more than 3 hours, was left on the tarmac overnight, or is dispatched immediately for emergency and medical needs. Further, there are currently no aircraft departure screenings to detect terrestrial vertebrate species other than BTS. Inbound commercial and private aircraft are rarely inspected, internally or externally.

Examples include planes pulled into service after being in storage or in a repair facility, privately owned or leased aircraft, charter planes, and airfreight aircraft.

Provide a pre-clearance staging area for all military aircraft requiring immediate departure from Guam. Urgent military missions such as search and rescue (CSAR) and medical evacuation (MEDEVAC), immediate humanitarian efforts, or special mission deployments by the military will not be delayed to accomplish a BTS (or other terrestrial vertebrate species) inspection. A USDA-APHIS-WS terrestrial vertebrate species-proof staging area can be built and staffed to accommodate aircraft solely for immediate departure at Andersen AFB and applicable airfields on Guam, including sustained funding and implementation of control measures in and around staging areas such as trapping, spotlight searches, bait stations, and USDA-APHIS-WS canine team inspections for BTS, trapping and baiting for rodent species, and toad-proof barriers for anurans.

Provide USDA-APHIS-WS-approved temporary barriers for military and commercial aircraft left on the tarmac overnight. The greatest concern regarding aircraft parked on the tarmac overnight is the potential for terrestrial vertebrate species to access wheel wells and baggage holds (Vice and Pitzler 2008). Temporary barriers minimize the probability of terrestrial vertebrate species access to stationary aircraft left unattended overnight. This recommendation would be fulfilled through the re-authorization of the BTS Control and Eradication Act of 2004 (H.R. 3479).

For military and commercial sectors, formalize a notification process for destinations receiving aircraft from Guam that missed BTS inspection, including creating increased capabilities for responding to notifications. The system that currently exists for notifying destinations that an aircraft departed from Guam without a BTS inspection is an informal process and is not necessarily followed. When notification is made, there is typically a limited response; locations do not have the ability to respond to those arriving aircraft. While the DoD has a more formal notification process, destination locations still lack response capabilities (Vice, personal communication).

Coordinate biosecurity among contractors (military and civilian) involved in regional military air transportation. Entities involved in air transportation activities need to be included in biosecurity measures to ensure regulatory compliance, close gaps in inspection processes, and improve effectiveness of inspection efforts. For example, the military recently solicited for Transient Alert Aircraft services on Andersen AFB, Guam (30 June 2010), to perform numerous and diverse services, including aircraft movement and operations, safety management, special events support, emergency and training support, requested vehicle escorts, and management of publications and forms (U.S. Air Force 2010). Mitigation includes establishing agreements to facilitate inspections, determining communication networks, and implementing efficient biosecurity measures.

Expand control efforts to reduce BTS populations around commercial and military airport and airfield facilities. Reducing pest populations at military and commercial aircraft arrival and departure points reduces the probability of contamination from surrounding sources, and limits the attraction by predatory species to sources of prey. Control efforts, which are already being performed for BTS,

warrant expansion of efforts, including ground searches, area-wide trapping and suppression efforts, upkeep of perimeter fencing, and fence line searches.

Expand control efforts to reduce rodent populations around commercial and military airport and airfield facilities. Control of rodents is usually done on a response-basis such that detected rodent evidence will typically illicit the response to trap. Response to rodents or rodent evidence detected (feces, evidence of gnawing) in airport buildings or the surrounding grounds should be immediate. Even a single mouse or rat species can endanger aircraft passengers and compromise aircraft operations by gnawing at cables and wiring (WHO/HQ 1995). The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes and standard operational control methods as practical ways of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, ports, and storage areas; however, stable, long-term funding for enforcement would be necessary.

Address military-related aircraft training and operations. Aircraft training exercises that use either improved (paved runway) or unimproved (unpaved landing sites) to practice landing/takeoff and air field support (including loading/unloading of fuel, munitions, cargo, and personnel), need to implement and manage biosecurity measures, such as those used for BTS (e.g., USDA-APHIS-WS approved snake-barriers, spotlight/hand-capture, and trapping) and rodents (e.g., trapping), as well as for species not usually targeted, such as geckos and frogs.

Facilitate training/education programs regarding terrestrial vertebrate pest species for inspectors. Train personnel to detect myriad species and provide continued education on species updates, such as changes to regulations and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border and border screenings.

There are limited methods for dealing with terrestrial vertebrate pest species detected aboard aircraft. Biosecurity measures for responding to incidents of terrestrial vertebrate pest species aboard aircraft are limited; for rodents, snake species, and insects, aircraft fumigation is an option, but it does not guarantee finding or exterminating such species detected within the aircraft, and it does not specifically target amphibian species.

Expand capacity at Guam's airports and airfields (military and commercial) to conduct comprehensive terrestrial vertebrate pest species inspections of arriving and departing aircraft. Inspections at operational airports and airfields on Guam may not adequately detect a terrestrial vertebrate invasive species moving in aircraft for various reasons like outdated equipment, understaffing, or inadequate regulation and enforcement.

Agricultural inspections at operational airports and airfields on Guam may not adequately detect a terrestrial vertebrate invasive species moving in aircraft. Agricultural inspections focus on plant pests and diseases such as plant pathogens and insect species, hence they do not directly inspect for, or report on, terrestrial vertebrate pests.

Rapid response measures for aircraft detections need to address terrestrial vertebrate pest species in addition to BTS. Rapid response is necessary for preventing species spread at the border and post-border via responses to species sightings. Rapid response measures for BTS are insufficient for responding to and preventing introductions of other terrestrial vertebrate species like frogs and rodents. In a more ideal world there would be response teams for each taxa group, but its unlikely that this can be achieved. Micronesia and Hawai'i currently do have a regional response team of highly training IAS responders who's training has been based on one taxa group, alien snakes but it should be clear that that training while focused on alien snake ED and RR also took into consideration the reality of the situation and therefore was for many years provided in a broadened manner so that trained responders could in fact support response actions to various taxa. This was done in part since the reality is that for most of the islands of Micronesia, the same responders will be call on for most taxa so as much as possible the alien snake training was conducted with the understand of a board array of concepts and tools needs to be addressed as team members will likely participate in responses to multiple taxa groups. And this in fact has happened and will continue to happen. The regional response team has supported response and detection work on a variety of snake species as well as lizards. Ultimately much of the underlying components of a response situation will in fact be standardize (or should be) and with appropriate field leadership and some individuals to lead the specific field activities modified for the correct taxa group then successful responses can be mounted across taxa groups by the same core set of well trained responders. Incident command structure is what the alien snake team used in the past to set up and conduct its field work and all responses regardless of taxa group should be following the same or similar format adjusted as needed for the specifics of that group. This flexibility is in fact part of the core concept of ICS training. What the lacking is training for more individuals, especially for the non-U.S. jurisdictions and dedicated leadership or coordinators. The ability to training additional staff for ED and RR work is readily available if courses can be provided on site (within the various jurisdictions). Coordination and leadership for response activities could come from a variety of sources and it may be worthwhile to utilized the emergency response planning documents prepared by the RRT Coordination office in conjunction with each jurisdiction as these existing materials will provide a guideline for how best to develop a more generic response capacity for the region. Additionally, IS coordinators for each jurisdiction as well as a region IS position would greatly enhance the ability to respond effectively to expected incursions of IAS throughout the region.

Expand financial resources in the CNMI (Saipan, Tinian, Rota primarily) to maintain expensive control programs. Efficient detection and prevention of introductions of terrestrial vertebrate species depends on biosecurity measures implemented and the resources allocated to accomplish them, such as border inspections, control and eradication efforts, and rapid response programs. For example, lack of funds to purchase mice for BTS trapping efforts on Tinian create a risk in delaying or ceasing control/eradication efforts (T. Castro, K-9 Dog Handler, BTS Program, CNMI, USDA 2010).

Communication is inadequate between the military and BTS inspection officials on Tinian to allow for proper inspections of aircraft associated with military training to occur. Develop effective SOPs for communication between groups that promote formalized processes for inspecting all aircraft arriving on Tinian from Guam.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor USDA-APHIS-WS-approved staging areas.

8.7.4.2 Water Transportation

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels departing Guam in both military and civilian sectors. Comply with 100% BTS outbound interdiction for vessels departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS from Guam, and the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 that authorizes a cooperative program to control the BTS outside its historic range. Representatives of USDA, the Department of Commerce, DoD, and Interior; the CNMI; the Territory of Guam; and the State of Hawai'i, comprise the BTS Control Committee (formed in May 1993), advocate for 100% BTS inspection of vessels leaving Guam.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels departing Saipan in both military and civilian sectors. For military and commercial vessels, the BTS Technical Working Group Plan (2009) specifies 100% BTS outbound interdiction on Saipan and other areas where incipient populations may be evident in the future, such as Tinian and Rota, where Guam-based military actions are proposed.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial vessels, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes vessels arriving to Hawai'ian Islands like Oahu, Maui, and Hawai'i from Guam and Saipan used as commercial, military, and military-contracted cargo and barge shipping vessels, and vessels used for military training and mission deployment. Interdiction measures include inter-agency coordination, such as expanded communication networks to notify Hawai'ian seaports of vessel arrivals from Guam and Saipan that missed BTS inspection; funding to increase inspection capacity for U.S.-bound vessels departing from Saipan and Guam; and pre-clearance arrangements with Hawai'ian port officials, both military and commercial.

Expand the capacity of USDA-APHIS-WS canine teams for vessel conveyance inspections on Guam. Current demand for canine inspections of ocean vessels arriving and departing Guam needs to be expanded to meet 100% BTS inspection policy for departing vessels, as well as account for expected increase in water transportation activity due to the military relocation.

Enhance canine teams in the CNMI for BTS inspections of vessels on Saipan, Tinian, and Rota. Implementation of inspection capabilities for Saipan are necessary because of BTS presence on the island, because Saipan receives much of its cargo from Guam and the other Mariana Islands receive most of their cargo from Saipan, and because of expected increased activity from military training and

deployment missions and commercial travel. USDA-APHIS-WS canine inspections of aircraft departing Saipan need to be implemented to meet 100% BTS inspection policy for departing aircraft, and to meet expected increase in the island's air transportation activity due to the military relocation. USDA-APHIS-WS canine inspections for BTS on vessels arriving Tinian and Rota from Guam and Saipan are necessary to keep the islands BTS-free, protect the native ecology and the agricultural interests of each island, and to account for expected increased activity from military and commercial travel. Military training on Rota is expected to increase aircraft traffic, hence increasing the probability of species transport. Current canine inspections of vessels operating on Tinian and Rota need to be created to meet 100% BTS inspection policy for departing vessels, to inspect vessels arriving from Guam or Saipan that missed BTS inspection at departure point, and to account for expected increase in the island's vessel transportation activity (arrivals/departures) due to the military relocation.

Assign at least one USFWS personnel at military and commercial seaports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, assist in the handling and processing of terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border should a vessel-related incidence occur.

Conduct an internal and external inspection on military vessels arriving to Guam. Military vessels "enjoy sovereign immunity from interference by all other governmental authorities" including police, health, customs, and immigrations (U.S. Navy 2009b; Hart 2010), compromising biosecurity efforts undertaken to prevent further introductions of unwanted terrestrial vertebrate species to Guam. Certain military vessel arrivals to Guam warrant internal and external inspections. Military vessels arriving from Saipan where an incipient BTS population exists need to be screened by USDA-APHIS-WS canine teams on Guam if the vessel was not inspected at its departure point, especially if the vessel is transient and departs Guam without a BTS inspection (i.e., for emergency/medical use). Military vessels that arrive to Guam from Asian ports such as those in Japan, China, and Korea should be inspected for species of mice, birds, and amphibian and reptile species hitchhiking within cabin and cargo compartments.

Continue to expand rapid response capabilities at military and commercial seaports on Guam, Pohnpei, Palau, Yap, Chuuk, Kosrae, Marshall Islands and the CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent the opportunity for introduced pest species to become established. Rapid response takes place at the border and post-border, at levels ranging from federal to community involvement. The expansion of capabilities of rapid response programs would result in an increase in training and rapid response skills, while expanding communication networks. In addition, these programs provide information on species of concern, like BTS, to civilian and military, including residential communities, adjacent to seaports, and allows the public to be part of rapid response programs, with involvement levels ranging from organized community watch-groups to individuals calling into a pest species hotline for immediate reporting of a sighting.

Perform internal inspections of vessels during washdown procedures, both general and retrograde washdown, to detect and capture terrestrial vertebrate hitchhiking species. Military procedures for

washing vessels focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within a vessel go undetected. This includes vessels involved in routine military training and operations, military deployment missions, and vessels staged as cargo for transport. Coordinate with the on-site commanders to supervise washdown facilities and inspection areas. For general washing, the 36th ABW may provide portable high-pressure washers and a cleaning area, and future plans include repair of a 36 Transportation Squadron vehicle washing area (U.S. Navy 2005b).

Minimize distance between washdown facilities (general and retrograde wash facilities) and seaports of embarkation. Military vessels departing from a washdown facility (general or retrograde) should cover a minimal distance to port of embarkation to prevent post-contamination prior to loading. For example, for military embarkation operations, "...a cargo staging and vehicle washdown area would be provided in proximity, but not adjacent to, the wharf" (U.S. Navy 2009a, Vol. 1, pg. 2-11, section 2.2.3.1), and the final ROD (2010) states that after a training event on Guam is complete, "vehicles and equipment will return to the wharf or airfield" to be washed and inspected prior to being loaded on to the ships or flying off-island." However, washdown facility locations, or type (general or retrograde), are not specified by the military.

Implement measures to control terrestrial vertebrate species at and around washdown facilities. Terrestrial vertebrate species control efforts at washdown facilities are needed to prevent post-contamination of washed vessels staged for loading, and to reduce populations of pest species in surrounding areas. Control efforts include constructing USDA-APHIS-WS-approved species-proof barriers around secured washing and staging areas, collection/screening of wastewater run-off, and implementation of trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species.

Conduct inspections on commercial and private vessels arriving to and departing Guam. Comply with 100% BTS outbound interdiction for vessels departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS, by conducting inspections on vessels departing Guam. Commercial and private vessels are rarely inspected, internally or externally. Such vessels include but are not limited to boats used for fishing, recreational sailing, and those in the charter industry. Expand the use of visual and USDA-APHIS-WS canine team inspections. Expand vessel inspections to include terrestrial vertebrate species other than BTS and rodents, and conduct internal vessel inspections for rodent, snake, and amphibian populations.

Provide a pre-clearance staging area for all military vessels requiring immediate departure from Guam. Compliance with 100% BTS inspection of vessels leaving Guam is not achieved if urgent military missions, immediate humanitarian efforts, or special mission deployments by the military depart without delay for a BTS (or other terrestrial vertebrate species) inspection. Such vessels include but are not limited to amphibious vessels like Landing Craft Air Cushions (LCAC), patrol boats such as PACV/ACV, PBL, PBR, and PCF, and rigid inflatable boats. A USDA-APHIS-WS terrestrial vertebrate species-proof staging area can be built and staffed to accommodate applicable vessels for immediate dispatch from

Guam at seaports and applicable beach launch sites (for amphibious craft), including sustained funding and implementation of control measures in and around staging areas such as trapping, spotlight searches, bait stations, and USDA-APHIS-WS canine team inspections for BTS, trapping and baiting for rodent species, and toad-proof barriers for anurans.

Provide USDA-APHIS-WS-approved temporary barriers for military and commercial vessels staged on land overnight. Vessels staged overnight on land for storage, cleaning, repair, or special deployment offer hitchhiking terrestrial vertebrate species access to external and internal compartments and storage holds. Temporary barriers minimize the probability of terrestrial vertebrate species access to vessels left unattended overnight.

Coordinate biosecurity among contractors (military and civilian) involved in regional military water transportation. Entities involved in water transportation activities need to be included in biosecurity measures to 1) ensure regulatory compliance, 2) close gaps in inspection processes, and 3) improve effectiveness of inspection efforts. Mitigation includes establishing agreements to facilitate inspections, determining communication networks, and implementing efficient biosecurity measures.

Expand control measures to reduce pest species populations around commercial and military seaport and beach access point facilities. Reducing pest populations at military and commercial seaports and beach access points where vessels arrive and depart reduces the probability of contamination from surrounding sources. Efforts include but are not limited to ground searches, upkeep of perimeter fencing, implementing USDA-APHIS-WS-approved terrestrial vertebrate species-proof barriers, and specific trapping for species of rodents and snakes. When rodents or rodent evidence (feces, evidence of gnawing) is found in buildings or the surrounding grounds, immediate control steps must be taken. Even a single mouse or rat species can endanger the health of ship passengers and compromise vessel operations by gnawing at cables and wiring. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, ports, and storage areas, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement would be necessary.

Address military-related vessel training and operations. Vessels used in training exercises at seaports or at beach access points require internal and external inspections for terrestrial vertebrate species, especially BTS. Further control measures should also be implemented at least for BTS (e.g., USDA-APHIS-WS-approved snake-barriers, spotlight/hand-capture, and trapping) and rodents (e.g., trapping, baiting), as well as for species not usually targeted, such as geckos and frogs.

Facilitate training/education programs regarding terrestrial vertebrate pest species for inspectors. Train personnel to detect myriad species and provide continued education on species updates, such as changes to regulations and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border and border screenings.

Increase vessel inspections for BTS and other terrestrial vertebrate species during seasonal peaks in military and commercial water transportation to and from Guam. This recommendation addresses seasonal increases in military vessel traffic, private vessel traffic, and commercial ship and barge traffic. During these seasonal peaks, when vessels departing Guam are inspected for BTS, they should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Military retrograde and general washdown procedures for vessels departing Guam are not specifically for detecting hitchhiking terrestrial vertebrate pest species. Foremost, because BTS presence is likely missed by external washing and inspection procedures for departing vessels, movement of these vessels does not comply with 100% BTS inspection policy, as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via vessels.

Agricultural inspections at operational seaports on Guam may not adequately detect a terrestrial vertebrate invasive species moving in vessels. Agricultural inspections focus on plant pests and diseases such as plant pathogens and insect species, and do not directly inspect for or report on terrestrial vertebrate pests.

Expand capacity at Guam's seaports (military and commercial) to conduct comprehensive terrestrial vertebrate pest species inspections of arriving and departing vessels. Inspections at operational seaports on Guam may not adequately detect a terrestrial vertebrate invasive species moving in a vessel because of outdated equipment, understaffing, or inadequate regulation and enforcement.

Develop new methods and further develop current methods for detecting and controlling terrestrial vertebrate pest species aboard vessels. There are limited methods for dealing with terrestrial vertebrate pest species aboard vessels. Biosecurity measures aboard vessels include adhering to good sanitation practices (e.g., proper food storage and garbage disposal), routine checks by crewmembers (e.g., for rodent droppings, cast skin from ecdysis), screening all cargo coming aboard (e.g., on Guam and Saipan for BTS), and active trapping and baiting programs. Methods implemented must target multiple species. For example, methods that specifically target rodents do not guarantee effectiveness on other pest species such as amphibians.

Rapid response measures for vessel detections need to address terrestrial vertebrate pest species in addition to BTS. Rapid response is necessary for preventing species spread at the border and post-border via responses to species sightings. Rapid response measures for BTS are insufficient for responding to and preventing introductions of other terrestrial vertebrate species like frogs and rodents.

Expand financial resources in the CNMI (Saipan, Tinian, Rota primarily) to maintain expensive control programs. Efficient detection and prevention of introductions of terrestrial vertebrate species depends upon biosecurity measures implemented and the resources allocated to accomplish them, such as border inspections, control and eradication efforts, and rapid response programs.

Improve protocols for inspecting the holds of commercial and military ships. Transit times for ships sailing between Guam and Saipan are less than 1 day, increasing the probability of survival for species

stowed aboard. Ship inspections are inadequate and performed perfunctorily due to time and staffing constraints. Regulations only apply to cruise ship vessels but not routinely and not entirely.

Conduct USDA-APHIS-WS inspections on vessels staged at Guam Shipyard facilities. There is no mention of impact or mitigation measures for the increased activity at the Guam Shipyard as a result of military activity. The Guam Shipyard provides vital shore industrial support, repair, maintenance, overhaul, and dry-docking services to military vessels such as those of the Military Sealift Command, Coast Guard, and local federal agencies on island. They provide authorized repair to Jones Act commercial ships such as Matson Navigation and Sealand Services, and shore support services to GovGuam agencies. Guam Shipyard has facilities and capabilities not found elsewhere in the Western Pacific, including a foundry, the largest motor rewind facility in the Pacific, a special building for environmentally controlled sandblasting and painting, micro-miniature circuit board repair, corrosion control, and an industrial laboratory. It is the only facility in the Western Pacific certified by the U.S. Department of Transportation to perform re-certification requirements on breathing air and high pressure air cylinders. With these amenities and services, biosecurity measures must be implemented and maintained at Guam Shipyard. Such measures would include building and maintaining perimeter fencing and vertebrate-proof staging areas, using USDA-APHIS-WS canine team inspections (e.g., of facilities, stored vessels), adhering to proper sanitation and material storage procedures, enforcing noncompliance such as unpermitted actions like the loading of cargo (Aguon 2009), and continued trapping (e.g., rodents, snakes, geckos).

Increase inspection frequency and quality for commercial shipping vessels from the major shipping lines inbound to Guam. Commercial shipping vessels calling on the Port of Guam are typically cleared rapidly, within 30 minutes, by GCQA (Merefalen, personal communication), with emphasis on regulated waste inspections and reviewing cargo manifests. Both the number and thoroughness of inspections need to be increased, with expanding capacity to randomly inspect vessels without delaying shipping schedules. This requires increased staffing and training of inspection personnel and strong communication between port officials, inspection agents, and vessel owners/operators.

Require the use of rat guards on mooring lines. Military and commercial vessels at seaport facilities in the Micronesia Region should be required to use rat guards on mooring lines. Currently, rat guards are used at ports with known rodent infestations. Internal Health Regulations only require rat guards to be in place where plague is endemic to the port (Regulation 40-12 SECNAVINST 6210.2A AFR 161-4, DoD, 1992, Section 9, p 2). However, ships may harbor insidious rodent populations, or unknown rodent infestations may occur at seaports; therefore, rat guards should be made a standard requirement.

Rat guards on mooring lines may not prevent BTS from ship access. Use of rat guards by vessels in port may not prevent BTS or other arboreal species access to the ship via mooring lines. The maximum diameter of a rat guard is 122 centimeters (48 inches) or 96 centimeters (38 inches) (NAVMED P-5052-26 2008, BUMED Instruction 6250.14A Feb 16, 2001).

Amphibious craft laydown locations and facilities for storing, maintaining, and deploying amphibious vehicles (chapter 5, FEIS/FOEIS 2010) should incorporate control efforts to prevent transport and

spread of terrestrial vertebrate hitchhikers that could contaminate vessels. Amphibious vehicle laydown areas are required to store, wash down, maintain, and deploy amphibious vehicles, such as landing craft and amphibious assault vehicles. LCACs would also utilize this area. Specific components of the laydown area include two new concrete ramps, which are similar to recreational boat ramps seen at private marinas, paving for amphibious vehicle parking, personal vehicle parking, staging equipment, amphibious vehicle washing, four support buildings for administration, small boat storage, and maintenance

http://guambuildupeis.us/documents/final/volume_1/Vol_01_Ch02_Overview_of_Proposed_Actions.pdf.

There are proposed to be as many as 4 LCACs, 14 amphibious assault vehicles, and 8 small reconnaissance boats permanently based in such an area. Recommendations for amphibious craft laydown locations include constructing and maintaining USDA-APHIS-WS-approved terrestrial vertebrate species-proof barriers, implementing measures to control and reduce pest populations within buildings, in stored/staged vehicles, and the on surrounding grounds. The governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources; however, stable, long-term funding for enforcement would be necessary.

Implement protocol for preventing terrestrial vertebrate species transport via amphibious vehicle operation/use or transport. Amphibious military vehicles are both terrestrial and marine vessels, and as such, are capable of transporting and spreading terrestrial vertebrate hitchhikers over land and water (U.S. Navy 2005c). Amphibious vehicles include, but are not limited to, amphibious armored personnel carriers, amphibious assault vehicles, amphibious land rovers, amphibious bikes and ATVs, amphibious trucks and barges such as lighter, amphibious resupply, cargo vehicles, hovercrafts, and LCAC (Figures 11-3a to 3c). The amphibious task force would require an area to load and unload personnel, vehicles, and other cargo. Equipment cleaning and inspections associated with bio-hazard and customs requirements would also occur in this area. These operations are collectively referred to as waterfront embarkation. The amphibious ships would be berthed at Victor Wharf (the wharf traditionally assigned for amphibious shipping in Apra Harbor). A new port operations building would be constructed at the wharf, and a cargo staging and vehicle washdown area would be provided in proximity to but not adjacent to the wharf. Washdown facilities should follow biosecurity protocol (e.g., routine inspection of facilities and equipment staging areas, collection/screening of wastewater run-off, perimeter fencing, lighting for night activities, USDA-APHIS-WS-approved vertebrate-proof staging areas).

Figures 11-3a to 11-3c:

Types of Amphibious Vessels and Vehicles



a. LARC-V), b. AAV, c. LCAC

Sources: a. Guide to South Padre Island; b. Defense Industry Daily, LLC; c. .U.S. Navy, Mark Patterson II

Implement terrestrial vertebrate species inspection procedures for vessels with ramp-loading capabilities. Vessels capable of loading at piers, wharves, or beaches via a ramp with direct access to the hull are used in support of military activity to transport equipment, troops, tracked or wheeled vehicles, and amphibious crafts to beachheads or piers via a ramp with direct access to the hull. These include Roll-on/Roll-off Ships, Landing Craft Utility vessels (Figures 11-4a to 4d), Joint High Speed Vessels (JHSV), and LCAC. Hitchhikers can gain access to these vessels when ramps are deployed, or from the cargo load.

Figures 11-4a to 11-4d: Landing Craft Utility Vessels With Direct Access To Hull From Beach



4.a.



4.b.



4.c.



4.d.

Sources: a. Lawrence Livermore National Laboratory; b. US Air Force, Staff Sgt. D. Myles Cullen; c. US Navy, 1st Class David A. Levy; d. US Navy, 2nd Class Bradley J. Sapp

Implement terrestrial vertebrate species inspection procedures for high-speed-military vessels operating in the Micronesia Region. HSV serve as Logistic Support Vessels, provide a technically advanced and highly capable platform for deployment of troops, equipment, and vehicles, and are advantageous because of their payload capacity, high-speed transport, and distance capabilities. Such vessels include the HSV Westpac Express catamaran (Marine Corps) operating in the area of Guam, Okinawa, and Japan (Tack 2010), HSV, JHSV, and LCAC (Figures 11-5a to 5d) The high speeds mean forces and cargo reach destinations in a shorter time with shorter intervals between trips. Shorter transit times equates to increased probability of species survival during transport, the long-distance

capabilities increase the range of potential spread of species, and increased payload capacities along with greater diversity in types of cargo transported equates to a higher probability of species presence.

Figures 11-5a to 11-5d: High Speed Transport Vessels



5.a.



5.b.



5.c.



5.d.

a. HSV/TSV cutaway, b-c. TSV-1X Spearhead, d. HSV-2, l. Westpac Express
Source: Defense Industry Daily, LLC

Implement USDA-APHIS-WS inspections for aircraft carriers arriving and departing Guam. Given their ability to embark different combinations of aircraft, carriers are vessels that are highly flexible naval platforms. If the Port of Guam becomes a home port for an aircraft carrier fleet and/or is a port of call for visiting/transiting aircraft carrier activity in the Micronesia Region, USDA-APHIS-WS terrestrial vertebrate inspections on both arriving and departing carriers should be conducted, including staged equipment. Spell out criteria for inspection process; comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to ocean vessels departing Guam, and inspect arriving carriers when the last port of call was in a country of concern.

8.7.4.3 Air Cargo

8.7.4.3.1 Military Air Cargo

Recommendations in the military air cargo pathway focus on cargo itself as a mode of species transport, including how the cargo is packed and handled, the cargo conveyance (e.g., crate, container, pallet, box, individual items), and the associated packing material used. Overlap occurs between commercial and military sectors. Military air cargo includes cargo transported for the military via both commercial (military-civilian contracts) and military routes. For example, military-civilian contracted air shipments include cargo for military use that is ordered and received by commercial businesses for pickup by military personnel or military-civilian subcontractors. Military transport includes systems owned by, contracted for, or controlled by DoD; for example, U.S. Transportation Command (USTRANSCOM) (DoD 2003, 2004). Military air cargo poses a risk of terrestrial vertebrate species transport because transport typically involves short travel durations (increased species survival), species harborage is climate controlled (aircraft cabins), types of cargo are considered high-risk because of their use (e.g., personnel field gear and training equipment, vehicles), and varying inspection procedures (arrivals versus departures, immediate versus pre-scheduled flights).

Expand capacity of the USDA-APHIS-WS canine program on Guam to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection policy for military air cargo departing Guam, per the NDAA, Public Law 110-181, Section 314.

Establish capacity of the USDA-APHIS-WS canine program on Saipan to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection of military cargo departing Saipan, per the NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Establish capacity of the USDA-APHIS-WS canine program on Tinian and Rota to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection policy for military air cargo departing Tinian and Rota, per the NDAA, Public Law 110-181, Section 314 requiring interdiction for areas where incipient populations may be evident in the future.

Implement rapid response procedures for terrestrial vertebrate pest species involving military air cargo shipments and transport, as for BTS. No response networks or capabilities exist for species other than BTS, either on Guam or the CNMI. Train personnel involved in the cargo transport and inspection processes about the importance of pest interdiction at the border. Include skills training for identifying, capturing, and containing detected species. Expand capacity for initiating rapid response efforts at the border, as well as post-border, and create the capacity to perform random inspections of cargo imports as a preventative measure. Develop clear response plans with specific goals and objectives, as well as roles and responsibilities.

Conduct USDA-APHIS-WS canine inspections for BTS on Tinian and Rota of inbound military air cargo from Guam and Saipan. Prevention is touted as the most cost-effective measure in biosecurity efforts against biological invasion. To prevent the insidious spread of BTS to Tinian and Rota via the transportation of military air cargo shipments during proposed relocation, adherence to the 100% BTS outbound inspections by USDA-APHIS-WS canine teams on Guam and Saipan should be coupled with inbound USDA-APHIS-WS canine inspections on Tinian and Rota for: 1) high-risk cargo items, 2) air cargo shipments that departed Guam and Saipan without a BTS inspection, 3) cargo conveyances that appear damaged, and 4) random checks for BTS and other terrestrial vertebrate pest species. Supporting military cargo that is air shipped to Tinian and Rota from Guam or Saipan in advance of the training exercise is subject to the routine cargo inspection processes conducted on Tinian and Rota for inbound cargo. Military air cargo shipment arrivals to Tinian and Rota need to be thoroughly checked by CNMI Quarantine Inspectors to ensure that a BTS inspection was conducted on Guam and/or Saipan, and shipments are not harboring other terrestrial vertebrate pest species such as mice or frogs (U.S. Navy 2005b). A USDA-APHIS-WS-approved terrestrial vertebrate species-proof barrier used at entry points on Tinian and Rota for staging inbound military air cargo for inspection would help prevent unwanted species introductions.

Military cargo for airdrop on Saipan, Tinian, and Rota warrant thorough USDA-APHIS-WS canine inspection before departing Guam. Air-dropped military cargo departing Guam must be thoroughly cleaned and packed to facilitate USDA-APHIS-WS inspections for BTS and other terrestrial vertebrate pest species immediately prior to cargo loading or for staging in a USDA-APHIS-WS-approved area until departure.

Military procedures for cleaning gear and equipment used after training and field operations do not target terrestrial vertebrate pest species. Tent cleaning and inspection processes emphasize agricultural pest risks and do not adequately address the risk of transporting an invasive terrestrial vertebrate species. The emphasis on preventing the movement of invasive species associated with tent cities is on departure from Guam and BTS. No emphasis is placed on the risk of bringing new invasive species to Guam.

Current agricultural inspections of military air cargo do not target terrestrial vertebrate species. Inbound military air cargo is subject to routine inspection processes conducted by respective jurisdictions, like Guam and CNMI Customs and Quarantine Inspectors; however, agricultural inspections of military air-shipped cargo at military and commercial airports on Guam, Saipan, Tinian, and Rota focus on detecting plant pests and pathogens, and do not target terrestrial vertebrate species like BTS, frogs, and mice.

All military air cargo departing Saipan is to be cleaned, inspected, and immediately loaded on the aircraft for transport. Some items included in military cargo are high-risk due to their exposure to the outdoors, such as camping gear. To prevent the spread of BTS from Saipan, military air cargo that has been thoroughly cleaned should receive USDA-APHIS-WS canine inspection for BTS, and be loaded quickly and efficiently. Immediate loading of cargo reduces the risk of contamination of staged cargo.

Facilitate inspection of military air cargo shipments to improve BTS detection by USDA-APHIS-WS canine teams. Detection of BTS via canine and/or visual inspection is less effective if cargo is: 1) sealed within a conveyance container or crate, 2) complex, meaning it is not symmetrically shaped and stacked, or 3) inspected indoors with fumes from operating equipment, such as forklifts and delivery trucks. Further, BTS are less likely to be detected if the air cargo shipment is delivered to the port area and loaded, with minimal disturbance, directly onto the aircraft; the nocturnal habits of the BTS make this assumption important during daylight hours (Vice and Pitzler 2008).

Develop a labeling and tracking system for high-risk military air cargo. The ability to label and track high-risk military cargo shipments and their inspection history can streamline the transportation process and open avenues for implementing pre-clearance procedures while still maintaining biosecurity from terrestrial vertebrate pest species. High-risk cargo includes cargo originating from high-BTS-density areas, break bulk items, and outdoor items. Examples of high-risk military air cargo include construction equipment/materials, military equipment returning from a near-jungle bivouac, and cargo used in military training and deployment missions. Because outbound air cargo items originate from numerous sources throughout Guam (Vice and Pitzler 2008), a labeling and tracking system can help to identify air shipments that: 1) have been exposed to high-risk areas, 2) contain high-risk cargo items, and 3) have received official inspections, with information including the date and location of inspection, and name of inspector. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software.

Coordinate USDA-APHIS-WS agreements with military and non-military air cargo shipping agencies to prevent terrestrial vertebrate species transportation. Despite high levels of cooperation by most cargo export entities, USDA agents still make regular discoveries of previously unknown cargo handling processes or companies operating on or out of Guam, and there are several private companies on Guam that refuse to provide information on, and access to, outbound cargo for inspection purposes (Vice and Pitzler 2008). Expand capacity for inspections of cargo handling and packing facilities, with requirements for: 1) allowing frequent inspections (e.g., USDA-APHIS-WS canine, visual searches), 2) being subject to random inspections, 3) more stringent packing and handling procedures (e.g., inspections of complex-packed cargo prior to packing), 4) requiring use of vertebrate species-proof barriers, and 5) implementing long-term pest species control programs at facilities. Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, USDA-APHIS-WS canine inspection, and final loading. Require packers to individually handle and pack cargo items, especially those labeled as high risk. Provide personnel training and equipment for dealing with detections. It is recommended that air cargo be packed and tightly contained rather than remain as bulk. The probability of visually detecting species like BTS in complex cargo is lower than in cargo with few potential hiding places; for example, cargo that is symmetrically shaped, stacked, palletized, and tightly wrapped will have fewer hiding places than loosely packed, unpalletized bulk materials (Vice and Pitzler 2008).

The military personnel (734th Air Mobility Squadron on Andersen AFB) responsible for the packing process must be trained in proper species' identification of White List and Black List species. When building up pallets, Air Mobility Squadron personnel will handle and stack each box individually; therefore, unless a hitchhiker is already inside the box or crate when it arrives at the warehouse, it is likely to be detected. Address the issue of hitchhikers already packed when arriving at military warehouses by expanding inspection capabilities and increasing stringency in packing/handling of cargo; without this, there is a gap in biosecurity for the military sector, and an increase in the potential for transporting BTS from Guam. Aircraft operate 24 hours a day, but with the exception of trans-shipments originating outside of Guam, any cargo that is loaded onto an aircraft needs to be inspected by the USDA-APHIS-WS canine team.

Reduce site-specific BTS populations at military airports and airfields on Guam and Saipan to support interdiction measures. Implement BTS control efforts at military airport and airfield facilities and their surrounding areas. Such measures include but are not limited to spotlight searches and perimeter trapping. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating BTS habitat and food sources at cargo warehouses, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Reduce site-specific terrestrial vertebrate pest populations at military airports and airfields on Guam and Saipan. Similar to measures for BTS, specific control measures for terrestrial vertebrate pests like rodents, amphibians, and lizard species should be implemented around military air transportation activities to reduce local populations and decrease probability of species transport. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, seaports, and storage areas, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement would be necessary.

Expand capacity of USDA-APHIS-WS to implement BTS control measures at military airports and airfields on Guam during nighttime cargo loading and unloading. USDA-APHIS-WS should conduct BTS surveillance during nighttime military cargo loading, staging, and transferring activities. Further, USDA-APHIS-WS can coordinate BTS spotlight searches of staging areas, fence lines, and any tree lines/forest areas in proximity to runways/taxiways that are designated as drop zones. These areas should be targeted during inbound and exiting traffic times (U.S. Navy 2005a). According to Figure 2.1-1 of the FEIS, there are five aviation areas (three paved, two unpaved) where nighttime surveillance should be conducted.

All military air shipments inbound to the region containing agricultural items, both food and non-food, and construction equipment, should be inspected for terrestrial vertebrate pest species. Agricultural imports are known to transport terrestrial vertebrate pest species of amphibians and reptiles (Christy et al. 2007a; Christy et al. 2007b; Vice et al. In preparation), but inspections generally look for insects and plant pathogens, and do not target terrestrial vertebrate species. Shipments typically considered

elevated risk for accidental transport include ornamental plants, agricultural produce, aquaculture shipments (including eggs and fry), live Christmas trees, and construction materials and equipment (Vice et al. In preparation).

Air cargo, including military munitions, imported to islands in the Micronesia Region and departing from Guam and Saipan should receive USDA-APHIS-WS inspections for terrestrial vertebrate pest species. Pest species of snakes and frogs (Christy et al. 2007a; Christy et al. 2007b) have been found in military air cargo and munitions arriving from outside the Micronesia Region, indicating a need for inspections of such imports, given that agricultural inspections of imports do not target terrestrial vertebrate pest species. Departure of cargo and munitions from Guam and Saipan requires 100% BTS inspection by USDA-APHIS-WS canine teams. Inspections of imports should take place during daylight hours.

Expand control measures for amphibian and reptile species detected in military air cargo. There are limited control measures in use for amphibians such as frogs and toads, and reptiles like lizards and snakes that are transported in military air cargo. Expand the capacity for responding to, and controlling, detected amphibians and reptiles in air cargo shipments.

Facilitate military-civilian relations in the CNMI for inspecting military air cargo. Improve communication between the U.S. military and government officials on Saipan, Tinian, and Rota to allow for proper inspections of cargo associated with the military, especially cargo used in military training and field exercises. Expand capacity for inspecting military equipment and vehicles transported after field training. Develop and practice cleaning procedures for military cargo used in field training as a preventative measure. Implement and practice joint-agency rapid response capabilities.

All military personnel baggage transported as cargo to and from Guam and the CNMI on military planes and helicopters should be inspected for terrestrial vertebrate species. While regulations exist for the inspection of aircraft with a focus on BTS, checked military baggage inspection does not target terrestrial vertebrates. However, such inspection is needed because military personnel checked baggage transported via military air transportation may pose a high risk for smuggling species both in and out of the region.

Monitor if seasonal peaks occur for military air cargo transportation, and expand inspection capabilities during these peaks. Monitoring is needed if military air cargo increases in volume or frequency seasonally. If seasonal peaks do occur, inspection capabilities should be expanded during these peaks for the detection of BTS and other terrestrial vertebrates.

Monitor if seasonal peaks occur for military air passenger transportation, and expand inspection capabilities during seasonal peaks. Monitoring is needed if military air passenger transportation increases in volume or frequency seasonally. If seasonal peaks do occur, inspection capabilities should be expanded during these peaks for the detection of BTS and other terrestrial vertebrates.

Expand the inspection capabilities for military airfreight containers. Military containerized cargo is considered high risk because: 1) only a portion of containers are inspected; 2) some containers are permeable to snakes; 3) containers often sit open on the tarmac outside warehouses, providing opportunities to harbor hitchhikers; 4) climate-controlled containers may be of even higher risk because they may provide optimal environmental conditions to promote the survival of a hitchhiker; and 5) there are terrestrial vertebrate species such as snakes that can survive containerized air transport. Mitigation includes use of container scanners, which are currently not available on Guam, but are available on Saipan (currently in disuse because of insufficient funds).

Create and implement protocol to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. While air cargo such as mail is considered low-risk due to its contents and processing methods, the caveats of mail being less-containerized than freight and incurring a longer staging time while enough mail accumulates for a shipment, remain. Mail destined to other Micronesia Islands (Palau, Chuuk, Yap) is considerably higher risk for snake incursion. The potential for contamination of mail can be reduced by implementing a more-contained method of shipment for mail and continuing the same inspection process for the mail as freight, but not within the same warehouse nor within proximity to freight so that the potential for incursion is reduced.

Expand the capacity for pre-move inspections of military household goods at the residence. Andersen AFB's traffic management office has agreed that, as part of its pre-move inspections, it will identify any household shipments containing BTS high-risk materials. Arrangements are currently being made to train the inspectors to identify potentially high-risk items during these initial site visits. The proximity of each housing area to potential BTS habitat will be considered when determining risk factors. Specify the "pre-move" inspection plan components, such as training protocol, labeling procedures, how to estimate proximity to BTS habitat, and documentation of inspections.

Inspect military household goods before they are sealed in a conveyance. Detection probability decreases when household goods are packed, crated (in 4 x 8 x 8 foot wooden boxes), and sealed at the residence before being transported to the packing agent's facility (Vice and Pitzler 2008). Close/seal cargo containers staged overnight, or erect temporary barriers and employ control methods for terrestrial vertebrate species until containers are sealed for transport.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor staging areas.

Facilitate USDA-APHIS-WS inspections of military air embarkation procedures comparable to, compatible with, and co-located with, existing Andersen AFB operations for loading and unloading cargo to and from an aircraft. The Quarantine Regulations of the Armed Forces states that cargo is

subject to inspection by a representative of the USDA to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is considered part of the United States.

Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 318.13-8 and 318.13-10) of the Code of Federal Regulations states that cargo moving between Guam, CNMI, Hawai'i, and the continental United States is subject to agricultural inspection (7 CFR § 318). OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases ; however, terrestrial vertebrate species are not targeted, hence incidents may go unreported, and particular species may go undetected.

8.7.4.3.2 Commercial Air Cargo

Recommendations for commercial air cargo focus on the cargo itself as a mode of transport, with packing and handling influencing the risk level. Overlap occurs between military and commercial air cargo sectors. One example is that checked baggage of military personnel traveling as passengers on commercial flights is considered commercial air cargo. Commercial air cargo poses a risk of terrestrial vertebrate species transport because transport typically involves short travel durations (increased species survival), species harborage is climate controlled (aircraft cabins), inconsistencies exist in inspection equipment availability (e.g., lack of x-ray machines for agricultural inspections), there are insufficient numbers of inspectors, and the volume of airfreight material being moved is substantial.

Expand capacity of the USDA-APHIS-WS canine program on Guam to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection of air cargo departing Guam, per the NDAA, Public Law 110-181, Section 314.

Establish capacity of the USDA-APHIS-WS canine program on Saipan to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection policy for air cargo departing Saipan. Comply with 100% BTS inspection of cargo departing Saipan, per the NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Establish capacity of the USDA-APHIS-WS canine program on Tinian and Rota to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection policy for air cargo departing Tinian and Rota. Comply with 100% BTS inspection of cargo departing Tinian and Rota, per the NDAA, Public Law 110-181, Section 314 requiring interdiction for areas where incipient populations may be evident in the future.

Implement rapid response procedures for terrestrial vertebrate pest species involving air cargo shipments and transport, similar to those in place for BTS. No contact networks exist for species other than BTS either on Guam or the CNMI, and this is an area of much needed expansion for efficient and comprehensive response to species introduction.

Conduct USDA-APHIS-WS canine inspections for BTS on Tinian and Rota of inbound air cargo from Guam and Saipan. Because prevention is the most cost-effective measure in biosecurity efforts against biological invasion, preventing the insidious spread of BTS to Tinian and Rota via air cargo shipments requires strict adherence to the 100% BTS outbound inspections by USDA-APHIS-WS canine teams on Guam and Saipan; couple this with inbound USDA-APHIS-WS canine inspections on Tinian and Rota for: 1) high-risk cargo items, 2) air cargo shipments that departed Guam and Saipan without a BTS inspection, 3) cargo conveyances that appear damaged, and 4) random checks for BTS and other terrestrial vertebrate pest species. Air cargo arriving to Tinian and Rota from Guam or Saipan is subject to routine cargo inspection processes conducted by CNMI Quarantine Inspectors to ensure that a BTS inspection was conducted on Guam and/or Saipan, and shipments are not harboring other terrestrial vertebrate pest species such as mice or frogs (U.S. Navy 2005a). A USDA-APHIS-WS-approved terrestrial vertebrate species-proof barrier used at entry points on Tinian and Rota for staging inbound air cargo for inspection would help prevent unwanted species introductions.

Current agricultural inspections of military air cargo do not target terrestrial vertebrate species. Agricultural inspections of military air cargo (inbound and outbound) at military and commercial airports on Guam, Saipan, Tinian, and Rota focus on detecting plant pests and pathogens, and do not target terrestrial vertebrate species like BTS, frogs, and mice.

Facilitate inspection of air cargo shipments to improve BTS detection by USDA-APHIS-WS canine teams. Detection of BTS via canine and/or visual inspection is less effective if cargo is: 1) sealed within a conveyance container or crate, 2) complex, meaning it is not symmetrically shaped and stacked, or 3) inspected indoors with fumes from operating equipment, such as forklifts and delivery trucks. Further, BTS are less likely to be detected if the air cargo shipment is delivered to the port area and loaded, with minimal disturbance, directly onto the aircraft; the nocturnal habits of BTS make this assumption important during daylight hours (Vice and Pitzler 2008).

Develop a labeling and tracking system for high-risk air cargo. The ability to label and track high-risk air cargo shipments and their inspection history can streamline the transportation process and open avenues for implementing pre-clearance procedures while still maintaining biosecurity from terrestrial vertebrate pest species. High-risk cargo includes cargo originating from high-BTS-density areas, break bulk items, and outdoor items. Examples of high-risk air cargo include outdoor household goods like children's toys, garden hoses, camping equipment, and air freight shipments of larger items like barbecue grills, swing set components, or appliances, and construction equipment/materials/supplies. Because outbound air cargo items originate from numerous sources throughout Guam (Vice and Pitzler 2008), a labeling and tracking system can help to identify air shipments that: 1) have been exposed to high-risk areas, 2) contain high-risk cargo items, and 3) have received official inspections, with information including the date and location of inspection, and name of inspector. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software.

Coordinate USDA-APHIS-WS agreements with commercial air cargo shipping agencies to prevent terrestrial vertebrate species transportation. Despite high levels of cooperation by most cargo export entities, USDA agents still makes regular discoveries of previously unknown cargo handling processes or companies operating on or out of Guam, and there are several private companies on Guam that refuse to provide information on and/or access to outbound cargo for inspection purposes (Vice and Pitzler 2008). Expand capacity for inspections of cargo handling and packing facilities, with requirements for: 1) allowing frequent inspections (e.g., USDA-APHIS-WS canine, visual searches), 2) being subject to random inspections, 3) more stringent packing and handling procedures (e.g., inspections of complex-packed cargo prior to packing), 4) requiring use of vertebrate species-proof barriers, and 5) implementing long-term pest species control programs at facilities. Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, USDA-APHIS-WS canine inspection, and final loading. Require packers to individually handle and pack cargo items, especially those labeled as high risk. Provide personnel training and equipment for dealing with detections. It is recommended that air cargo be packed and tightly contained rather than remain as bulk. The probability of visually detecting species like BTS in complex cargo is lower than in cargo with few potential hiding places; for example, cargo that is symmetrically shaped, stacked, palletized, and tightly wrapped will have fewer hiding places than loosely packed, unpalletized bulk materials (Vice and Pitzler 2008). Implement procedures to reduce site-specific populations of terrestrial vertebrate species at air cargo facilities and grounds to support interdiction measures USDA-APHIS-WS. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, and seaports.

Reduce site-specific BTS populations at airports and airfields on Guam and Saipan to support interdiction measures. Implement BTS control efforts at airports and airfield facilities and their surrounding areas. Such measures include but are not limited to spotlight searches and perimeter trapping. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating BTS habitat and food sources at cargo loading areas and warehouse facilities, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Reduce site-specific terrestrial vertebrate pest populations at airports and airfields on Guam and Saipan. Similar to the measures in place for BTS, specific control measures for terrestrial vertebrate pests like rodents, amphibians, and lizard species should be implemented around air transportation activities to reduce local populations and decrease probability of species transport. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, loading areas, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Expand capacity of USDA-APHIS-WS to implement BTS control measures at airports and airfields on Guam during nighttime cargo loading and unloading. USDA-APHIS-WS should conduct BTS surveillance during nighttime military cargo loading, staging, and transferring activities. Further, USDA-APHIS-WS can coordinate BTS spotlight searches of staging areas, fence lines, and any tree lines/forest areas in proximity to runways/taxiways that are designated as drop zones. These areas should be targeted during inbound and exiting traffic times (U.S. Navy 2005a). According to Figure 2.1-1 of the FEIS, there are five aviation areas (three paved, two unpaved) where nighttime surveillance should be conducted.

All commercial air shipments inbound to the region containing agricultural items, both food and non-food, should be inspected for terrestrial vertebrate pest species. Agriculture imports are known to transport terrestrial vertebrate pest species of amphibians and reptiles (Christy et al. 2007a; Christy et al. 2007b; Vice et al. In preparation), but inspections generally look for insects and plant pathogens, and do not target terrestrial vertebrate species. Shipments typically considered elevated risk for accidental transport include ornamental plants, agricultural produce, aquaculture shipments (including eggs and fry), live Christmas trees, and construction materials and equipment (Vice et al. In preparation).

All military personnel checked baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected in compliance with the TSA 9/11 Act. Military personnel checked baggage for commercial air transportation poses a high risk for smuggling species both into and out of the region. In the Pacific Islands, smuggling is generally very easy because of poor inspections for contraband animals conducted on arriving baggage (e.g., Kraus and Cravalho 2001). The 9/11 Act, Chapter 10, requires the TSA to establish a system for industry to conduct 100% BTS screening of cargo transported on passenger aircraft in the United States at the piece-level, commensurate with passenger baggage. By August 2010, cargo not screened in accordance TSA-approved processes and procedures cannot be uplifted by a passenger aircraft in the United States (www.TSA.gov). In compliance with the 9/11 Act, TSA is an important operating entity at A.B. Won Pat International Airport to detect smuggled contraband of terrestrial vertebrate species, and staffing should be expanded to account for increased military use of commercial air transportation pathways, and the increase in commercial air cargo associated with proposed military relocation and expected passenger plane travel.

Expand the inspection capabilities for commercial airfreight containers. Containerized cargo is the most common type of air cargo being flown in and out of Guam and the Micronesia Region. For example, United Airlines exports the bulk of commercial airfreight leaving Guam, and approximately 90% of these shipments comprised general freight (Vice and Pitzler 2008). Containerized cargo is considered high risk because: 1) Customs and Quarantine agents only inspect a portion of containers; 2) some containers are permeable to snakes; 3) containers often sit open on the tarmac outside warehouses, providing opportunities to harbor hitchhikers; 4) climate-controlled containers may be of even higher risk because they may provide optimal environmental conditions to promote the survival of a hitchhiker; and 5) there are terrestrial vertebrate species such as snakes that can survive containerized air transport. Mitigation includes use of container scanners, which are currently not available on Guam, but are available on Saipan (currently in disuse because of insufficient funds).

Monitor if seasonal peaks occur for commercial air transport, and increase inspection capabilities during these seasonal peaks. There is a need for monitoring the volume and frequency of commercial air cargo during relocation and post-relocation. If seasonal peaks are found to occur, inspections of air cargo departing Guam should be expanded, with screenings targeting BTS and other terrestrial vertebrates.

Expand inspection capabilities during seasonal peaks in commercial air passenger transportation. More commercial passenger flights depart Guam during the summer months, which may reflect peak tourist season, school summer recess, and summer holiday travel (Vice and Pitzler 2008). During these seasonal peaks, aircraft departing Guam, when inspected for BTS, should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. The risk of contamination actually can stem from mail containers being handled, staged, and shipped in the same manner as general freight (Vice and Pitzler 2008), because mail is then in proximity to the high-risk cargo during the inspection process. While cargo such as air mail is considered low-risk due to its contents and processing methods, mail is less-containerized than freight and incurs a longer staging time while enough mail accumulates for a shipment. Mail destined to other Micronesian islands (Palau, Chuuk, Yap) is considerably higher risk for snake incursion; outbound mail is stored in open containers that are stored on the ramp side of the United cargo facility at A.B. Won Pat International Airport (Vice and Pitzler 2008). The potential for contamination of mail can be reduced by implementing a more-contained method of shipment and continuing the same inspection process for the mail as freight, but not within the same warehouse nor within proximity to freight so that the potential for incursion is reduced.

Inspections are constrained by resources to only inspect a portion of air freight conveyance crates and containers, therefore increase funding and feasibility of these inspections. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods need to be devised and implemented to randomly search containers regardless of documentation, type of shipment, and country of origin. Allocate funding to increase the amount of containerized and crated air cargo shipments that can be inspected. Paperwork associated with arriving air cargo shipments in crates and containers needs to be automated to allow for more rapid selection of containers to be screened, and open avenues for implementing pre-clearance procedures.

Inspect cargo at both departure and arrival points if transported on open barges. Cargo is considered high risk if sent on open barges because this type of transport generally moves a high proportion of break-bulk items that originate near heavily vegetated locations such as new construction sites where heavy equipment is stored in proximity to jungle areas (Vice and Pitzler 2008). Break-bulk roughly includes those items too large to be containerized, like heavy construction equipment (e.g., cranes, bulldozers, dump trucks), building materials (e.g., rebar, lumber, pipe, scrap metal, concrete forms,

cinder blocks), fuel canisters (e.g., oxygen, acetylene, propane tanks), small boats, and in some instances, private vehicles. Many inter-island shipments are on open barges where the ambient air temperature and air turnover rates increase the likelihood of species survival during transport (Vice and Pitzler 2008).

Inspect household goods before they are sealed in a conveyance. Detection probability for BTS decreases when household goods are packed, crated (in 4 x 8 x 8 foot wooden boxes), and sealed at the residence before being transported to the packing agent's facility (Vice and Pitzler 2008). Close/seal cargo containers staged overnight, or erect temporary barriers and employ control methods for terrestrial vertebrate species such as temporary barriers until containers are sealed for transport.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor staging areas.

8.7.4.4 *Sea cargo*

8.7.4.4.1 *Sea cargo Arrivals*

An estimated 90% of all imports to Guam come through the Commercial Port at Apra Harbor. This includes the majority of food, commercial goods, and many of the supplies that support the U.S. Military on Guam. The relocation on Guam will have a significant impact on container volumes during the construction phase and afterward. According to The 2008 Port Authority of Guam's Master Plan, during the construction phase, the containerized cargo volume will increase 500% above 2007 import levels. After construction, the volume will be approximately 200% greater than 2007 levels.

Increase the capacity to perform random inspections for terrestrial vertebrate species in containerized commercial cargo arriving to Guam and Saipan. GCQA does not routinely open containerized commercial cargo shipments; containers are tagged for inspection only if they arrive from a country of concern, have improper or suspect labeling, or contain items that pose an agricultural risk by potentially harboring soils, insects, and plant pathogens (Merfalen, personal communication). Similar inspection procedures are in place on Saipan and Tinian (USDA-APHIS-WS 2010). Agricultural inspections, when conducted, do not target terrestrial vertebrate pest species and therefore may miss potential hitchhikers. Further, persons involved in the intentional transport of species, such as legal imports for the pet trade or in illegal acts, may strategically ship from an origin of least concern in order to remain undetected. Inspecting for terrestrial vertebrate species and performing random inspections in addition to SOPs for inspecting containerized commercial cargo is a preventative measure against illegal acts of species transport, and increases the probability of detecting hitchhikers.

Build a centralized USDA-APHIS-WS-approved staging area for containerized commercial cargo arriving to Guam at the Port of Guam. Containerized commercial cargo arriving at the Port of Guam identified as requiring an inspection is tagged by GCQA and moved from the port to one of Guam's 78

freight stations until it is inspected at the station by USDA-APHIS-WS. This method decentralizes the inspection process of containerized cargo, with most cargo inspected in numerous warehouses

throughout the island. This presents a high risk for multiple, simultaneous introductions of terrestrial vertebrate species to Guam (USDA-APHIS-WS 2010). A centralized inspection facility at the Port of Guam for arriving cargo would reduce cargo transport, and hence species transport, from the port-of-entry.

Implement an electronic system for recording, tracking, and identifying manifests associated with containerized commercial cargo arrivals to Guam and Saipan to streamline import process while maintaining biosecurity. Although all arriving cargo is subject to inspection, containerized cargo is selected for inspection based on the shipping company's manifest that itemizes the containers contents (Merfalen, personal communication). Larger, established shippers like Matson and CSX tend to be more reliable than smaller, less established operations. The system of recording, identifying, and tracking these manifests is paper-based; these systems are vulnerable to missing or lost documentation, unregulated and recurring breaches in biosecurity, and being omitted from integration with other agencies using electronic tracking capabilities. Over the past several years, CBP required a shift to electronic access for cargo manifests for arrivals from the continental United States. In addition, USDA-APHIS recently initiated an electronic system for permits called ePermits. GCQA does not have access to either system, and still relies on paper manifests; it is expected that GCQA will have access to ePermits as soon as Guam PPQ allows, but this has not yet been decided at the time this document was written. Hand-held computerized devices (e.g., SuperTracker[®]) can be used by GCQA to organize manifest information for the inspection process.

Develop a system for selecting containers to be inspected for terrestrial vertebrate species. PPQ-Agriculture Quarantine Activity System is a set of sophisticated tools for selecting and monitoring containers for agricultural pests. Similar tools need to be developed to identify, monitor, and track containers for terrestrial vertebrate species inspections. Criteria would include type of cargo, origin of cargo material, shipping company, structural damage to the container, and random pick.

Expand capacity for increased random inspections for terrestrial vertebrate species in containerized cargo arrivals. Presently, USDA-APHIS and jurisdictional Customs and Quarantine agencies are unable to meet current inspection demands of containerized cargo arrivals to Guam and the CNMI. Expected increases in container cargo arrivals to the Micronesia Region will render the already burdened inspection process ineffective. If there are fewer containers targeted for agricultural inspections because of insufficient resources, and given that agricultural inspections do not focus on terrestrial vertebrate species, an even higher probability exists for transporting such species in containerized cargo. Increase the number of USDA-APHIS-WS canine inspection teams at Apra Harbor, for both the commercial port and COMNAVMAR.

Military aircraft transported as cargo (aboard an aircraft carrier or other military vessel with aircraft transport capabilities) must be inspected, cleaned, and washed down at the port-of-entry. Aircraft are considered cargo if transported to locations aboard another aircraft or vessel, and hence should be subject to inspections when unloaded from the transport conveyance. This is especially important

because while some aircraft will remain unused during transport, planes and helicopters aboard an aircraft carrier can depart and arrive as their support vessel moves, increasing the probability of transporting species from different points of origin should these aircraft depart the transport conveyance and land before returning. Aircraft as cargo arriving to Saipan from Guam, or to Guam from Saipan, must be inspected for BTS if the inspection does not occur upon departure, and officials at arriving locations need to be notified with the appropriate information. Expand capability of jurisdictions to respond to notification of missed BTS inspections. In addition, military aircraft must undergo and adhere to regulations for cleaning and washdown procedures before entry to Guam (as per USDA and APHIS guidelines), and additionally inspect for terrestrial vertebrate species, which are not targeted and therefore likely missed. Perform internal inspections during general and retrograde washdowns to detect and capture terrestrial vertebrate species located within the aircraft cargo. Military procedures for washing aircraft focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within an aircraft being washed go undetected. This includes aircraft involved in routine flight operations, aircraft transported as cargo items (via air or water transport), or those staged upon a departing aircraft carrier.

Military amphibious vehicles arriving via water must be inspected, cleaned, and washed down at a retrograde wash facility before entry to Guam. Washdown procedures for military vehicles do not target terrestrial vertebrate species per se, and therefore cleaning of military amphibious vehicles will likely miss such hitchhikers, including amphibian and reptile species, like coqui frogs from Hawai'i. Further, cleaning is focused on external surfaces, so those species within vehicles will travel undetected. Tracked vehicles can only be cleaned on shore as long as they can be reloaded without recontamination of the treads, otherwise they must be cleaned on the ship's well deck (AFPMB 2008).

Privately owned vehicles (POVs) arriving via water through military and commercial routes must be washed down at a port facility before they are permitted entry to Guam. Personal vehicle cargo originates from numerous sources, increasing the locations from which a species may be moved, and the types of species moved. Procedures for washing vehicles imported to Guam focuses on agricultural inspections and primarily of external surfaces, thereby missing terrestrial vertebrates potentially present. Further, a small percentage of vehicles arrive contaminated with soil. Vehicles suspected of carrying species, for example if detected by visual or auditory means during transport, should be quarantined. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to being shipped from the port of departure. Vehicles may be cleaned at the port-of-entry provided wastewater soil is collected and fully drained into an approved collection system to mitigate the risk of introduction amphibian species. For certain anurans like coqui (*E. coqui*), an aural inspection during peak time of vocalizations can be conducted to detect such hitchhiking vertebrates.

Military assault vehicles arriving as cargo via water must be washed down at a retrograde wash facility before they are permitted entry to Guam. Assault vehicles have the ability to cover large and remote tracks of heavily vegetated fields, exposing them to contamination by terrestrial vertebrate species inhabiting such terrain. Vehicles small enough to drive through the ships' side ramps, such as

High Mobility Multipurpose Wheeled Vehicles, must be cleaned and washed down in designated areas in the port facility. Large trucks that are too large for the side ramps will be transported by Air Cushion or hovercraft (LCAC) to a coastal cleaning area. Vehicles must be internally inspected. The battery and battery box should be removed, cleaned, and reinstalled because the crevices of the battery box provide hiding places. Trucks that are equipped with collapsible sides should have the sides disengaged, and all recessed areas and ledges cleaned (AFPMB 2008). Common areas to be inspected include top and bottom access points, paying particular attention to crevices. Also, control efforts around the washdown facility should be in place. Construct USDA-APHIS-WS-approved species-proof barriers to secure washing and staging areas, implement trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species, and expand large-area trapping efforts to reduce local populations.

Implement inspection procedures for vehicle cargo aboard high speed-military vessels. High-speed military vessels are used for rapid delivery of cargo. Vessels like the LCAC are capable of a 60 ton payload (up to 75 tons in an overload condition) at speeds greater than 40 knots. Such rapid transit increases species survival during transport, hence these vessels and their cargo pose a risk. Cargo can include vehicles and equipment that may harbor terrestrial vertebrate species.

Construction vehicles arriving via water must be washed down and inspected before being permitted entry to Guam, Saipan, Tinian, and Rota. No specifications were provided in the FEIS/OEIS regarding the types and amounts of construction vehicles to be used in the relocation on Guam or for construction of training ranges on Saipan, Tinian, and Rota, making this a high risk for importing unwanted species. Construction vehicles include machinery like bulldozers, excavators, and bobcats, as well as forklifts, concrete mixers and their pumps, dump trucks, and ATVs (Vice and Pitzler 2008). Construction vehicles can carry species from one work site to the next. Although construction is for military purposes, equipment transport will likely be by subcontracted construction company employees. Detailed cleaning and inspection of vehicles and equipment used in construction must be conducted at the port of entry. USDA-APHIS requirements must be met and should be augmented with internal and external inspections for terrestrial vertebrate species. Delineation of responsibilities for the military meeting these requirements is presented in AFPMB Tech. No. 31 (2004).

The Importer Security Filing (CBP) system, akin to that required for imports to the United States, should be implemented and enforced for break bulk arriving in Guam. Under the Importer Security Filing and Additional Carrier Requirements (“10 +2” program), break bulk cargo imported to the United States by vessel must be electronically submitted to the CBP in the form of an Importer Security Filing. This requirement only applies to cargo arriving in the United States by ocean vessel; it does not apply to cargo arriving by other modes of transportation. Failure to do so could ultimately result in monetary penalties of \$5,000, and increased inspections and delay of cargo. If goods for which an Importer Security Filing has not been filed arrive in the United States, CBP may withhold the release or transfer of the cargo; CBP may refuse to grant a permit to unlade for the merchandise; and if such cargo is unloaded without permission, it may be subject to seizure. Importer Security Filing Importers, or their agent, must provide eight data elements, no later than 24 hours before the cargo is laden aboard a vessel destined to the United States. Those data elements include: seller, buyer, applicant identification

number, consignee number, manufacturer, ship of party, country of origin, and Commodity Harmonized Tariff Schedule of the United States number.

Provide written animal and plant health import and interstate movement requirements (USDA-APHIS regulations) for all break-bulk import contractors, and engage in formal, signed agreements with these bulk imports contractors, especially those operating from origins of concern. There will be substantial increases in break bulk cargo to be shipped through the Port of Guam for construction and infrastructure upgrades due to the relocation. It is vital that contractors be aware of the requirements for pre-departure inspection and pest mitigation prior to export of these countries. Enforcement is needed during relocation to ensure contractors adhere to requirements or face fines or other penalties.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route via water as well as on the ground. Low-risk cargo such as mail may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. The risk of contamination actually can stem from mail containers being handled, staged, and shipped in the same manner as general freight after arrival (Vice and Pitzler 2008), because mail is then in proximity to the high-risk cargo during the transport and inspection process. Implement procedures to separate low- and high-risk cargo on arrival, for staging and inspection purposes, as well as for quarantine reasons.

WPM arriving as cargo must be accompanied by proper forms and labels. WPM can harbor myriad terrestrial vertebrate species, including amphibians, mammals, and reptiles. To prevent hitchhikers aboard such cargo, material is required to be treated and marked at the place of origin, and accompanied by authentic phytosanitary certificates on arrival in Apra Harbor. Examples of WPM include crates, pallets, dunnage, packing blocks, drums, cases, load boards, pallet collars, skids, veneer peeler cores, sawdust, wood wool, wood shavings, raw wood cut into thin pieces, and cable spools. The treatment of WPM is enforced under the ISPM (USDA-APHIS 2007; ALSC 2009). The treatment and inspection of WPM is governed under 7 CFR. The regulations allow manufacturers and shippers two options: heat treatment or treatment with methyl bromide. For materials to receive the ISPM No. 15 quality mark, materials must be inspected by an agency accredited by either the ALSC for heat treatment (ALSC 2009), or the National Wood Pallet and Container Association for methyl bromide fumigation (NWPCA 2009). Inspection procedures by both agencies must follow ISPM No. 15 regulations. Part 305 of Title 7 covers phytosanitary treatments and states that treatments are to occur at USDA-APHIS certified facilities and are to be monitored by APHIS officials (Title 7, Part 305). Part 381 of Title 7 defines regulated WPM as dunnage, crating, pallets, packing blocks, drums, cases, and skids (Title 7, Part 318). Currently all regulated WPM are required to have the International Plant Protection Convention (IPPC) quality mark, unless it is a DoD shipment (USDA-APHIS 2010). The exemption of regulations on WPM shipped by DoD leaves a risk of introduction of pests and vertebrates through untreated WPM. Fraudulent or suspected fraudulent certifications or cargo manifests should be investigated with penalties implemented. Random inspection of such cargo can prevent illegal transport of species through a legal route and incidents of smuggling.

Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging process prior to arrival as imported cargo, or after arrival when it is staged for loading for inland transport. It is optimal for packers to individually handle and pack cargo items, especially those considered high risk. Mandate and enforce regulations pertaining to palletized cargo, including procedures for labeling, packing, and transport prior to arrival, and eventual staging and loading for inland transport upon import. Personnel must be trained how to identify high-risk cargo and handle it in a manner to reduce possible contamination. Palletized cargo should be packed tightly and symmetrically, as well as wrapped with a protective covering. The probability of visually detecting species in complex cargo is lower than in cargo with few potential hiding places. This is especially true with BTS detection by canine teams (Vice and Pitzler 2008).

8.7.4.4.2 *Sea cargo Departures*

Most water-transported cargo departing Guam is shipped as surface freight out of Apra Harbor. The harbor has two sides; the Commercial Port (GovGuam) and the COMNAVMAR (military). All vessel traffic is managed by The Port Authority of Guam (GovGuam), which assigns vessels to commercial or military berthing areas.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Guam. Comply with 100% BTS inspection of military sea cargo departing Guam, per NDAA, Public Law 110-181, Section 314.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Saipan. Comply with 100% BTS inspection of military cargo departing Saipan, per NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Tinian and Rota. Comply with 100% BTS inspection of military cargo departing Tinian and Rota, per NDAA, Public Law 110-181, Section 314 requiring interdiction for areas where incipient populations may be evident in the future.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to cargo arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial sectors, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes cargo arrivals from Guam and Saipan, where BTS exist, being shipped to the Hawai'ian Islands of Oahu, Maui, and Hawai'i. Interdiction measures should be expanded to include improved inter-agency coordination of communication networks to notify Hawai'ian seaports of cargo arrivals from Guam and Saipan that missed BTS inspection, and funding to increase inspection capacity for U.S.-bound cargo departing from Saipan and Guam.

Inspection of departing military containers must be focused on higher-risk container types such as open top containers. The military uses several types of containers for shipment of gear, ranging from a tricon (triple container that is a lockable, weatherproof, reusable, prefabricated container with a cargo

capacity of 5,579 kg [12,300 pounds]) to standard commercial containers to open top containers (container without a permanent metal top, instead tarpaulin is used, supported by roof bows to protect cargo from the elements) (Defense Transportation Regulation Part II: Cargo Movement April 2010). Open top containers are the highest risk container type for the transport of BTS. No information was found on the staging of the open top containers. Procedures should be implemented to separate out these containers of cargo to prevent cross-contamination from adjacent cargo sources. Stage these containers separately, and perform random inspections.

Expand capacity to inspect departing freight containers including funds allotted for container scanners. The movement of invasive vertebrate species in containerized cargo is a significant pathway, and a large number of species may be moved (ANSTF and NISC 2007; USDA-APHIS-WS 2010). In addition, some transit times for ships sailing between Guam and other islands are short (less than 1 day), increasing the probability of survival for species stowed in cargo aboard. Cargo container inspections are regulated in international law under the sponsorship of the WHO. Inspection access is granted through WHA58.3 Revision of the International Health Regulations (WHO 2005). Containers and their cargo departing Guam are subject to 100% BTS inspection, in compliance with NDAA, Public Law 110-181, Section 314. Yet container scanners are currently not available on Guam. They are available on Saipan, but not used due to funding limitations even though containers are considered high risk items used in the shipping process (ANSTF and NISC 2007).

Commercial sea cargo shipping companies must comply with the 100% inspection policy, and no direct route for shipments from Guam to Hawai'i should be maintained. Surface cargo leaving Guam for the U.S. mainland is primarily shipped by two companies, the CSX Corporation and Matson. Shipments from these two companies are first routed through ports in Asia before arriving in the U.S. mainland and comprise only containerized cargo. CSX ships approximately 65 to 70 outbound containers per week containing items that originate on Guam, 25 to 30 (roughly 40%) are filled with household goods, and 7 to 8 (11%) contain vehicles; both high risk item types due to their extended exposure to the outdoors (Vice and Pitzler 2008). Matson conducts service to Hawai'i from Guam, via Oakland, California. BTS have been repeatedly found in the Hawai'ian Islands. Since 1981, eight BTS are known to have arrived on the island of Oahu through commercial and military aircraft from Guam (BTS Technical Working Group 2009). The indirect route of surface cargo from Guam to Hawai'i should be maintained. Cargo bound for Hawai'i should be inspected again prior to departure from Oakland, California, to prevent the establishment of BTS in Hawai'i.

The staging time of smaller commercial containers departing Guam needs to be reduced. Often, smaller commercial containers sit at residential lots under "door to door" services (Matson) for long periods of time before being transported to the port and sealed. Customers that use the "door to door" service are given the option of either using Matson trucking for pickup of the container at their residence, or they may hire their own trucking service approved by the Uniform Intermodal Interchange and Facilities Access Agreement. However, the staging time of the container at the residence is not heavily regulated, and the container sits unsealed for at least 1 week.

Develop procedures to reduce risks of transporting terrestrial vertebrate species in household goods containerized at the residence for shipment. Standard procedures for packing household goods within containers for shipping are currently insufficient in preventing terrestrial vertebrate species transport. Movers drop off a standard 20- or 40-foot shipping container to the residence; if packing is not done in 1 day, they may leave the container overnight. If containers are brought to the shipping facilities not full, companies will leave them open, usually outside, at shipping facilities while filling. While staged in these instances, open containers offer entry opportunities to species. Further, when containers are sealed at the residence and staged at the facility for inspection, the possibility of detecting species is greatly diminished. For example, BTS canine inspections of cargo are less effective when performed on the sealed container only.

Reduce the outdoor staging time for transporting POVs either by military personnel or the public, and construct USDA-APHIS-approved perimeter fencing around staging areas. POVs being shipped by military personnel arrive at the lot daily and often sit outside for several weeks before being containerized on site. WS agents inspect any newly arriving vehicles (interior and exterior) daily and any vehicles that are scheduled to be containerized that day (Vice and Pitzler 2008). Reducing the staging time in combination with installation of USDA-APHIS approved fencing will help prevent species such as BTS from hitchhiking onto POVs. Also, with the increase in POVs due to force flow (increase in population due to military relocation) there is a greater potential for inspections to be delayed or missed unless there is an increase in the number of WS inspectors operating at the Fleet Industrial Service Center.

Departing military amphibious vehicles being transported as sea cargo must be inspected, cleaned, and washed at a laydown area prior to departure. Amphibious vehicles will need to be deployed from Guam to neighboring islands such as Tinian, Rota, and Saipan. These vehicles must be inspected, cleaned, and washed down prior to departure to prevent the spread of BTS that may hitchhike aboard these vehicles. The amphibious vehicle laydown area created at Apra Harbor will be required to store, wash down, maintain, and deploy amphibious vehicles, such as landing craft and amphibious assault vehicles. LCACs would also utilize this laydown area. Vehicles must be vacuumed to prevent the transport of plant propagation materials and pests. Once at the retrograde washdown area, vehicles are exposed to either high pressure (minimum 90 pounds per square inch) water or steam. After vehicles are washed, they will be inspected to ensure all soil has been removed and also should be inspected for vertebrate pests (AFPMB 2008). Common areas to be inspected include top and bottom access points, paying particular attention to crevices.

Departing WPM are subject to inspection and should not be stored outdoors. Certain WPM poses a high risk of transferring BTS and other species, such that all WPM must be inspected prior to departure from Guam. If WPM is stored outdoors, it should be stored in a cage covered with insect-proof netting, vegetation should be removed from the storage site, and the storage site should be sealed with concrete and thoroughly cleaned on a regular basis.

Palletized military munitions must be inspected and should be packed tightly and symmetrically.

Munitions are typically palletized and shipped as sea cargo on military vessels. The Asian Beauty snake (*Elaphe taeniura friesi*) was discovered in a shipping container holding munitions on Guam that had been shipped from Okinawa and held in storage for approximately 2 months in 2004 (Vice et al. In preparation). Munitions primarily depart Guam from Kilo Wharf in Apra Harbor. Pallets of munitions are containerized in the Munitions Storage Area on Andersen AFB or Naval Ordnance Annex and are loaded directly onboard military vessels at Kilo Wharf. In some circumstances, pallets of munitions are moved directly from either base to Kilo Wharf, for staging prior to direct loading onboard. Currently, canine inspections are conducted on all munitions as needed; however, both the pallets of munitions and the container that carries the palletized munitions should undergo canine inspections prior to departure. A caveat to this recommendation is that BTS detections by canine inspection are reduced if sealed wooden crates are used. Further, area-wide trapping and spotlight searches for BTS can reduce local populations, and routine inspections with USDA-APHIS-WS canine teams of munitions storage facilities can help prevent accidental transport.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground.

Surface mail delivered parcel post is picked up and processed in the same manner as air mail, up to the point it is dispersed from the main post office in Barrigada. After the sorting process, surface mail is loaded directly into a 40-foot container staged at the post office and delivered weekly to the Apra Harbor Commercial Port for shipment. Most notably, mail containers may sit open until they are filled or scheduled for shipping, offering entry opportunities for terrestrial vertebrate species. Currently there is an intensive trapping program that limits the potential for snakes to immigrate into outbound surface mail or the containers in which it is stored, and this program must be maintained and expanded with an increase in departing mail. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008). The risk of contamination can stem from mail containers being handled, staged, and shipped in the same manner as general freight (Vice and Pitzler 2008), because mail is then in physical proximity to the high-risk cargo during the inspection process. Close containers if staged outside overnight. Provide USDA-APHIS-approved temporary barriers to prevent reptiles, amphibian, and rodents from entering.

Construction equipment, vehicles, and supplies departing from work sites need to be cleaned on-site to prevent movement of terrestrial vertebrate species.

Movement of construction equipment from work sites can transport species to new inter-island locations, and then off island if cleaning is not performed at port of embarkation. Proper facilities and procedures need to be in place for cleaning equipment on site for terrestrial vertebrate species in particular, prior to moving it for transport. For example, all contractors doing major construction, excavation, or earth moving are required to have a free inspection of their site and equipment by CNMI-DFW's BTS staff, with contractors also required to have their workers participate in a free, brief on-site snake prevention training workshop provided by CNMI-DFW. There is no fee to the contractor or workers for this service (<http://www.dfw.gov.mp/Wildlife/Brown%20Tree%20Snake.html>).

8.7.4.5 *People and Baggage*

Recommendations concerning people and baggage pertain to the travelers and their carry-on items (hereafter referred to as baggage). People tend to opt for the quickest mode of travel, making travel duration short and species survival high for this pathway. Risks associated with the recommendations for this pathway are due to intentional and unintentional transport of vertebrates, and the agencies in place for inspections do not target this pathway for the detection of vertebrates. Transport of people and their baggage can occur either by air or water, and is either commercially or military-operated, with each mode differing in the inspection process at the border. Commercial air transport of people and baggage includes commercial airlines or private charters, while commercial water transport consists of cruise ships or private charter boat passengers. On the other hand, military air transport of personnel may be involved in purely transportation from airfield to airfield, routine aviation training, or immediate departures of urgency (warfare, medical). Similarly, military water transport of personnel includes transport from one base to another, training missions, and immediate departures or urgency (warfare, rescue).

Provide a separate screening area for inspecting military personnel and their baggage at commercial airports. Due to the nature of military service travel, personnel must move quickly through ports without delay. Screening of uniformed military personnel is cumbersome; fatigues contain many pockets and folds, boots have intricate lacing, and travel bags may be difficult to unpack and inspect quickly. Similar to separate screening areas in commercial airports for inspecting persons with disabilities, a separate screening area for inspecting military personnel and their baggage should be implemented when travel is through a commercial airport. In addition, personnel are exempt from some of screening procedures imposed on the civilian passengers; personnel are not required to take off their boots unless the walk-through alarm sounds. These recommendations will facilitate compliance with 100% BTS inspection policy for military air cargo departing Guam, departing Saipan, and arriving to Tinian and Rota, and allow military to continue without delay to gate boarding.

Agricultural forms for arriving commercial passengers must be available in multiple languages, given the lingual diversity of Micronesia. Incomplete or inaccurate descriptions on agricultural forms can lead to the unknowing import of prohibited vertebrates. While some incompleteness and inaccuracies may be due to dishonesty of the traveler, it may also be due to illiteracy of the default language on the declaration form; a less complex problem that can be solved practically. In addition, multi-lingual agents will be needed to review the forms and assist passengers with filling out the forms. A communications study found when individuals are forced to use a non-native language to communicate, their overall orientation to communication may change, resulting in increased apprehension, decreased willingness to initiate communication, and decreased perceptions of communication competence (Burroughs and Marie 1995). The most commonly used languages in the region most affected by the relocation are English, Chamorro, and Chuukese. The incorporation of all of these languages into declaration forms is likely to reduce incompleteness and inaccuracies due to language. Additionally, these three languages should be spoken by the staffed agents (collectively) assisting passengers with form completion.

Penalties such as fines must be publicized, disseminated on forms, and enforced. It is difficult to enforce regulations without repercussions in place. Biological invasions are likely to increase in number and magnitude without negative reinforcement (penalties) pertaining to regulations. The agencies charged with the enforcement of inspection regulations (TSA, USDA-APHIS) and issuing of fines must use communication and coordination as well as education and training to disseminate the penalties associated with particular violations of travel. Therefore, paperwork of violations and the penalties incurred must be filed within a well-organized system, forms must prompt comprehensive information, and documentation must be easily accessible to the enforcement.

Increase surveillance measures in military and commercial airports and harbors at port entry points and screening check points. Use of surveillance equipment and procedures can help alert officials and inspection staff to transport of terrestrial vertebrate species, either smuggled or imported without knowing that the species is prohibited (Black Listed). Military uniforms have lots of pockets, folds, and baggy areas and maybe used for the concealment of transported species. Also, importing contraband items is an issue as well. Surveillance is a way of finding out if the inspection and enforcement process is working and of refining the entire biosecurity system. Implement video surveillance to monitor activity, and provide plain clothes enforcement officers for initiating rapid response measures during peak travel times.

An MCI program should be initiated on Guam. Immediate military personnel departures such as medical emergencies or rapid deployment missions may pose a higher risk of vertebrate movement because they may undergo less stringent or missed inspections. However, by mandate of the MCI, all passengers, crewmembers, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the CTUS must be inspected or examined prior to departure. All travelling personnel must complete U.S. Customs Accompanied Baggage Declaration, DD Form 1854 while civilian crewmember must complete Customs Form 5129. Urgent departures such as medical emergencies are still subject to MCI inspection, and expeditious inspection should not preclude taking the steps necessary to detect prohibited articles prior to departure, as stated by MCI (<http://www.tpub.com/maa/137.htm>). While MCI does not yet operate on Guam, the institution of this program is much needed and advocated for Guam by the U.S. Navy and PPQ.

Expand the number and sensitivity of detection equipment (x-ray) for departure checkpoints at airports in Guam and CNMI and implement x-ray machine use at Apra Harbor. It is important for inspection checkpoints to be properly equipped with an adequate number of machine vision technology devices because detection probability increases with machine sensitivity. While some inspection procedures are manual, inspection agents rely heavily on technological equipment to assist in the screening process. Currently, x-ray machines are in use for screening of departing passengers and baggage at Andersen AFB and Francisco Ada International Airport, among other airports in the region, but are not in use at harbors as of yet. The two x-ray machines for screening departing passengers and baggage at A.B. Won Pat International Airport were inoperable at the time this document was written, and awaiting replacement machines (Berringer, personal communication). While x-ray machines are in place at these locations, the models may be outdated and lacking in sensitivity, as well as in disrepair.

New advances in technology such as an image-feature based approach (Chen et al. 2002) may increase detections of vertebrate species.

8.7.5 Intentional Pathway Recommendations

Intentional transport of terrestrial vertebrate species occurs for a myriad of reasons. Intentional transport of species can pose serious risks because many animals are moved by private individuals, unregulated industry retailers, and smugglers that use both legal and illegal routes of import/export. For example, illegal species of amphibians and their eggs can be accidentally or intentionally brought in through the legal import of aquaculture products, and individuals boarding planes may smuggle species such as snakes, crocodiles, and lizards in their carry-on luggage (Bodry 2007; 2008). Overall, intentional transport of terrestrial vertebrates is difficult to monitor and track, as well as to regulate and enforce, especially through military sectors, which makes these pathways of particular concern. Of note, the only mode for intentionally transporting species not discussed is fur ranching, due to very low risk impact and lack of examples from the Micronesia Region.

8.7.5.1 Pet Trade

- Risk of importation 3
- Risk of establishment 3
- Hazard 3
- Total risk 9 **HIGH**

Pet trade recommendations focus on the transport of live terrestrial vertebrate species, adults and juveniles, including eggs of amphibian and bird species. Pet trade animals can be species of reptiles, amphibians, birds, and mammals, representing a diverse group of species potentially transported. Included are all acquisitions of pet animals, whether purchased from commercial pet stores, Internet dealers, or wild caught and imported by interested individuals, as well as the deliberate release of animals to establish populations that will then be harvested to sell as pets (USDA-APHIS-WS 2010). Also included are hybrid species bred specifically for the pet trade that do not normally exist in the wild.

Develop a Black List of terrestrial vertebrate species for each jurisdiction, the entire region, or both, to ban from importation and possession, and conversely develop a White List of species cleared for importation. Lists of species that are cleared or banned from importation will aid inspectors as to which species pose threats to human health and safety, the economy, and native ecology. Updating information on these lists, including regulations and policies, also helps in dealing with new and emerging pests. In the United States, species importations are viewed as “innocent until proven guilty” (Gray Listed). However this is against BMPs of implementing prevention measures. Development of a Black List is much more effective at prohibiting unwanted species (Witmer and Fantinato 2003; Pitt and Witmer 2007; Fowler et al. 2008). Lists can be updated by USDA-APHIS and utilized regularly by inspection agents.

Create training and education programs for inspectors in proper identification of species both White and Black Listed. Military personnel inspectors, and those with USFWS and USDA, act as border agents to prevent transport of terrestrial vertebrate species. Familiarity with White and Black Listed species can prevent misidentification and introduction of unwanted species. Training would include taxonomic identification of species, continued education regarding species' updates, changes to regulations, and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border, such as effectiveness of screening equipment to detect terrestrial vertebrate species. Develop multimedia educational material to further facilitate proper identification of species, with written descriptions, physical attributes, and animal behavior, as well as immediate human health and safety concerns (e.g., venomous snakes) and rapid response contact information (see Distance Diagnostic and Identification System [University of Florida 2010]).

Assign USFWS personnel at military and commercial air and seaports of entry. Even when import restrictions on some pets do apply, illegal importation of species occurs and poses a high risk primarily because resources are insufficient to address issues surrounding smuggling (USDA-APHIS-WS 2010). USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, be a presence for law enforcement, and be part of a rapid response plan at the border should an aircraft or vessel-related incident occur. USFWS personnel will need to be familiar with species that are White-Listed and those banned from import, as well as trained in proper taxonomic identification of species.

Utilize current available technology to monitor pet trade Internet activity. The Internet is often an unregulated pathway, thereby creating an opportunity to import and introduce terrestrial vertebrates without detection at the border point of entry. Surveillance of Internet activity in regards to the sale or trade of animals, including monitoring the frequency and popularity of specific websites, can reduce the transport of potentially unwanted species, and serves to prevent introduction. The Invasive Species Internet Monitoring System automates the process of searching the Internet for suspect sites (e.g., Internet storefronts, chat rooms) involved in the sale or trade of targeted species (Suiter and Sferrazza 2007). This information can lead to data on the most common routes and modes of transportation, and breaches in current importation bans (e.g., importing snakes to Hawai'i).

Facilitate an expansion in pet trade monitoring through a sense of community ownership regarding the negative impacts of the illegal pet trade. Implement educational programs and materials that convey the hazards associated with the import of illegal pets. Create a response network by which community members may report incidences of illegal pet trafficking, propagation of breeding stocks, sales (independent or retail), unintentional and intentional releases into the wild, and rapid response to species sightings in the wild. Coordinate community efforts with local jurisdictional governments to enhance biosecurity efforts by residents. Provide meetings and newsletters to plan and develop procedures, and answer individual questions and concerns.

Place restrictions on the transportation of psittacines. Whether species of psittacines are captive bred or wild caught, rapid and successful establishment of non-indigenous psittacine species is common

worldwide, with resulting human health impacts (e.g., from bird droppings, transmitted diseases like the HPAI subtype H5N1), economic impacts (control costs), and ecological impacts (e.g., increased competition for food and nest sites, displacement of native species). Among birds, wild caught species pose a greater risk of establishment than do species that have been bred in captivity for many generations, because they retain the instinctual ability to survive after release (Carette and Tella 2008). Create agreements with pet shops and animal dealers to educate and regulate trade in psittacines; develop avenues to curtail smuggling due to restrictions and regulations that make transport of species more difficult; and create a system for tracking and monitoring species that are imported, if only via the honor system. Restrict the import by individuals in the private sector of certain psitticine species (Black List).

Follow similar procedures to those of Hawai'i Department of Agriculture for import restrictions by private sector: "Require a pre-arrival seven-day (168 hours) isolation from mosquitoes under the supervision of an accredited veterinarian and must enter the State within 36 hours of completing isolation. In addition, a Certificate of Veterinary Inspection must state that birds were not vaccinated for any disease with a vaccine containing a live agent within 60 days of shipment. The Certificate of Veterinary Inspection must also list individual bird identification numbers (leg band, wing band, or electronic microchip) and contain a statement that the birds are 'Free of external parasites.' All birds entering the State must be kept in isolation from other resident birds for a period of 30 days at the importer's premises. All shipments shall be in mosquito-proof containers that are either new or those thoroughly cleaned to the satisfaction of the accredited veterinarian issuing the Certificate of Veterinary Inspection. Importation of animals through the USPS is not allowed. All imported psittacines, whether from foreign or domestic origin, should first enter Guam via A.B. Won Pat International Airport, which should be the only entry port for imported birds, with all shipments subject to inspection and penalties for non-compliance. Inspections should be conducted at the newly constructed Airport Animal Quarantine Holding Facility prior to release. An agent of the airline will submit the birds for inspection. The hours of operations when inspections can be performed to accommodate shipment arrivals must be posted, and an 'after-hours' staff for unexpected or re-scheduled commercial shipments or chartered/private freight arrivals should be assembled. Birds not meeting entry requirements are to be returned to a port of entry in the continental United States or a foreign port in the case of international movement, with notification of contaminated cargo and proper authorization to do so.

It is imperative quarantine the birds upon entry to protect human health and safety. Construct a Quarantine Holding Facility at the A.B. Won Pat International Airport. Confounding factors include screening of cargo for species in military aircraft arriving Andersen AFB and military vessels through the COMNAVMAR, privately owned and chartered (private and commercial) aircraft imports, and unscheduled commercial airfreight imports.

Restrict imports of snakes to island nations. Native species on islands evolved without any terrestrial predators, and hence are vulnerable to terrestrial vertebrate species that prey upon them. Snakes are insidious predators that, unlike rodents or other small mammals, may be difficult to detect because of nocturnal and/or arboreal habits of some species, they don't leave obvious signs of presence or make

noise, and they are difficult to control once established. Similar to regulations enforced by Hawai'i State Department of Agriculture for animal import by individuals in the private sector, at least restricting the import (Black List) of snakes should be considered.

Enforce existing regulations and expand regulatory drivers in the Pet Trade industry. Successful importation of unwanted terrestrial vertebrate pest species increases the probability of introduction and establishment, and is partly due to moderate and high public interest for importing pet species, and a lack of government regulations on the pet trade industry. Enforcement of existing regulations should be upheld, such as APHIS regulations for importing animals from foreign origin, 42 CFR § 71.51 (for dogs), Guideline for Transport from the CITES, protocols of the CDC, and the WBCA. Expand regulations for the pet trade industry to curtail acts of illegal importation, and create avenues for safe imports. Examples include developing and implementing the use of White and Black Lists, assigning a USFWS officer at borders, and coordinating voluntary agreements with pet stores and businesses in the pet trade industry.

8.7.5.2 *Aesthetic Releases*

- Risk of importation 3
- Risk of establishment 2
- Hazard 3
- Total risk 8 **HIGH**

Recommendations to prevent the unintentional and intentional release of animals for aesthetic reasons shares similarities with the Pet Trade recommendations. Animals may be intentionally released into the wild because the species is considered in some way desirable (Kraus 2009a). Examples include freshwater turtles and frogs released into backyard ponds, songbirds and some parrots because they invoke nostalgia, and lizards because of species' characteristics (e.g., eats insects, are colorful) (e.g., Long 1981; Kraus and Campbell III 2002). Mitigation is post-border, as animals released will most likely be from local residents or newly relocated persons. However, education is needed for inspectors and individuals at the border ports of entry, as an intentional release may stem from the person self-justifying the release of a 'wild' animal back into the wild, or the unintentional release of them not knowing the potential impacts the species may cause. Animals introduced via aesthetic release may be obtained legally from imported commercial stock (i.e., pet stores), Internet purchases, or illegal trading. Recommendations therefore overlap with those concerning the pet trade, including those that restrict movement of certain taxa like birds and reptiles (snakes and lizards). The availability of animals in Micronesia varies on the supply of local commercial stock, Internet purchases, illegal activity, and the frequency with which citizens travel overseas and return with animals. Military personnel travel is rarely restricted by inspection procedures, thereby making that pathway a concern for illegal imports.

Assign USFWS personnel at military and commercial air and seaports of entry. Even when import restrictions on some animals do apply, illegal importation of species occurs and poses a high risk primarily because resources are insufficient to address issues surrounding smuggling (USDA-APHIS-WS

2010). USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, be a presence for law enforcement, and be part of a rapid response plan at the border should an aircraft or vessel-related incident occur. USFWS personnel will need to be familiar with species that are White Listed and those banned from import, as well as trained in proper taxonomic identification of species.

Create cooperative agreements with pet retailers to detect bulk and repeated purchases of animals.

USDA-APHIS and USFWS agents should work to create agreements with pet retailers operating in the Micronesia Region. Under such agreements, the agents will maintain open communication about topics such as noticeably large increases in sales and demand, types of species listed in inventories, and the types of clientele. An effective method of attaining such information is a routine online survey to be completed by the retailer.

Implement educational programs and materials that convey the hazards associated with the release of unwanted terrestrial vertebrate pest species.

Animal releases are primarily performed by the public. Public education can help prevent intentional or accidental importation and release of pest species (USDA-APHIS-WS 2010). Provide education through the distribution of printed materials that include examples of how released animals can become human health and safety, economic, and ecological, threats once established. Target schools to educate children on the importance of preserving natural ecosystems. Adults should be targeted as they will be the group most likely to release, smuggle and inadvertently harbor pest species. The military sector and foreign contract workers should be focused upon with extra effort.

Begin to regulate against aesthetic releases of terrestrial vertebrates. While specific regulations exist regarding the importation of pets (see GARR Title 9, 1997), regulations regarding release of animals are less developed and detailed, such that release remains relatively unmonitored. The only mention of regulation to prevent release is at the pier or airport inspection areas; Section 2 of § 1103 (GARR) states that under no circumstances shall any animal be turned loose at the port, and that hogs and sheep may be confined in temporary pens or crates, cattle and horses may be tied, and dogs and cats shall be confined in crates. Require specific taxa such as birds and mammals (rodents) be quarantined immediately upon arrival in compliance with existing APHIS requirements. Therefore the regulation only restricts release at the port of entry with no regulations against releases post-border, which is when aesthetic releases are most likely to occur. Under a new regulation, if an intentional release is known to occur in the community and is reported, individuals involved should be subject to a penalty such as fines.

8.7.5.3 Food Use

- Risk of importation 3
- Risk of establishment 3
- Hazard 3
- Total risk 9 **HIGH**

The importation of domesticated animals as a food source is common worldwide. The continued importation of animals via this pathway makes this a high-risk pathway. As a consequence, transport and release of domesticated food species onto islands lacking them is typically viewed as simply exercising the right to feed oneself, and the practice continues around the globe (Kraus 2009b). However, some domesticated animals introduced as a farmed food source can successfully establish and some species can be highly invasive and ecologically destructive (sheep, pigs, frogs). Also, newly introduced food species often coincide with the immigration of new ethnic groups to a place making this motive both culturally and demographically linked.

Imported poultry and eggs must be quarantined, and inspected, and poultry must be vaccinated by a Territorial veterinarian for health condition prior to entry on Guam under Title 9 GARR 1997 and USDA-APHIS regulations and inspection. All poultry and hatching eggs must remain on board or be confined on the pier or airport inspection area until passed by the inspector under this regulation. With poultry being the natural host for pullorum disease, health inspections and quarantine quell human health threats, as pullorum disease can also affect humans. In addition, poultry can carry NDV, a virus that may be present in high concentrations in the bodily secretions of infected birds. The virus is spread by air, contact with body secretions, and by contaminated water and feed (UNH Extension Program, http://extension.unh.edu/resources/files/Resource000792_Rep815.pdf).

Prohibit the farming of frogs and freshwater turtles for food. Large frog species continue to be known as an easy way to raise protein in one's backyard either for direct consumption or, more often, for commercial sale (Kraus 2009b). However, frog farming remains a difficult industry with limited success and commonly leads to introductions of frogs when failed farms are abandoned (Kraus 2009b). Frog farming has not been attempted much in Micronesian countries, and therefore it remains a plausible commercial endeavor in the region. Freshwater turtles such as the Chinese soft-shelled turtles, (*Pelodiscus sinensis*) have been introduced and spread through the farming industry. The inexperience of farming of these taxa makes the risk of introduction high for the Micronesia Region and the importation of these species for farming purposes should be prohibited as a preventative measure.

Aquaculture shipments entering Guam must have an import permit, certificate of origin, and health certificate, and should undergo physical inspection for amphibians and their eggs. Aquaculture shipments are not always physically inspected, even though these shipments are a known pathway for the unintentional and intentional introduction of amphibians and their eggs (Christy et al. 2007b; Kraus 2009a). Illegal import of terrestrial vertebrate pest species can occur through legal means, such as with aquaculture imports. USFWS only has nine ports in the United States that are designated to approve shipments of live fish and fish parts for aquaculture, and these are in the Continental United States and Hawai'i. The Designated Port Exception Permit is required if Guam or CNMI is the first port of entry for a fish shipment. USFWS approval of fish shipments is intended to prevent harmful exotic species from establishing and approval is typically granted contingent on the permit being complete. Aquaculture shipments should be physically inspected upon arrival, especially those containing live freshwater species such as catfish and tilapia, which are more prone to containing tadpoles that are not clearly

evident amongst the imported fish fry being shipped in nontransparent containers, which further complicates inspections.

Use digital resources to track the trade and importation of animals for food use in the Micronesia Region. The illegal import of terrestrial vertebrate pest species can occur through legal means, such as with animals imported for food use. The Internet can be used to identify the sale of prohibited or non-compliant importation of animals for food use. The Invasive Species Internet Monitoring System automates the process of searching the Internet for suspect sites (e.g., Internet storefronts, chat rooms) involved in the sale or trade of targeted species (Suiter and Sferrazza 2007) for the pet trade, and this tool may be applied to detect breaches in legal importation of animals for food use.

Educate the community about the dangers of maintaining populations of potentially invasive species for food. This education should include ensuring that overseas workers who may come to the region for construction and other projects are aware of the risks associated with such practices. Create educational materials, broadcast public service announcements on the radio, and submit newspaper articles outlining the impacts of establishing populations of species for food. These materials should include examples of species known to be introduced for food use, and also known to be highly invasive in one or more countries (e.g., rabbits [*Oryctolagus cuniculus*], banteng [*Bos javanicus*], water buffalo [*Bubalus bubalis*], Polynesian rat [*Rattus exulans*], spotted turtledove [*Streptopelia chinensis*], water frogs [*Rana ridibunda*]) (Crook 1973; Atkinson 1978; Long 1981; Lever 1994; Arano et al. 1995; Pagano and Schmeller 1999; Athens et al. 2002; Courchamp et al. 2003; Long 2003a; Pagano et al. 2003; Vorburger and Reyer 2003; Towns et al. 2006; Hunt 2007).

8.7.5.4 *Animals for Entertainment*

- Risk of importation 2
- Risk of establishment 2
- Hazard 3
- Total risk 7 **MODERATE**

Some species are imported purely to entertain members of the community. Two major examples of this in Micronesia include importation for stocking zoological facilities, and poultry importations for the popular and legal pastime of cockfighting. While the containment and display of these species is inherent to both zoological facilities and fighting cock owners, accidental releases to the wild occasionally occurs as a result of these practices.

Laws and regulations regarding zoological facilities need to be established and/or improved for all jurisdictions with the possible except of Hawai'i. Regulations for Hawai'i may in fact be an appropriate starting place for the other jurisdictions. The situation which occurred on Guam when the zoological facility in southern Guam closed last decade highlight the fact that there are gaps in existing regulations and protocols for Guam and likely other jurisdictions in this regard. In the Guam

case, some of the animals from the zoological facility which closed were never accounted for suggesting that they may have ended up in the general community or even been released.

Zoological facilities should update and maintain secure caging, as well as improve security measures at the facilities. Most records of releases at zoos are accidental due to non-secure caging, but there have also been several instances of intentional releases of animals by personnel at larger, public zoos (Shaw 1946; Long 1981). Zoological facilities should conduct and document inspections routinely of their caging structures, and weak points must be addressed immediately. The facilities should also selectively hire security staff to prevent instances of criminal animal release. Currently, there is one zoo on Guam (previously with two), one on Rota, and one on Saipan (Stanford, personal communication). A relatively low amount of activity makes the risk of importation rather low, but the rather poor maintenance standards evinced by many private zoos make risk of release into the wild rather high (Kraus 2009b).

Species in zoological facilities should be kept only in small numbers, and breeding pairs are of higher priority for cage maintenance. If large colonies or cohorts of breeding adults of both sex classes of a species are kept within the same cage, there is a higher risk of establishment if a release does occur. Cages that contain breeding pairs should be of higher priority for the inspection and maintenance of cage security.

USDA-APHIS agents, in coordination with GCQA, must verify permits and health inspections for animals being imported for the purpose of stocking zoological facilities. Importation of zoological stock animals to Guam requires an import permit obtained from Guam's office of the Director of Agriculture and animals are subject to inspection by the territorial veterinarian prior to entry to Guam (9 GARR § 1111) as well as the AWA, which is implemented by APHIS through its Enhanced Animal Welfare Act Enforcement Plan.

USDA-APHIS agents at airports throughout Guam and the CNMI must report and confiscate fighting roosters arriving from the U.S. mainland. While cockfighting events remain legal in Guam and the CNMI, the export of fighting roosters and associated cockfighting weapons from the U.S. mainland is considered a felony under the Animal Fighting Prohibition Enforcement Act of 2007. Guam is a known hotspot for cockfighting, such that all imported roosters arriving in Guam should be considered imported for cockfighting purposes. Eggs have less of a chance of surviving transport because of the higher physiological demands of eggs as compared to adult chickens. Under this recent piece of legislation, pressure has been applied to stop commercial airlines from transporting fighting roosters. Airlines such as United, Philippine, and Korean Airlines refuse to transport fighting roosters as a precautionary upholding of the Animal Fighting Prohibition Enforcement Act. This act will stop the importation of adult fighting roosters, reducing the overall number of domesticated birds entering Guam and the CNMI. People who claim their imported roosters are pets should be subject to a monitoring program using periodic paperwork and inspections to track the actual use of the roosters imported.

8.7.5.5 *Game Hunting*

- Risk of importation 1
- Risk of establishment 2
- Hazard 3
- Total risk 6 **MODERATE**

Game hunting on Guam and throughout the CNMI is a cultural practice, and also functions in game population management because it is a low-cost management tool to reduce feral animal populations; thereby reducing habitat destruction on the island (Conry 1988b). Game introductions typically include only mammals and birds; reptiles and amphibians are not moved for this purpose (Kraus 2003; 2009a). The animals hunted on Guam are all introduced species such as the Philippine deer, wild pig, and black francolin. Similar to other Pacific Islands (Hawai'i), pigs have the most negative impact on forests and agriculture on Guam (Conry 1988a). Many of the ungulates introduced for game purposes have proven very destructive of native ecosystems on Pacific Islands and elsewhere (Stone 1985; Conry 1988b; Wardle et al. 2001; Wiles 2005; Hughey and Hickling 2006; GISD 2010). This is both because of direct herbivory on native vegetation as well as trampling of the substrate (e.g., Duncan and Holdaway 1989), both of which lead to plant death and increased erosion (Kraus 2009b). Due to their negative impact on the environment (erosion, trampling vegetation), Asiatic water buffalo (carabao) can no longer be hunted, and populations are being controlled by hormone injections to reduce reproductive rates. Once popular game, the fruit bat and Phillipine turtle dove are no longer allowed to be hunted due to declining populations (<http://www.guamdawr.org/wildlife/hunting/>).

Regulations preventing further importation of feral animals for recreational hunting must be upheld and expanded. USDA-APHIS oversees the importation of feral animals from foreign ports through the facilitation of international trade and monitoring of animal health at the border. Uphold APHIS regulations for certain species whether feral or not for foreign origin imports to Guam; APHIS regulations take precedence when they are more restrictive than the laws and regulations of the U.S. federal government. APHIS regulations would not apply to shipments coming to Guam from the United States (non-foreign origin), but imports to Guam from the United States are not considered foreign imports. As it stands, feral animals may be imported to Guam with proper permitting and approval by the Director of the Department of Agriculture (Title 9, GARR 1997). There should be no further importation of feral animals for the purpose of recreational hunting, because the game densities are more than sufficient on Guam (e.g., wild pigs; Conry 1988a), especially if more hunting areas were to be opened for access.

Additional hunting areas should be opened for public access, and hunting by military personnel on military lands is encouraged. Guam law requires hunters to obtain written permission to hunt on private property, and public lands for hunting are often surrounded by military and private parcels, making hunting access logistics difficult (Conry 1988b). In particular, the Air Force and Navy already control large parcels of land where game is found, and Andersen AFB, NCS, and the Naval Facility have hunting programs, but access is restricted to military personnel. If personnel are not frequently hunting

on these lands, herds of game will accumulate and habitat degradation becomes rampant. The military should work with GDAWR and USFWS to facilitate public hunting access on military lands of lower-level restriction during regimented times. Also, with the increase in military personnel on Guam as a result of the relocation, there lies an opportunity to increase hunting on military lands.

8.7.5.6 Biocontrol

- Risk of importation 1
- Risk of establishment 3
- Hazard 2
- Total risk 6 **MODERATE**

Biocontrol introductions are those made for the purpose of providing predatory control of another pest species, and typically itself is also of alien origin. Ironically, most of these releases have failed to control the pests they were intended to destroy but have become pests themselves (Kraus 2009b). Classic examples include the introduction of cats for controlling rodents that damage agriculture (Dickman et al. 2010), mongoose for controlling rats and snakes (Long 2003b, a; Watari et al. 2008), and cane toads released for controlling sugar cane pests (Lever 2001), all involving governmental support. While government-backed biocontrol has become less common due to the large amount of failed examples, biocontrol by private actions remains a risk. There is a general lack of public knowledge regarding the dangers of biocontrol and some recent introductions are initiated by private entities, under the belief that the pest can be controlled directly by the predator without any indirect, adverse effects. Attempts of biocontrol by private actions will be closely associated with the pet trade, as this is the most likely source for exotic animals for intentional release.

Place USFWS and USDA-APHIS inspectors on military bases in Guam and CNMI and initiate proper training of Military Customs personnel to recognize and prohibit importation of potential biocontrol-use species. The importation of species by military aircraft is worsened by the fact that USFWS does not have inspectors stationed at military bases in the region, so the probability of interception is unlikely. Depending upon the species, APHIS may also have import regulation requirements. The military route has led to numerous illegal importations of banned reptiles into Hawai'i (Hawai'i Department of Agriculture records), and some of these species include those released elsewhere for control of house pests. Similar activities likely occur on military bases in Micronesia and would likely increase with the relocation of military personnel on Guam and in CNMI, making this a likely source of importations for the purpose of private biocontrol initiated by individuals (Kraus 2009b).

Educate the public about regulated and scientifically proven effective control measures in place for BTS and other biting snakes. BTS and other snakes pose human health risks due to painful bites which can be life-threatening, depending on the species. Approximately one in every thousand hospital visits on Guam is due to a BTS biting incident, with victims including infants, agricultural workers, and BTS field staff (Rodda et al. 1999), leading to a large-scale economic impact as well. Many people have a deep-seated fear of snakes, and the vast majority of people resent snakes inside homes, stores, and other

human environments (BTSCC 1996). Due to the high incidence of bites, it is natural for members of the community to want to protect themselves and others from snake pests, and they may resort to biocontrol under private actions. However, these attempts would be ineffective; there are no effective natural predators of BTS on Guam. Feral cats, feral pigs, and monitor lizards prey on snakes, but their effect is minimal (BTSCC 1996).

Furthermore, the introduction of the mongoose to Guam has been proposed due to its reputation as a snake predator even though they are not adapted to do so. Mongooses are diurnal and cannot climb well, unlike BTS. Previous introductions of mongooses to control the habu in Pacific Islands have failed, and resulted in additional ecological problems, including the extirpation of some native herpetofauna (BTSCC 1996).

Proposed biocontrol measures must be approached with extreme vigilance, and those considered for action must undergo long-term scientific trials. Vertebrate biocontrol releases have tended to have high probabilities of successful establishment (Long 2003b; Kraus 2009a) due to high propagule pressure. For example, the introduction of the mongoose to Pacific Islands was an early attempt of biocontrol of an agricultural pest species, with the approach rooted in predator-prey dynamics. Yet, the mongoose has proven too general of predator, causing the decline of native bird and reptile species (Simberloff 1992). In Hawai'i, 22% of 243 biocontrol agents were documented to attack organisms other than their intended targets (Funasaki et al. 1988). In application, the biocontrol attempt may often lead to unforeseen ecosystem consequences that worsen the original problem (Matthews and Turner 2009) or create new management problems.

While countries such as Australia (McFadyen 1989) and New Zealand (Fowler et al. 2000), have established effective regulatory policies for biological control, the United States does not have an integrated policy on the implementation of biocontrol, and policies can differ vastly in stringency by state (Messing and Wright 2006). For these reasons, proposed biocontrol measures must be approached with vigilance; rigorous, long-term scientific trials must be required and fielding of professional and community opinions is integral.

8.7.5.7 *Scientific Research*

- Risk of importation 1
- Risk of establishment 3
- Hazard 3
- Total risk 7 **MODERATE**

Releases associated with scientific research can be attributed to two main types: 1) deliberate or accidental releases from medical research facilities, and 2) deliberate releases to study ecology or behavior of the released specimens (Kraus 2009b). Accidental release from inadequate caging or mishandling of species may also occur. Examples of problematic releases from research facilities include the escape of monkey species, which quickly establish in the wild given the proper environmental

conditions and food availability (Long 2003), or the establishment and rapid spread of escaped frog species (e.g., *Xenopus laevis*) (Lafferty and Page 1997). The importation for scientific research will not be a common occurrence in Micronesia, because the region has few medical or research facilities, with one medical school found in FSM and various biological research labs at the University of Guam (Western Pacific Tropical Research Center, Cancer Research Center and Guam Aquaculture Development and Training Center).

Scientific research in U.S. territories that involve terrestrial vertebrates must be approved by the Institutional Animal Care and Use Committee and undergo routine inspections in compliance with the AWA. All U.S. research facilities where vertebrates are used for research must have an active Institutional Animal Care and Use Committee permit for research prior the implementation of protocols. For example, at the University of Guam, the committee inspects animal facilities at least semi-annually and reviews any practices involving pain to animals and the condition of animals to ensure compliance with the AWA, 7 U.S.C. § 2143 et seq.; 9 CFR 1, §2.31 and the standards of the United States Public Health Service as set forth in the Guide for the Care and Use of Laboratory Animals (http://www.uogonline.com/gateway/forms/rules_regs_proc_man.pdf, accessed September 30, 2010). Facility inspections will help to ensure proper secure caging is maintained and proper quarantine protocols are in place.

Caging and containment of vertebrates used in research must be routinely inspected and maintained, and security personnel must be in place at the facility. Research facilities should conduct and document inspections routinely of their caging and containment structures, and weak points must be addressed immediately. Like zoological facilities, there is a risk of accidental or intentional release by staff of captive vertebrates. The facilities should also hire security personnel to prevent instances of intentional animal release by individuals.

The importation of monkeys and *Xenopus laevis* for research use should be banned from Guam and the CNMI. Currently, the regulations on importation of vertebrates to Guam do not mention the policy on importation of vertebrates for the use of research (Title 9 GARR). However, the regulations should be updated to specifically address this motive for importation and restrict problem species such as monkeys and *Xenopus laevis*.

8.7.5.8 Religious Ceremonies

- Risk of importation 1
- Risk of establishment 1
- Hazard 2
- Total risk 4 **LOW**

Intentional releases of terrestrial vertebrate species can occur during religious ceremonies or because of religious beliefs. Birds and turtles are the most common terrestrial vertebrates used for release (Severinghaus and Chi 1999, Kraus 2009a), but mammals, frogs, and snakes are targeted as well

(Agoramoorthy and Hsu 2005, 2007; Corlett 2010). Many of these released animals are purchased from pet stores, with one study finding one-quarter of all birds stocked in Taipei pet stores slated for this purpose (Severinghaus and Chi 1999), making this motive tied to the pet trade and its associated risks and recommendations. Therefore, the risk of religious ceremony release can be intercepted if the recommendations suggested for the pet trade are successfully implemented.

Create agreements with groups of concern that are known to participate in religious releases of vertebrates. There are two major sources of vertebrate releases for religious purposes, the Buddhist and Taoist practice of releasing captive animals as an expression of compassion to improve one's karma (Shiu and Stokes 2008) and Christian snake-handling cults in the southern United States who release venomous snakes (Wilson and Porras 1983). The risk of establishment is high for this motive because of the typically large volume of animals released and the high frequency of release, leading to high propagule pressure. The risk from this motive is low for Micronesia at present, although this could change if larger numbers of practicing members of groups of concern immigrated to the region. Attempts should be made to create agreements with groups of concern directly regarding the release of vertebrates. This motive is very difficult to regulate, as releases occur in large numbers and may be incidental or routine, depending on the sect of the religious group. Educational materials that outline the human health and safety, economic, and ecological threats of vertebrate release should be disseminated to practicing groups of concern in Micronesia.

8.7.5.9 *Bioterrorism*

- Risk of importation 1
- Risk of establishment 1
- Hazard 3
- Total risk 5 **LOW**

Optimal characteristics for bioterrorism agents include being very small in size (microscopic), hazardous to humans, easy and inexpensive to produce, and rapid spatial dissemination. Well-known examples include anthrax, bubonic plague, and smallpox. Vertebrates do not fit these desirable characteristics themselves due to their relatively large size. One possible exception would be that a large number of venomous snakes could be introduced for such a purpose, but the numbers required for importation for the task (hundreds to thousands) could likely not easily be overlooked by a border-security system (Kraus 2009b). Therefore, the risk of this motive for vertebrates as bioterrorism agents themselves is low, and any importation for this purpose will likely be detected by inspectors. However, it must not be overlooked that bioterrorism agents may be tactically introduced via a domesticated non-human vertebrate host. Epizootic outbreaks may first be noticed in vertebrate species such as livestock, where the agent was introduced along with a host that was cleared at the border. Due to prolonged and close exposure of livestock to people, the zoonotic agent then infiltrates the human health circuit. The potential for introduction of a bioterrorist agent will be of particular concern for Guam due to projected extensive military presence on the island. In general, the increases in human population, both military

and civilian, are expected to significantly increase the likelihood of wildlife pathogen introductions and spread via humans.

Health certificates (issued by the USDA Animal Health Division or by the state veterinarian for the state of origin), must accompany imported livestock, and such livestock is subject to health inspections by the territory veterinarian(s) and quarantined if needed. All animals that have been exposed to, are suffering from, or appear to have the symptoms of a contagious or infectious disease, shall in addition to the inspection be subject to quarantine under regulations of the government of Guam (2 GARR § 1110.5) and required USDA-APHIS Animal Health Permits. Depending on the species of livestock, inoculations or pathogen assay tests may be required prior to entry (e.g., horses, cattle). Bird species, especially those in the pet trade like psittacines, should be quarantined upon arrival.

Livestock operations on Guam shall undergo routine inspections by the Department of Agriculture (Guam) to determine the health condition of all animals boarded at each farm. This mandate is in compliance with § 62104.3. Standards of Care for Livestock (GCA Government Operations: <http://www.justice.gov.gu/compileroflaws/GCA/05gca/5gc062.pdf>).

A network must be established for the reporting of animals exhibiting symptoms of zoonotic agents. A cooperative network for communication must be made involving the CDC, USDA-APHIS, livestock owners, and local veterinarians, among others to exchange information regarding detections of symptoms caused by hazardous pathogens in livestock. The goal of such a network is to readily disseminate alerts within the region to prevent further spread of bioterrorist agents in the case they are introduced.

8.8 CONCLUSION

Biosecurity is a management process that requires a specific and appropriate framework in which to operate effectively. Additionally, a biosecurity strategy requires sustained and managed funds, the capabilities to address myriad security issues, and flexibility to undergo regular assessment and refinement as needs change and new risks are identified. This biosecurity plan accomplished the following goals: 1) identified pathways by which species may be transported, introduced, and established; 2) identified risks associated with pathways and the threats posed to human health and safety, the economy, and ecology; and 3) provided recommendations for the prevention and mitigation of the identified risks. Furthermore, a comprehensive pathway analysis was used, which accounts for the interrelatedness of pathway use and overlap of military and civilian sectors.

This plan provides guidance and instruction to prevent and mitigate risks associated with the military relocation in the Micronesia Region; comply with stringent environmental legislation; and coordinate with agencies at the federal, state, and local level.

9 PORT-PATHWAY MITIGATION ANALYSIS

9.1 GUAM MITIGATION CAPABILITIES AND INFRASTRUCTURE

Table 12-1: Mitigation Measures for Guam Airports and Maritime Ports

Mitigation Capabilities/Infrastructure	Airports	Maritime Ports Containerized (DoD)	Maritime Ports Containerized Cargo All Sources	Maritime Ports Break Bulk Cargo	Maritime Ports Bulk Cargo
Inspect	X	X	X	X	X
Identify	X	X	X	X	X
Control	X	X	X	X	X
Quarantine	X	X	X	X	X
Treat/disinfect/decontaminate	X	X	X	X	X
Review permits, licenses, sanitation certificates	X	X	X	X	X
Train	X	X	X	X	X
Monitor/transfer garbage to approved disposal company	X	X	X	X	X

9.2 GUAM CRITICAL INFRASTRUCTURE PROFILES

9.2.1 A.B. Won Pat International Airport-Guam

Table 12-2: A.B. Won Pat International Airport-Guam

Description	Current Mitigations	Impact of Military Relocation
300 flights per week. Seven international airlines and six air freight couriers operate out of the A.B. Won Pat International Airport. The airport has 21 aircraft parking positions with 18 common use terminal gates (55% commercial, 24% air taxi; 21% local general aviation; <1% transient general aviation) (AirNav 2007).	<p>Inspection of aircraft, baggage, and cargo by GCQA—about 120 inspectors assigned to airport and seaport.</p> <p>Collaborate with APHIS to enforce regulations.</p> <p>Monitor garbage.</p> <p>Port control measures: Quarantine, Decontamination, Treatment/washing</p> <p>Arriving commercial aircraft are not usually inspected for terrestrial vertebrate species. All aircraft departing Guam, commercial or military, are inspected for BTS (EO 13112, Invasive Species).</p> <p>Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Container scanners are not available on Guam.</p>	The large additional number of people arriving on Guam during the buildup will strain the already limited resources of GCQA.

9.2.1.1 ***Prioritized Actions-A.B. Won Pat International Airport–Guam***

- The international airport foreign inspection area is large enough to accommodate the increased flights and to enhance inspectional needs.
- However, personnel specially trained for agricultural quarantine inspections and equipment (e.g., x-ray machines) for inspection of all baggage must be increased.
- GCQA should designate agricultural specialists on all shifts. There should be additional personnel for passenger baggage and aircraft inspection daily (assigned to all shifts).
- GCQA should have inspectors that specialize in agricultural inspections. Due to shift work and the large number of inspection sites, GCQA should plan to increase total staff with specialists dedicated to agricultural inspection. Inspectors should be available for agricultural products on all shifts at the international airport.
- X-ray machines are inoperable. Obtain adequate capacity for inspection of luggage and large boxes. Expand numbers of x-ray stations from two to four with new x-ray units that have conveyor belts at ground level on front and back.
- Detector dogs should be available at all international airport shifts. Increase staffing of agricultural detector dogs from four to eight. Agricultural detector dogs should be used in mail and cargo inspections.
- GCQA should have access to the USDA-APHIS ePermits system. Access can be provided by APHIS.
- Legislation should allow full access to GCQA to CBP targeting databases so inspectors in Guam routinely can examine manifests and hold and release cargo for 2 to 3 days prior to ship arrivals.

Funding Priorities

- GCQA must explore all opportunities to expand legislative authority to increase user fees to allow GCQA to fund the necessary increase in inspectors and equipment for more entry inspections and a reliable mitigation infrastructure.
- GCQA should consider raising these fees for biosecurity and agricultural inspections. The funding structure of USDA and CBP can be utilized as a guide.

9.2.1.2 ***General Recommendations-A.B. Won Pat International Airport-Guam***

Resources

- Staffing at A.B. Won Pat International Airport for agriculture inspections should be expanded to permit GCQA inspection of all incoming passenger baggage during the increased military use of commercial air transportation pathways, the increase in commercial air cargo with the proposed military relocation, and expected passenger plane travel. Ensure adequate numbers of inspectors, identifiers, pest survey specialists, etc. to carry out mitigation measures effectively.

GCQA should be funded and staffed at optimum levels for all necessary inspection and quarantine activities.

- X-ray machines should be available and work properly to maximize baggage screening. Increase the number of detection equipment (x-ray) at airports in Guam from two to four. The sensitivity of the machines should be increased.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports and plant and animal inspection facilities.
- Install container scanners at the port facility. Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected.
- Ensure garbage collected in sterile areas are handled and processed as regulated garbage.

Inspection

- Conduct inspections on commercial/private aircraft arriving to Guam and departing.
- Inspect all arriving conveyances for illegal animals or animal products.
- Increase inspection rates of commercial air freight.
- Inspect passengers transiting to other locations in the Micronesia Region for regulated agricultural commodities.
- Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods should search containers randomly regardless of documentation, type of shipment, or country of origin. Paperwork with arriving air cargo shipments in crates and containers should be automated for more rapid selection of containers to be screened and for new avenues for pre-clearance procedures.
- All military personnel checked baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected for compliance with USDA-APHIS regulations. Expand the inspection capabilities for military airfreight containers.
- A communications network for continuously shared relevant new information among inspectors is recommended.

Control

- Implement measures to control invasive species at and around washdown facilities. Control measures include barriers, trapping, and insect population reduction.
- Construct barriers around aircraft staging areas to protect aircraft from hitchhikers.

Treatment

- All military air cargo departing Guam should be cleaned, inspected, and loaded on the aircraft for transport immediately.

Surveillance

- Increase airport surveillance measures.

Rapid Response

- Improve airport rapid response capabilities.

9.2.2 Andersen Air Force Base-Guam

Table 12-3: Andersen Air Force Base-Guam

Description	Current Mitigations	Impact of Military Relocation
<p>Air Mobility Command aircraft transports military cargo not consigned to commercial carriers. Military aircraft used in medical/emergency missions depart Guam with little or no notice for inspection. Military training operations are conducted by the Army, Marine Corps, Air Force, and Navy.</p>	<p>Inspection of aircraft Vector/arthropod controls Medical and agricultural quarantine Aerosol disinfection</p> <p>Aircraft moving between Hawai'i, Guam, Puerto Rico, Virgin Islands, and the continental U.S. must undergo USDA/GCQA inspection by inspectors with authority to board military aircraft (Section II, Subsection C of the Quarantine Regulations of the Armed Forces Section 10 of OPNAVINST 6210.2, USDA requirements for movement of animal and plant diseases and pests). With no internal inspection and cleaning, hitchhiking pests and animals go undetected. Arriving military aircraft usually are not inspected for terrestrial vertebrate species. All aircraft departing Guam, commercial or military, are inspected for BTS according to EO 13112, Invasive Species, by APHIS-WS.</p> <p>Planned Improvements: Additional aircraft will be housed on Andersen AFB by the Marine Corps.</p>	<p>Unknown schedule or frequency of military flights aside from those supporting periodic training missions on Tinian.</p> <p>Increase in military flights and passengers to and from Guam.</p>

9.2.2.1 Prioritized Recommendations-Andersen Air Force Base-Guam

- The present passenger facility at Andersen AFB is far too small for baggage inspection. The facility should be tripled in size and it should have an inspection table with sufficient lighting and a conveyor belt.
- GCQA coordination at flight arrivals with Andersen AFB personnel must be improved so that advance notice may be given for all flight arrivals into Guam.

9.2.2.2 General Recommendations-Andersen Air Force Base-Guam

Resources

- There should be an adequate number of inspectors, identifiers, surveyors, etc. to carry out mitigation measures effectively.
- Military funding for biosecurity efforts in the region should be proportionate to the increase in cargo volume expected by the military relocation.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses, and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports.
- Place GCQA inspectors on military bases in Guam and initiate proper training of military customs personnel to assist in smuggling prevention, animal confiscation, law enforcement and coordination with rapid response teams.

Infrastructure

- A pre-clearance staging area for all military aircraft requiring immediate departure from Guam is needed.

Inspection

- Facilitate USDA-APHIS-PPQ and WS inspections of military air embarkation procedures comparable to, compatible with, and co-located with Andersen AFB operations for loading and unloading aircraft cargo. The Quarantine Regulations of the Armed Forces state that cargo is subject to inspection by the USDA to prevent the introduction or spread of animal and plant diseases or pests. For the purposes of these regulations, Guam is part of the United States.
- Conduct internal and external inspections on military aircraft arriving at Guam.
- MCI programs should augment and improve inspectional capacity for all military arrivals and departures.
- Expand the inspection capabilities for military airfreight containers.
- A communications network for continuously sharing relevant new information among inspectors is recommended.

Control

- Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction.
- Construct barriers around aircraft staging areas to protect aircraft from hitchhikers.

Treatment

- All military air cargo arriving and departing Guam should be cleaned, inspected, and loaded for immediate transport.

Surveillance

- Increase surveillance measures in military airports and screening checkpoints.

Rapid Response

- Improve airport rapid response capabilities.

9.2.3 Apra Harbor

9.2.3.1 Apra Harbor Military Seaport-Guam

Table 12-4: Apra Harbor-Military Seaport-Guam

Description	Current Mitigations	Impact of Military Relocation
Military Maritime Traffic MIRC is a major naval training area that includes Guam, the islands of Saipan, Tinian, Rota, and Farallon de Medinilla, and the training area W-517 (U.S. Navy 2009a). Exercises involve 3 to 30 ships and last 5 to 21 days. Training events may occur 1 to 5 times per year. The southern end of Apra Harbor on Guam has four major wharves available for docking ships: Victor Wharf, Sierra Wharf, Polaris Point, and Kilo Wharf. Navy waterfront facilities are located in both outer and inner harbors. Waterfront facilities for the U.S. Coast Guard are located in the inner harbor.	Inspection Decontamination Treatment Monitoring garbage Port control measures Quarantine Treatment / washing GCQA has authority to inspect military vessels per an MOU with USDA-APHIS-PPQ. Planned Improvements: New embarkation area for loading and unloading ships new amphibious vehicle lay-down area, four waterfront projects	Large increase in military vessel calls and cargo expected to enter through this facility.

9.2.3.2 Prioritized Recommendations-Apra Harbor-Military Seaport-Guam

- The military port of Guam should have centralized points of inspection of break bulk and containerized cargo.
- DoD and GCQA should cooperate in a local MOU to enhance collaboration and develop protocols for inspection of military vessels by GCQA personnel for agricultural compliance purposes.
- Institute a military customs inspector program with GCQA and DoD agreement to augment inspections of military vessels.

- Initiate military pre-clearance program for cargo and military assets moving from Okinawa to Guam. This program should be aligned with other APHIS-PPQ military training and pre-clearance initiatives.
- APHIS-PPQ should train GCQA for conducting inspections, treatments, data analysis, and safeguarding methods.
- Priority for surveillance of exotic and destructive insects should include trapping for: 1) exotic fruit flies, 2) Khapra beetle (in cargo and cargo warehouses); and 3) tropical forest pests.
- An inspection pest risk committee to analyze pest detection information should be formed with participation of GCQA, APHIS, and territorial officials.

9.2.3.3 *General Recommendations-Apra Harbor-Military Seaport-Guam*

Resources

- There should be sufficient numbers of inspectors, identifiers, surveyors, etc. to carry out mitigation measures effectively.
- Military funding for biosecurity efforts in the region should be proportionate to the increase in cargo volume expected by the military relocation.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports and plant and animal inspection facilities.
- Station GCQA inspectors on military bases in Guam and initiate proper training of military customs personnel to assist in smuggling prevention, processing insect pests, plant and animal diseases, and confiscated animals, enforcing laws, and coordinating with rapid response teams.
- Increase the number of agriculture and WS canine inspection teams at the seaport.

Inspection

- Inspect all arriving conveyances for illegal animals or animal products.
- A communications network for continuously sharing relevant new information among inspectors is recommended.
- Visually inspect all incoming construction vehicles, equipment, and materials, including those previously treated or cleaned (due to high chance of recontamination with hitchhikers).
- Manage the grounds around military seaports and beach access point facilities to reduce populations of target invasive species, and stop existing wildlife populations from interacting with introduced wildlife at ports of entry.
- Inspect all military arriving vessels internally and externally.
- Improve protocol for inspecting the holds of military ships.

- Implement inspection procedures for vehicle cargo aboard high-speed military vessels.

Control

- Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction.
- Construct barriers around cargoes and aircraft staged on land overnight to protect from hitchhikers.

Treatment

- Military aircraft transported as cargo (aboard an aircraft carrier or other military vessel with aircraft transport capabilities) must be inspected, cleaned, and washed down at the port of entry.
- Military amphibious vehicles arriving via water must be inspected, cleaned, and washed down at a retrograde wash facility before entry.
- POVs arriving via water through military routes must be washed down at a port facility before entry.
- Military assault vehicles arriving as cargo via maritime vessels must be washed down at a retrograde wash facility before entry.
- WPM should be compliant with ISPM No. 15.

Training

- Provide training to improve inspection and identification expertise for WPM pests WPM.

Surveillance

- Increase surveillance measures in military and commercial air- and seaport entry points and screening check points.

9.2.4 Apra Harbor Commercial Seaport-Guam

Table 12-5: Apra Harbor-Commercial Seaport-Guam

Description	Current Mitigations	Impact of Military Relocation
<p>Jose D. Leon Guerrero Commercial Port of Guam is located at the northern end of Apra Harbor with commercial and recreational facilities in the outer harbor. The Commercial Port has six berths with the main cargo terminal for port access for vessels with unusual draft and cargo container handling requirements.</p> <p>The majority of the large ships are operated by Matson Navigation Company and Horizon Lines. The Kyowa Shipping Company also operates in the area from the ports of Busan, South Korea and Yokohama, Japan into the port on Saipan. Regional shipping from the ports of Guam and Saipan throughout the region is by Kyowa, Seabridge Marine, and Micronesia Express Service. Islands serviced by these providers in the region: Guam; Saipan and Tinian (CNMI); Majuro (RMI); Pohnpei, Chuuk, Kosrae and Yap (FSM); and Palau.</p>	<p>Inspection Decontamination Monitoring Port control measures Quarantine Treatment/washing</p> <p>GCQA inspect only a portion of containers. GCQA and USDA/APHIS/WS inspect containerized freight at Port of Guam’s 78 freight stations across the island (de-centralized). Planned Improvements: The Port of Guam plans significant improvements to present facilities.</p>	<p>Large increase in vessel calls and maritime containers.</p> <p>Source: Master Plan 2008, Port Authority of Guam</p>

9.2.4.1 *Prioritized Recommendations-Apra Harbor-Commercial Seaport-Guam*

- Improve pest exclusion by increasing GCQA staffing of inspectors significantly at the commercial seaport to inspect incoming ships and cargo for pests and invasive species.
- A significantly larger workforce is necessary without a centralized inspection area.
- There is a major risk of dissemination of pests and diseases with the present cargo/container system on Guam.
 - Ensure that GCQA can staff significantly more inspectors at the commercial seaport to inspect incoming ships and cargo fully. A significantly larger inspectional workforce is necessary without centralized inspection areas in Guam.
 - Port of Guam must develop facilities for inspection of containers and devanning of cargo. These facilities should be incorporated into the Port of Guam Master Plan and must adhere to standards for sufficient lighting and inspection tables as specified by the APHIS-PPQ Manual for Agricultural Clearance.

- Safeguarded areas for storing and staging vehicles and cargo must be maintained. Vegetation-free areas of 1.8 meters (6 feet) or more must be maintained around the area as well as physical barriers.

9.2.4.2 *General Recommendations-Apra Harbor- Commercial Seaport-Guam*

Resources

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at both the commercial and military seaports.
- There should be sufficient numbers of inspectors, identifiers, surveyors, etc., to carry out mitigation measures effectively.
- GCQA should be funded and staffed at optimum levels for all necessary inspection and quarantine activities
- Develop a reference collection of plausible insect pests and wildlife (i.e., taxidermy mounts) to aid in the identification of incoming species.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at port offices.
- Increase the number of canine inspection teams stationed at Apra Harbor Commercial Port

Infrastructure

- Build a centralized USDA-APHIS-approved staging area for containerized commercial cargo arriving at the Port of Guam.

Inspection

- Inspect all arriving conveyances for insect pests and illegal animals or animal products.
- Expand the inspection capabilities for commercial containers. Containerized cargo is the most frequent type sent in and out of Guam and the Micronesia Region.
- Randomly sample imports (e.g., cargo containers) for insects, animal products, and wildlife.
- Implement x-ray detection for baggage screening.
- Improve protocol for inspecting commercial ship holds.
- Designate entry inspection requirements and personnel for construction materials.
- Visually inspect all incoming construction vehicles, equipment, and materials, including those previously treated or cleaned (due to high chance of recontamination by hitchhikers).
- Develop improved methods for inspecting timber.

- Inspect cargo at both departure and arrival points if transported on open barges moving break-bulk items that originate near heavily vegetated locations and new construction sites where heavy equipment is in proximity to jungle areas.
- A communications network for continuously sharing relevant new information among inspectors is recommended.

Control

- Manage the grounds around commercial seaports and beach access point facilities to reduce populations of target invasive species, and stop existing wildlife populations from interacting with introduced wildlife at ports of entry. Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction. Construct barriers around cargoes and aircraft staged on land overnight to protect from hitchhikers.

Treatment

- POVs arriving via ships through commercial routes must be washed down at a port facility before entry.

Training

- Train inspectors in proper techniques for detecting, extracting, and recognizing pests from WPM.
- Create additional training and education programs for inspectors in proper identification of quarantine species.
- Facilitate training/education programs for inspectors in changing livestock and poultry hazards.
- Conduct background surveys at ports-of-entry so customs and quarantine personnel are familiar with the local animals.

Surveillance

- Increase surveillance measures in military and commercial airports, seaport entry points, and screening checkpoints.

9.2.5 Guam Marinas

Table 12-6: Guam Marinas

Description	Current Mitigations	Impact of Military Relocation
Guam also has two marinas, Hagatna Marina (Gregorio D. Perez Marina) and Agat Marina, administered by the Port Authority of Guam (PB International 2008). There are at least three major recreational fishing events that utilize these marinas (Guam Marianas International Fishing Derby, the Fisherman’s Festival, and the Annual Marianas Underwater Fishing Federation Competition). The fishing derby averages around 70 boats and 300 fishermen. A total of 75 teams participated in the derby departing from both the Agat and Hagatna Marinas in 2009.	Both have chain link fences on their perimeters but are in generally poor condition.	Additional unscheduled maritime traffic and events.

9.2.5.1 *Prioritized Recommendations - Guam Marinas*

- Provide advance notifications of arrival to GCQA inspectors.

9.2.6 Guam Postal Station

Table 12-7: Guam Postal Station

Description	Current Mitigations	Impact of Military Relocation
Domestic mail cannot be inspected without a warrant and the presence of the postal inspector.	Guam postal authorities do not always authorize access to mail x-ray facility.	Mail volume is expected to increase with population.

9.2.6.1 *Prioritized Recommendations-Guam Postal Station*

- Install new x-ray machine for inspection of international mail.
- Canine inspection teams should have daily access to mail. Canines should be scheduled on a standard shift.
- GCQA and APHIS must collaborate with the USPS to develop more efficient mail inspection protocol.
- These entities must work closely with the U.S. Attorney’s Office and the Federal Magistrate to establish, implement, and maintain a domestic mail program to enable inspectors to work with USPS to execute federal warrants for opening and inspecting first class mail.

9.2.6.2 General Recommendations-Guam Postal Station

Authority

- Grant GCQA the authority to inspect domestic mail from the United States with coordination of APHIS-PPQ, U.S. Attorney, and a Federal Magistrate.

Resources

- GCQA should be staffed at levels sufficient to inspect the increased number of packages expected as a result of the military relocation.
- Deploy canine inspection teams to mail facilities for faster and more efficient screening of international and domestic mail.

Inspection

- X-ray all incoming international mail parcels. The existing x-ray machine is not operable.

Survey

- Record and analyze and share with appropriate authorities and stakeholders data on pest interceptions in mail.

Collaboration

- Encourage collaboration between customs officials, agricultural officials, and mail facility staff with the overall goal of decreasing the number of quarantine plant materials introduced to Guam through the mail pathway.

9.2.7 Guam Plant Inspection Station

Table 12-8: Guam Plant Inspection Station

Description	Current Mitigations	Impact of Military Relocation
Guam Plant Inspection Station	All plants and plant materials must be inspected at a Plant Inspection Facility on Guam.	Increased shipments of propagative plant material.

9.2.7.1 Prioritized Recommendations - Guam Plant Inspection Station

- With increases in population and traffic, the present staffing would be overwhelmed. Staffing must be augmented by following new positions: 1) botanist, 2) data entry personnel, and 3) agriculture commodity inspectors.

9.2.7.2 General Recommendations - Guam Plant Inspection Station

Resources

- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses, and other diagnostic equipment) and supplies (e.g. reference materials, identification keys) at plant and animal inspection facilities.

9.3 MICRONESIA LOCATION PROFILES

9.3.1 Commonwealth of the Northern Mariana Islands

9.3.1.1 Saipan-Francisco C. Ada Saipan International Airport

Table 12-9: Francisco C. Ada Saipan International Airport

Description	Current Mitigations	Impact of Military Relocation
<p>Several major airlines and a commuter terminal, mostly commuter flights. Direct flights from Guam, Japan, Korea, Hong Kong, Manila, and China. Tourism is an economic driver.</p>	<p>Cleared by Saipan Customs and Saipan Quarantine. 14 quarantine officers (24/7). Specifically trained BTS inspectors with the CNMI DFW and rapid responders including three BTS canine teams., visual inspectors, and trappers.</p> <p>Immigration and Customs officials are available during scheduled operations, or by prior arrangements with the chief of Immigration Saipan. Container scanners are not operable. No baggage x-ray machine available.</p> <p>Planned Improvements: Improvements underway at airport.</p>	<p>The major impact of military relocation will be increased tourism for Saipan.</p>

9.3.1.1.1 Prioritized Recommendations-Francisco C. Ada Saipan International Airport

- Increase the number of inspectors to meet anticipated demands with appropriate coverage.
- Explore legislative measures for user fees to expand staffing and to procure necessary vehicles and equipment.
- Acquire one new baggage x-ray machine for more efficient baggage and box screening.
- Establish a trapping and surveillance program for exotic and injurious plant pests and diseases. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have a BTS trapping program at both the air and sea ports in Saipan.

9.3.1.1.2 General Recommendations-Francisco C. Ada Saipan International Airport

Resources

- Expand the number and sensitivity of detection equipment (x-ray) at airports in CNMI.
- Expand financial resources in the CNMI to maintain and enhance border inspection, control and eradication, and rapid response programs. Consideration legislatively-approved user fees for arriving air passengers and cargoes.
- Implement an electronic system for recording, tracking, and identifying manifests for containerized commercial cargo arrivals to Guam and Saipan to streamline import process while maintaining biosecurity.
- Install container scanners or repair those in disuse because of insufficient funds.

Inspection

- Expand the inspection capabilities for air and sea containers and increase and strengthen performance accountability.

Treatment

- Maintain permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment at the seaport in Saipan.
- Wash down and inspect construction vehicles arriving via water before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesia Region monitoring and surveillance program for foreign animal and plant introduction would improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others

9.3.1.2 Tinian-Tinian Air Transports

Table 12-10: Tinian Air Transports

Description	Current Mitigations	Impact of Military Relocation
Mostly commuter flights. Night flights from Saipan and Guam for the hotel and casino; 90% of tourists visiting the CNMI from East and Southeast Asia. Flights to Tinian are 0.33% of Guam’s flight volume.	Immigration and Customs officials are available during scheduled operations, or by prior arrangements. No baggage x-ray machine available.	Estimates will be considerably increased during military exercises in Tinian. The major impact of the military relocation for Tinian will be greatly increased use of the island for regular and frequent military exercises and other

	<p>One BTS canine team.. and trapping for BTS with CNMI DFW.</p> <p>Planned Improvements: Improvements underway at airport.</p>	<p>purposes.</p>
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9.3.1.2.1 *Prioritized Recommendations-Tinian Air Transports*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections.
- Inadequate resources for regulated garbage.

Prioritized Actions

1. Construct and maintain a military-use washrack facility for cleaning soil-contaminated vehicles and equipment returning to Guam from regular military exercises.
2. Acquire new x-ray machine for examination of baggage and boxes.
3. Explore legislation for user fees for incoming passengers, cargo, and conveyances to fund biosecurity and agriculture quarantine/inspection.
4. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include, but not limited to: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have trapping program for BTS.
5. Ensure adequate resources for the disposal of domestic garbage (landfill) and regulated garbage (sterilizer or incinerator).

9.3.1.2.2 *General Recommendations -Tinian Air Transports*

Resource

- Expand financial resources in the CNMI to maintain border inspection, control and eradication, and rapid response programs.
- Expand the number and sensitivity of detection equipment (x-ray) at airports in the CNMI.
- Initiate proper training of military personnel to assist in smuggling prevention, animal confiscation, law enforcement, and coordination with rapid response teams.
- Establish appropriate operations for handling regulated garbage.

Inspection

- Ensure appropriate advance notice of arrival provided by military to CNMI agriculture officials.
- All military personnel baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected in compliance with federal and territorial regulations.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the commercial seaport in Tinian.
- Construction vehicles arriving via water must be washed down and inspected before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesia Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.1.3 Rota-Rota Air Transports

Table 12-11: Rota Air Transports

Description	Current Mitigations	Impact of Military Relocation
Rota has an emerging tourism industry targeting service members, increasing development, and has legalized gambling. Flights to Rota are 1.18% of Guam’s flight volume.	Immigration Customs and Quarantine are available during scheduled aircraft operations and upon prior arrangements with field supervisors. No baggage x-ray machine available. One BTS canine team and trapping for BTS with CNMI DFW. Planned Improvements: Improvements underway at airport.	The major impact of military relocation will be increased tourism due to the proximity to Guam.

9.3.1.3.1 Prioritized Recommendations-Rota Air Transports

All Micronesian island economies (except Guam) share similar challenges and issues:

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections

With Rota building a gambling casino, there will be more traffic from Guam and other locations. Therefore, due to the proximity to Guam:

1. Enact legislation for user fees to increase staffing and inspectional capacity for prevention of spread of invasive species.
2. Set up and establish a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have a trapping program for BTS (but this could be improved).

9.3.1.3.2 General Recommendations-Rota Air Transports

Resources

- Expand financial resources in the CNMI to maintain border inspection, control and eradication effort, and rapid response programs

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.
- Construction vehicles arriving via water must be washed down and inspected before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.2 Federated States of Micronesia

Table 12-12: Federated States of Micronesia

Description	Current Mitigations	Impact of Military Relocation
The four FSM states of Micronesia: Kosrae, Pohnpei, Chuuk, and Yap, form an independent nation that has signed a Compact of Free Association with the United States.	Any aircraft or vessel entering FSM are subject to inspections by customs, immigration, agriculture, and administrative personnel (LIS). All aircraft are inspected for stowaways, presumably human. The FSM developed a National Biosecurity Biodiversity Strategy and Action Plan (NBISAP) in 2002. Each of the four FSM states has a Biodiversity Strategy Action Plan Three trained ED/RR personnel in Pohnpei	The impact of the military relocation will include: 1) some increase in tourism, 2) increased employment in Guam for FSM population, and 3) increased air travel to and from Guam.

9.3.2.1 *Prioritized Recommendations -Federated States of Micronesia*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
 - Lack of surveillance for plant and animal pests and diseases.
 - Lack of sufficient infrastructure for air and sea cargo inspection activities
1. Enact legislation for user fees to fund infrastructure improvements for entry inspection
 2. Establish public outreach program for workers and visitors to Guam on entry requirements to and from FSM.
 3. Set up and establish a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle.

9.3.2.2 *General Recommendations - Federated States of Micronesia*

Resources

- Expand FSM financial resources to maintain border inspections at their air and sea ports and expand control and eradication and rapid response capabilities.
- Obtain and maintain operability of detection equipment (x-ray) at all FSM airports for baggage screening and inspection.

- Expand the inspection capabilities for air and sea containers and for the exportation of agricultural products.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.

Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesia Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, , including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.3 Republic of the Marshall Islands

Table 12-13: Republic of the Marshall Islands

Description	Current Mitigations	Impact of Military Relocation
<p>The RMI is an independent island group that has signed a Compact of Free Association with the United States.</p> <p>Main ports are Kwajalein and Majuro.</p>	<p>All aircraft and vessels entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel. Aircraft known or suspected to harbor insects or agricultural pests must be sprayed with an insecticide. Any employee of the RMI Ports Authority may enter an aircraft for the purpose of inspection.</p> <p>Three trained ED/RR staff in Majuro</p>	<p>The impact of the military relocation will be: 1) some increase in tourism, 2) increased air travel to and from Guam and Hawai'i.</p>

9.3.3.1 *Prioritized Recommendations-Republic of the Marshall Islands*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and diseases.
- Lack of sufficient infrastructure for air and sea cargo inspections.

Prioritized Actions

1. Enact legislation to fund infrastructure improvements and increased inspections for agricultural and environmental pests and diseases.
2. Establish public outreach program for workers and visitors to Guam on entry requirements to and from RMI.
3. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, and 3) tropical wood pests.

9.3.3.2 *General Recommendations-Republic of the Marshall Islands*

Resources

- Expand financial resources in the FSM to maintain border inspections at the airport and seaport, and control and eradication and rapid response capabilities.
- Obtain and maintain operability of detection equipment (x-ray) at all FSM airports for baggage screening and inspection.
- Expand the inspection capabilities for air and sea containers.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.
- Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesia Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.4 Palau

Table 12-14: Palau

Description	Current Mitigations	Impact of Military Relocation
Palau is an island nation that has signed a Compact of Free Association with the United States.	All aircraft and vessels entering or leaving Palau are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel. Aircraft known or suspected to harbor insects or agricultural pests must be sprayed with an insecticide. Any employee of the Palau Ports Authority may enter an aircraft for the purpose of inspection. Two trained ED/RR staff	The impact of the military relocation will be: 1) increased tourism due to greater availability of recreational activities and interest in ecotourism activities on Palau, and 2) increased air travel to and from Guam.

9.3.4.1 Prioritized Recommendations –Palau

All Micronesia island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections.

Prioritized Actions

1. Enact legislation to fund infrastructure improvements and increased inspections for agricultural and environmental pests and diseases.

2. Ensure appropriate biosecurity within Palau in regards to the established Macaque Monkeys in Anguar to prevent spread to the rest of Palau as well as other locations within Micronesia.
3. Establish public outreach program for workers and visitors to Guam on entry requirements to and from Palau.
4. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, and 3) tropical wood pests.

9.3.4.2 *General Recommendations-Palau*

Resources

- Expand Palau’s financial resources to maintain border inspections at the airport and seaport and control and eradication and rapid response capabilities.
- Maintain operability of detection equipment (x-ray) at Palau’s airport for baggage screening and inspection.
- Expand the inspection capabilities for air and sea containers.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.
- Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesia Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.4 AIRPORT OPERATIONAL STATISTICS FOR GUAM AND CNMI INTERNATIONAL AIRPORTS

Table 12-15: Aircraft Operational Statistics for Guam and CNMI International Airports

	Guam ^a	Tinian ^b	Saipan ^c	Rota ^d
Aircraft based on the field	83	6	22	-
Single engine airplanes	20	4	14	-
Multi-engine airplanes	10	2	8	-
Jet airplanes	52	-	-	-
Helicopters	1	-	-	-
Average aircraft operations/day	108	36	108	127

% commercial flights	55	<1	18	27
% air taxi flights	24	98	61	69
% local general aviation flights	21	1	2	3
% transient general aviation flights	<1	<1	16	<1
% military flights	<1	<1	1	<1

^a For the 12-month period ending 04 May 2007 (AirNav 2010b);

^b For the 12-month period ending 04 May 2009 (AirNav 2010d)

^c For the 12-month period ending 31 December 2007 (AirNav 2010a); ^dFor the 12-month period ending 08 May 2008 (AirNav 2010c)

9.5 MICRONESIAN REGION AIR TRANSPORTS

Table 12-16: Micronesian Region Air Transports

Location	No. of Daily flights	Relationship to the number of Guam flights	Air Transport Companies (targets for outreach)
Guam ^a	108	--	Commuter flights include Freedom Air, Cape Air, and Pacific Island Aviation.
Tinian ^b	36	.33	Freedom Air (daily flights) and the privately chartered Star Marianas Air
Saipan ^c	108	1.0	
Rota ^d	12	1.18	Commuter flights include Freedom Air and Cape Air, primarily from Saipan and Guam
Regional			Private jet plane charters from Aviation Concepts, Airport Group International, and Guam flight services

^a For the 12-month period ending 04 May 2007 (AirNav 2010b);

^b For the 12-month period ending 04 May 2009 (AirNav 2010d)

^c For the 12-month period ending 31 December 2007 (AirNav 2010a); ^dFor the 12-month period ending 08 May 2008 (AirNav 2010c)

9.6 MILITARY RELOCATION ESTIMATED IMPACT ON PATHWAYS

Table 12-17: Pathway Impact Factors Related to Military Relocation

Pathway	VS Risk Rating ^a	WS TV Risk Rating ^a	WS WD Risk Rating ^b	Likely Sources
Population (people)	Negligible	High		Japan, Korea, Taiwan Hong Kong and the Philippines
Baggage		High		Japan, Korea, Taiwan Hong Kong and the Philippines
Aircraft-military	Very low	High		Non-specific
Aircraft-commercial	Very low	High		Japan, Korea, Taiwan Hong Kong and the Philippines
Cargo-containers (military)		High		Okinawa, U.S. mainland, Hawai'i
Cargo-containers (all sources)	Very low	High		S. Korea, Taiwan, CNMI, Japan, United States via Hawai'i
Cargo-break bulk (all sources)	Very low	High		United States, S. Korea, Indonesia, China, Philippines, Japan, Singapore, Taiwan, Thailand, CNMI

Pathway	VS Risk Rating ^a	WS TV Risk Rating ^a	WS WD Risk Rating ^b	Likely Sources
Cargo-bulk (all sources)	Very low	High		United States, S. Korea, Indonesia, China, Philippines, Japan, Singapore, Taiwan, Thailand, CNMI
Commercial maritime vessels	Very low	High		Australia, China, Korea, Hong Kong, Japan, Malaysia, Philippines, Singapore, Taiwan, Thailand, Micronesia Region, New Zealand and the United States.
Military maritime Vessels	Very low	High		Non-specific
Construction equipment/materials	Very low	High		U.S., Indonesia, China, Philippines, Japan; wood from Palau; cement and concrete from FSM
WPM	Very low	High		Any country; possibly higher risk from CNMI, FSM, American Samoa, Palau, RMI; United States, Japan, Korea, Europe
Domestic and International mail	Very low			Malaysia, Thailand, United States, Australia, China
Regulated garbage	Low			
Imports of biological commodities (below)	Negligible to Low	Low to Moderate		Various sources
Propagative Plants				United States, Japan, S. Korea, Philippines, CNMI, FSM, Palau, Thailand, Taiwan, Costa Rica, Ecuador, and Puerto Rico
Plant Products (commodities)				United States (92%), Korea (3%), FSM (2%)
Livestock	Negligible			United States, Hawai'i
Poultry	Low			United States, Hawai'i (legal imports); Philippines, other Asian countries (smuggling)
Non-poultry birds	Very low			United States (legal imports); Mexico, Central America, and South America, Japan, Hong Kong, and Indonesia (smuggling)
Cats and dogs	Negligible			United States, Australia, Japan, CNMI
Animal products	Low			
Exotic pet		High		Pacific rim, other Micronesia Region islands
Aesthetic		High		East Asia, Pacific rim, other Micronesia Region islands
Food Use		High		East Asia, Pacific rim, other Micronesia Region islands
Animals for entertainment		Moderate		East Asia, Pacific rim, other Micronesia Region islands
Game hunting		Moderate		
Biocontrol		Moderate		
Scientific research		Moderate		
Religious ceremonies		Low		Cambodia, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, Thailand, and Vietnam, United States

Pathway	VS Risk Rating ^a	WS TV Risk Rating ^a	WS WD Risk Rating ^b	Likely Sources
Bioterrorism		Low		Nonspecific
Intentional releases (biocontrol; aesthetic)				
Wildlife disease:			Low to High	
West Nile Disease			High	U.S. mainland
HPAI			Moderate	Southeast Asia
Avian Malaria parasites			Moderate	
Henipaviruses			Moderate	Australia, Philippines
END			Moderate	
Hantavirus			Low	China, Pacific rim
Rabies virus			Low	
Yersinia pestis			Low	China, Pacific rim
Tick-borne encephalitis			Low	

Note: Pathway impact factors related to military relocation (based upon estimates from the U.S. Navy 2010a; Port of Guam Master Plan 2008)

^a Overall (VS) or total (WSTV) risk rating

^b Impact risk rating (WSWD)

9.7 MITIGATION REQUIREMENTS BY PATHWAY

Table 12-18: Mitigation Requirement by Pathway

Pathway	Pre-test/certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
Passengers				X	X	X	
Baggage				X			X
Aircraft-military			X	X			X
Aircraft-commercial			X	X			X
Cargo-containers (military)				X		X	X
Cargo-containers (all sources)				X		X	X
Cargo-break bulk (all sources)				X		X	X
Cargo-bulk (all sources)				X		X	X
Maritime vessel-military				X			X
Maritime vessel-commercial							X
Construction equipment-materials		X		X			X
WPM				X			X
Mail				X			
Regulated garbage			X	X	X		X
Plant propagative				X	X		X

Pathway	Pre-test/certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
materials							
Plant products	X	X		X	X		
Soil				X	X		X
Livestock	X				X	X	X
Poultry	X	X			X		
Pet birds	X	X			X		
Dogs and cats	X			X	X	X	X
Other animals		X			X	X	
Animal products				X	X		

Source: U.S. Navy 2010a; Port of Guam Master Plan 2008

9.8 PATHWAY IMPACTS AND MITIGATION PROCEDURES

Table 12-19: Pathway Impacts and Mitigation Procedures

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
A	Military personnel/families transport from U.S. to Guam—commercial aircraft	Invasive hitchhikers/Exotic (import) plant or animal	Aircraft passenger-crew	Commercial passenger flight increases (not able to be determined due to unknown schedule/pace for relocation)	Inspection, hold of passengers, crew
			Aircraft cabin, hold		Inspection, hold of conveyance
			Aircraft exterior		Inspection, hold of conveyance
			Air baggage		Inspection, hold of baggage
			Air cargo		Inspection, hold of cargo
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal import		
		Animal pest or pathogen/vector	Animal or animal product import		
		Zoonotic infection	Aircraft-passenger-crew		Inspection
B	Off-island construction workers and dependents and off-island workers for Induced jobs/dependents Transport from Pacific rim to Guam—commercial aircraft	Invasive hitchhikers	Aircraft passenger-crew	Increased flights to Guam are expected to increase the transport of invasive pests and diseases.	Inspection
			Aircraft cabin		Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal (import or smuggled)		
		Animal pest or pathogen/vector	Animal or animal product (import or smuggled)		
		Zoonotic infection	Aircraft passenger-crew		Inspection

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
C	Military cargo transport from Okinawa to Guam—commercial or military vessel	Invasive hitchhikers	Vessel crew	Expected to increase during buildup due to relocation of military resources. (Source: Master Plan 2008, Port Authority of Guam)	Inspection
			Vessel cabin, hold		Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Bulk cargo		Inspection, control
			Break bulk cargo		Inspection, control
			Packaged cargo		Inspection, control
			Containers		Inspection, control
			Garbage		Monitoring, disposal
		WPM	Inspection, control, treatment		
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
Invasive animal	Animal import	Permit review, inspection, identification, quarantine, treatment			
Animal pest or pathogen/vector	Animal or animal product import	Inspection			
Zoonotic infection	Vessel crew	Inspection			
D	Shipment construction equipment/materials from Pacific Rim or Micronesia to Guam—commercial vessel	Invasive hitchhikers	Vessel crew	Estimated cargo shipments to greatly increase during military buildup. Expected to remain well above 2011 levels after buildup for (Source: Master Plan 2008, Port Authority of Guam)	Inspection
			Vessel cabin, hold		Inspection, control, treatment
			Vessel baggage (crew)		Inspection
			Vessel exterior		Inspection, control, washing
			Stone, sand, etc.		Inspection, control, treatment
			Garbage		Monitoring, disposal
			Equipment/vehicle		Inspection, control, treatment, washing
			WPM		Inspection, control, treatment
		Invasive hitchhikers/wood boring insects/	Timber		Inspection, control, treatment
		WPM	Inspection, treatment		

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
		Zoonotic infection	Vessel crew		Inspection
E	Domestic and international mail from Hawai'i to Guam	Invasive hitchhiker (seed, insect)	Package/Post office	Larger mail volume with increased population on Guam.	X-ray inspection
		Bioterror agent (zoonotic)			X-ray inspection
		Invasive plant/pest	Plant or plant product		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal		
		Animal pest or pathogen/vector	Animal or animal product		
F	Military exercises from Tinian to Guam—amphibious vessels, vehicles; 1 week 12 times per year	Invasive hitchhikers	Aircraft cabin, hold	Special events	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection
G	Military exercises from Tinian to Guam—aircraft; 1 week 12 times per year	Invasive hitchhikers	Vessel cabin, hold	Special event, unscheduled	Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal import		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product import		Permit review, inspection, identification, quarantine, treatment
		Zoonotic infection	Aircraft-passenger-crew		Inspection

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
H	Transport from Guam to Hawai'i—commercial aircraft	Invasive hitchhikers	Aircraft cabin, hold	Commercial passenger flight increases are possible from Hawai'i.	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
		Aircraft passenger-crew	Inspection		
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
Animal pest or pathogen/vector	Animal or animal product (import or smuggled)	Inspection			
Zoonotic infection	Aircraft-passenger-crew				
I	Domestic and international mail from Guam to Micronesia	Invasive hitchhiker (seed, insect)	Package/Post office	Insignificant increase expected.	X-ray inspection
		Bioterror agent (zoonotic)			X-ray inspection
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal import		
		Animal pest or pathogen/vector	Animal or animal product		
J	Civilian air travel (personnel, contractor family, friends)—to/from Guam, other Micronesian Region islands	Invasive hitchhiker	Aircraft cabin, hold	Commercial passenger flight increases are expected.	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
		Aircraft-passenger-crew	Inspection		
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			Permit review, inspection, identification, quarantine, treatment
		Invasive animal	Animal (import or		Permit review, inspection,

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
			smuggled)		identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product (import or smuggled)		Inspection
		Zoonotic infection	Aircraft-passenger-crew		Inspection
K	Military exercises on Tinian—amphibious vessels, vehicles—from Guam to Tinian; 1 week 12 times per year	Invasive hitchhikers	Aircraft cabin, hold	Special event, unscheduled	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection, control,
L	Military exercises on Tinian—aircraft—from Guam to Tinian; 1 week 12 times per year	Invasive hitchhikers	Vessel cabin, hold		Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel	Inspection	
			Gear	Inspection, control	

9.9 APHIS-VETERINARY SERVICES RISK RATINGS

Table 12-20: APHIS-VS Risk Ratings

Pathway	Release Assessment - Legal	Release Assessment - Illegal	Exposure Assessment	Consequence Assessment	Overall Risk	Likely Sources
Conveyance-Aircraft	Very low	N/A	Medium	Guam and Micronesia: Very Low U.S.: Very low	Very Low	
Conveyance-Maritime vessels	Very low	N/A	Medium	Guam and Micronesia: Very Low U.S.: Very low	Very Low	

Pathway	Release Assessment - Legal	Release Assessment - Illegal	Exposure Assessment	Consequence Assessment	Overall Risk	Likely Sources
People	Negligible	Negligible	N/A	N/A	Negligible	U.S. Mainland, Hawai'i, Philippines, China, Korea
Livestock	Negligible	Negligible	N/A	Guam and Micronesia: N/A U.S.: N/A	Negligible	
Poultry	Negligible	Very low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Non-poultry birds	Negligible	Very low	Medium	Guam and Micronesia: Very low U.S.: Very low	Very Low	
Cats and dogs	Negligible	Negligible	N/A	Guam and Micronesia: N/A U.S. N/A	Negligible	
Animal products	Negligible	Low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Garbage	Negligible	Very low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Other cargo	Very low	N/A	Medium	Guam and Micronesia: Very low U.S.: Very low	Very Low	

9.10 APHIS-WS TERRESTRIAL VERTEBRATES RISK RATINGS

Table 12-21: APHIS-WS Terrestrial Vertebrates Risk Rating

Pathway	Total Risk	Likely Sources
Conveyance-Aircraft	HIGH	
Conveyance-Maritime vessels	HIGH	
Cargo	HIGH	
Construction	HIGH	
Plant products	HIGH	
WPM	HIGH	
Garbage	HIGH	

Table 12-22: APHIS-WS Terrestrial Vertebrates Risk Rating

INTENTIONAL	Importation	Establishment	Hazard	Total Risk	Likely Sources
Pet trade	3	3	3	9 HIGH	
Aesthetic releases	3	2	3	8 HIGH	
Food use	3	3	3	9 HIGH	
Animals for entertainment	2	2	3	7 MODERATE	
Game hunting	1	2	3	6 MODERATE	
Biocontrol	1	3	2	6 MODERATE	
Scientific research	1	3	3	7 MODERATE	
Religious ceremonies	1	1	2	4 LOW	
Bioterrorism	1	1	3	5 LOW	

9.11 APHIS-WS WILDLIFE DISEASES RISK RATINGS

Table 12-23: APHIS-WS Wildlife Diseases

Pathway	Probability of Infection	Alternate Probability	Impact of Infection	Alternate Impact	Likely Sources
Hantavirus	Moderate		Low		
Rabies virus	Minimal		Low		
West Nile Virus	Minimal		High		
HPAI	High		Moderate	Moderate	
Japanese Encephalitis Virus	High		Minimal	Low	
Avian Malaria Parasites	High	Minimal	Moderate	Moderate	
Henipaviruses	Minimal	High	Moderate	Moderate	
NDV	Minimal	High	Moderate	Moderate	
Yersinia pestis	Minimal		Low		
Tick-Borne Encephalitis	High		Low	Moderate	

10 QUALITY ASSURANCE AND IMPROVEMENT

Every security plan is measured by how it achieves its stated objectives. The MBP was developed to prevent the introduction of invasive species and pathogenic agents into Hawai'i, Guam and the Micronesia Region, a lofty goal with the broad range of potentially invasive species and frequency of conveyances that can transport plants, animals, pests, vectors, and pathogens to these locations. The MBP must assist biosecurity planners in doing their best to prevent unintentional introductions. The MBP must adequately describe in detail:

1. Risks for specific pathways and species
2. Compliance, inspection, treatment, and other mitigation procedures
3. Pre-clearance, monitoring, and outreach programs that can prevent introductions
4. Military relocation events that could affect the types and frequencies of releases
5. Rapid response teams, resources, and procedures for species eradication

Few security plans effectively cover all requirements, particularly early in the process. An improvement planning program is essential for continual MBP review for gaps, inconsistencies, and any other required improvement. Too often, organizations delay such review processes until a critical gap causes an unfortunate event. The MBP therefore builds in a process for continual improvement. Each of the five features listed should to be tested regularly, as should command and control, communications, funding, and resource allocation, all important support functions.

10.1 INTRODUCTION TO MBP IMPROVEMENT PLANNING PROGRAM

The MBP Improvement Planning Program is an overarching framework for planning and implementing MBP upgrades based on a concept of operations, federal authorities, best practices, and a system of capabilities-based training and tests within an overall objective of continual improvement in MBP effectiveness. The Improvement Planning Program is the foundation for all aspects and processes in MBP TT&E events and a mechanism for needed improvements.

10.2 CONCEPT OF OPERATIONS

The Concept of Operations is the foundation for TT&E Program framework. It includes major planning areas required to build the program:

- MBP scope, policies, and procedures
- Authorities and requirements
- Program objectives
- Roles and responsibilities
- Maintaining executive-level support

- Budgeting, funding allocation, and resource management
- MBP integration with partners and stakeholders
- Training on biosecurity policies, roles, and processes
- Development planning meetings and event coordination
- Multi-year TT&E schedule (calendar of events)
- Collaborative biosecurity agreements with external organizations
- TT&E program design and planning
- Corrective action plan
- Reports to headquarters, partners, and stakeholders

10.3 MBP IMPROVEMENT PLANNING DEVELOPMENT EVENTS

To develop an effective MBP improvement plan, various types of planning, training, and test events are recommended. A comprehensive improvement planning program includes:

- Training seminars
- Improvement planning conferences
- TT&E workshops
- TT&E events
- After-action conferences

10.3.1 Training Seminars

A training seminar should be scheduled annually to present current MBP policy, regulations, procedures, and responsibilities to key personnel, partners, and stakeholders. The event is an opportunity to make changes to the plan, especially in light of events in the field and observations from test exercises.

10.3.2 Improvement Planning Conferences

An improvement planning conference should be scheduled annually for an opportunity to communicate recovery objectives, identify resources, and track Improvement Plan (accomplishments and actions against current capabilities. The conference would be a forum for key personnel to review MBP actions recorded in previous year's after action reports and corrective action plans. The improvement planning conference will:

- Evaluate current MBP capabilities.
- Review progress toward achieving assigned corrective actions.
- Set new priorities for future TT&E events.

- Announce new policy, regulations, and procedures when appropriate.
- Establish biosecurity planning priorities for the current year.

The improvement planning conference would be held at least 60 days before the first TT&E event of the year. Improvement planning conference participants should be aware of their recovery planning responsibilities and be prepared to prioritize outstanding improvement planning corrective actions.

Participants should establish a multi-year training and exercise plan schedule during this conference. This living document schedules and tracks training and test exercises best planned according to a building-block process that designs test events according to current capabilities and realistic objectives.

10.3.3 TT&E Workshops

The TT&E event workshop should design a specific TT&E event in according to improvement planning conference objectives and priorities. Planning decisions for the type of exercise, event schedule, format, participants, emergency scenario, and actual content should all be influenced by improvement planning conference priorities and objectives as well as perceived capabilities. This performance and capabilities-based approach is consistent with the tiered, building-block plan for improving recoverability.

Table 13-1: Improvement Planning Events

Improvement Planning Events	
Seminar	Schedule an annual seminar to train key personnel on MBP authorities, strategies, plans, policies, procedures, protocols, response resources, and concepts for the biosecurity planning processes.
Planning Conference	Conduct regular planning conferences with the MBP Improvement Planning Committee or Working Group to determine training and testing budgets, resources, formats, objectives, and schedules and to manage the improvement plan and the Corrective Action Plan.
Workshop	<p>Conduct a workshop with the MBP Coordinator, Planning Committee, and participating representatives to plan TT&E event objectives, agenda, formats, participants, location, and logistics.</p> <p>TT&E Event Planning, Design, and Development</p> <p>The important considerations for design and development of the various TT&E events include:</p> <ul style="list-style-type: none"> -TT&E Format -Training and testing schedule -Test objectives -Logistics (event Information, equipment, and supplies) -Event roles and responsibilities -Emergency scenario design -Exercise documentation (guides, evaluation templates, etc.) -Review of actions for lessons learned -Metrics for assessment of biosecurity capabilities <p>TT&E Events</p>

	Test formats based upon objectives are chosen from decision- and operations-based test events.
Decision-Based Test Events	
 <p>Table Top Exercise</p>	In table top exercises, key personnel discuss hypothetical scenarios in an informal and relaxed setting. Table top exercises test knowledge and abilities to access plans, policies, and procedures; systems and operations needed to prevent, mitigate, and respond to incidents. This format depends on the engagement of participants, their assessment of current policies, procedures, and plans, and their recommendations for improvements.
Games	Games are simulations of operations involving two or more teams depicting an actual or assumed real-life situation. Games explore decision making processes and their consequences.
Operations-Based Test Events	
Drills	Drills are coordinated, supervised activities to validate a single, specific operation or function.
 <p>Functional Exercises</p>	Functional exercises evaluate individual capabilities, multiple functions, function activities, or interdependent functions through an exercise scenario with event updates that drive management activity. Functional exercises present complex problems that require rapid, effective responses by trained personnel in highly stressful, time-constrained environments. They utilize incident command systems, unified command, and multi-agency coordination centers (e.g. Emergency Operations Centers (EOCs)). Movement of personnel and equipment is simulated; adversarial groups can stress the incident.
 <p>Full-Scale Exercises</p>	Most full-scale exercises are complex, multi-agency, multi-jurisdictional, and multi-organizational exercises that validate many facets of preparedness. The focus is on implementing and analyzing plans, policies, procedures, and cooperative agreements developed in discussion-based exercises. Operational realities present complex and realistic problems that require critical thinking, rapid problem-solving, and effective responses by trained personnel. A scripted scenario has built-in flexibility for updates to drive activities. Full-scale exercises are conducted in real time, creating a stressful, time-constrained environment closely mirroring real events. They may include first responders under NIMS principles and may include functional play from multi-agency coordination centers, EOCs, or hospitals not at the exercise incident response site.

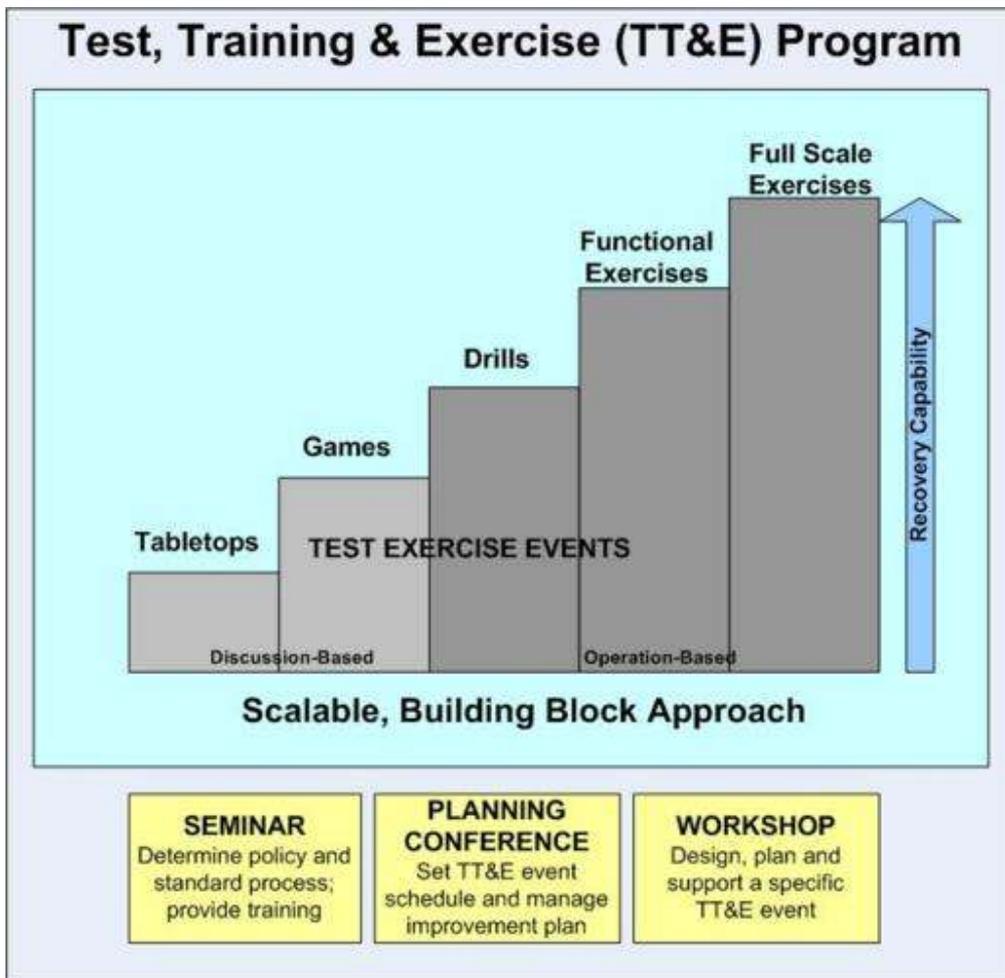
10.4 TT&E PROGRAM PLANNING PROCESS

Table 13-2 depicts the appropriate TT&E event for accomplishing each Improvement Planning Program component.

Table 13-2: Improvement Program Planning Events

TT&E Component	Seminar	Planning Conference	Planning Workshop	TE	Drill	Functional Exercise
Train in MBP policies, regulations, standards, and procedures	X					
Establish a planning and implementation framework for determining long-term objectives, policies, and processes		X				
Establish roles and responsibilities		X				
Design a multi-year MBP training and testing schedule		X				
Decide test event objectives, schedule, design, and format			X			
Discuss the effectiveness of MBP policies and procedures				X		
Test the performance of a specific function or operation					X	
Test the capability to perform comprehensive MBP operations in actual work situations and environments						X
Assign duties for plan remedies from after-action recommendations		X		X	X	X
Manage Improvement Plan		X				

Figure 13-1: Types of TT & TT&E Formats



10.5 ROLES AND RESPONSIBILITIES

Table 13-3 depicts typical roles in improvement planning events and common responsibilities for event design, production, facilitation, and reporting.

Table 13-3: Improvement Planning Roles and Responsibilities

Exercise Role	Responsibility
Improvement Planning Coordinator or Committee	This individual or committee manages all objectives, designs, plans, developments, and assessments. Sets MBP improvement planning program objectives. Develops TT&E Concept of Operations for improvement planning. Implements MBP policies and directives. Directs or oversees TT&E event planning. Approves TT&E event objectives. Manages MBP improvement planning resources and funding. Encourages participation and coordination of TT&E event activities.
Event Planner	Directs and budgets event resources. Implements event objectives received from the planning conference and event workshop. Develops a suitable test emergency scenario. Designs the TT&E format and agenda. Develops discussion topics to target test objectives. Designs and produces event documents (participant’s, facilitator’s, and observer’s guides). Designs and produces a participant assessment survey and Exercise Evaluation Guide.
Facilitator	Provides pre-event guidance, leads the test exercise events, leads discussions, and generally guides events toward stated objectives. Executes the event plan as determined by the workshop. Directs event staff and instructs observers. Keeps proceedings to planned agenda and objectives. Inserts emergency scenario information into the test event. Keeps proceedings on schedule and within scope. Offers questions and leads discussions. Encourages input and records responses from participants, leads review of “Lessons Learned.”
Controller	Directs all or a select area/component of on-site response events during functional or full-scale exercises.
Evaluator	Judges responses in real time during functional or full-scale exercises.
Observer	Observes actions and discussions during functional or full-scale exercises.
Players	Also referred to as participants, these individuals are the subjects of the training and testing; during the event, they are immersed into a fictitious emergency scenario and asked to respond appropriately according to their responsibilities.
Simulators (actors)	Actors with a script to “act out” during an functional or full-scale exercises (e.g. playing perpetrator or victim roles).

10.6 TT&E EVENT PLANNING

Improvement planning personnel adopt a “crawl-walk-run” or “building-block” approach in designing long-term objectives and event schedules. Early TT&E events focus on basic skills, knowledge, requirements, and capabilities, and successive events build in additional test demand as capabilities are proven. For all events, test design and emergency scenarios establish realistic and achievable goals for participants.

For each TT&E event, planners must ask:

- What objectives should be accomplished?
- How should these objectives be accomplished?
- Who should be responsible for the objectives?
- How effective are plans in obtaining required information and guiding planning and response actions?

The answers to these questions change as capabilities and test challenges increase.

Test event planning requires decisions on planning components:

- Event type and format
- Event date, timeframe, and location
- Person or persons designated as event planner(s)
- Personnel invited as participants
- Primary test objectives
- Personnel invited as observers
- Event documentation for reference and reporting
- Logistics (documents, refreshments, etc.)
- Evaluation of event activities and outcomes

10.7 TEST EXERCISE DOCUMENTATION

Develop effective exercise documentation for all facilitators, controllers, exercise players, and observers.

Table 13-4: Test Exercise Documentation

Document	Purpose
Situation Manual	Participant handbook for discussion-based exercises, particularly table top exercises. Includes background information on exercise scope, schedule, and objectives and presents the scenario narrative to drive participant discussion.
Exercise Plan	Used for operations-based exercises. As an exercise synopsis is distributed to players and observers in advance; addresses objectives and scope, assigns roles and responsibilities. Does NOT reveal detailed scenario information like the hazard.
Controller and Evaluator Handbook	Supplements the Exercise Plan with more detailed information about the exercise scenario and describes exercise controllers' and evaluators' roles and responsibilities. Distribution closely controlled.
Master Scenario Events List	Chronological timeline of expected actions and scripted events (i.e., injects).
Player Handout	A 1 to 2 page quick reference for exercise players (distributed before exercise) on safety procedures, logistical considerations, exercise schedule, and other essentials.
Exercise Evaluation Guides	Help evaluators collect and interpret relevant exercise observations. Briefs evaluators on tasks they should see completed or discussed during the exercise; includes space to record observations and questions to address after the exercise as a first step in the development of the After Action Report/Improvement Plan.

10.8 CORRECTIVE ACTION PLANS

The after action report documents TT&E event outcomes and incorporates observations into a formal set of recommendations for improvements. An after-action conference informs participants, planning committees, and stakeholders of after action report priority recommendations.

- Analyze strengths and areas for improvement in formally evaluating biosecurity; report in the after action report lessons learned from exercise data.
- Develop a corrective action plan to track needed improvements and related responsibilities.

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1 **Appendix A: Terrestrial Risk Assessment**

2 **Details**

3 This is an edited version of the original appendix submitted to DoD.

4 The original document was a collection of four risk assessments that were completed independently by
5 four teams of staff from the offices listed below.

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16 Human Health and Safety Project
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18 Hilo, Hawai'i 96721
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20 Wildlife Services
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22 Ecology of Emerging Viral & Bacterial Diseases in Wildlife Project
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26 Veterinary Services
27 Centers for Epidemiology and Animal Health
28 2150 Centre Avenue, Building B
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1 **A1 INTRODUCTION**

2 This risk analysis was developed by the U.S. Department of Agriculture (USDA) Animal and Plant Health
3 Inspection Service (APHIS) at the request of the U.S. Department of Defense (DoD). It is intended to
4 serve as a basis for the development of the biosecurity plan to mitigate plant and animal health risks
5 posed to the Micronesia Region by a planned U.S. military relocation in the Region as referred to in the
6 Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) prepared by the
7 Department of the Navy for the proposed military relocation (U.S. Navy 2010a). For the purposes of this
8 risk analysis, the Micronesia Region is defined as Guam, the Commonwealth of the Northern Mariana
9 Islands (CNMI), the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI),
10 and the Republic of Palau (Figure A1-1).

11 The objectives of this risk analysis are to

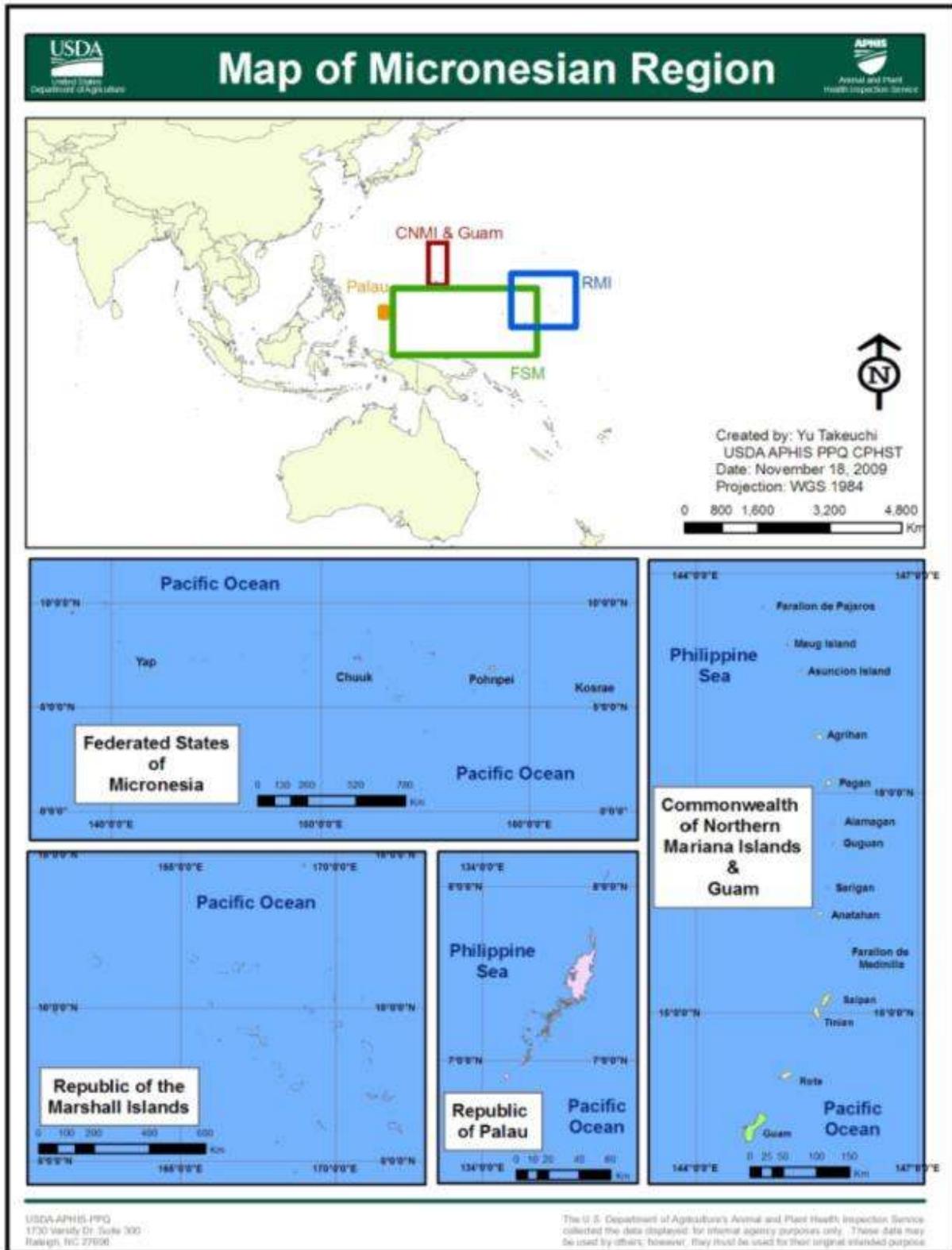
- 12 • Identify exotic terrestrial vertebrates, animal disease agents, and plant pests and diseases
13 that may pose a threat to terrestrial animal and plant health if introduced into the
14 Micronesia Region;
- 15 • Identify the pathways by which these organisms may be moved;
- 16 • Evaluate the relative importance of these pathways with regard to the likelihood that these
17 organisms will be moved; and
- 18 • Evaluate the expected impact of pest introductions on terrestrial animal and plant health in
19 the Micronesia Region.

20 This risk analysis was conducted collaboratively between APHIS-Plant Protection and Quarantine (PPQ),
21 APHIS-Wildlife Services (WS), and APHIS-Veterinary Services (VS). The document is organized into four
22 main sections: plant pests, terrestrial vertebrates, wildlife diseases, and livestock diseases. While a
23 general approach was coordinated among the collaborating groups, each group selected the specific
24 methodology most appropriate to their primary focus.

25 While the scope of this risk analysis includes the entire Micronesia Region, many of the perspectives
26 presented herein focus on Guam. The majority of DoD activities will occur directly on Guam, making this
27 the area for which the most specific information exists and where consequences will be felt most
28 immediately. Guam is the largest point of entry for the Micronesia Region, serving as both the gateway
29 and bellwether for the rest of the Region; one assumption of this analysis is that exotic species issues
30 significant in Guam are relevant throughout the Micronesia Region.

1

Figure A1-1: Map of the Micronesia Region



2

1 **A1.1 OVERVIEW OF THE PROPOSED MILITARY RELOCATION**

2 The three main components of the military relocation as proposed by the DoD are: 1) relocation of U.S.
3 Marine Corps forces to Guam; 2) construction of a nuclear-powered aircraft carrier transient berthing
4 facility in Apra Harbor, Guam; and 3) establishment of an Army Air and Missile Defense Task Force on
5 Guam (U.S. Navy 2010a). The expected consequence of these actions is an increase in the number of
6 people living on Guam and, consequently, increased traffic to and from Guam, increased construction
7 activities, and increased commodity imports.

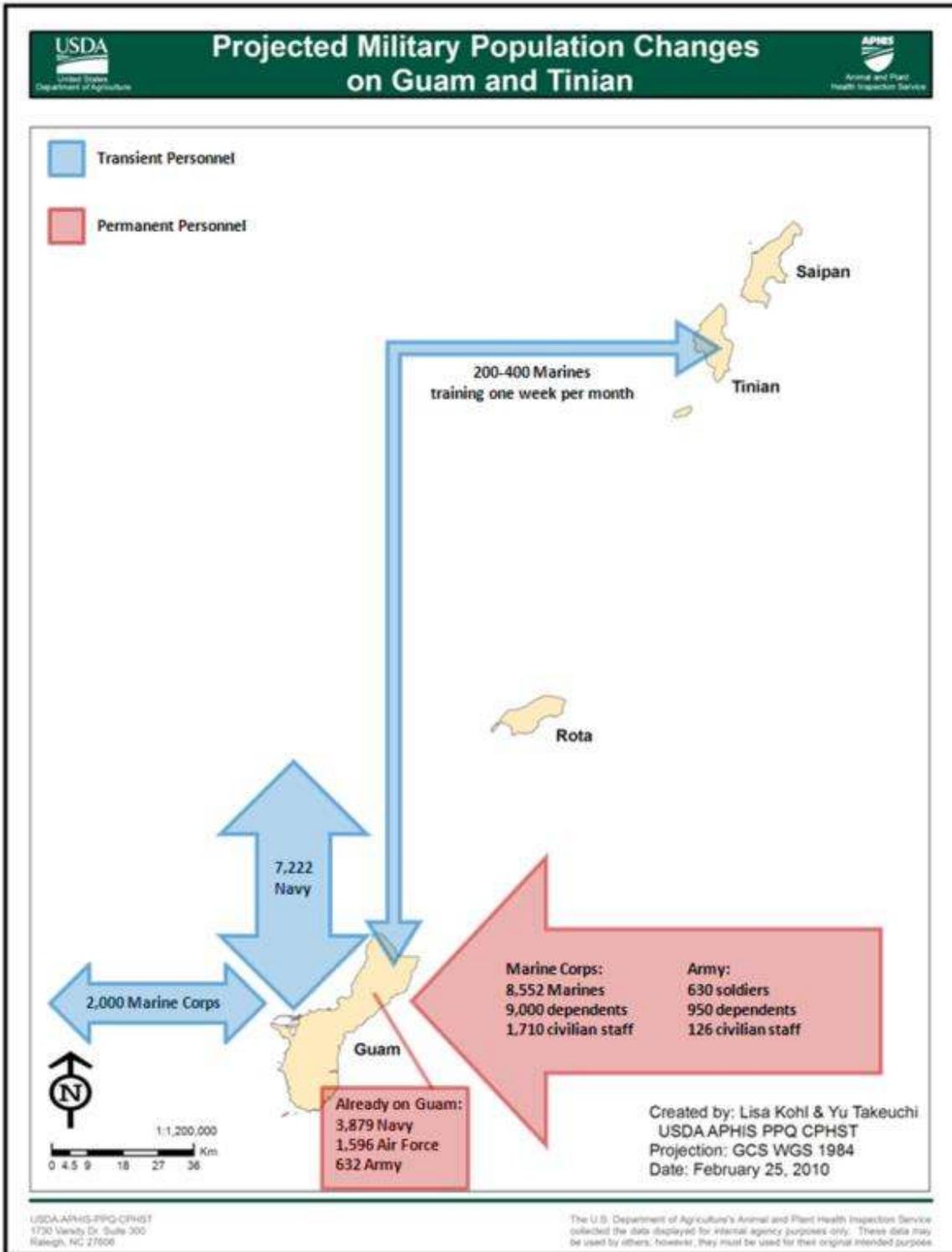
8 Approximately 8,600 Marines and 9,000 dependents will be relocated to Guam (Figure A1-2) (U.S. Navy
9 2009f). In addition, there will be a transient population of approximately 2,000 personnel (U.S. Navy
10 2009h). Port capacity will be expanded to accommodate transient berthing of a nuclear-powered
11 aircraft carrier in Apra Harbor (U.S. Navy 2009b). The aircraft carrier is part of a Carrier Strike Group,
12 which includes aircraft and escort ships. In total, a Carrier Strike Group includes more than 7,000
13 personnel. The Carrier Strike Group would be in port for a maximum of 63 days per year, for up to 21
14 days per visit (U.S. Navy 2009b). An Army Air and Missile Defense Task Force (U.S. Navy 2009e),
15 requiring movement of approximately 630 Army personnel, 126 civilians, and 950 dependents to Guam,
16 is also proposed. The U.S. Armed Forces personnel stationed in Guam will originate from a variety of
17 duty stations.

18 Infrastructure improvements on Guam will be needed to accommodate the relocation (U.S. Navy
19 2009h). Utility, roadway, housing, and port expansion construction projects related to the proposed
20 actions are expected to result in population increases due to an influx of workers. The size of the
21 population on Guam from off-island is forecast to peak at almost 40,000 in 2014, resulting in an increase
22 in movement of people and goods into and throughout the Micronesia Region.

23

1

Figure A1-2: Projected Military Population Changes on Guam and Tinian



2
3

Source: U.S. Navy 2009h

1 **A1.2 POLITICAL RELATIONS AND RELEVANT LEGISLATION**

2 Several U.S. federal laws are directly applicable to the proposed action, including the National
3 Environmental Policy Act (Title 42, United States Code [U.S.C.] section 4321) which requires federal
4 agencies to address the impact of invasive species on their actions; the Endangered Species Act (16
5 U.S.C. § 1531 et seq.) which requires federal agencies, in consultation with the U.S. Fish and Wildlife
6 Service (USFWS) and/or the National Oceanic and Atmospheric Administration, to ensure that actions
7 they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed
8 threatened or endangered species or result in the destruction or adverse modification of designated
9 critical habitat of such species; and the Federal Noxious Weed Act (7 U.S.C. § 2814), which requires
10 federal agencies to develop management programs for the control of weeds. The Federal Seed Act
11 authorizes USDA to regulate the trade of seeds, and the Plant Protection Act authorizes USDA to
12 regulate the trade of plant materials to control and minimize the economic, ecological, and human
13 health impacts that harmful plant pests can cause. The Animal Health Protection Act (8 U.S.C. § 8301 et
14 seq.) authorizes USDA to regulate the import, export, and interstate movement of animals and articles
15 to prevent the introduction or dissemination of livestock pests or diseases. APHIS uses these authorities
16 to protect U.S. agriculture, forests, and other natural resources from harmful pest species. USDA
17 implementing regulations include those listed in Titles 7 and 9 of the U.S. Code of Federal Regulations
18 (CFR): 7 CFR § 319.56 for regulation of agricultural commodities for consumption; 7 CFR 319.37 for
19 regulation of plants for propagation; 7 CFR § 319.69 for regulation of agricultural packing materials, and
20 9 CFR § 70-99 for regulation of import, export, and interstate movement of animals and animal
21 products.

22 **A1.2.1 Guam and the Commonwealth of the Northern Mariana Islands**

23 Guam is an unincorporated, organized territory of the United States, and its people are citizens of the
24 United States. The powers of the government of Guam are set forth in the Organic Act of Guam, and
25 part of the U.S. Constitution applies to its governance. The Act permits the Governor to establish
26 agencies and regulations as needed to protect public health and prevent the spread of disease (Guam
27 2004). The Guam Department of Agriculture (GDOA) carries out pest survey and control programs
28 (Berringer 2009). Guam law authorizes GDOA to quarantine, inspect, fumigate, disinfect, destroy, or
29 exclude commodities infested with pests or any article that is or may be injurious to the agricultural
30 industries and forest resources of the territory (Guam CQD 1997; 9 GARR, Division 1, Chapter1). GDOA is
31 further authorized to enforce applicable regulations governing the importation into Guam of any
32 agricultural commodities from anywhere outside of the territory, at any time or place within the
33 territory (Guam CQD 1997; 9 GARR, Division 1, Chapter 1).

34 The Director of GDOA issues permits required for importation of regulated plants and plant products
35 into Guam. Phytosanitary certificates are required for the importation of rooted plants and seedlings;
36 cuttings and grafts of woody plants; ornamental plants and other horticultural plants; cut flowers;
37 flower bulbs, corms, tubers, rhizomes, and other vegetative plant propagating materials; fresh fruits of
38 regulated plants; seeds meant for propagation purposes; and soil. These certificates must be issued by
39 the Plant Protection Service of the country of origin of the plants. If the country from which a

1 consignment is imported into the territory of Guam is not the country of origin, the consignment must
2 be accompanied by a phytosanitary certificate of the country of origin; in case of importation of fruits,
3 the certificate may also have been issued by the country from which the consignment was last
4 dispatched (9 GARR, Division 1, Chapter 1).

5 Each shipment of plants into the territory of Guam must be marked to show name and address of
6 shipper or owner, name of consignee, contents, and the state and country where the contents were
7 grown. Any person transporting, receiving, or importing plants, plant products, or soil must have an
8 import permit. All shipments of plants are examined at their port of entry and, if found infested with any
9 pest liable to be detrimental to agriculture, the shipments are destroyed, treated, or processed at the
10 owner's expense. All plants shipped into the territory of Guam must be free of soil, and all regulated
11 articles (9 GARR, Division 1, Chapter 1) are subject to inspection upon arrival in Guam. Shipment or
12 transport of live insects, plant pathogenic agents, and all other plant pests into the territory of Guam is
13 prohibited. Specific commodities from various countries are also regulated (9 GARR Division 1, Chapter
14 1).

15 All importations of domestic animals into the territory of Guam from foreign countries are subject to the
16 regulations of, and require permits from, USDA. In general, no permits are required for animals
17 imported from the United States. Feral animals, reptiles, insects, and birds may only be imported into
18 the territory with a permit issued by USDA (9 GARR, Division 1, Chapter 1). All animals are subject to
19 inspection upon their arrival in the territory; those animals that have been exposed to, are suffering
20 from, or appear to have the symptoms of a contagious or infectious disease are subject to quarantine.
21 Animals must enter the territory through commercial ports or the international airport. Specific animal
22 types are further regulated (9 GARR, Division 1, Chapter 1).

23 The CNMI is an unincorporated, organized commonwealth, and its people are citizens of the United
24 States. The constitution of the CNMI can be modified only with consent of both the U.S. Congress and
25 CNMI (DOI OIA 2007; 2009b). Citizens of the CNMI elect a non-voting member to the U.S. House of
26 Representatives, but they have no vote in the electoral college (110th Congress 2008).

27 Port operations in both Guam and the CNMI are guided by U.S. federal regulations. Agricultural
28 inspectors at Guam and CNMI ports of entry have access to USDA inspection manuals that specify the
29 percentage of cargo to be inspected and additional risk management principles. While these resources
30 are available, specific requirements are determined by locality, not the United States. The municipalities
31 comprising the CNMI create and enforce local laws, including laws that regulate agricultural materials;
32 local laws do not preempt those of the Commonwealth. The GDOA Biosecurity Division, Guam Customs
33 and Quarantine Agency (GCQA), and CNMI Department of Lands and Natural Resources Division of
34 Agriculture are charged with preventing the introduction and establishment of alien species in their
35 respective territories (Guam CQD 1997; GDOA 1997). GDOA, GCQA, and the CNMI Department of Lands
36 and Natural Resources collaborate with U.S. federal agencies to prevent the introduction of invasive
37 pests. USDA-APHIS-PPQ provides oversight and support for agricultural quarantine and inspection
38 activities for both Guam and the CNMI. However, the actual work associated with agricultural

1 quarantine and border inspection activities is carried out by GCQA and the CNMI Department of Lands
2 and Natural Resources, each providing officers that serve as APHIS cooperators.

3 **A1.2.2 The Freely Associated States: Federated States of Micronesia, Republic of the Marshall 4 Islands, and Palau**

5 FSM and RMI became independent nations in 1979, followed by Palau in 1994 (DOI OIA 2009c, d, a).
6 After gaining their independence, FSM, RMI, and Palau each entered into a Compact of Free Association
7 with the United States. As part of this agreement, the United States has unlimited access to the land and
8 waterways belonging to each of these nations. In return, the United States provides financial assistance
9 and defense (DOI OIA 2009c, d, a). Unlike territories or commonwealths, nations in free association are
10 not bound by the U.S. Constitution, but they have agreed to be bound by certain U.S. laws such as the
11 National Environmental Policy Act.

12 **A1.2.2.1 *Federated States of Micronesia***

13 FSM is composed of more than 600 islands which are organized into four states: Chuuk, Kosrae,
14 Pohnpei, and Yap (DOI OIA 2009d). The Code of the Federated States of Micronesia (FSMC) (updated
15 1997) describes authorities to regulate agriculture and livestock (FSMC Title 18, Chapter 2 § 206). Key
16 provisions include authorization of a coconut development authority to engage in manufacture,
17 processing, trading, marketing, and quality control of all products derived from the coconut tree,
18 reflecting the importance of coconut in the Micronesia Region.

19 Quarantines may be used to prevent the introduction and further dissemination of injurious insects,
20 pests, and diseases into and within FSM. The Secretary of Resources and Development issues plant and
21 animal quarantines and regulations relating to their administration and enforcement. Agricultural
22 quarantine inspectors appointed by the Secretary of Resources and Development enforce the provisions
23 of plant and animal quarantine controls, quarantines, and regulations. The Secretary of Resources and
24 Development possesses the power to deputize anyone to serve and enforce the FSM laws including
25 customs and immigration inspections (FSMC Title 18, Chapter 2 § 206).

26 All animals and plants or parts thereof, including seeds, fruits, vegetables, and cuttings entering or
27 transported within FSM are subject to inspection by agricultural quarantine inspectors and may be
28 treated, destroyed, or refused entry into or movement within FSM if they are known to be, or are
29 suspected of being, infected or infested with disease or pests (FSMC Title 18, Chapter 2 § 206). All
30 aircraft and vessels or their cargoes, including baggage, ship's stores, and ballast, entering or moving
31 within FSM are subject to inspection by agricultural quarantine inspectors; U.S. Armed Forces aircraft
32 and vessels are subject to existing military security regulations. Vessels and aircraft traveling into or
33 within FSM and known or suspected to be harboring plant pests are subject to spraying with insecticides
34 or other treatment. FSM inspectors also monitor the shipment of vehicles. It is possible that the
35 shipment of used vehicles may have assisted with the spread of Giant African Snails to Kosrae.

36 Any animals, plants, or other quarantine material in transit through FSM on aircraft or vessels must be
37 kept aboard while in port. If it is necessary to transfer quarantine material from one vessel or aircraft to

1 another, such transfer must be made under the direction of an agricultural quarantine inspector, and
2 with safeguards as deemed necessary.

3 **A1.2.2.2 Republic of the Marshall Islands**

4 RMI consists of more than 1,200 islands and atolls, most of which are uninhabited (RMI EPPSO 2005b).
5 The RMI Chief of Agriculture administers plant and animal quarantine controls and regulations (PacLII
6 2004a). Agricultural quarantine inspectors, under the direction of the Chief of Agriculture, enforce said
7 provisions. All animals and plants or parts thereof, including seeds, fruits, vegetables, cuttings, etc.,
8 entering or transported within RMI are subject to inspection and may be treated, destroyed, or refused
9 entry into or movement within RMI if they are known to be, or are suspected of being, infected or
10 infested with disease or pests. All aircraft and vessels or their cargoes, including baggage, ship's stores,
11 and ballast, entering or moving within the Republic are subject to inspection; U.S. Armed Forces aircraft
12 and vessels are subject to existing military security regulations (PacLII 2004a). Vessels and aircraft
13 traveling into or within RMI and known or suspected to be harboring insects or other agricultural pests
14 are subject to spraying with insecticides or other such treatment (PacLII 2004a).

15 Any animals, plants, or other quarantine material in transit through RMI on aircraft or vessels must be
16 kept aboard while in port, unless such material is otherwise enterable. If it is necessary to transfer such
17 quarantine material from one vessel or aircraft to another, such transfer must be made under the
18 direction of an agricultural quarantine inspector with safeguards as deemed necessary.

19 **A1.2.2.3 Palau**

20 Palau consists of more than 340 islands, nine of which are inhabited (Palau OPS 2008). Palau Animal and
21 Plant Quarantine Regulations (Palau BAMR 2006) stipulate that every conveyance and all of its cargo,
22 people, baggage, garbage, and provisions are subject to inspection and examination, treatment, or
23 quarantine. Garbage is prohibited entry to Palau without express permission and may require treatment
24 or destruction. Plants and plant material are prohibited from Palau without a permit, and plants and
25 plant material in transit through Palau are subject to quarantine or safeguarding measures; permission
26 to transit is required. Imported plants and plant parts must be free from soil; timber imports are subject
27 to inspection and treatment upon arrival and timber with bark attached is prohibited entry, unless
28 treated for pests. Grass, bamboo, and palm fronds are prohibited entry into Palau; soil, sand, and gravel
29 must have a permit in order to be allowed entry (Palau BAMR 2002; 2006).

30

1 **A2 TRAFFIC AND TRADE DATA**

2 **A2.1 PEOPLE**

3 Below, we summarize population sizes and movement patterns of people to and within the Micronesia
4 Region. We compiled these data from the November 2009 Guam and CNMI Military Relocation draft
5 EIS/OEIS and final EIS/OEIS (U.S. Navy 2009a; 2010a); government tourism and statistics office reports;
6 and other publicly available sources. Comparison of statistics among the island groups and among data
7 sources is complicated by differences in data availability, definition of terms such as visitor and tourist,
8 and data collection and analysis methods. However, the information that we present below should
9 provide insight into the current and forecast volumes and patterns of people movement to and within
10 the Micronesia Region.

11 **A2.1.1 Micronesia Region: Population and Visitors**

12 The total population of the Micronesia Region in 2009 was approximately 423,000 (Table A2-1) (USCB
13 2010). Most of the population lives in Guam or FSM (USCB 2010). The number of visitor arrivals in the
14 island groups in recent years has totaled more than 1.7 million annually, with most accounted for by
15 arrivals in Guam or the CNMI (RMI EPPSO 2008; SPC 2008).

16 **Table A2-1: Population Size and Number of Visitors to the Micronesia Region**

Region	Population ^a		Visitors ^b	
	Number	Percent	Number	Percent
Guam	178,430	42	1,225,323	71
FSM	107,434	25	20,150	1
RMI	64,522	15	6,959	<1
CNMI	51,484	12	389,261	22
Palau	20,796	5	93,031	5
Total	422,666	99 ^c	1,734,724	99 ^c

17 ^a Estimated midyear population, 2009 (USCB 2010).
18 ^b Visitor arrivals. Guam, CNMI, Palau, FSM: 2007 (SPC 2008). RMI: fiscal year (FY) 2007,
19 visitors to Majuro (RMI EPPSO 2008).
20 ^c Due to rounding, total does not equal 100.
21

22 **A2.1.2 Guam**

23 Most visitors to Guam arrive by air (BSP 2009a). Of those, most are from Japan or Korea (Table A2-2),
24 and most are traveling for pleasure (Table A2-3). Of the visitors who arrive on passenger vessels by sea,
25 most are from Japan or the U.S. mainland (PB International 2008). Approximately 20% of international
26 arrivals in Guam by sea are from cruise ship visits (Green 2004). In recent years, 4 to 10 cruise ships have
27 visited Guam per year, carrying an average annual total of approximately 2,900 passengers and crew,
28 and generally remaining in port for less than 24 hours (Table A2-4) (PAG 2010a). Most other
29 international arrivals by sea are from military and merchant ships, including traffic from U.S. Navy ships
30 and courtesy calls from the navies of Australia, New Zealand, and various Asian countries (Green 2004).

1 **Table A2-2: Visitors to Guam, by Region of Residence of Visitor; Air Arrivals**

Region of residence	Visitors (2008) ^a	
	Number	Percent
Japan	849,831	78
Korea	110,548	10
United States	52,797	5
CNMI/Micronesia	30,315	3
Taiwan	22,592	2
Philippines	10,867	1
Hong Kong	4,270	<1
Other	10,687	1
Total	1,091,907	100

2 ^a Arrivals by air; excludes transit arrivals and crew; includes civilians and military personnel
 3 (BSP 2009a).
 4

5 **Table A2-3: Visitors to Guam, by Purpose; Air Arrivals**

Purpose	Visitors (2008) ^a	
	Number	Percent
Pleasure	749,436	69
Get married	22,711	2
Business	22,531	2
Honeymoon	21,781	2
Golf	19,791	2
Friends/relatives	19,631	2
Government/military	15,191	1
Convention	8,266	1
Medical care	1,724	<1
Employment	1,254	<1
School	321	<1
Other	24,076	3
No response	175,194	16
Total	1,091,907	100

6 ^a Arrivals by air; excludes transit arrivals and crew; includes civilians and military
 7 personnel (BSP 2009a).
 8

9 **Table A2-4: Cruise Ship Arrivals in Guam, 2005-2009**

Year	Total number of arrivals	
	People ^a	Cruise ships
2005	1,749	4
2006	2,521	6
2007	3,009	7
2008	4,625	10
2009	2,433	5
Total	14,337	32

10 Source: PAG 2010a.

11 ^a Passengers and crew.

1 **A2.1.3 Commonwealth of the Northern Mariana Islands**

2 Most (90%) of the population of the CNMI lives on Saipan, with 5% each on Tinian and Rota (U.S.
3 Department of Commerce 2001). Some areas within the CNMI are very sparsely populated, with a total
4 of six individuals counted in the 2000 Census on one such area, The Northern Islands municipality.

5 Most visitors to the CNMI arrive in Saipan, mainly as tourists from Japan or Korea (Table A2-5) (CNMI
6 Department of Commerce). Much of the economic activity on Tinian is associated with a casino, tourism
7 related to the island’s role in World War II, or marine activities (U.S. Navy 2010a). Most of the visitors to
8 the casino are from Asia, mainly from China, Japan, and Korea. The comparatively few visitors to Rota
9 are predominantly visitors from Guam or elsewhere in the United States, or from Japan.

10 **Table A2-5: Visitors to CNMI, by Region of Origin of Visitor**

Region of origin	Visitors (2002) ^a	
	Number	Percent
Japan	293,921	69
Korea	77,665	18
United States including Guam	34,306	8
Hong Kong	3,359	1
Taiwan	1,440	<1
Other	14,241	3
Total	424,932	99 ^b

11 Source: CNMI Department of Commerce 2002

12 ^a Fiscal year.

13 ^b Due to rounding, total does not equal 100.

14

15 A large proportion of the movement of people within the CNMI occurs by sea (Green 2004). The ports of
16 Rota and Tinian each handle a large volume of passenger ferry traffic daily. Most of the international
17 arrivals by sea are from merchant vessels or cruise liners. In general, merchant vessels carry few people
18 on frequent port calls, whereas cruise liners carry more people on fewer port calls.

19 **A2.1.4 Federated States of Micronesia**

20 Most of the population of FSM lives in Chuuk (50%) or Pohnpei (32%) (FSM Division of Statistics 2013).
21 Most visitors to FSM are from the United States or Asia (Table A2-6), traveling as tourists or on business
22 (Table A2-7). It is worth noting that the information in these tables may very well only be from visitors
23 arriving via aircraft, although this has not been ascertained. Most movement of people and goods
24 among the islands of FSM occurs by ship (Green 2004) (This may be less true in 2013 than a decade ago
25 when this information was published). International arrivals by sea are mainly from fishing vessels and
26 merchant ships.

1

Table A2-6: Visitors to FSM, by Region of Residence of Visitor

Region of residence	Visitors (2006)	
	Number	Percent
United States ^a	8,053	42
Japan	3,071	16
Europe	2,398	13
Asia (excluding Japan and Philippines)	1,525	8
Philippines	1,347	7
Pacific islands	1,158	6
Australia	1,077	6
Canada	203	1
New Zealand	183	1
Other	121	1
Total	19,136	101 ^b

2

Source: FSM Division of Statistics 2007

3

^a Whether the reported number of visitors from the United States includes visitors from Guam and the CNMI is unclear.

4

5

^b Due to rounding, total does not equal 100.

6

7

Table A2-7: Visitors to FSM, by Purpose

Purpose	Visitors (2006)	
	Number	Percent
Tourism and visits	13,345	70
Business/employment	4,529	24
Seamen and crew	493	3
Volunteer, religious, other	626	3
Not stated	143	1
Total	19,136	100

8

Source: FSM Division of Statistics 2007

9

A2.1.5 Palau

11 Most of the population of Palau lives in Koror (64%) or Airai (14%) (Palau OPS 2006). Approximately 80%
 12 of visitors to Palau are from Asia, mainly from Japan and Taiwan (Table A2-8) (Palau OPS 2009b). More
 13 than 90% of visitors to Palau are tourists Table A2-9 (Palau OPS 2009a). Similar to the case for CNMI and
 14 FSM, much of the movement of people and goods among the islands of Palau occurs by sea, mostly by
 15 inter-island trading vessels and ferries (Green 2004). Most international arrivals by sea are from fishing
 16 vessels and cruise ships. The cruise ships arrive primarily from Guam and Asia.

1

Table A2-8: Visitors to Palau, by Region of Residence of Visitor

Region of residence	Visitors (2007)	
	Number	Percent
Japan	29,476	32
Taiwan	29,298	31
Korea	14,440	16
U.S. mainland/Canada	6,250	7
Philippines	4,009	4
Guam	1,870	2
Europe	1,818	2
People's Republic of China	970	1
Australia/New Zealand	755	1
FSM	686	1
Germany	480	1
Hong Kong	473	1
CNMI	320	<1
Other	2,186	2
Total	93,031	101 ^a

Source: Palau OPS 2009b

^a Due to rounding, total does not equal 100.

2

3

4

5

Table A2-9: Visitors to Palau, by Purpose

Purpose	Visitors (2007)	
	Number	Percent
Tourism	84,566	91
Employment	4,641	5
Business	3,610	4
Other	214	<1
Total	93,031	100

Source: Palau OPS 2009a

6

7

A2.1.6 Republic of the Marshall Islands

9 Most (68%) of the population of RMI lives in Majuro or Kwajalein (RMI EPPSO 2005a). Kwajalein is home
10 to the Ronald Reagan Ballistic Missile Defense Test Site, which is owned by the U.S. government and is
11 home to approximately 75 U.S. government personnel, 1,600 contractor staff, and 1,000 family
12 members (GAO 2002). Approximately half of the visitors to Majuro are from Asia, mainly Japan; almost
13 one-fourth are from the Americas (Table A2-10) (RMI EPPSO 2008). Most visits to Majuro are for
14 business or holiday (Table A2-11) (RMI EPPSO 2008). As is the case for other island groups in the
15 Micronesia Region, much of the domestic movement of people and goods in RMI occurs by sea (Green
16 2004). Most of the international arrivals by sea are from fishing vessels and merchant ships.

1

Table A2-10: Visitors to Majuro, RMI, by Region of Residence of Visitor

Region of residence	Visitors (2007)	
	Number	Percent
Americas	1,690	24
Japan	1,600	23
Other Pacific island countries	1,024	15
Australia/New Zealand	496	7
Other Asian countries	320	5
Taiwan	311	4
Europe	275	4
Philippines	255	4
People's Republic of China	157	2
Other/not stated	831	12
Total	6,959	100

2

Source: RMI EPPSO 2008.

3

4

Table A2-11: Visitors to Majuro, RMI, by Purpose

Purpose	Visitors (2007) ^a	
	Number	Percent
Business	2,218	32
Holiday/vacation	2,060	30
Transit/stopover	1,415	20
Visiting friends/relatives	718	10
Other/not stated	548	8
Total	6,959	100

5

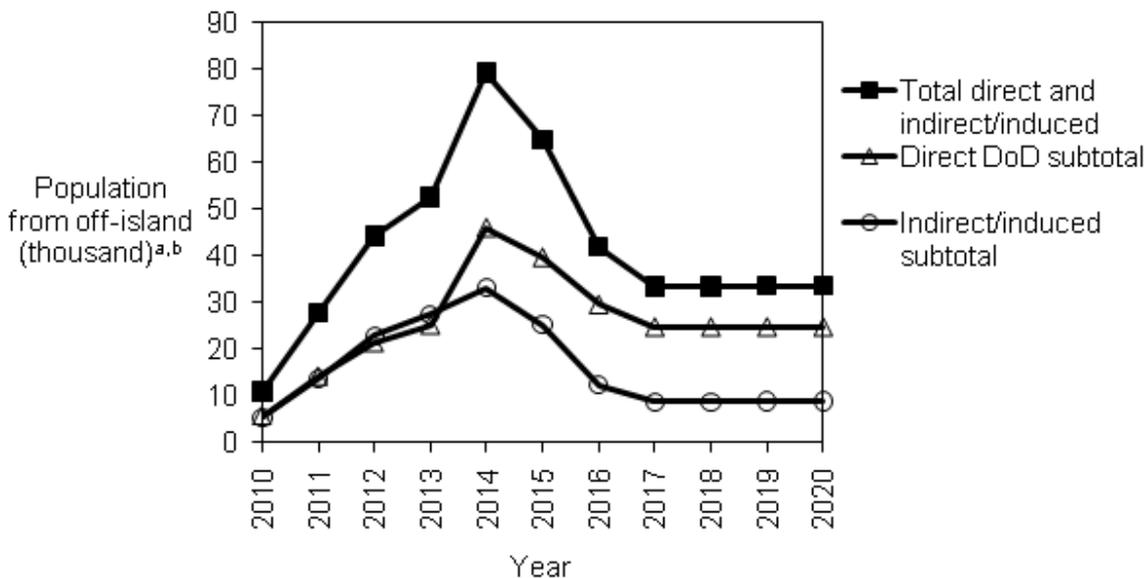
Source: RMI EPPSO 2008

6

1 **A2.1.7 Population Impacts of Proposed Actions**

2 The estimated changes in Guam’s population size from 2010 to 2020 are shown in Figure A2-1.

3 **Figure A2-1: Estimated population on Guam from Off-Island, 2010-2020¹**



4

5 ^a Does not include transient population of up to 7,222 personnel associated with aircraft Carrier Strike

6 Group, and transient population of up to 6,213 personnel associated with Marine Corps vessels

7 berthed at Apra Harbor (U.S. Navy 2010a).

8 ^b Source: U.S. Navy 2010a

9

10 The population from off-island is forecast to grow through 2014,⁷ concurrent with the planned increase

11 in DoD project construction work and the planned arrival in 2014⁷ of most of the Marines that are to be

12 relocated to Guam (U.S. Navy 2010a). The total number of individuals from off-island is estimated to

13 peak in 2014⁷ at almost 80,000. From 2014² to 2017, the DoD and non-DoD populations from off-island

14 are forecast to decrease with the completion of construction projects. In 2017,⁷ the population from off-

15 island is estimated to decrease to approximately 33,400. The changes in estimated population size on

16 Guam from off-island from 2010 to 2020⁷ are shown by population category in Table A2-12 (U.S. Navy

17 2010a).

¹The National Defense Authorization Act (NDAA) for Fiscal Year 2012, signed into United States law on December 31, 2011, by President Barack Obama, imposed restrictions on the Secretary of Defense’s usage of funds to develop infrastructure associated with the U.S. Marine Corps relocation to Guam. Additionally, Congress did not authorize or appropriate funding for the Guam realignment in FY 12. As the pace of construction is subject to the availability of funds, it is anticipated that the realignment will proceed at a slower rate than originally anticipated.

1

Table A2-12: Estimated Population on Guam from Off-island, 2010-2020

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population ^{a,b}											
Direct DoD											
Marines											
Active duty	510	1,570	1,570	1,570	10,552	10,552	10,552	10,552	10,552	10,552	10,552
Dependents	537	1,231	1,231	1,231	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Navy											
Active duty	0	0	0	0	0	0	0	0	0	0	0
Dependents	0	0	0	0	0	0	0	0	0	0	0
Army											
Active duty	0	50	50	50	50	630	630	630	630	630	630
Dependents	0	0	0	0	0	950	950	950	950	950	950
DoD civilians											
Workers	102	244	244	244	1,720	1,836	1,836	1,836	1,836	1,836	1,836
Dependents	97	232	232	232	1,634	1,745	1,745	1,745	1,745	1,745	1,745
Non-DoD construction workers, DoD projects											
Workers	3,238	8,202	14,217	17,834	18,374	12,140	3,785	0	0	0	0
Dependents	1,162	2,583	3,800	3,964	4,721	2,832	1,047	0	0	0	0
Subtotal, direct DoD	5,646	14,112	21,344	25,125	46,051	39,685	29,545	24,713	24,713	24,713	24,713
Indirect/induced											
Workers	2,766	7,038	11,773	14,077	16,988	12,940	6,346	4,346	4,346	4,482	4,482
Dependents	2,627	6,685	11,184	13,373	16,138	12,293	6,028	4,372	4,372	4,413	4,413
Subtotal, indirect/induced	5,393	13,723	22,957	27,450	33,126	25,233	12,374	8,718	8,718	8,895	8,895
Total direct and indirect/ induced	11,038	27,835	44,301	52,575	79,178	64,918	41,919	33,431	33,431	33,608	33,608

2 Source: Modified from U.S. Navy 2010a

3 ^a Does not include transient population of up to 7,222 personnel associated with aircraft Carrier Strike Group, and transient population of up to 6,213 personnel associated
4 with Marine Corps vessels berthed at Apra Harbor (U.S. Navy 2010a).

5

1 From 2010 to 2014,² the largest proportions of the estimated total population from off-island are
 2 accounted for by non-DoD workers and their dependents for DoD construction projects, and workers
 3 and their dependents for indirect and induced jobs. Most of the estimated increases from 2015 to 2020
 4 are due to increases in the number of Marine Corps and Army personnel, DoD civilians and their
 5 dependents, and workers and their dependents for indirect and induced jobs. The non-DoD construction
 6 worker and indirect or induced populations are forecast to decrease sharply after peaking in 2014 with
 7 the peak in construction activity. These decreases might not be as sharp or as large as forecast,
 8 depending on the number of workers who remain on Guam (U.S. Navy 2010a).

9 The population estimates described above do not include an estimated maximum number of 7,222
 10 personnel in port at any given time associated with the aircraft Carrier Strike Group, and a transient
 11 population of up to 2,000 personnel associated with Marine Corps vessels berthed at Apra Harbor (U.S.
 12 Navy 2010a). These two groups are not expected to be in port concurrently.

13 The estimates also do not include training visits to the Micronesia Region by Japan Self Defense Forces
 14 personnel. The training is expected to include various types of ground, air, and maritime training in
 15 Guam, the CNMI, and surrounding sea and airspace. Each type of training exercise could involve
 16 approximately 500 to 3,000 personnel, training for 1 to 4 weeks, 1 to 6 times per year (Table A2-13).

17 **Table A2-13: Japan Self Defense Forces Training in the Micronesia Region**

Total number of personnel ^a	Duration (weeks per visit)	Frequency (times per year)	Training Location	Military Service
3,000	4	1	Guam, Tinian, Pagan, and surrounding sea and airspace	Japan Self Defense Forces, U.S. forces
3,000	1	3		
3,000	1	3		
3,000	1	3		
3,000	1	3		
600	4	1	Beaches of Guam, Tinian, and Pagan	Japan Ground Self Defense Force, U.S. Marine Corps
1,050	2	4	Guam, Tinian, and sea and airspace surrounding Guam and CNMI	Japan Maritime Self Defense Force, U.S. Navy
490	4	1		
700	2	6	Guam and CNMI airspace, Farallon de Medinilla range, Andersen Air Force Base	Japan Air Self Defense Force, U.S. Air Force

18 Source: U.S. Navy 2010a

19 ^a Maximum training requirements for the Japan Self Defense Forces in the Micronesia Region; rough estimates
 20 prepared for the Guam and CNMI Military Relocation EIS/OEIS.
 21

² Ibid. pA2-6.

1 **A2.2 MARITIME TRAFFIC AND CARGO**

2 The Micronesia Region is well connected through maritime shipping routes to Asia (China, Japan, and
3 Korea) and the United States (Figure A2-2). The majority of maritime traffic in the Region moves
4 between the U.S. west coast and Guam, between Asia and Guam, and within the Region (Figure A2-2)
5 (PB International 2008). On a less frequent basis, vessels operate between Australia, Papua New Guinea,
6 and Guam (PB International 2008). Container ships, larger vessels such as break-bulk cargo ships, and
7 smaller regional vessels usually operate on routine schedules in the Micronesia Region. Waterways to
8 the east/northeast connect with Hawai'i and the continental United States, while the waterways
9 running north and west connect to the CNMI and with ports in Asia. Horizon Lines and Matson
10 Navigation Company operate large container ships that navigate the route from China to California,
11 returning to China by way of Hawai'i and Guam, with potential stops at other Micronesian ports, such as
12 RMI and FSM.

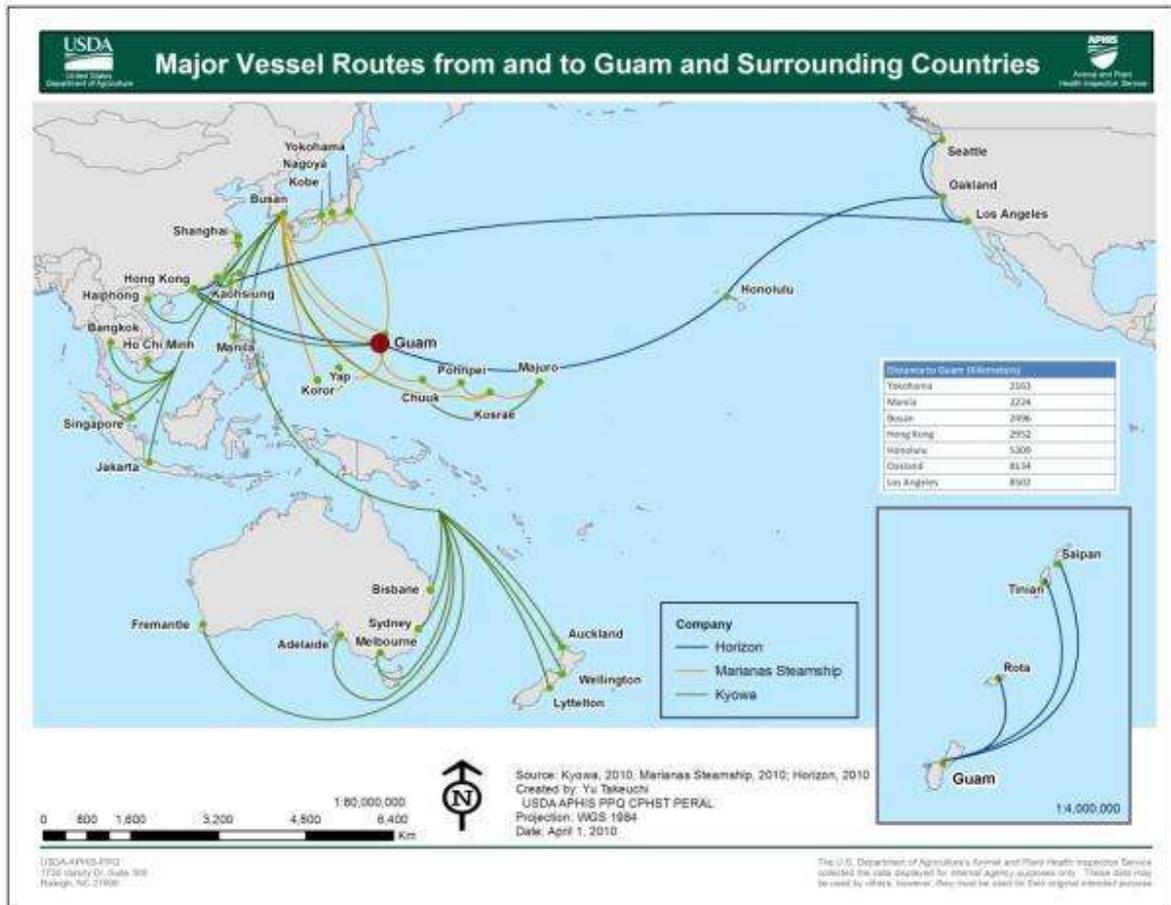
13 **A2.2.1 Civilian Ports**

14 The Jose D. Leon Guerrero Commercial (Maritime) Port of Guam is the main port in the Micronesia
15 Region, handling almost 90% of all imports to Guam (PB International 2008) and serving as the
16 transshipment hub for the Region; the port also receives cargo for the military bases on Guam (Table
17 A2-14). Data availability is very limited, especially regarding military vessels, and port statistics often do
18 not differentiate between vessel types (e.g., container vessels, break-bulk cargo vessels, and petroleum-
19 carrying vessels). Horizon Lines and Matson Navigation Company operate the majority of large ships in
20 the Region (Horizon Lines 2010b, c; Matson 2010a, b). The military relocation is expected to increase
21 maritime vessel traffic to Guam (PB International 2008) by an estimated 149 container vessels per year
22 (U.S. Navy 2009a), in addition to a substantial increase in the number of break-bulk vessels (PAG 2010b)
23 (Table A2-14). Container volumes will also increase (Tables A2-14 and A2-15).

24

1

Figure A2-2: Shipping Routes in the Micronesia Region



2

Note that this is a representative figure and some ship lines are not included.

3

Source: Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Mariana Express Lines 2010a; b

4

5

Table A2-14: Vessel and Container Traffic at Jose D. Guerrero Commercial (Maritime) Port

	Fiscal year				
	2006	2007	2008	2009	2015 ^a
Number of vessels (arrivals and departures)					
Container	109	151	165	161	310
Break bulk/ro-ro	299	165	171	192	- ^b
Barges	17	21	17	21	-
Cruise	6	7	10	5	20-30
Fishing	771	651	566	499	-
Number of containers handled (loaded or unloaded)					
Total	84,321	99,630	99,908	94,073	190,000
U.S. military cargo ^c	15,009	14,994	15,008	15,023	89,000

6

Source: PB International 2008; PAG 2010b

7

^a Projected peak traffic year during the military relocation; numbers are estimates.

8

^b N/A: Estimate not available.

9

^c Estimates.

10

1 **Table A2-15: Vessel traffic at ports in Guam, the CNMI, Palau, RMI, and FSM**

	Number of port visits per year ^a				
	Guam	CNMI–Saipan	Palau–Koror	RMI–Majuro	FSM ^b
International shipping activity					
Merchantmen ^c	560	460	36	84	178
Cruise	12	8	2	0	2
Warships	- ^d	58	13	19	-
Fishing–oceanic	260	10	185	360	852
Yachts	25	25	20	20	55
Domestic shipping activity					
Inter-island traders	-	-	300	300	300
Inter-island ferries	55	750	-	-	6
Tourist charter boats	6,000	5,000	100	400	610
Fishing–local	-	1,000	500	200	4,000
Local work boats	600	600	-	250	230
Local craft	-	4,000	-	15,000	12,500

2 Source: Nawadra et al. 2002; Green 2004

3 ^a Estimates based on 2002 to 2004 data.

4 ^b Traffic numbers for FSM are totals for the ports of Pohnpei, Weno, Yap, and Okat. These figures may
5 include “double-counting” if vessels were included in more than one port’s total.

6 ^c Merchantmen vessels are those carrying commercial cargo and include container ships, bulk cargo,
7 and roll-on roll-off vessels. In Saipan, 330 container vessels arrive per year. In Palau, mostly
8 containerized cargo arrives from vessels originating in Guam.

9 ^d N/A: Data not available.

10
11 The Cargo Preference Act of 1904 (10 U.S.C. § 2631) requires that all supplies purchased for the U.S.
12 Armed Forces be transported on U.S. flag vessels when transported by vessels at sea (US DOT 2009).
13 Waivers for cargo moving between elsewhere in the United States and Guam can only be granted by the
14 Secretary of the U.S. Department of Homeland Security (US DOT 2009). Of interest, Matson Navigation
15 Company (a leading U.S. flag ship carrier operating in the Pacific) has purchased four new vessels for an
16 Asian service that conducts weekly service to Guam (PB International 2008). The types and volumes of
17 maritime vessel traffic at ports in the Micronesia Region are summarized in Table A2-15.

18 The Port of Saipan clears approximately six cargo vessels (250 cargo containers) per week; the Port of
19 Tinian clears up to two cargo vessels per week and two daily inter-island passenger vessels (Berringer
20 2009). Cargo vessels occasionally arrive at the Port of Rota. Most vessels arriving in Saipan and Tinian
21 carry transshipments from Guam. Vessels from Guam calling in Saipan often stop in Tinian first.

22 Palau is well connected to Asia and the mainland United States, as well as to other islands in the region.
23 Shipping lines service Malakal Commercial Dock, operating on a 30-day interval, bringing cargo from the
24 U.S. west coast, Japan, Australia, Taiwan, Hong Kong, the Philippines, Guam, and elsewhere. Another
25 shipping line operates mostly in Asia and brings cargo from Korea, Japan, the Philippines, Hong Kong,
26 Taiwan, Saipan, Guam, and Yap. Transshipments between Guam and Palau are routine (Berringer 2009).

27 Small vessels, including privately owned outboard motor boats, move freight between the islands of
28 Palau. These vessels are multipurpose, moving people and freight together. The exact number of small
29 vessels involved in transport is not known, but at least several hundred outboard motorboats operate in

1 the area (Jimenez et al. 2009). Freight often consists of firewood and perishable commodities including
 2 fruits and vegetables.

3 **A2.2.2 Cargo**

4 Break-bulk cargo volumes are expected to substantially increase due to the amount of construction
 5 materials that will arrive on Guam in response to the proposed military relocation (PB International
 6 2008). The Port of Guam processed 155,000 revenue tons of break-bulk cargo during 2007. It is
 7 anticipated that the volume of break-bulk cargo processed through the Port of Guam will increase from
 8 current levels to 270,000 to 320,000 revenue tons per year during 2010 through 2013 (PB International
 9 2008). However, these figures may change if construction plans change.

10 The maritime port in Guam processes more containers than any other port in the Region and serves as
 11 the main transshipment hub. Approximately 94,000 sea cargo containers arrived at the Port of Guam in
 12 2009. This number is expected to more than double by 2015 (approximately 95,900 more containers
 13 arriving), mostly due to the military relocation (Tables A2-14 and A2-16) (PAG 2010b). The number of
 14 containers associated with construction projects and military container shipments (e.g., household
 15 goods, private vehicles, and commissary products) is anticipated to increase and peak in 2015, after
 16 which the majority of the construction is expected to be finished and the relocation of military
 17 personnel to Guam completed (PB International 2008). DoD containers are expected to account for
 18 approximately one-fourth of total container volume processed through the Port of Guam (PB
 19 International 2008). The number of containers handled to support imports for the local/tourist market is
 20 projected to steadily increase. Little change is projected for the volume of transshipment containers
 21 coming into Guam (PB International 2008). Detailed data regarding container traffic at other maritime
 22 ports in the Micronesia Region were unavailable.

23 **Table A2-16: Forecast Number of Sea Cargo Containers Entering Guam**

Year	Number of containers			
	Total	Type		
		Transshipment	DoD	Local and tourism
2010	129,000	12,000	39,000	78,000
2011	149,000	11,000	58,000	80,000
2012	172,000	11,000	78,000	83,000
2013	178,000	11,000	81,000	86,000
2014	182,000	11,000	85,000	86,000
2015	190,000	11,000	89,000	90,000
2016	180,000	11,000	76,000	93,000
2017	152,000	11,000	46,000	95,000
2018	146,000	12,000	38,000	96,000
2019	148,000	12,000	38,000	98,000
2020	150,000	12,000	38,000	100,000
2021	151,000	12,000	38,000	101,000
2022	153,000	12,000	38,000	103,000
2023	155,000	12,000	38,000	105,000
2024	157,000	12,000	38,000	107,000
2025	158,000	12,000	38,000	108,000

24 Source: PAG 2010b

1 Transshipped containers enter a country through one port, are then loaded onto a different vessel, and
2 exit for their final destination in a different country (PB International 2008; PAG 2010b).

3 **A2.2.3 Military Seaport**

4 Approximately four contract cargo vessels per week arrive at Naval Base Guam, as well as naval ships
5 carrying personnel and cargo (Berringer 2009). Currently, the number of U.S. Navy ships operating in
6 and around Guam at any given time ranges from 0 to 10; ship lengths range from 110 meters (361 feet)
7 for a nuclear submarine (SSN) to 333 meters (1,093 feet) for a nuclear aircraft carrier (CVN). The number
8 of naval ships operating in and around Guam may increase with the military relocation; specific
9 estimates were not provided in the EIS/OEIS. Training activities involving vessel movements occur
10 intermittently and are short in duration, ranging from several hours to several weeks (U.S. Navy 2009b).

11 **A2.3 AIR TRAFFIC AND CARGO**

12 **A2.3.1 Civilian Air Traffic and Air Cargo**

13 From September 2008 to September 2009, there were 20,985 flight arrivals, about 20 daily flights, at
14 A.B. Won Pat International Airport, of which fewer than 2% were dedicated cargo flights (Table A2-17)
15 (GIAT Operations Division Records 2009). The amounts of air cargo processed through the airport in
16 2003 to 2008 are summarized in Table A2-18. Passenger arrivals and departures at A.B. Won Pat
17 International Airport are projected to increase 3% to 4% per year from 2008 to 2023 and air cargo (in
18 metric tons), which includes shipments of agricultural commodities, is projected to increase 7% per year
19 during the same time period (Tagawa and Torres 2007) which may increase the number of dedicated
20 cargo flights arriving at the airport. The airport hosts several flights to Japan, Korea, China, Taiwan, the
21 Philippines, Indonesia, Australia, and Hawai'i.

22 Within the Micronesia Region, A.B. Won Pat International Airport provides air service to the CNMI (Rota
23 and Saipan), FSM (Chuuk, Kosrae, Pohnpei, and Yap), Palau (Koror), and RMI (Kwajalein and Majuro).
24 Saipan International Airport services approximately 13 flights daily; Rota International Airport averages
25 2 to 3 inter-island flights per day, as well as one direct flight from Japan per month; and Tinian
26 International Airport services inter-island flights (Berringer 2009). The Palau airport provides 7 weekly
27 turn-around services between Guam and Palau, with stops on Yap and Saipan (Law-Byerly 2010b).

1 **Table A2-17: Number of Flight Arrivals at A.B. Won Pat International Airport, by Month,**
 2 **September 2008 to September 2009**

Month	Number of flight arrivals	
	All flights ^a	Dedicated cargo flights
2008		
September	1,541	29
October	1,509	34
November	1,592	1
December	1,737	1
2009		
January	1,769	45
February	1,525	0
March	1,683	31
April	1,559	34
May	1,684	29
June	1,394	33
July	1,576	27
August	1,721	34
September	1,695	26
Total	20,985	324

3 Source: GIAT Operations Division Records 2009

4 ^a Wide-body jets, standard jets, small jets, and propeller aircraft.

6 **Table A2-18: Commercial Air Cargo Processed through A.B. Won Pat**
 7 **International Airport**

Year	Cargo weight (metric tons) ^a		
	All cargo	Imports	Exports
2003	31,479	17,587	13,892
2004	34,266	18,837	15,429
2005	32,016	17,917	14,099
2006	31,926	16,904	15,022
2007	28,378	15,380	12,998
2008	29,144	17,528	11,616

8 Source: Jacobs Consultancy 2007, GIAT Operations Division Records 2009

9 ^a Commercial air cargo.

11 **A2.3.2 Military Air Traffic and Cargo**

12 Andersen Air Force Base (AFB) is located on the northern end of Guam and is home to the 734th Air
 13 Mobility Squadron, 36th Operations Group, and the Helicopter Sea Combat Squadron (HSC-25) (U.S.
 14 Navy 2009a). Aircraft arrivals at Andersen AFB include military flights, contract flights for military
 15 dependents, and approximately 10 cargo flights per week (Berringer 2009). Civilian and military air
 16 traffic will increase to accommodate the population increase associated with the military relocation. The
 17 percent increase in commercial flight traffic during the relocation is unknown. However, the number of
 18 flight operations of helicopters, jets, and propeller aircraft at Andersen AFB is projected to increase 45%

1 by 2014 (U.S. Navy 2009a). In addition to flight traffic, air cargo traffic will increase to accommodate the
2 increase in population and relocation activities.

3 Andersen AFB supports Air Mobility Command flights for military personnel and their dependents. In
4 2006, 29,524 flight operations were conducted at Andersen AFB (U.S. Navy 2009a). The Air Force plans
5 on increasing its use of the base, bringing the total number of annual airfield operations up to 68,139 by
6 2014. Of these airfield operations, 18,951 are expected to involve the HSC-25 Squadron's MH-60S
7 Knighthawk helicopters, and 732 are expected to be transient operations generated by the air wing
8 associated with the visiting aircraft carrier. The remainder will be local and transient operations.

9 Of the flight operations conducted in 2006, only 18,951 operations involved equipment based at
10 Andersen AFB (all helicopters) (U.S. Navy 2009a). In addition, 602 jet operations, 52 rotary wing
11 operations, and 78 helicopter operations were conducted with equipment associated with visiting
12 aircraft carrier wings. Finally, 9,841 local and transient operations were conducted. Under the proposed
13 actions, additional aircraft would be based at Andersen AFB by the Marine Corps. Equipment based at
14 Andersen AFB would be used in 23,416 operations in 2014³ (18,852 helicopter; 4,564 jet) (U.S. Navy
15 2009a). Under the proposed actions, 1,704 jet operations, 156 rotary wing operations, and 234
16 helicopter operations would be conducted in 2014⁴ using equipment associated with visiting aircraft
17 carrier wings. The addition of these aircraft would result in 25,510 sorties at Andersen AFB in 2014 .
18 Under the proposed actions, up to 59 aircraft would reside at Andersen AFB on a space-available basis
19 when a CVN is in port. A typical air wing might include 20 Hornet aircraft, 10 Super Hornet aircraft, five
20 EA-6B aircraft, four E-2C aircraft, and six SH-60 aircraft.

21 **A2.4 AGRICULTURAL COMMODITIES**

22 **A2.4.1 Plants and Plant Products: Imports**

23 Some of the main types of plant products imported to Guam include fruits and vegetables, cut flowers,
24 and wood. Because Guam is a domestic trading partner with the rest of the United States, neither the
25 federal government nor Guam now systematically collects data regarding the specific amounts of
26 commodity trade between the two locations. As opposed to current practices, in 2002 (and before)
27 GDOA personnel collected such data. Data collected during these activities illustrate both the diversity
28 of plants and plant products imported into Guam and the diversity of their origins. These data are
29 summarized in the list below; the values in parentheses are the weight of the imported commodity in kg
30 and pounds rounded to the nearest pound. The total weight imported in 2002 was 13,148 metric tons
31 (28,986,463 pounds). It should be noted that these data do not include imported furniture from
32 Indonesia. It is worth noting that while the information presented below is interesting, it is outdated,
33 some locations which do export plant products to Guam such as Kosrae and Yap are not included and
34 some of the information is simply incorrect, for example Pohnpei does not produce alfalfa sprouts.

³ Ibid. p. A2-9.

⁴ Ibid.

1 **Australia**—oranges (9,099/20,060); live plants (306/676); onion (24,040/53,000); strawberry (503/1,109)

2 **China**—cut flowers (354/781); china garlic (998/2,200); china ginger (5,953/13,125)

3 **Chuuk**—banana hearts (38/83); banana/plantain (43,601/96,124); kava (45/99)

4 **CNMI**—green bean (69/152); string bean (44/97); coconut (23/50); cucumber (381/841); cut flowers

5 (5/11); eggplant (143/316); live plants (29/65); beef (18/40); pork (2,622/5,780); okra (11/24); chili

6 pepper (28/61); sweet potato (6,355/14,010); taro (6,600/14,551)

7 **Hong Kong**—garlic (39,022/86,029)

8 **Japan**—apple (1,284/2,830); asparagus (164/362); avocado (8/18); bamboo shoots (35/78); basil (2/5);

9 bean (49/109); blackberry (17/37); blueberry (20/45); bok choy (14/30); broccoli (30/66); burdock

10 (446/983); green cabbage (11/24); nappa cabbage (4/9); carrot (495/1,092); cherries (18/40); chervil

11 (5/11); chive (13/29); chrysanthemum (667/1,471); cilantro (28/62); grapefruit (4/8); kumquat (1/3);

12 lemon (5/12); lime (3/6); oranges (2,135/4,706); tangerine (14,553/32,084); cucumber (751/1,656); dill

13 (8/18); eggplant (808/1,782); endive (5/10); Belgian endive (23/50); garlic (33/72); ginger (22/48); grape

14 (74/163); kale (25/55); kay choy/yo cho (71/156); lemon grass (5/10); lettuce (21/46); frisse (6/13);

15 green lettuce (4/9); red lettuce (68/151); lily root (9/20); lotus root (20/45); mango (28/62); marjoram

16 (0.5/1); marsh mallow (2/4); bitter melon (10/23); cantaloupe (32/70); Crenshaw melon (3/7);

17 honeydew (3/7); mint (45/100); mizuna (0.5/1); mushrooms (4,334/9,554); mustard greens (34/74);

18 nectarine (20/44); okra (32/71); onion (726/1,601); green onion (649/1,430); leek (135/297); shallot

19 (34/74); oregano (0.5/1); papaya (15/32); parsley (395/870); pea pod (4/9); sugar pea (24/52); peach

20 (120/264); bell pepper (1,356/2,989); chili pepper, (16/35); jalapeño pepper (1/2); perilla (413/910);

21 plum (29/63); potato (45/100); sweet potato (183/404); pumpkin (556/1,226); radicchio (14/30); radish

22 sprouts (300/661); radish/daikon (5,525/12,181); rosemary (3/6); sage (1/2); seeds (5/10); spinach

23 (740/1,631); squash (95/210); strawberry (210/462); taro (0.5/1); tarragon (1/2); thyme (1/2); tomato

24 (845/1,862); turnip (123/271); watercress (18/40); yam (459/1,011); *Zanthoxylum* spp. (1/2)

25 **Korea**—alfalfa sprouts (4/9); apple (27,809/61,309); apricot (40/88); bean (449/989); green bean (12/26);

26 bean, soy (10/22); bean, sprouts (1,489/3,283); bok choy (158/349); bracken fern (24/53); burdock

27 (239/526); green cabbage (1,501/3,310); nappa cabbage (29,460/64,948); pechay cabbage (260/573);

28 red cabbage (49/108); carrot (50/110); Swiss chard (82/180); cherries (65/144); chestnut (315/694);

29 chicory (239/528); Chinese bellflower (14/31); chrysanthemum (1,740/3,835); grapefruit (40/88); lemon

30 (25/55); orange (11,513/25,382); tangerine (37,450/82,563); collard greens (2/4); corn (61/135);

31 cucumber (21,281/46,916); cut flowers (3,965/8,741); dandelion green (28/62); eggplant (3,045/6,713);

32 gai lon (31/68); garlic (2,120/4,674); bottled garlic (83/184); wild garlic (2/4); ginger (57/126); ginkgo nut

33 (3/7); ginseng (4/9); grape (4,683/10,324); kale (2/4); kay choy/yo cho (4/9); seaweed (6/13); lettuce

34 (4,364/9,620); frisse (20/44); green lettuce (1,329/2,930); lolla lettuce (20/44); red lettuce

35 (1,383/3,050); lo bok (3/7); lotus root (78/171); marsh mallow (87/192); bitter melon (210/462);

36 cantaloupe (3,703/8,163); Crenshaw melon (17/37); honeydew (80/176); mugwort (35/77); mushrooms

37 (5,610/12,369); mustard greens (4/9); olive (16/35); onion (1,952/4,303); green onion (981/2,162); leek

38 (117/258); shallot (9/20); parsley (75/166); green pea (6/13); peach (3,193/7,039); pear

1 (44,455/98,007); bell pepper (8,523/18,790); chili pepper (1,521/3,354); jalapeño pepper (260/574);
2 perilla (1,028/2,267); persimmon (21,039/46,383); plum (1,335/2,943); potato (713/1,571); sweet
3 potato (4,023/8,870); pumpkin (5,230/11,530); pumpkin leaf (82/180); radicchio (2,096/4,620); radish
4 sprouts (184/405); radish/daikon (16,693/36,802); sage (5/11); sesame leaf (288/634); spinach
5 (7,406/16,327); squash (96/211); strawberry (111,964/246,838); taro (31/68); tomato (5,904/13,015);
6 turnip (2/4); processed vegetables (15/33); watercress (79/174); watermelon (14,032/30,936); yam
7 (20/44)

8 **Malaysia**—wood (11,693/25,780)

9 **Netherlands**—cut flowers (20,544/45,292)

10 **New Zealand**—apple (13,679/30,156); grapefruit (154/340); lemon (272/600); cut flowers (2,442/5,384);
11 green lettuce (169/372); cantaloupe (483/1,064); mushrooms (3,119/6,876); onion (141,074/311,015)

12 **Palau**—live plants (2/5)

13 **Philippines**—bamboo handicrafts (48/105); cut flowers (375/827); eggplant (34/75); handicrafts
14 (57/125); live plants (15/32); mango (180,261/1,279,256)

15 **Pohnpei**—alfalfa sprouts (1,711/3,772); banana/plantain (32,795/72,300); betelnut (196/433); cucumber
16 (49/108); cut flowers (100/220); kava (25,811/56,903); papaya (74/162); piper leaf (71/157); spinach
17 (3/7); taro (71/156)

18 **Singapore**—cut flowers (1,855/4,090)

19 **Taiwan**—apple (11/25); bamboo shoots (16/36); bean (15/34); carrot (88/194); celery (53/117); chive
20 (361/795); cut flowers (30,985/68,311); kale (27/59); live plants (406/894); mushrooms (167/368); onion
21 (7/16); green onion (7/15); green pea (103/227); pea pod (80/176); snow pea (36/80); sugar snap pea
22 (68/151); spinach (122/270); taro (2/5); processed vegetables (13/29); watercress (56/124)

23 **Thailand**—carrot (2/4); celery (5/10); chive (28/62); cut flowers (5,467/12,052); live plants (748/1,649);
24 pea pod (21/46); spinach (5/10); processed vegetables (3/7); watercress (5/10)

25 **United States**—alfalfa sprouts (886/1,953); anise (292/644); apple (575,315/1,268,353); apricot
26 (2,405/5,304); artichoke (1,496/3,298); arugula (2/4); asparagus (101,014/222,698); avocado
27 (14,036/30,945); bamboo handicrafts (70/154); banana hearts (23/50); banana/plantain
28 (929,204/2,048,544); basil (172/379); bay leaf (12/26); bean (2,279/5,020); green bean (4,214/9,291);
29 mongo/mun bean (181/400); bean sprouts (15/34); string bean (479/1,057); beet (2,092/4,611);
30 betelnut (412/909); blackberry (1,228/2,707); blueberry (1,510/3,328); bok choy (22,123/48,775);
31 bracken fern (1/2); broccoli (310,839/685,282); Brussels sprout (383/844); green cabbage,
32 (581,827/1,282,708); nappa cabbage (258,750/570,446); pechay cabbage (9,392/20,706); red cabbage
33 (19,788/43,624); savoy cabbage (1,081/2,384); carrot (411,791/907,843); cauliflower (53,882/118,789);
34 celery (168,996/372,572); Swiss chard (437/964); chayote (1,404/3,095); cherimoya (136/300); cherries
35 (26,192/57,743); cherry (10,209/22,506); chervil (4/8); chicory (182/401); chive (88/195); Christmas

1 trees (23,243/51,241); chrysanthemum (14/30); cilantro (4,564/10,062); grapefruit (96,162/212,002);
2 kumquat (5/10); lemon (161,961/357,062); lime (12,047/26,558); orange (600,186/1,323,183);
3 tangerine (90,323/199,129); collard greens (3,054/6,733); corn (22,168/48,872); cranberry (124/274);
4 cucumber (46,675/102,901); cut flowers (34,741/76,590); date/jujube (57/126); dill (143/316); eggplant
5 (2,504/5,521); endive (1,357/2,991); Belgian endive (562/1,239); chicory endive (215/475); escarole
6 (444/979); fennel (72/159); fig (108/237); gai lon (1,163/2,565); garlic (49,841/109,880); bottled garlic
7 (299/660); wild garlic (8/18); ginger (49,479/109,082); grape (419,840/925,589); grass stolons
8 (327/720); guava (91/200); jicama (536/1,181); kale (1,104/2,435); kava (132/291); kay choy/yo cho
9 (664/1,464); kiwi (26,306/57,995); lemon grass (54/120); lettuce (27,427/60,466); butter lettuce
10 (7,845/17,295); cello lettuce (633,654/1,396,969); frisse (1,364/3,008); green lettuce (26,519/58,465);
11 lolita lettuce (134/295); red lettuce (13,015/28,694); Romaine lettuce (311,463/686,659); live plants
12 (76,907/169,550); lo bok (20,506/45,208); lotus root (23/51); lychee (105/231); mango
13 (210,986/465,145); marjoram (15/34); marsh mallow (1/2); cantaloupe (499,679/1,101,604); honeydew
14 (287,472/633,768); mice (152/336); mint (221/488); mushrooms (33,736/74,375); mustard greens
15 (842/1,857); nectarine (19,915/43,905); nuts (680/1,500); okra (247/545); onion (991,166/2,185,147);
16 green onion (129,404/285,287); leek (4,118/9,078); shallot (733/1,617); oregano (30/66); palm
17 (138/304); papaya (845/1,883); parsley (40,690/89,705); parsnip (18/40); green pea (71/156); pea pod
18 (52/115); pea shoot (7/15); snow pea (4,046/8,919); sugar snap pea (2,710/5,974); peach
19 (13,154/29,000); peanut (1,637/3,610); pear (309,135/681,527); bell pepper (287,602/634,054); chili
20 pepper (1,161/2,559); jalapeño pepper (1,088/2,399); perilla (22/49); persimmon (3,712/8,183);
21 pineapple (404,374/891,491); piper leaf (5/10); plum (33,362/73,550); pomegranate (1,384/3,052);
22 potato (1,493,325/3,292,218); sweet potato (1,872/4,128); pumello (6,953/15,329); pumpkin
23 (11,283/24,874); pumpkin leaf (1/2); quince (5/10); radicchio (2,761/6,087); radish sprouts
24 (1,828/4,029); radish/daikon (20,466/45,119); raspberry (1,524/3,360); rhubarb (47/104); rosemary
25 (147/325); rutabaga (252/555); sage (16/36); sesame leaf (4/9); spinach (17,362/38,277); squash
26 (47,062/103,755); star fruit (13/29); strawberry (57,790/127,405); taro (12,269/27,049); tarragon
27 (12/26); thyme (59/130); tomatillo husk (271/598); tomato (474,596/1,046,305); turnip (570/1,257);
28 turnip greens (345/760); processed vegetables (43,339/102,160); watercress (355/782); watermelon
29 (302,733/667,412); yam (9,091/20,043); yucca (472/1,041); zucchini (2,547/5,616)

30 **Yap**–betelnut (110,647/243,935); kava (266/587); piper leaf (3,323/7,327); taro (16/36)

31 An important caveat to the data presented above is the omission of many cereal crops. Data regarding
32 the volume and value of cereals imported from the United States to Guam are not available. However,
33 imports of cereals from non-U.S. origins to Guam totaled more than \$3 million in 2008, with the majority
34 of shipments originating from Thailand, Japan, and Taiwan (Table A2-19) (GTIS 2010).

35

Table A2-19: Cereal Imports to Guam, 2006-2008

Reporting country or region	U.S. dollars		
	2006	2007	2008
Thailand	871,307	2,067,395	3,198,206
Japan	3,341	2,045	14,918
Taiwan	62	182	2,874

India	5,533	0	0
Philippines	136,526	0	0
South Korea	0	42	0

Source: GTIS 2010

In 2002, the United States was the largest source of live plants for propagation imported into Guam, which totaled 76,907 kg (169,550 pounds) (see above). Hawai'i and Florida are significant sources of ornamental plants. Orchids are imported primarily from Thailand and Taiwan, while most bromeliads are imported from the Philippines. As shown in the list above, relatively small amounts of live plants are imported from the FSM, CNMI, and Palau (Campbell 2010d). Cut flowers imported into Guam likely originated from South America (Colombia and Ecuador) with some originating from Asia (USDA-APHIS-PPQ 2010a).

Wood imports to Guam from foreign trading partners totaled more than \$3 million in 2007 (GTIS 2010). The majority of these imports were finished products or building materials from neighboring Asian nations. In 2008, trading partners within the Micronesia Region exported fruit and vegetable commodities to Guam worth \$1.3 million (GTIS 2010).

FSM imported \$2 million to \$4 million in cereals each year from 2007 to 2009 from the United States (GTIS 2010). Data for other areas within the Micronesia Region were not available.

Another important caveat to the list above is the lack of information regarding informal imports such as the importation of taro from Palau and the FSM. These items are typically imported by family members for home consumption or by the small scale markets that cater to the various island and Asian groups now living on Guam. As an example, the Alii Fish Market in Dededo, Guam regularly imports Colocasia and Cyrtosperma taro and other Palauan food items for sale to its mainly Palauan clientele. The same generalizations regarding food imports to the informal sector also can be made for the other Micronesian island groups who reside on Guam. The import of taro plants and fresh taro products is prohibited to Guam, in order to prevent the dissemination of taro diseases. Per regulations, the Alii Fish Market imports taro (both Colocasia and Cyrtosperma) that has been cooked, frozen and wrapped in plastic.

A2.4.2 Plants and Plant Products: Domestic Production and Exports

Guam produces a variety of fruit, including coconuts, melons, papaya, guavas, mangoes, mangosteens, and nuts (FAO 2010a) (Tables A2-20 and A2-21).

Table A2-20: Non-Animal Agricultural Production on Guam, 1998-2008, by Hectare

Commodity	Number of hectares harvested, by year		
	1998	2003	2008
Bananas	10	15	15
Coconuts	9,300	9,300	9,600
Cucumbers and gherkins	10	15	15
Fruit, fresh	200	300	300
Maize	10	15	15
Nuts	45	50	70

Commodity	Number of hectares harvested, by year		
	1	1	5
Onions, dry	1	1	5
Roots and tubers	100	120	170
Sweet potatoes	4	6	10
Tomatoes	5	10	15
Vegetables, fresh	165	170	200
Total	9,850	10,002	10,415

Source: Data are estimates of FAO 2010a

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2
3

1 **Table A2-21: Non-Animal Agricultural Production on Guam, 1998-2008, by Metric Ton**

Commodity	Number of metric tons harvested, by year		
	1998	2003	2008
Bananas	230	345	350
Cabbages and other Brassica	90	100	120
Citrus	80	90	110
Coconuts	51,875	52,000	53,200
Cucumbers and gherkins	260	390	400
Eggplants	20	30	35
Fruit, fresh	1,400	2,100	2,100
Maize	20	30	35
Mangoes, mangosteens, guavas	50	60	70
Nuts	114	126	180
Onions, dry	2	2	10
Oranges	60	70	90
Other melons	340	350	370
Roots and tubers	1,500	1,800	2,500
String beans	94	95	110
Sweet potatoes	50	75	130
Tomatoes	60	120	160
Vegetables, fresh	1,500	1,550	1,900
Watermelons	2,200	2,300	2,500
Total	59,945	61,633	64,370

2 Source: Data are estimates of FAO 2010a

3
 4 Of these commodities, some percentage is exported, although the majority of production is consumed
 5 by the domestic market. Historically, the primary recipients of exported fruit and vegetable commodities
 6 are Canada, the United Kingdom, and the Netherlands (GTIS 2010). The majority of exported vegetables
 7 are legumes; Canada, Iceland, and the Netherlands are primary recipients (GTIS 2010). Wood is also
 8 exported from Guam, and is sent to India and the Philippines (GTIS 2010). The primary destination for
 9 Guam plant product exports is FSM (Table A2-22).

10

1

Table A2-22: Plant Product Exports from Guam, June 2008 to March 2010

Number of shipments	Destination	Commodity	Total weight (pounds)
3	CNMI, Rota	Fruits and vegetables	445
10	CNMI, Rota	Live plants	142
56	CNMI, Saipan	Cut flowers	11,855
8	CNMI, Saipan	Live plants	452
1	CNMI, Saipan	Seeds	10
1	CNMI, Tinian	Cut flowers	152
1	FSM	Fruits and vegetables	8,511
1	FSM, Chuuk	Cut flowers	203
13	FSM, Chuuk	Fruits and vegetables	14,774
1	FSM, Pohnpei	Cut flowers	2
7	FSM, Pohnpei	Live plants	74
1	FSM, Yap	Cut flowers	4,983
33	FSM, Yap	Fruits and vegetables	271,799
1	Massachusetts	Chilled algae	39
77	Palau	Cut flowers	4,429
10	Palau	Fruits and vegetables	9,982
1	Palau	Live plants	12
1	Philippines	Live plants	4
1	RMI, Majuro	Fruits and vegetables	960
1	Texas	Coconut	52

2

Source: Data provided by GCQA

3

4 Coconut is the largest crop, in number of metric tons harvested in RMI (GTIS 2010); production totaled
5 27,500 metric tons (60,627,122 pounds) in 2008 (FAO 2010a). Export data for FSM and RMI were not
6 available.

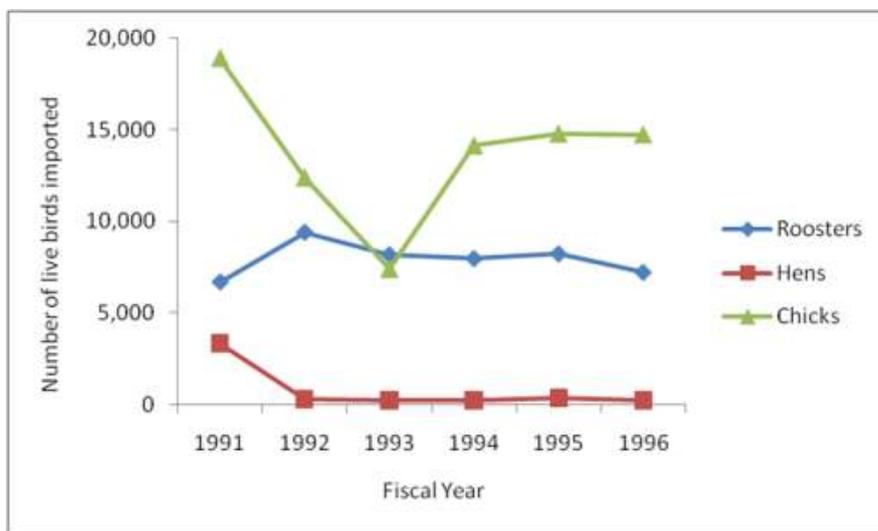
7 **A2.4.3 Animals and Animal Products: Imports**

8 Data on livestock imports were available from the Global Trade Atlas (GTIS 2010). Guam has
9 experienced a decline in annual live animal imports after a peak in 2003 and 2004 totaling more than
10 10,000 per year. The number of animals imported dramatically declined to about 100 animals per year
11 between 2004 and 2007 and remains below 10 per year at present. Imported animals originated
12 primarily from Australia (84%) with the rest being sourced from Asia (the Philippines, South Korea,
13 Thailand, Japan, Indonesia, and Singapore), Canada, and Denmark. The majority of import records in the
14 Global Trade Atlas do not include the animal species. According to the territorial veterinarian, no
15 livestock have been imported to Guam over the last 5 years (Poole 2009). Additionally, according to
16 published reports, no cattle have been imported in the last two decades (Duguies et al. 2000). Swine
17 semen has been imported in the past, but no records were found to indicate recent importations (Poole
18 2009).

19 Importation of poultry breeding stock to Guam is restricted and subject to U.S. federal regulations; most
20 poultry breeding stock have been imported from the continental United States and Hawai'i. During fiscal
21 years 1991 to 1996, most of the imported birds were day-old chicks, with some roosters and few hens

1 (Figure A2-3). The number of bird imports declined following the imposition of restrictions on transit of
 2 birds after the outbreak of West Nile fever in the continental United States. According to a GCQA 2002
 3 report on animal imports, no chicks or hens were imported in 2002 (GovGuam 2002). Global Trade
 4 Information Services reported one shipment of 14,000 live chickens from Denmark in 2003 (GTIS 2010).
 5 No data are available from GCQA on animal importations after 2002 (Campbell 2010a). Current demand
 6 for poultry breeding stock is partially met by GDOA, which runs an experimental farm that hatches and
 7 raises poultry for local farmers. We were not able to identify data specific to the number of hatching
 8 eggs and day-old chicks imported, but nearly all of these imports are from Hawai'i and the continental
 9 United States (USDA-APHIS-PPQ 1997; GovGuam 2002; DNRL 2003; Dela Cruz 2009; Poole 2009).

10 **Figure A2-3: Trends in the Importation of Live Birds to Guam, FY 1991 to FY 1996**



11

12 Source: USDA-APHIS-PPQ 1997

13 The GCQA 2002 report documents animal imports and indicates that on average, 9,400 roosters were
 14 imported annually during the 1990s. These numbers have declined, starting shortly after the West Nile
 15 fever outbreak in the continental United States. Only 12 roosters were imported to Guam in 2002 from
 16 CNMI (GovGuam 2002). While more current data are not available from GCQA, there is reason to believe
 17 that the trend reversed shortly after, with increasing numbers of roosters brought in and used to supply
 18 a burgeoning cock fighting industry (Poole 2009). In unpublished reports, Guam Animals In Need
 19 indicated that approximately 6,000 roosters were imported between 2003 and 2005; these increasing
 20 numbers of rooster imports are also consistent with the increasing popularity of cock fighting on Guam
 21 as discussed in a 2008 Honolulu newspaper article (Boylan 2008). However, in 2002, a federal law was
 22 implemented that prohibits the interstate transit of birds used for fighting, and United Airlines recently
 23 banned the air freight transportation of adult poultry (Huemer 2007), suggesting the trend will be
 24 reversed once again with far fewer roosters imported.

25 In the past, the annual number of pet birds imported ranged from 42 to 6,505 (FY 1991 to FY 1996)
 26 (USDA-APHIS-PPQ 1997). These numbers drastically declined after the implementation of importation
 27 and quarantine requirements designed to prevent the introduction of West Nile virus (WNV) from the

1 continental United States. Based on the last available Guam-specific animal import data, there are no
2 records of pet birds having been imported into Guam in 2002 (GovGuam 2002). Since GCQA took over
3 inspection responsibilities in 2003, animal import numbers have not been reported. However, according
4 to the territorial veterinarian on Guam the approximate number of pet birds coming to Guam is
5 currently less than a dozen per year (Poole 2009).

6 The number of dogs and cats imported into Guam annually is low, with estimates ranging from 10 to 100
7 animals a year (Poole 2009). In the GCQA 2002 animal report, 113 dogs and 29 cats were imported to
8 Guam in 2002 (GovGuam 2002). The majority of imports originated from the continental United States
9 and Australia, with a few animals imported from Japan and CNMI (USDA-APHIS-PPQ 1997).

10 Most food imports originate in the continental United States. In FY 2009, imports from the rest of the
11 United States accounted for more than 85% of meat products, 98% of egg products, and 75% of dairy
12 products imported into Guam. Data for imports of animal products and byproducts from foreign sources
13 over the period 2005 to 2009 were obtained from the Global Trade Atlas (GTIS 2010) and are
14 categorized by the harmonized schedule (HS) codes. The volume of foreign meat imports increased from
15 2005 to 2009, mostly due to a steady annual increase in the volume of imported pork over the last 5
16 years as shown in Table A2-24, and in Figure A2-4 and Figure A2-5.

17

1 **Table A2-24: Annual Percent Volume of Foreign Meat Imports to Guam, 2005-2009**

HS code	Commodity	Year					Countries or regions of origin
		2005	2006	2007	2008	2009	
Percent of total foreign meat imports, by weight ^a							
0201	Bovine meat, fresh and chilled	<1	0	<1	<1	<1	Australia, Japan
0202	Bovine meat, frozen	50	39	38	36	20	Australia, New Zealand
0206	Bovine, edible offal (also from swine, sheep, goats, equines)	3	2	3	2	1	Australia, New Zealand, Japan
0210	Bovine meat and edible offal salted, dried and flour and meal	1	<1	<1	<1	<1	Australia
0203	Swine meat, fresh and chilled	11	21	26	34	53	Australia, Denmark, Sweden
0204	Sheep and goat, meat, fresh and chilled	3	2	1	1	2	Australia, New Zealand
0207	Poultry, meat and offal, edible	0	0	0	0	0	None
0208	NESOI ^b	0	<1	<1	<1	<1	Taiwan
1601	Sausages and similar products	<1	<1	<1	0	0	Philippines, Denmark, South Korea
1602	NESOI, meat, offal or blood, prepared or preserved	31	35	32	27	24	Australia, New Zealand, Denmark, Brazil
Total imports (metric tons)		1,188,131	1,178,731	1,246,523	1,390,422	1,651,126	

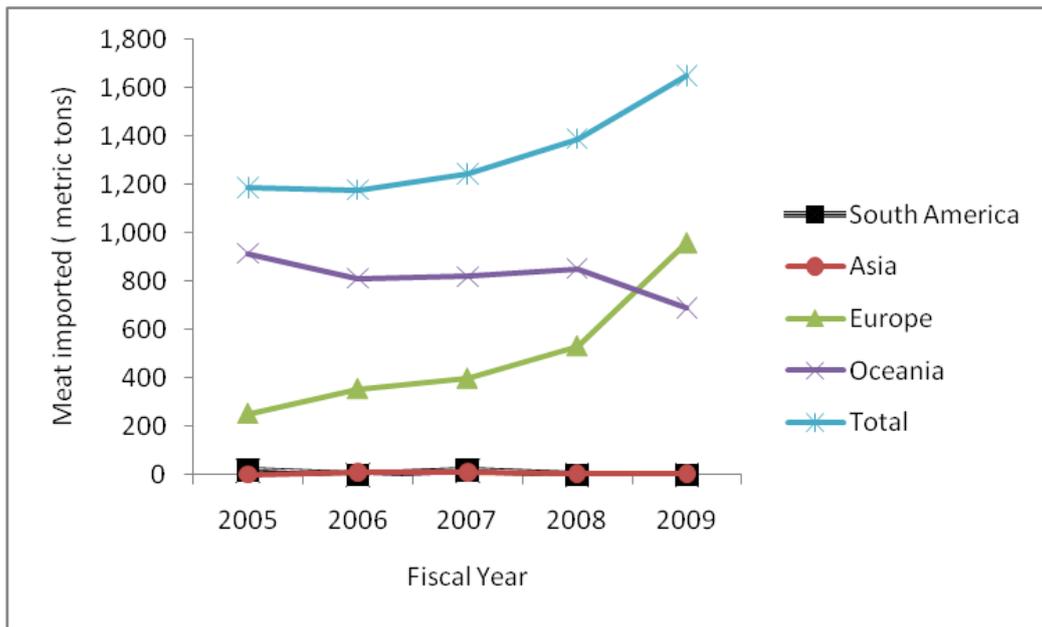
2 Source: Official trade data for partner countries exporting to Guam; GTIS 2010

3 ^a Due to rounding, not all totals equal 100.

4 ^b NESOI: Not elsewhere specified or indicated.

5

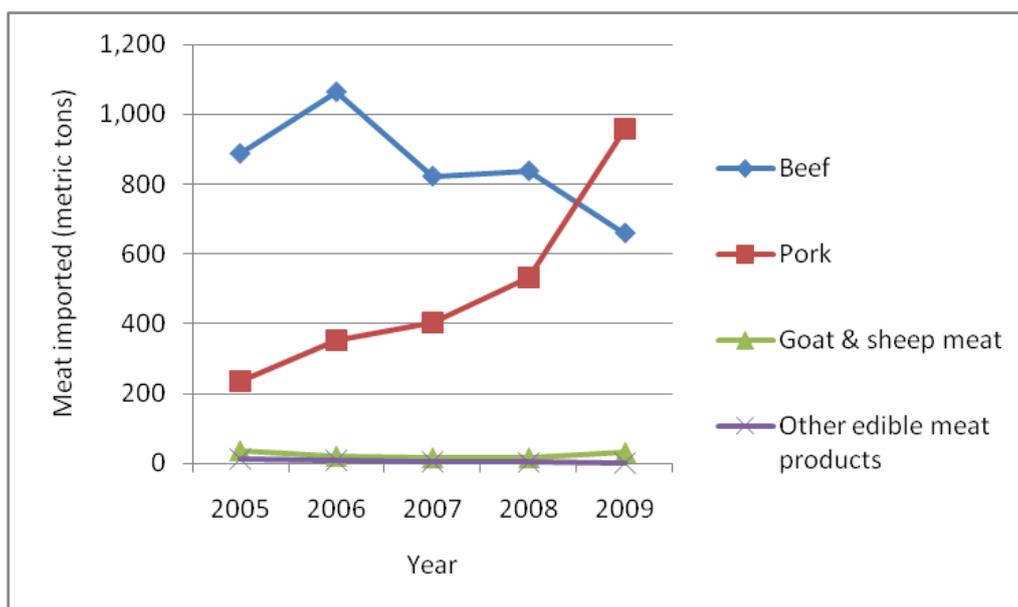
1 **Figure A2-4: Foreign Meat Imports To Guam By Continent of Origin, 2005-2009**



2
3 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
4

5 Volumes of beef imports decreased from 2006 to 2009 (GTIS 2010). No foreign imports of poultry
6 products were recorded, indicating that all or nearly all poultry products were sourced from the United
7 States. Meat from goats and sheep constituted less than 5% of total meat imports and was imported
8 exclusively from Australia and New Zealand. Other edible preparations, including preserved or prepared
9 meat, blood, sausages, and similar products, represented 24% of total meat imports for 2009. Most
10 foreign-origin meat was imported from Denmark (58%), Australia (21.8%), and New Zealand (19.9%),
11 with less than 1% imported from elsewhere (the Philippines, Japan, and Taiwan) (Table A2-25). Imports
12 of beef came primarily from New Zealand and Australia (99%) and less than 1% from Japan.

1 **Figure A2-5: Annual Volumes of Foreign Meat Imports to Guam, 2005-2009**



2
3 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
4 Includes: HS codes for bovine (0201, 0202, 0206, 0210), pork (0203), and sheep (0204) sources. No
5 poultry product imports were reported for the period. Other edible meat products include HS codes
6 160220, 160290, and 1601.
7

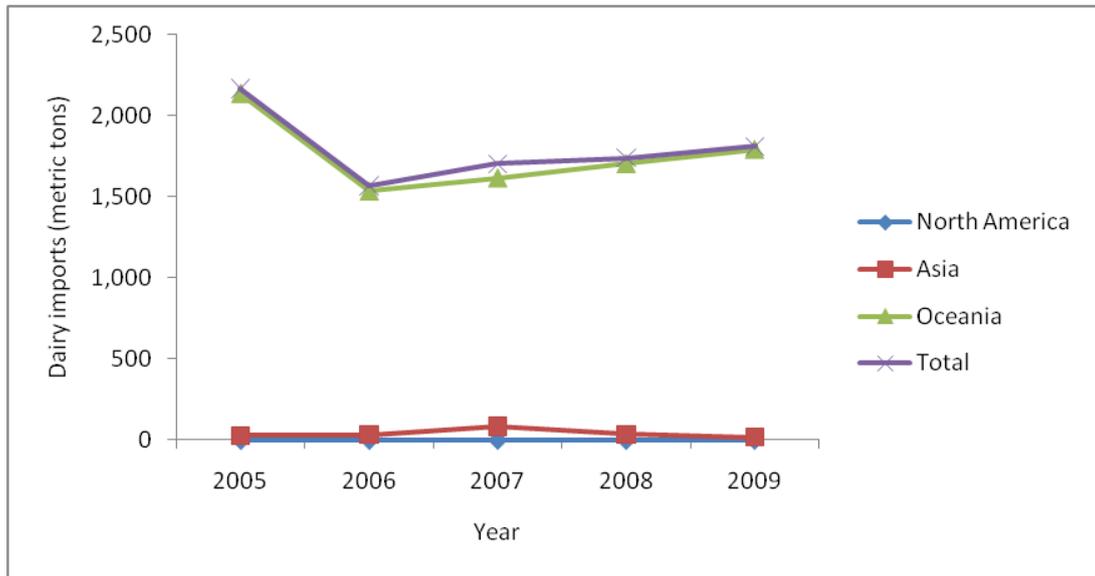
8 **Table A2 25: Annual Percent Volume of Foreign Meat and Other Edible Animal Product**
9 **Imports To Guam By Country and Continent of Origin, 2005-2009**

Continent	Reporting country or region	Year				
		2005	2006	2007	2008	2009
Percent of total meat imports, by weight ^a						
Americas	Brazil	2	0	1	0	0
	Total	2	0	1	0	0
Asia	Philippines	<1	<1	<1	<1	<1
	Japan	0	0	0	<1	<1
	South Korea	<1	0	0	0	0
	Taiwan	0	<1	<1	<1	<1
	Total	<1	<1	<1	<1	<1
Europe	Denmark	21	30	32	34	58
	Netherlands	0	0	0	4	0
	Total	21	30	32	38	58
Oceania	Australia	38	39	32	33	22
	New Zealand	39	29	36	29	20
	Total	77	68	68	62	42
Total, all countries (kilograms)[kg]		1,188,131	1,178,731	1,246,523	1,390,422	1,651,126

10 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
11 Volumes of imports of meat (includes HS codes for meat (160210, 160220, 160239, 160241, 160242, 160249,
12 160250, 160290) and other edible animal products (160100).
13 ^a Due to rounding, not all totals equal 100.

1 Non-U.S. imports of dairy products have remained relatively stable over the last 4 years, with annual
 2 volumes averaging approximately 1800 metric tons (Figure A2-6).

3 **Figure A2-6: Annual Volumes Foreign Dairy Imports to Guam by Continent of Origin,**
 4 **2005-2009**



5
 6 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
 7

8 Each year from 2005 to 2009, New Zealand and Australia supplied more than 95% by weight of all dairy
 9 imports to Guam from foreign origins. During the same time period, 1% or less of all dairy imports were
 10 from each of several other regions, including the Philippines, Japan, Taiwan, and Canada (Table A2-26).

11 **Table A2-26: Annual Percent Volume Dairy Imports to Guam By Country and Continent of**
 12 **Origin, 2005-2009**

		Year				
Continent	Reporting country or region	2005	2006	2007	2008	2009
Percent of total dairy imports, by weight ^a						
Americas	Canada	0	0	1	<1	<1
	Total	0	0	1	<1	<1
Asia	Philippines	1	2	4	1	1
	Japan	<1	<1	<1	<1	<1
	Taiwan	<1	<1	0	0	0
	South Korea	0	0	<1	<1	<1
	Total	2	2	4	1	<2
Oceania	New Zealand	77	83	87	89	90
	Australia	21	15	9	9	9
	Total	98	98	96	98	99
Total, all countries (kg)		2,167,695	1,568,790	1,703,495	1,741,506	1,812,721

13 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
 14 ^a Due to rounding, not all totals equal 100.

1 From 2005 to 2009, 80% to 90% of dairy imports were non-sweetened and non-concentrated dairy
 2 products; the rest were cheeses and sweetened or concentrated milk products (Table A2-27).
 3 Sweetened and concentrated milk products and cheese represented on average 12 and 4% of imports
 4 from Asia respectively.

5 **Table A2-27: Foreign Dairy Product Imports to Guam, 2005-2009**

HS code	Commodity	Year					Countries of Origin
		2005	2006	2007	2008	2009	
Percent of foreign dairy product imports, by weight ^a							
0401	Milk and cream, not concentrated or sweetened	62	78	82	74	88	Australia, New Zealand, South Korea, Philippines, Thailand
0402	Milk and cream, concentrated or sweetened	20	11	12	15	7	Australia, New Zealand, Japan, South Korea, Philippines, Thailand, Canada
0406	Cheese and curd	18	11	7	10	6	Australia, New Zealand, Japan, Philippines
Total product imports (kg)		2,167,695	1,568,790	1,703,495	1,741,506	1,812,721	

6 Source: Official trade data for partner countries exporting to Guam; GTIS 2010

7 ^a Due to rounding, not all totals equal 100.

8
 9 In the last 5 years, all foreign imports of egg products have come from Asia (Thailand, Japan, and
 10 occasionally from Taiwan) with the volume of imported egg products oscillating between 20 and 30
 11 metric tons. In 2005, almost 80% of foreign imports of egg products were from Japan (Table A2-28).
 12 However, from 2007 to 2009 an increasingly large proportion of egg product imports have come from
 13 Thailand (Table A2-28).

14 **Table A2-28: Percent of Egg Product Imports to Guam by Country of Origin, 2005-2009**

Reporting country or region	Year				
	2005	2006	2007	2008	2009
Percent of egg product imports, by weight ^a					
Thailand	21	22	61	81	100
Japan	79	75	31	19	0
Taiwan	0	3	7	0	0
Total egg product imports (kg)	35,476	31,347	21,567	31,778	22,134

15 Source: Official trade data for partner countries exporting to Guam; GTIS 2010

16 ^a Due to rounding, not all totals equal 100. The volumes of egg product imports for years with no
 17 reported imports are assumed to equal zero.

18
 19 Limited veterinary services throughout Micronesia and lack of inspection for slaughter activities
 20 preclude the possibility of commercial trade of locally produced animal products, including meat, eggs,
 21 and milk.

1 **A2.4.3.1** *Animal Product Imports by the U.S. Armed Forces*

2 The Defense Commissary Agency provides groceries to military personnel, retirees, and their
3 dependents (Melton 2009). All perishable food products procured by the Defense Commissary Agency,
4 including meat, eggs, and fresh dairy products, come into Guam from other parts of the United States.
5 All meat products procured by the Defense Commissary Agency require USDA certification (Melton
6 2009). Military food comes into the military port where it is inspected by military veterinarians prior to
7 distribution. These food commodities are inspected to assure the product matches the paperwork, and
8 for quantity and approved source. Most of the distributors are based in California.

9 Currently there are over 200 domestic and foreign sources of food for which the U.S. Army Veterinary
10 Corps must provide inspection services for the military bases on Guam (VETCOM 2009). In 2010, there
11 will be an increase in the number of approved foreign sources. Some of the new suppliers will be located
12 in Vietnam and China. Locally sourced food items are limited to some fruits and vegetables and are
13 provided by less than 20 local retailers or businesses. Animal products are not sourced from local
14 suppliers. Most suppliers of locally procured food products are located in CNMI (Saipan and Rota) (DeCA
15 2009; Melton 2009).

16 To accommodate the expected increase in the number of military personnel on Guam, the Defense
17 Commissary Agency expects to increase business operations to 7 days a week and increase the
18 quantities of imported products procured from current suppliers (Melton 2009). It is important to note
19 that the Defense Commissary Agency does not resupply the Carrier Group, which is expected to harbor
20 in Guam for up to 120 days each year. However, the commissary would be available to military
21 personnel disembarking from these ships.

22 **A2.4.3.2** *Animal Byproducts*

23 The value of hide and skin imports to Guam has increased significantly during the last decade, with most
24 products coming from Europe and Asia (Table A2-29). The highest import value was recorded in 2003
25 from Colombia. All imports were of treated products. The importation of leather and treated hides,
26 skins, and capes is permitted without restriction (Poole 2009, 9 CFR § 95).

27

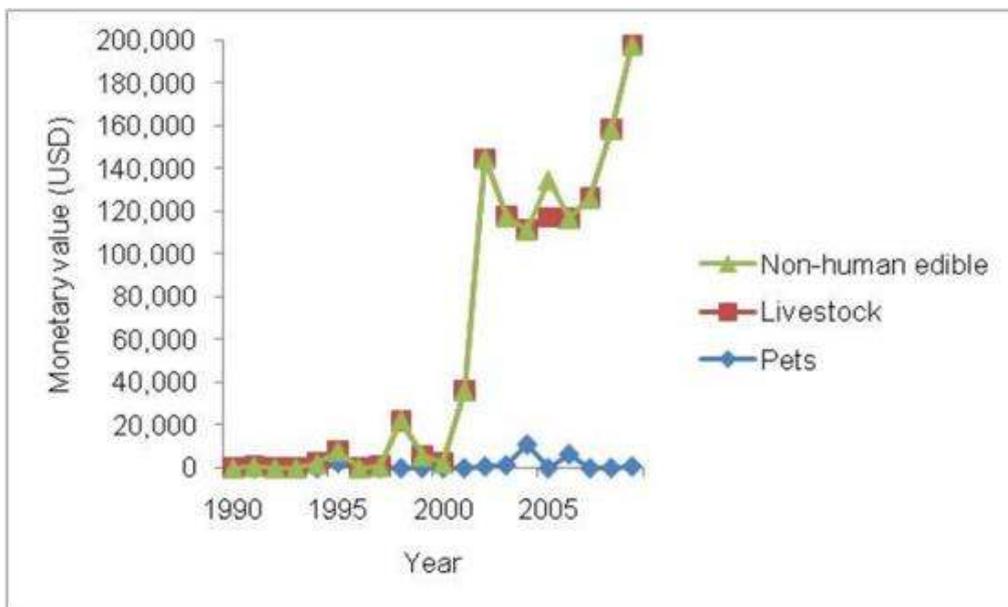
1 **Table A2-29: Value (USD) Foreign Imports of Raw Hides, Skins, and Leathers**
 2 **to Guam, 1997-2008**

Continent	Country	Value (USD) of imports, by year					
		1997	1999	2003	2006	2007	2008
Asia	Thailand	0	0	0	0	0	315
	Indonesia	0	622	0	0	0	0
Europe	France	0	0	0	2,281	2,562	0
	Italy	0	0	0	0	0	5,975
	United Kingdom	0	0	0	0	4,496	0
America	Colombia	0	0	101,015	0	0	0
Oceania	Australia	704	0	0	0	0	0
Total		704	622	101,015	2,281	7,058	6,290

3 Source: Official trade data for partner countries exporting to Guam; GTIS 2010
 4 Data restricted to the years for which importations were recorded; HS codes for the commodities included in
 5 this list are 4113 (leather of other animals, no hair); 4114 (chamois leather, patent, laminated, and metallized
 6 leather); 4106 (goat or kidskin leather, no hair); 4107 (leather of bovine/equine, no hair). HTSTUS, chapter 41:
 7 raw hides, skins, and leather.
 8

9 Most commercial pet food and livestock feed sold in Guam is produced in the United States and is a
 10 domestic import (Poole 2009). Only a small portion is imported from foreign sources. In Figure A2-7, we
 11 present the amounts, in U.S. dollars, of animal feed and intermediary products imported to Guam for
 12 the last two decades.

13 **Figure A2-7: Annual Value of Imported Animal Feed and Intermediary Products**
 14 **to Guam, 1990-2009**



15 Source: Global Trade Atlas (GTIS 2010)

16 Most foreign imports of pet food and animal feed during the last 5 years were preparations for animals
 17 other than dogs and cats. Commercial food for dogs and cats and animal products unfit for human
 18

1 consumption represent less than 0.1% of the total volume of foreign feed imports from 2000 to 2009,
 2 with the exception of 2005 where they accounted for approximately 15%. Foreign imports of dog and
 3 cat food started in 2002, but dropped after 2005, reflecting a preference for U.S.-produced feed. Taiwan
 4 was the main foreign source for dog and cat food, with one importation each from the Philippines
 5 (2003) and Australia (2004).

6 **A2.4.4 Animals and Animal Products: Domestic Production and Exports**

7 The livestock inventory for Guam was obtained from the U.S. Census of Agriculture (2007) (USDA NASS
 8 2009a). Over the last decade, both the number of farms and the total number of livestock have
 9 declined. The biggest declines have been in the pig and goat populations with reductions of 70% and
 10 30%, respectively. Cattle and carabaos (water buffalo) are less important as production animals and
 11 their populations have always been relatively small (Table A2-30). Swine are the most important
 12 production animal for Guam, with around 600 domestic pigs on the island.

13 **Table A2-30: Guam Livestock Inventory, 1998-2007**

Livestock	1998		2002		2007		Percent change 1998 to 2007	
	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals
Carabaos	4	60	8	97	4	12	0	-80
Cattle	18	(D) ^a	12	154	13	112	-28	N/A ^b
Dairy	1	(D)	2	(D)	1	(D)	0	N/A
Non-dairy	18	150	12	134	13	110	-28	-27
Hogs and pigs	75	2,287	34	675	22	635	-71	-72
Goats	19	179	6	81	10	124	-47	-31
Horses	1	(D)	1	(D)	2	(D)	100	N/A

14 Source: 2007 Census of Agriculture, 1998 Census of Agriculture

15 ^a (D): data withheld to avoid disclosing data for individual farms.

16 ^b N/A indicates data withheld and thus unavailable for calculation.

17
 18 Semi-feral and feral pigs are distributed island-wide with greater numbers found in the secondary
 19 limestone forests of the north and ravine forest of the south (Conry 1988a). The estimated feral pig
 20 density in Northwest Field on Andersen AFB was 110 pigs/square kilometer (km²) in 1987 (0.44
 21 pigs/acre) (Conry 1988a), and had not significantly changed by the late 1990s (Lujan and Wiles 1997).

22 Approximately 300 wild carabaos inhabit Guam (U.S. Navy 2009f). To control the carabao population,
 23 the Navy, in cooperation with the U.S. Geological Survey and the Wildlife Defense Fund, has in the past
 24 used a contraceptive drug and supported an adoption program, and the Navy culled 126 animals (U.S.
 25 Navy 2009f). Other wildlife species include the Philippine deer. Recent surveys estimate deer density
 26 15.3 deer/km² at the Naval Magazine and around the Andersen munitions storage area, respectively
 27 (Brooke 2009).

28 In the Micronesia Region, most poultry farming consists of small commercial or backyard operations
 29 (Duguies et al. 2000). Guam limits residents to no more than 20 birds in residential areas (GCA 2010c).
 30 Chickens comprise the largest poultry population on Guam (Table A2-31). Most poultry for human
 31 consumption is imported from the continental United States (Jimenez et al. 2009). Small flocks of feral

1 chickens are commonly seen on Guam. The number of feral chickens is high, although there are no
 2 precise estimates of population size (USDA-APHIS WS 2009).

3 **Table A2-31: Numbers of Poultry and Poultry Farms in Guam, 1998-2007**

Poultry	1998		2002		2007		Percent change, 1998 to 2007	
	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals
Chicken hens, 4 months old or older	42	11,540	26	1,046	8	182	-81	-98
Chickens, less than 4 months old	28	2,002	17	1,657	6	272	-79	-86
Roosters and pullets	32	805	17	271	6	79	-81	-90
Fighting roosters	20	445	11	224	2	(D) ^a	-90	N/A ^b
Ducks	25	2,021	11	450	2	(D)	-92	N/A
Pigeons	10	459	1	(D)	1	(D)	-90	N/A
Other poultry	6	252	–	–	–	–	N/A	N/A
Total	163	17,524	83	3,648	25	533	-85	-97

4 Source: 1998 Census of Agriculture, USDA-NASS 2009a

5 Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 20, 1998.

6 ^a (D): data withheld to avoid disclosing data for individual farms. Data indicated by dashes were not reported.

7 ^b N/A indicates data withheld and thus unavailable for calculation.

8
 9 No published reports exist on the number of pet bird owners or pet birds on Guam. Based on American
 10 Veterinary Medical Association estimates for areas of similar size, there may be approximately 4,000 pet
 11 birds on Guam (AVMA 2007). We could not find estimates for the number of pet dogs and cats on
 12 Guam, nor could we find estimates of the current size of the stray population. The number of stray dogs
 13 and cats on Guam was last estimated in 1967 as between 20,000 and 60,000 (Glosser and Yarnell 1970).

14 The numbers of livestock and poultry in CNMI in 1998 to 2007 were larger than those in Guam. They are
 15 summarized in Table A2-32 and Table A2-33.

16 **Table A2-32: Numbers of Livestock and Livestock Farms in CNMI, 1998-2007**

Livestock	1998		2002		2007		Percent change, 1998 to 2007	
	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals
Cattle	29	1,789	55	1,319	63	1,395	117	-22
Dairy	3	14	– ^a	–	7	83	133	493
Non-dairy	28	1,775	55	1,319	62	1,312	121	-26
Hogs and pigs	24	831	61	2,242	62	1,483	158	78
Goats	10	249	15	198	19	276	90	11
Horses	1	(D) ^b	2	(D)	1	(D)	0	N/A ^c

17 Source: 1998 Census of Agriculture, USDA-NASS 2009a

18 Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 20, 1998.

19 ^a Data for dairy were unavailable for the year 2002.

20 ^b (D): data withheld to avoid disclosing data for individual farms.

21 ^c N/A indicates data withheld and thus unavailable for calculation.

1

Table A2-33: Number of Poultry and Poultry Farms in CNMI, 1998-2007

Poultry	1998		2002		2007		Percent change, 1998 to 2007	
	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals
Chicken hens,								
4 months old or older	14	29,409	68	7,027	41	6,381	193	-78
Chickens,								
less than 4 months old	8	4,885	52	4,463	46	3,319	475	-32
Roosters and pullets	5	228	57	884	41	951	720	317
Fighting roosters	6	60	41	898	26	1,025	333	1,608
Ducks	4	460	12	186	10	351	150	-24
Pigeons	4	251	17	711	9	343	125	37
Other poultry	- ^a	-	5	21	3	20	N/A ^b	N/A
Total	41	35,293	252	14,190	176	12,390	329	-65

2

Source: 1998 Census of Agriculture, USDA-NASS 2009b

3

Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 30, 1998.

4

^a Data for other poultry were not available in the 1998 census.

5

^b N/A: data were not available for 1998 and thus not available for calculation of the percent change for the period 1998 to 2007.

6

7

8 A2.5 CONSTRUCTION**9 A2.5.1 Equipment**

10 Equipment in excess of what is currently available will be needed on Guam to complete construction of
 11 new military facilities, civilian infrastructure, and port improvement and expansion. Approximately 50
 12 logistics elements (bulldozers, trucks, and forklifts, for example) will be transported to Guam to support
 13 relocation and post-relocation activities (U.S. Navy 2009h) A range of equipment will be imported for
 14 commercial port improvements (Table A2-34); some of this equipment is currently available and some
 15 will be moved onto Guam.

16

Table A2-34: Equipment Needed for the Commercial Port Improvements

Type	Quantity
Container quay cranes	4
Top picks	5
Yard tractors	22
Yard chassis	50
Side picks (empties)	6
Break bulk ship cranes	2
Mafi trailers	8
Forklifts, 30 ton	1
Forklifts, 10 ton	1
Forklifts, 7.5 ton	2
Forklifts, 5 ton	6

17

Source: PB International 2008

18

19 Grading equipment, trucks, cranes, and specialty hopper trucks used to move cement will likely be
 20 imported to accomplish land clearing and construction goals (U.S. Navy 2009h). Specifically, equipment

1 will be needed for clearing, grading, grubbing, and demolition of existing road pavement, earthwork,
2 and landscaping (U.S. Navy 2009f). In addition to equipment used for clearing land, equipment will also
3 be needed for building construction.

4 **A2.5.2 Housing**

5 Housing demand estimates we consider here represent an approximation of the number of housing
6 units required for the Guam civilian population (U.S. Navy 2009h) under the proposed action. We
7 assume temporary foreign construction workers will live in the dormitory housing provided by
8 contractors and active-duty military personnel will be housed on base or on ships (U.S. Navy 2009i).

9 The forecast housing demand for the relocation is large. One source suggests that housing demand will
10 significantly increase during the relocation, to 11,893 units by 2014, and decrease to 3,205 units after
11 construction ceases in 2017 (U.S. Navy 2009i). At an earlier date, Guam was thought to have available
12 housing (approximately 2,800 units) to offset some of this anticipated housing demand, which was
13 thought to be sufficient for private-sector housing needs during 2010 (U.S. Navy 2009i). If additional
14 housing is developed, large quantities of excess housing may be realized when the construction phase is
15 completed (U.S. Navy 2009i).

16 For much of the construction for the proposed relocation, foundations, walls, and roofs would be
17 primarily made from concrete (U.S. Navy 2009h). Concrete batch plants may be established on large
18 construction sites for cast-in-place construction, although precast facilities at additional sites may also
19 be utilized (U.S. Navy 2009h). Some wall construction may use concrete masonry units, which would be
20 produced at an offsite facility and subsequently moved to the construction sites (U.S. Navy 2009h). For
21 family housing (presumably military), one source suggests that the military may favor the use of precast
22 concrete panels that will be transported to Guam as needed for new housing units (PB International
23 2008).

24 **A2.5.3 Apra Harbor**

25 Approximately 1.1 million cubic yards of dredged material will need to be removed from Apra Harbor to
26 accommodate military vessels (U.S. Navy 2009h). As part of the overall construction process for the
27 harbor, some fill could be mixed with stone that could be used to support the shoreline and the wharf
28 piles (U.S. Navy 2009h). In addition, the Port Authority of Guam recently proposed filling several acres of
29 currently submerged land to provide space for port expansion (U.S. Navy 2009b). Should this expansion
30 project be conducted, the U.S. Navy has a memorandum of agreement with the Port Authority of Guam
31 to provide fill from proposed dredging projects, dependent on material suitability and logistics (U.S.
32 Navy 2009h). Nonetheless, due to concerns over the potential of liability from this material, the
33 preferred use of dredged material has been proposed to have it be stored on DoD lands (U.S. Navy
34 2009d).

35 **A2.6 MAIL**

36 The U.S. Postal Service (USPS) provides public mail service to the Micronesia Region. Mail sent between
37 the United States, Guam, CNMI, RMI, Palau, and FSM is considered domestic (USPS 2009).

1 Approximately 95% of Guam’s incoming mail is domestic (Berthoud 2009) originating from Hawai’i and
2 the mainland United States (Ericksen 2010). Several private shipping companies also operate in the
3 Micronesia Region. These companies consider mail traveling between the United States and the
4 Micronesia Region to be international mail.

5 Guam’s main post office, located in Barrigada, is the service hub for USPS mail in the Micronesia Region.
6 Surface mail and airmail destined for the Micronesia Region are sorted at this facility for Guam, CNMI,
7 RMI, Palau, and FSM. The majority of international mail destined for Guam arrives from Japan and the
8 Philippines. All domestic mail from the mainland United States and most international mail destined for
9 the Micronesia Region is processed in Honolulu, Hawai’i, before being sent to Guam (Ericksen 2010).

10 Military personnel stationed in Guam receive mail through one of the four USPS post office branches
11 that are located within military installations (Law-Byerly 2010a). Military mail is sent to Army Post Office
12 (APO) or Fleet Post Office (FPO) addresses through the USPS distribution network and through the
13 Military Postal Service Agency (MPSA) 2010).

14 In 2008, approximately 1,104 metric tons (2,433,903 pounds) and 4,111 metric tons (9,063,204 pounds)
15 of mail were sent from and received in Guam, respectively (BSP 2009a). Approximately 20,000 to 30,000
16 packages arrive in Guam each week, and the majority of parcels are addressed to businesses in Guam
17 (Ericksen 2010). The USPS does not keep records of mail volumes for any of the other locations in the
18 Micronesia Region (USPS 2010a), but these locations likely receive and send much smaller volumes of
19 mail. For example, RMI received 0.238 metric tons (525 pounds) of mail during the 2008 fiscal year
20 (Marshall Islands Journal 2008). The APO/FPO addresses in Okinawa currently receive about 1,587.5
21 metric tons (3,499,838 pounds) of mail total per year from the United States and Japan (Berthoud 2009).
22 Mail volumes on Guam are expected to greatly increase as a result of the military relocation; an
23 additional 18,000 packages per week, or 900,000 packages per year, may be delivered to the Naval Base
24 alone (Ericksen 2010).

25 **A2.7 REGULATED GARBAGE AND SOLID WASTE**

26 To protect against the introduction of exotic animal and plant pests and diseases, importation of
27 garbage from all foreign countries except Canada into the United States is prohibited. Movement of
28 garbage from Hawai’i, Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin Islands, RMI, and
29 Palau to any other state is prohibited with few exceptions. As discussed below, the term “garbage”
30 refers to all waste material that is derived in whole or in part from fruits, vegetables, meats, or other
31 plant or animal (including poultry) material, and other refuse that has been associated with any such
32 material. The term “agricultural waste” refers to byproducts generated by the rearing of animals and the
33 production and harvest of crops or trees. Animal waste, a large component of agricultural waste,
34 includes waste (feed waste, bedding and litter, and feedlot and paddock runoff, for example) from
35 livestock, dairy, and other animal-related agricultural and farming practices (9 CFR § 94).

36 Garbage is regulated if it is on or removed from a conveyance that has been in any port outside the
37 United States and Canada within the previous 2 years. Garbage generated during international or

1 interstate transit including food scraps, table refuse, galley refuse, food wrappers or packaging
2 materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters,
3 or dining rooms, is regulated; this also includes meals and other food that were available for
4 consumption by passengers and crew on an aircraft but were not consumed (9 CFR § 94).

5 All regulated garbage must be contained in tight, covered, leak-proof receptacles during storage on
6 board a conveyance while in the territorial waters, or while otherwise within the territory of the United
7 States. Per Presidential Proclamation 5928 (1988), territorial seas extend 12 nautical miles offshore,
8 while the Submerged Lands Act places state property boundaries 3 miles offshore for most states. Given
9 the unique relationship between the United States, Guam, and countries within the Micronesia Region,
10 alternate interpretation of these different boundaries may occur. If unloaded, regulated garbage must
11 be moved under the direction of an inspector to an approved facility for incineration, sterilization, or
12 grinding into an approved sewage system. Any person or entity engaged in the business of handling or
13 disposing of regulated garbage must first enter into a compliance agreement with APHIS unless the
14 regulated garbage is handled under the direct supervision of an APHIS inspector (9 CFR § 94).

15 Garbage management practices can affect the likelihood that pests in waste will escape into the
16 environment, or that the waste will serve as a source of disease transmission (Novak 1995; Gale 2004;
17 Auclair et al. 2005; Gould and Huamán Maldonado 2006; McCullough et al. 2007; Wichuk and
18 McCartney 2007; Graiver et al. 2009; Jacobson et al. 2009). Garbage management options at sea include
19 disposal at sea, incineration, shredding, compaction, and storage for disposal on land (Nawadra et al.
20 2002). Within the Micronesia Region, port demand for waste reception facilities is highest in Guam
21 (Nawadra et al. 2002). Most of this demand is accounted for by domestic inter-island passenger and
22 cargo vessels, tourist boats, and commercial fishing boats. Waste, including regulated garbage, from
23 large merchant vessels is generally not accepted in Guam, and the commercial port generally does not
24 accept waste from international vessels. At the commercial port, commercial marinas, and fisheries
25 wharves in Guam, waste is collected by private waste collection companies under compliance
26 agreements with APHIS and is subject to Port Authority and government policies and regulations. In
27 general in the Micronesia Region, waste from international vessels that contains food waste is treated as
28 quarantine garbage. In Guam, regulated garbage and rejected cargo seized from international vessels
29 are incinerated.

30 Solid waste generated on land can be broadly categorized as municipal, commercial, or industrial.
31 Detailed, reliable data regarding the composition of each of these waste streams in the Micronesia
32 Region, and waste generation rates for each stream, are not available. However, domestic solid waste
33 generated on Pacific islands, including islands of the Micronesia Region, has been estimated to include
34 large proportions of packaging waste, food waste, and garden waste (WHO 1996). Municipal,
35 commercial, and industrial waste in Guam is disposed of at Ordot Dump, an unlined, uncapped landfill
36 that is scheduled to be closed in 2011 (GSWRIC 2010). A new landfill is under construction. The civilian
37 solid waste management system includes waste collection services, three waste transfer stations, and
38 two landfills for disposal of demolition debris (U.S. Navy 2010a). Household food waste is fed to pigs

1 and chickens, or used as fertilizer (Nawadra et al. 2002). Quarantine and hospital waste is incinerated
2 (Nawadra et al. 2002).

3 DoD waste is disposed of at the Navy Sanitary Landfill located on the Navy base, or at the landfill located
4 at Andersen AFB (U.S. Navy 2010a). At both of these landfills, waste is buried daily. Wood, such as
5 crates, and other green waste at the Andersen AFB landfill is shredded; the shredded waste is used for
6 landscaping on and off base. Waste from Navy ships berthed at Apra Harbor is disposed of at the Navy
7 Sanitary Landfill.

8 The U.S. Navy is responsible for all waste reception and disposal at the naval port. Commercial garbage
9 skips are used for waste reception, and the naval facility has its own landfill for all garbage. All items
10 must be disposed of in accordance with U.S. federal laws (7 CFR § 330.400). Garbage is separated for
11 recycling at the ports and all items for recycling are stored separately at the military landfill site (located
12 on the base) and, in general, are shipped off island on military vessels. Oil, metals, plastics, batteries,
13 and paper wastes are recycled. Toxic wastes are stored while awaiting removal from the island.

14

1 **A3 PLANT PESTS**

2 This section of Micronesia Biosecurity Plan—Methods and Strategies to Manage Invasive Species
3 Impacts to Agriculture, Natural Resources, and Human Health and Safety Project—was prepared by
4 APHIS-PPQ, Center for Plant Health Science and Technology; APHIS Policy and Program Development,
5 Environmental and Risk Analysis Services; and North Carolina State University. The suggested citation for
6 this section is: Meissner, H., R. Ahern, T. Culliney, A. Lemay, A. Hiser, L. Kohl, O. Lenahan, A. Suazo, and
7 Y. Takeuchi. 2010. Plant pests. In *Terrestrial plant and animal health risks associated with the U.S.*
8 *military relocation in the Micronesia Region.* United States Department of Agriculture, Animal and Plant
9 Health Inspection Service. Washington, D.C.

10 **A3.1 SUMMARY**

11 Our objective was to evaluate the risk of exotic plant pest introduction into the Micronesia Region as a
12 result of the planned military relocation on Guam, identify safeguarding gaps, and provide suggestions
13 for improved safeguarding. We evaluated pest risk based on pathways of introduction. The pathways
14 discussed are: people; containers, conveyances, and equipment; wood packaging material (WPM);
15 construction materials; plant propagative material; mail; agricultural commodity imports; and garbage.

16 Our evaluation is qualitative. Due to an overall lack of quantitative data, we did not consider it
17 scientifically justifiable to rate risk, even in semi-quantitative terms (e.g., by assigning “high”, “medium”,
18 and “low” ratings). Such ratings are only meaningful when they are clearly defined and assigned with
19 legitimate confidence. If these conditions cannot be met, such ratings are likely to mislead the reader
20 and promote poor decision-making.

21 We do not expect the military relocation to lead to a fundamental change in the types of pests
22 introduced into the Micronesia Region. Similar types of pests to those that currently enter the Region
23 could potentially be introduced more frequently and may thus establish sooner than they would have
24 otherwise.

25 **A3.2 INTRODUCTION**

26 The introduction of exotic plant pests can have enormous economic and ecological consequences. Exotic
27 plant pests may destroy crops, change landscapes, and drive native species to extinction. Not only
28 agricultural production but also forestry, tourism, and even local climate can be impacted by exotic
29 species. Most exotic species introductions have been facilitated by humans, either inadvertently or
30 deliberately (Baker 1986b; Mack et al. 2000; Ruiz et al. 2000; Mack and Lonsdale 2001; Naylor et al.
31 2001; Reichard and White 2001; Fuller 2003; Kraus 2003).

32 Agriculture is not a particularly large economic sector in Guam or the rest of the Micronesia Region, but
33 many subsistence farmers rely on crop production and various plant species have great cultural value.
34 Most notable among these plants are coconut, numerous varieties of banana, taro, papaya, avocado,
35 breadfruit, and mango. The introduction of pests affecting any of these plant species may have a serious
36 impact on the people and the culture of the Region.

1 Guam has undergone extensive development, particularly over the last 60 years. Numerous exotic
2 species have been introduced over the years and have taken their toll on Guam’s native fauna and flora.
3 The rest of the Micronesia Region, however, possesses a more intact natural environment, with
4 numerous indigenous plant and animal species existing on many of the islands. Guam serves as a
5 gateway to the Micronesia Region, and any exotic species introduced into Guam may from there reach
6 other parts of the Region.

7 The objective of this section was to assess the risk of exotic plant pest introductions into the Micronesia
8 Region associated with the planned military relocation on Guam. In the context of this section, we
9 define plant pests as all terrestrial invertebrates, plant pathogens, and weeds that affect plants of
10 economic, ecological, or cultural significance. Thus, plant pests include arthropods, mollusks,
11 nematodes, fungi, viruses, viroids, bacteria, phytoplasmas, and weeds.

12 **Approach**

13 This is a qualitative risk assessment, organized by pathways of introduction through which plant pests
14 may enter the Micronesia Region. While it was not feasible to address every possible pathway, we
15 discuss those of likely importance, as identified through expert solicitation and preliminary literature
16 research. The pathways discussed are movement of people; containers, conveyances, and equipment;
17 WPM; construction materials; plant propagative material; mail; agricultural commodity imports; and
18 garbage. Soil contamination (on containers, vehicles, etc.), while a very important and common means
19 of spreading plant pests, was not considered an independent pathway, but was instead discussed in the
20 context of the other pathways. For each of these pathways, we describe pest risk in general terms and
21 then evaluate the additional pest risk created as a direct or indirect result of the military relocation
22 (both during and after the relocation activities).

23 For the evaluation of pest risk, we used information from a variety of sources, including published
24 scientific literature, public and government-internal databases, expert interviews, and our personal
25 observations during site visits to the Micronesia Region. In general, relevant data were scarce, especially
26 data specific to the Micronesia Region and data suitable for quantitative analysis. Because of this lack of
27 information, we did not consider it meaningful to formally employ a quantitative or semi-quantitative
28 rating system to categorize any components of pest risk (likelihood of introduction, likelihood of
29 establishment, severity of impact).

30 Based on our assessment of pest risk and biosecurity challenges associated with each pathway, we offer
31 a list of suggested safeguarding measures. The purpose of these suggestions is not to provide detailed
32 operational guidance but, rather, to contribute insights as a basis for developing a comprehensive
33 biosecurity plan.

34 Due to the large number of plant pests potentially threatening the Micronesia Region, it was not feasible
35 to discuss each individual pest in detail. Instead, we present an annotated list of potential pest threats
36 (Section A7). While we identified the most obvious potential invaders, it is important to note that the
37 universe of plant pests that may enter the Micronesia Region is largely unknown.

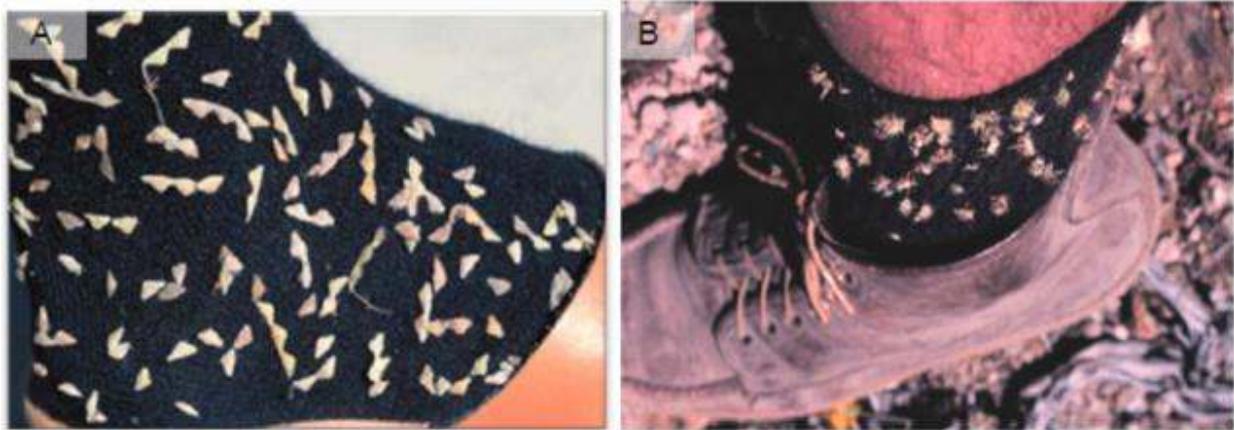
1 **A3.3 RISK ASSESSMENT**

2 **A3.3.1 Pathway: People**

3 The likelihood of pest introduction increases with the number of visitors to a location (Lonsdale 1999).
4 People may spread plant pests by unknowingly carrying pests on themselves, their clothing, or their
5 shoes; by inadvertently transporting pests on objects such as household items, handicrafts, or
6 agricultural products; or by moving pests deliberately. A large number of people will enter the
7 Micronesia Region as a result of the proposed military relocation (Figure A3-1), increasing the frequency
8 of plant pest introductions. Specifically, DoD estimates that the number of people on Guam from off-
9 island will increase eight-fold to almost 80,000 by 2014 . While some of these people will leave again
10 after the relocation phase, an estimated 33,000 will remain on the island permanently (Table A3-1).
11 Because the majority of these people will be military and their dependents, there will be a turnover of
12 people approximately every 2 years. This turnover has a potential multiplying effect on pest pressure.

13 Plant pathogens are easily transported on clothing and boots (Wellings et al. 1987; Cushman and
14 Meentemeyer 2008), where they can remain viable for several months (Norman and Strandberg 1997).
15 Young et al. (2007) reported a large number of fungi and bacteria in soil on air passengers' shoes. Soil on
16 shoes can facilitate the spread of nematodes (Boag 1985), mollusks (Cowie 2001), and weeds (DiTomaso
17 2000; Wichmann et al. 2009). Many plant seeds are adapted to adhere to the fur of animals (Bullock and
18 Primack 1977); these adaptations also facilitate adherence to clothing (Vibrans 1999) (Figure A3-1).
19 Whinam et al. (2005) list 981 propagules (seeds and fruits) and five moss shoots representing 90 plant
20 species from 15 families that were transported to overseas locations on the clothing and equipment of
21 44 Australian expeditioners; clothing and outdoor items with Velcro® fasteners were identified as the
22 highest risk items. Mount and Pickering (2009) also found seeds adhering to uncovered socks, boots,
23 and laces. Some of the most aggressive introduced grasses on Guam, *Cenchrus echinatus*, *C. browneri*,
24 *Paspalum conjugatum*, and *Triumfetta semitriloba* (Space and Falanruw 1999; Motooka et al. 2003), are
25 thought to have spread throughout Guam and CNMI on military personnel' clothing during World War II
26 (Fosberg 1960).

1 **Figure A3-1: Weed Seeds Found on Airline Passengers Entering Hawai'i from New Zealand**
2 **(A, B)**



3 Photos courtesy of USDA-APHIS-PPQ

4
5
6 Military training exercises, as well as popular outdoor activities like hiking and bicycling, facilitate pest
7 spread by bringing people into close contact with the natural environment. Military training exercises
8 are of special concern as they often cause movement of relatively large numbers of people over
9 extensive areas, involve frequent changes of location, and extend over relatively long time periods. In
10 addition, military exercises tend to create large areas of disturbed land, which may facilitate the
11 establishment of introduced species. Studies of disturbed military training sites have shown that exotic
12 plant species can rapidly colonize these areas (Lozon and MacIsaac 1997; Hirst et al. 2003; Leis et al.
13 2005; Yager et al. 2009). Space et al. (2000) list 69 species of invasive plants that are present on Guam
14 but not on Tinian. Tinian is the main site for planned military exercises, and propagules of these plants
15 could potentially be carried there by military personnel.

16 People often transport plant pests or plant materials deliberately, although usually without being aware
17 of the potential biological consequences of their actions. For example, seeds, plants, and flower bulbs
18 are frequently intercepted in airline passenger baggage (Liebhold et al. 2006; McCullough et al. 2006;
19 USDA-APHIS-PPQ 2010a). These items may themselves be pests (if they are invasive plants), or they may
20 be infested with pests. Table A3-1 lists quarantine pests intercepted from the baggage of commercial
21 airline passengers traveling to Hawai'i from Japan, South Korea, and the Philippines, among the main
22 origins of visitors to Guam and CNMI. Table A3-2 lists interceptions from the baggage of airline
23 passengers traveling to Hawai'i from within the Micronesia Region (USDA-APHIS-PPQ 2010a),
24 demonstrating the possibility of pest introductions to Hawai'i from Micronesia. Among the intercepted
25 pests were organisms that would almost certainly have severe negative impacts if introduced into the
26 Micronesia Region, such as certain ants and fruit flies. Agricultural materials have also been found in the
27 duffle bags of military personnel traveling to Guam (Jimenez et al. 2009).

1 **Table A3-1: Pest Interceptions From Airline Passenger Baggage of Visitors Traveling From**
 2 **Japan, South Korea, and the Philippines to Honolulu, Hawai'i in 2009**

Origin	Plant inspected	Plant part	Associated pest	Pest type
Japan	<i>Brassica</i> species	leaves	Thysanoptera, species of	thrips
Japan	<i>Citrus</i> sp.	fruit	<i>Aonidiella</i> sp.	scale insect
Japan	<i>Citrus reticulata</i>	fruit	<i>Unaspis yanonensis</i>	scale insect
Japan	<i>Diospyros kaki</i>	fruit	Aphididae, species of	aphid
Japan	<i>Diospyros kaki</i>	fruit	<i>Tetranychus</i> sp.	mite
Japan	<i>Diospyros kaki</i>	fruit	Pyralidae, species of	moth
Japan	<i>Diospyros kaki</i>	fruit	Aleyrodidae, species of	whitefly
Japan	<i>Diospyros kaki</i>	fruit	Pseudococcidae, species of	scale insect
Japan	<i>Spinacia oleracea</i>	leaves	Coleoptera, species of	beetle
Japan	<i>Pyrus pyrifolia</i>	fruit	Pseudococcidae, species of	scale insect
Japan	<i>Spinacia oleracea</i>	leaves	Thysanoptera, species of	thrips
Japan	<i>Zea mays</i>		<i>Thrips</i> sp.	thrips
Philippines	<i>Adenium</i> sp.	propagative material	Coccidae, species of	scale insect
Philippines	<i>Allium sativum</i>	bulb	Acari, species of	mite
Philippines	<i>Allium sativum</i>	bulb	<i>Frankliniella</i> sp.	thrips
Philippines	brooms	dried leaves	<i>Phoma</i> sp.	fungus
Philippines	brooms	dried leaves	<i>Pestalotiopsis</i> sp.	fungus
Philippines	<i>Citrus maxima</i>	fruit	<i>Unaspis</i> sp.	scale insect
Philippines	<i>Citrus reticulata</i>	fruit	Diaspididae, species of	scale insect
Philippines	<i>Euphorbia</i> sp.	propagative material	Phlaeothripidae, species of	thrips
Philippines	<i>Euphorbia</i> sp.	propagative material	Prostigmata, species of	mite
Philippines	<i>Euphorbia</i> sp.	propagative material	Cicadellidae, species of	leafhopper
Philippines	<i>Ipomoea aquatica</i>	seed	<i>Ipomoea aquatica</i>	weed
Philippines	<i>Ipomoea batatas</i>	tuber	Curculionidae, species of	weevil
Philippines	<i>Lansium domesticum</i>	fruit	Thysanoptera, species of	thrips
Philippines	<i>Lansium domesticum</i>	fruit	Pseudococcidae, species of	scale insect
Philippines	<i>Lansium domesticum</i>	fruit	Diptera, species of	fly
Philippines	<i>Lansium domesticum</i>	fruit	Heteroptera, species of	insect
Philippines	<i>Lansium domesticum</i>	fruit	<i>Phomopsis</i> sp.	fungus
Philippines	<i>Lansium domesticum</i>	fruit	Bostrichidae, species of	beetle
Philippines	<i>Mangifera indica</i>	fruit	Diaspididae, species of	scale insect
Philippines	<i>Manilkara zapota</i>	fruit	Diaspididae, species of	scale insect
Philippines	<i>Momordica charantia</i>	fruit	<i>Bactrocera cucurbitae</i>	fruit fly
Philippines	<i>Momordica cochinchinensis</i>	fruit	Tephritidae, species of	fruit fly
Philippines	<i>Musa acuminata</i>	fruit	<i>Dysmicoccus</i> sp.	scale insect
Philippines	<i>Nephelium</i> sp.		Formicidae, species of	ant
Philippines	<i>Pachyrhizus erosus</i>	leaves	Formicidae, species of	ant
Philippines	<i>Pandanus</i> sp.	leaves	Pseudococcidae, species of	scale insect
Philippines	<i>Pandanus</i> sp.	leaves	Thysanoptera, species of	thrips
Philippines	<i>Pandanus</i> sp.	leaves	Formicidae, species of	ant
Philippines	<i>Psidium guajava</i>	fruit	Tephritidae, species of	fruit fly

Origin	Plant inspected	Plant part	Associated pest	Pest type
Philippines	<i>Solanum melongena</i>	fruit	<i>Frankliniella</i> sp.	thrips
South Korea	<i>Artemisia</i> sp.	leaves	<i>Thrips</i> sp.	thrips
South Korea	<i>Artemisia</i> sp.	leaves	Diptera, species of	fly
South Korea	<i>Castanea sativa</i>	seeds	<i>Cydia</i> sp.	moth
South Korea	<i>Castanea sativa</i>	seeds	<i>Curculio</i> sp.	weevil

Source: USDA-APHIS-PPQ 2010a

Table A3-2: Pest Interceptions From Airline Passenger Baggage of Visitors Traveling From Within the Micronesia Region to Honolulu, Hawai'i in 2009

Origin	Plant inspected	Plant part	Associated pest	Pest type
Guam	<i>Areca catechu</i>	fruit	<i>Frankliniella</i> sp.	thrips
Guam	<i>Areca catechu</i>	fruit	Formicidae, species of	ant
Guam	<i>Citrus aurantifolia</i>	fruit	Diaspididae, species of	scale insect
CNMI	<i>Areca catechu</i>	fruit	Pseudococcidae, species of	scale insect
CNMI	<i>Capsicum</i> sp.	fruit	Thysanoptera, species of	thrips
CNMI	<i>Capsicum</i> sp.	fruit	Diptera, species of	fly
FSM	<i>Anthurium</i> sp.	propagative material	<i>Vinsonia stellifera</i>	scale insect
FSM	<i>Areca catechu</i>	fruit	Aphididae, species of	aphid
FSM	<i>Areca catechu</i>	fruit	Pseudococcidae, species of	scale insect
FSM	<i>Areca catechu</i>	fruit	Formicidae, species of	ant
FSM	<i>Areca catechu</i>	fruit	<i>Frankliniella</i> sp.	thrips
FSM	<i>Areca catechu</i>	fruit	Diaspididae, species of	scale insect
FSM	<i>Areca catechu</i>	fruit	<i>Fiorinia</i> sp.	scale insect
FSM	<i>Areca catechu</i>	fruit	<i>Pinnaspis</i> sp.	scale insect
FSM	<i>Cananga odorata</i>	flower	Pseudococcidae, species of	scale insect
FSM	<i>Cananga odorata</i>	flower	Formicidae, species of	ant
FSM	<i>Cananga odorata</i>	flower	Heteroptera, species of	insect
FSM	<i>Capsicum</i> sp.	fruit	Thysanoptera, species of	thrips
FSM	<i>Capsicum</i> sp.	fruit	Diptera, species of	fly
FSM	<i>Citrus</i> sp.	fruit	Diaspididae, species of	scale insect
FSM	<i>Citrus</i> sp.	fruit	<i>Lepidosaphes</i> sp.	scale insect
FSM	<i>Citrus</i> sp.	fruit	<i>Pinnaspis</i> sp.	scale insect
FSM	<i>Cocos nucifera</i>	leaves	<i>Phyllosticta</i> sp.	fungus
FSM	<i>Ixora</i> sp.		Phlaeothripidae, species of	thrips
FSM	<i>Ixora</i> sp.		Aphididae, species of	aphid
FSM	<i>Plumeria</i> sp.		<i>Thrips</i> sp.	thrips
FSM	<i>Piper betle</i>	leaves	Pseudococcidae, species of	scale insect
FSM	<i>Piper betle</i>	leaves	Formicidae, species of	ant
FSM	<i>Tabernaemontana</i> sp.		Thysanoptera, species of	thrips
FSM	Unidentified plant	leaves	Thysanoptera, species of	thrips
FSM	Unidentified plant	flower	Pseudococcidae, species of	scale insect
RMI	<i>Citrus</i> sp.	fruit	Diaspididae, species of	scale insect
RMI	<i>Cocos nucifera</i>	fruit	Diaspididae, species of	scale insect
RMI	<i>Pandanus</i> sp.	propagative material	Tineidae, species of	moth
RMI	Unidentified plant	leaves	Thysanoptera, species of	thrips
Palau	<i>Areca catechu</i>	fruit	Thysanoptera, species of	thrips

Origin	Plant inspected	Plant part	Associated pest	Pest type
Palau	<i>Piper betle</i>	leaves	Lepidoptera, species of	moth/butterfly
Palau	Unidentified plant	leaves	Thripidae, species of	thrips
			Thysanoptera, species of	thrips

Source: USDA-APHIS-PPQ 2010a

People moving to new areas often bring plants with them to provide a sense of familiarity and home. Plants and other organisms may also be brought along to maintain a customary diet (McNeely 2001). In countries such as Japan and the Philippines, insects are commonly reared as pets (Kabuto 1997; Endo 1998) and may be very valuable. For example, four live giant rhinoceros beetles, *Trypoxylus dichotomus* (Coleoptera: Scarabaeidae) intercepted in Portland, Oregon, in passenger baggage from Japan (Figure A3-2) were valued at about U.S.\$2,500 each (Nelson 2010).

Figure A3-2: Live Giant Rhinoceros Beetles, *Trypoxylus dichotomus* (Coleoptera: Scarabaeidae) Intercepted in Portland, Oregon, in Passenger Baggage from Japan



Source: Customs and Border Protection

Personal effects that will be brought to Guam by the military and the civilian workforce may be contaminated with pests or pest-containing soil, especially items that have been stored or used outdoors, for example barbecue grills, outdoor furniture, bicycles, boats, cars, trailers, motorcycles, outdoor play sets, or yard decorations (USDA-APHIS 2007a). In addition, wooden objects such as outdoor furniture can harbor wood-boring pests (Mauldin 1984; Brown et al. 2004), which easily escape detection and cannot be removed by standard sanitation procedures, such as power washing.

Handicrafts such as baskets, floor mats, figurines, and hats, made from natural materials (e.g., coconut and Pandanus fibers or local woods) may be infested with pests. Wood-boring pests have been found in decorative wood carvings (Haugen and Lede 2001), and the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), was brought from the Dominican Republic to Florida on palm frond hats purchased by cruise ship passengers (Apgar 2007; Welbourn 2009). Hats are of particular concern because people may wear them during their travels and thus may spread plant pests between locations.

1 The proposed military relocation in Guam will move an estimated 11,000 permanent military personnel
2 along with 10,000 dependents to Guam by 2014 (U.S. Navy 2009h) . These people will arrive on Guam
3 with their baggage and household items, including outdoor equipment and vehicles (cars, motorbikes,
4 etc.). Up to 8,164 kg (18,000 pounds) of household items are allowed per person (DoD 2010b). The
5 associated potential for introducing pests is significant. Standard practice in military relocations is to
6 allow military personnel to complete their assignment in their current location, and then have their
7 replacement report to the new duty station (Fiedler 2010). This means there will not be a mass
8 movement of military personnel from Okinawa to Guam; rather, most military personnel to be stationed
9 on Guam will move there from the United States (including Hawai'i). Therefore, any pests brought along
10 in the baggage or personal effects of arriving military personnel will more likely originate in the United
11 States than in Japan or other foreign countries.

12 DoD currently relies on individual military personnel to clean and inspect their own clothing and
13 personal property in order to prevent the introduction of plant pests (U.S. Navy 2009j; DoD 2010f;
14 Houston 2010). While military personnel receive some information about the risks of moving plant pests
15 into Guam and around the Micronesia Region, this information may not be sufficient. For example,
16 military personnel do not generally receive training in pest detection, and thus may not know how to
17 search for pests, nor to recognize pests if found. A DoD guide for military personnel relocating to Guam
18 does not make any mention of plant pests (DoD 2010b). In addition, no oversight, compliance checks, or
19 quality control processes seem to exist to ensure that military personnel are following guidelines and
20 that procedures are effective in removing pests (Meissner et al. 2010).

21 GCQA inspects some portion of civilian and military passenger baggage for prohibited items, including
22 agricultural items; however, opening and searching every bag is not feasible, and functional x-ray
23 machines are not always available to screen passenger baggage (Meissner et al. 2010). In addition, as for
24 similar agencies elsewhere, drugs and weapons take priority over agricultural threats for GCQA.

25 **Expected impact of military relocation.** Apart from the additional military personnel stationed on
26 Guam, military exercises will lead to movement of military personnel within the Micronesia Region and a
27 temporary influx of foreign and U.S. Armed Forces for joint operations. Approximately 200 to 400
28 Marines are expected to train for 1 week at a time, 12 times per year on the island of Tinian (CNMI) (U.S.
29 Navy 2009g). In addition, the Japan Self Defense Forces plan to send 500 to 3,000 military personnel to
30 train on Guam, Tinian, and Pagan for 1 to 4 weeks, one to six times per year (U.S. Navy 2009c). While
31 USDA-APHIS has in the past set up cleaning operations on Tinian for military equipment returning to
32 Guam, no comparable phytosanitary efforts have been carried out for equipment moving from Guam to
33 Tinian or other locations within the Micronesia Region.

34 In addition to military personnel arriving on Guam, approximately 20,000 temporary workers are
35 expected to enter Guam for employment in construction (U.S. Navy 2009h), and approximately 17,000
36 workers will be hired for jobs in other fields such as healthcare (GMANews.TV 2009; U.S. Navy 2009h).
37 More than 20,000 dependents are expected to accompany these workers. The majority of the workers
38 will likely come from the Philippines, with smaller percentages coming from other Asian countries, from
39 elsewhere in the United States, and from within the Micronesia Region (U.S. Navy 2009h).

1 While these people are unlikely to bring large amounts of personal belongings, there are few safeguards
2 in place to ensure that what they do bring is free of pests. An overall elevated demand for specialty
3 ethnic items has the potential to increase the amount of plants and plant pests smuggled into the
4 Micronesia Region. Additionally, some of the temporary workers moving to Guam from within the
5 Micronesia Region may travel home regularly to visit family and friends, potentially facilitating the
6 spread of plant pests throughout the Micronesia Region. No processes are in place for educating
7 incoming workers about biosecurity and the potential impacts of introducing plant pests (Martinez
8 2010).

9 The effects the military relocation will have on tourism are unknown. Currently, Guam receives more
10 than a million tourists annually, mainly families and young couples from Japan. While the majority of the
11 temporary workforce on Guam would not be very likely to engage in tourist activities outside of Guam, a
12 small part of the workforce may travel around the Micronesia Region or visit Hawai'i on the way to the
13 U.S. mainland. In addition, military personnel stationed on Guam may be visited by friends and family
14 who would not otherwise travel to Micronesia. At the same time, it is possible that an increased military
15 presence on Guam may make Guam less attractive to its traditional visitors.

16 **A3.3.2 Pathway: Conveyances, Containers, and Equipment**

17 Many types of organisms can be inadvertently transported as contaminating pests on or in conveyances
18 (aircraft, maritime vessels, personal vehicles) and shipping containers, as well as on equipment and
19 machinery. Plant pests may get onto or into a conveyance, container, or piece of equipment either
20 accidentally (e.g., weed seeds blown in by the wind) or because they are attracted by certain conditions.
21 For example, flying insects may be attracted by lights during nighttime loading (Caton et al. 2006; Fowler
22 et al. 2008), and arthropods or mollusks may find shelter on or in cargo containers. In addition, pests
23 that were originally associated with an agricultural commodity may be left behind in a container or
24 conveyance after unloading. Conveyances and containers tend to be relatively unmitigated and
25 unregulated as pathways for plant pests, in part because they are notoriously difficult to inspect and to
26 clean. Guam is the major hub for cargo and passengers entering and leaving the Micronesia Region.
27 Most cargo arrives from the U.S. mainland and Hawai'i, China, Korea, and Japan.

28 **A3.3.2.1 Pests on Aircraft**

29 Live pests have been intercepted in aircraft cabins and cargo holds (Evans et al. 1963; Rainwater 1963;
30 Russell et al. 1984; Goh et al. 1985). Aircraft cargo holds may be cooled to accommodate perishable
31 cargo, such as fruits, vegetables, and live plants, but these temperatures are not lethal to most plant
32 pests. Russell (1987) reported very high survival rates of mosquitoes, *Culex quinquefasciatus* (Diptera:
33 Culicidae); house flies, *Musca domestica* (Diptera: Muscidae); and flour beetles, *Tribolium confusum*
34 (Coleoptera: Tenebrionidae) in unpressurized wheel bays of a Boeing 747B at altitudes greater than
35 10,500 meters. Caton (2003) reported an average of two flights daily arriving in Miami from Central and
36 South America with quarantine pests in their cargo holds, estimating that one pest species per year may
37 become established in Florida as a result of this pathway. A large proportion of the interceptions were
38 species attracted to light. Dobbs and Brodel (2004) estimated that pest contamination occurs in about
39 10% of cargo aircraft arriving at Miami International Airport (MIA), Florida; this percentage accounts for

1 live pests found in aircraft cockpits, galleys, compartments, and the surfaces of cargo. Between 2006
2 and 2009, U.S. Customs and Border Protection (CBP) officers intercepted almost 1,500 live insects from
3 82 taxonomic families from aircraft cargo stores, quarters, or holds, demonstrating the large variety of
4 pests that are associated with this pathway (USDA-APHIS-PPQ 2010a).

5 **A3.3.2.2 Pests on Maritime Vessels**

6 Ships are not usually inspected for pest organisms; thus, most pest organisms present on ships remain
7 undetected. Nevertheless, close to 1,000 live plant pests, mostly insects, were intercepted from ships at
8 U.S. ports of entry between 2006 and 2009 (USDA-APHIS-PPQ 2010a). We do not know how many ship
9 inspections were carried out during this time, nor how they were performed. In July of 2010, a ship
10 arriving in Guam from Korea with cargo supporting the military relocation was found to be infested with
11 thousands of exotic spiders belonging to at least two different species (University of Guam ANRP 2010).

12 While data regarding the prevalence of plant pests on maritime vessels are very limited, several
13 characteristics of maritime vessels make it likely that they play a role in spreading plant pests: maritime
14 vessels often move or anchor close to shore, allowing an exchange between ship and land of flying
15 insects and organisms blown in the wind; maritime vessels may be loaded with huge amounts of diverse
16 cargo, presenting ample opportunity for plant pests to enter or leave the ship; movement of crew and
17 passengers between vessel and land provides a pathway for pests; and, because of the immense size
18 and complex shape of maritime vessels, pests are very difficult or impossible to detect.

19 **A3.3.2.3 Pests on Shipping Containers**

20 Like conveyances, shipping containers may harbor plant pests. The type of shipping container used
21 depends on the mode of transportation. Standard 20- and 40-foot metal containers (Figure A3-3) are
22 used in maritime shipping and have a long documented history of carrying pests. Air cargo containers
23 can be specialized to fit a particular type of aircraft and are typically smaller (Figure A3-4); however,
24 some aircraft can accommodate standard 20- or 40-foot containers.

25 **Figure A3-3: Shipping Containers Stored at Maritime Ports in Kosrae (A, B) and in Palau (C)**



26
27 Containers stored on bare ground and weeds growing close by increase the chance of contamination
28 with plant pests.

1

Figure A3-4: Air Cargo Containers



2

3

4 In a survey of the exterior sides (not the top or bottom) of maritime containers arriving in New Zealand,
5 soil was the main external contaminant and was found on about 4% of loaded and 1% of empty
6 containers (Border Management Group 2003). Gadgil et al. (2000) also inspected the exterior of
7 maritime containers arriving in New Zealand. The amount of contaminating soil found was low (10 to 50
8 grams [0.3 to 2 ounces]) in 63%, medium (50 to 500 grams [2 to 18 ounces]) in 29%, and large (greater
9 than 500 grams [18 ounces]) in 8% of all contaminated containers. Fungi of taxa containing plant
10 pathogens were isolated from 83%, and nematodes were isolated from 81% of the soil samples. Foliage
11 and woody material were also common contaminants. Overall, quarantinable contaminants
12 (contaminants containing plant pests, plant parasitic nematodes, or fungi of genera that contain plant
13 pathogens) were found on 23% of the containers. Containers from the Pacific Islands had one of the
14 highest contamination rates (47.5%); containers from Korea, Taiwan, and Japan had a contamination
15 rate of 13.7%. The authors concluded that the nature and frequency of contaminants on shipping
16 containers represents a pest risk to New Zealand.

17 Contamination of the interior (soil, seeds, live arthropods, plant material) was found in approximately
18 21% of loaded and 18% of empty sea cargo containers; live insects were present in 15% of loaded and
19 7% of empty containers (Border Management Group 2003). In another study, plant pathogenic bacteria
20 were isolated from soil on sea cargo containers entering New Zealand (Godfrey and Marshall 2002).

21 In contrast to sea cargo containers, only about 1% of air cargo containers arriving in New Zealand were
22 contaminated on the outside. However, 24% of these containers had contaminants on the inside, mostly
23 fresh plant materials such as leaves and twigs. Potentially quarantinable organisms (live fungi belonging
24 to genera that include plant pathogens, or live insects) were found in 13% of the containers. The
25 detection of fresh plant material containing pests, coupled with the fact that newly introduced pests
26 have been found in close vicinity to airport sheds, led the authors to conclude that air cargo containers
27 may provide a pathway by which exotic organisms can become established (Gadgil et al. 2002).

28 Between 2006 and 2009, insects belonging to 14 families, mollusks belonging to three families, and
29 weeds belonging to two families were intercepted on or in cargo containers entering the United States.
30 The refrigeration units on temperature-controlled containers are frequently contaminated with weed

1 seeds. For example, seeds of cogongrass, *Imperata cylindrica* (Poaceae), an introduced invasive
2 throughout much of the Micronesia Region, have been intercepted on the refrigeration components of
3 containers entering the United States (CBP 2010a). Terrestrial mollusks are frequently intercepted on
4 civilian and military cargo containers worldwide (Cofrancesco Jr. et al. 2007) (Figure A3-5).

5 **Figure A3-5: Snails on a Maritime Container**



6 Source: David Robinson

7
8

9 The Argentine ant, *Linepithema humile* (Hymenoptera: Formicidae), was brought to Hawai'i on military
10 equipment (Krushelnycky 2009), and species of *Solenopsis* and *Linepithema* have been intercepted at
11 U.S. ports of entry on maritime vessels (USDA-APHIS-PPQ 2010a). These and other ant species are an
12 important concern to the Micronesia Region, as they quickly colonize new areas, causing significant
13 ecological, human health, and economic impacts (Sherley and Lowe 2000; PIAG 2004).

14 **A3.3.2.4 Pests on Equipment, Machinery, and Personal Vehicles**

15 Weed seeds, insects, mollusks, and soil frequently become attached to equipment and vehicles in the
16 course of military operations, and are difficult to remove (Moerkerk 2006). Between 2006 and 2009,
17 pests belonging to the insect families Cerambycidae, Cochlicellidae, Lymantriidae, Miridae,
18 Pentatomidae, and Scarabaeidae; the mollusk family Hygromiidae; and the plant families Poaceae and
19 Asteraceae were intercepted at U.S. ports of entry on equipment and vehicles. Cogongrass is believed to
20 have been introduced into the Micronesia Region on heavy equipment (Hawley et al. 2006), and the
21 Argentine ant, *Linepithema humile*, was introduced into Hawai'i with military equipment (ISSG 2010).
22 Vehicles and equipment imported into New Zealand were found to be contaminated with soil containing
23 viable plant pathogenic fungi and nematodes (Biosecurity New Zealand 2007); of used vehicles
24 inspected, almost half were found to be contaminated with soil, some of it containing intact plant
25 material. In another study, soil 132 kilograms (kg) (291 pounds) was removed from wheels, tracks, body
26 work, and attachments of four construction vehicles, and an estimated 40,000 seeds were found in that
27 soil, in addition to bacteria, fungi, and intact plants (Hughes et al. 2010). The spread of the plant
28 pathogen *Phytophthora lateralis* (Oomycetes: Pythiales) in Oregon has been linked to vehicular
29 movement, including equipment used in logging activities (Jules et al. 2002). Ecologically disturbed sites,

1 such as those caused by military and construction activities, tend to provide good establishment
2 opportunities for pests, and especially weeds (Hobbs and Huenneke 1992).

3 **A3.3.2.5** *Safeguards*

4 Per a compliance agreement with USDA, GCQA has the authority to inspect any incoming containers,
5 equipment, and conveyances for pests. However, some disagreement exists about naval ships, and it is
6 not clear whether GCQA officers (rather than only federal officers) will be permitted by the DoD to
7 conduct inspections (U.S. Navy 2009k). Regardless, thorough inspection for pests on containers and
8 conveyances very rarely occurs. This is due to the logistical difficulty and the time intensiveness of such
9 inspections and is consistent with the situation at most other U.S. ports of entry.

10 In addition, because of limited space at the maritime port in Guam, inspection of incoming sea cargo
11 does not take place at the port itself, but at various off-site locations (Meissner et al. 2010). It is unclear
12 if these off-site locations are sufficiently equipped to prevent the escape of pests (Jimenez et al. 2009). It
13 is also unknown what safeguards, if any, are in place to prevent the escape of pests during transit
14 between port and off-site locations. While Guam’s commercial air and maritime ports have sealed
15 surfaces, reducing the likelihood that containers become contaminated with soil and other pests, off-
16 site locations and other ports in the Region may not.

17 DoD protocols require equipment and machinery to be cleaned prior to entry (AFPMB 2008; DoD 2009b)
18 (Figure A3-6). DoD protocols also instruct Marines to clean their own personal vehicles and equipment
19 (such as bikes and lawnmowers) before moving them into Guam (DoD 2010b, c). However, DoD does
20 not seem to have a functioning quality control program in place on Hawai’i and Micronesia installations
21 to ensure compliance with and effectiveness of these protocols, and no records of pests or
22 contaminations detected are available (Meissner et al. 2010). It also appears there may be differences in
23 the interpretation and application of DoD guidelines, as pointed out in a study on the transfer of exotic
24 species on U.S. Armed Forces equipment from U.S. bases in foreign countries to the United States,
25 which found that not all military bases cleaned outgoing material and equipment or inspected and
26 cleaned incoming material and equipment (Cofrancesco Jr. et al. 2007)

1 **Figure A3-6 Marines Decontaminating Military Equipment Returning from Kuwait at a**
2 **Special Quarantine Decontamination site in Guam**



3
4 Source: USDA-APHIS-PPQ
5

6 **A3.3.2.6 *Expected Impact of Military Relocation.***

7 Given that the number of pest interceptions is positively correlated with traffic volumes (Liebhold et al.
8 2006), expected increases in the number of incoming airplanes, maritime vessels, cargo containers,
9 military and construction equipment, and personal vehicles and equipment will lead to more frequent
10 exotic pest introductions.

11 In 2009, close to 100,000 containers were processed at Guam's maritime port; during the peak year of
12 the military relocation, the number of arriving containers is expected to be twice that number (see Table
13 A2-14 and Table A2-16) (PB International 2008). If approximately one quarter of arriving sea cargo
14 containers are contaminated with pest organisms (based on Gadgil et al. 2000; Border Management
15 Group 2003), we estimate that between 2010 and 2025, one quarter of a million contaminated sea
16 cargo containers will arrive in Guam as a direct or indirect result of the military relocation (Table A3-3).
17 The proportion of containers accounted for by the military sector is expected to increase from currently
18 15% to 50% during the peak of the military relocation, and to remain at between 30% and 40% after the
19 relocation (PB International 2008). Data regarding container traffic at other maritime ports in the
20 Micronesia Region were unavailable.

21 The number of air cargo containers entering Guam's international airport will rise to accommodate the
22 projected annual 7% increase (in metric tons) of air cargo from 2008 to 2023 (Tagawa and Torres 2007).
23 While we do not know the exact numerical increases in airplanes, maritime vessels, equipment, and
24 vehicles entering Guam and the Micronesia Region as a result of the military relocation, there is little
25 doubt that the increases will be considerable.

1 **Table A3-3: Estimated Number of Sea Cargo Containers and of Sea Cargo Containers With**
 2 **Contamination (Pests, Pathogens, Soil, Weeds) entering Guam⁵**

Year	Containers	Contaminated Containers ^a	Contaminated containers by type			Contaminated containers due to military relocation ^c
			Transshipment ^b	DoD	Non-DoD	
2010	129,000	30,186	2,760	8,970	17,940	8,019
2011	149,000	34,866	2,530	13,340	18,400	12,699
2012	172,000	40,248	2,530	17,940	19,090	18,081
2013	178,000	41,652	2,530	18,630	19,780	19,485
2014	182,000	42,588	2,530	19,550	19,780	20,421
2015	190,000	44,460	2,530	20,470	20,700	22,293
2016	180,000	42,120	2,530	17,480	21,390	19,953
2017	152,000	35,568	2,530	10,580	21,850	13,401
2018	146,000	34,164	2,760	8,740	22,080	11,997
2019	148,000	34,632	2,760	8,740	98,000	12,465
2020	150,000	35,100	2,760	8,740	23,000	12,933
2021	151,000	35,334	2,760	8,740	23,230	13,167
2022	153,000	35,802	2,760	8,740	23,690	13,635
2023	155,000	36,270	2,760	8,740	24,150	14,103
2024	157,000	36,738	2,760	8,740	24,610	14,571
2025	158,000	36,972	2,760	8,740	24,840	14,805

3 ^a Estimated based on a 0.23 container contamination rate (Gadgil et al. 2000).

4 ^b Transshipped containers enter a country only to be loaded onto a different vessel and then shipped to a
 5 different country.

6 ^c Calculated by subtracting the number of containers in 2009 from the forecast number and multiplying by
 7 the contamination rate (0.23). The 2009 container traffic volume is assumed to represent what the
 8 traffic volume would have been in Guam if there was no military relocation; thus, increases in container
 9 traffic are assumed to be due to the military relocation and do not take into account regular growth in
 10 trade. Source: PB International 2008. Contaminated container values are based solely on historical
 11 contamination rates and do not consider change in inspection protocols, personnel, or technology.
 12

13 **A3.3.3 Pathway: Wood Packaging Material**

14 WPM such as pallets, crates, and dunnage is widely used for shipping a large variety of cargo, including
 15 military cargo. WPM is a known pathway for exotic species introductions (Pasek 2000; Allen and Humble
 16 2002). In addition to wood-boring pests found inside WPM, a broad range of plant pests are routinely
 17 detected as contaminants on WPM, including arthropods, nematodes, mollusks, weed seeds, and fungi
 18 (Gu et al. 2006; USDA-APHIS-PPQ 2010a).

19 WPM is a circulating product, routinely reused, reconditioned, and reimported (Bush et al. 1997); thus,
 20 the origin of WPM often differs from the origin of the commodity with which it is being moved. To
 21 reduce the pest risk associated with WPM worldwide, the International Plant Protection Convention
 22 (IPPC) developed the International Standards for Phytosanitary Measures (ISPM) No. 15, “Guidelines for
 23 Regulating Wood Packaging Material in International Trade” (IPPC 2009), which prescribes either

⁵ Ibid.

1 fumigation or heat treatment according to specific treatment schedules for all WPM entering a country.
2 Treated WPM must display a specified ISPM No. 15 stamp in a visible location to facilitate compliance
3 checks at ports of entry. There is no requirement to repeat the treatment each time the WPM is re-
4 used. The United States began enforcement of regulations in accordance with ISPM No. 15 on July 5,
5 2006 (USDA-APHIS-PPQ 2006). However, even though ISPM No. 15 stipulates that the wood used for the
6 WPM be debarked, U.S. regulations do not require debarking for WPM entering the United States
7 (USDA-APHIS 2007b).

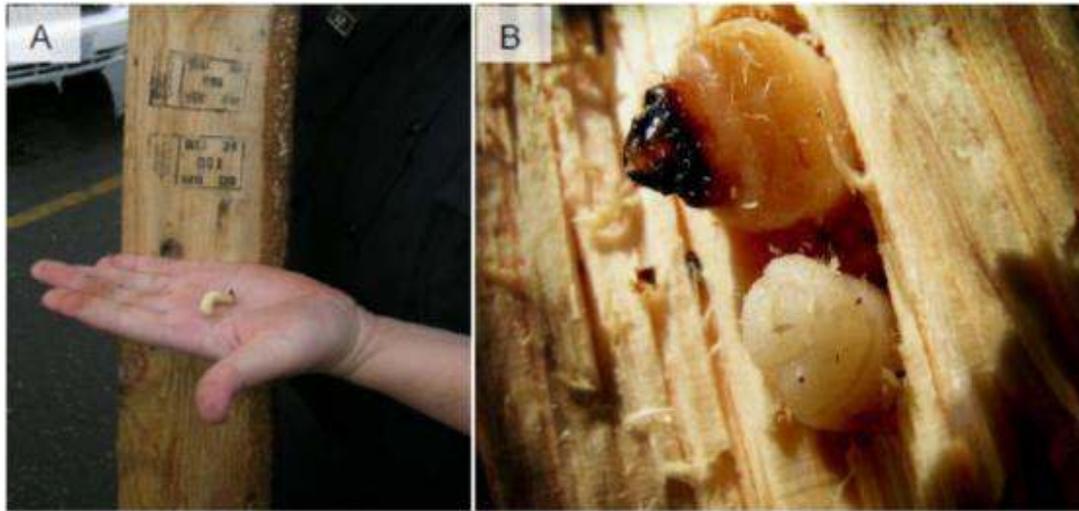
8 U.S. regulations apply to WPM imported from foreign origins into Guam, FSM, CNMI, and American
9 Samoa, in addition to the 50 U.S. States, Puerto Rico, and the U.S. Virgin Islands. However, movement of
10 WPM between the above-mentioned states and territories is considered domestic and is thus not
11 subject to these regulations (USDA-APHIS 2007b). Because the majority of cargo entering Guam is from
12 domestic locations (GovGuam 1995; 1999; 2000; 2002), this represents a potentially significant gap in
13 safeguarding. Palau and RMI are not following ISPM No. 15. In Palau, WPM is “subject to inspection and
14 treatment as prescribed, re-shipment or destruction at the expense of the importer or agent”; in
15 addition, packing materials that have been previously used for the transport of plant or animal materials
16 are not allowed to enter (Palau BAMR 1999). It is not known to what degree these regulations are
17 enforced or even can be enforced (ALSC 2010).

18 Beyond what is imposed by U.S. regulations, DoD stipulates that all new WPM under DoD contracts or
19 otherwise acquired by DoD must meet ISPM No. 15 requirements for shipments both inside and outside
20 of the United States (DSCC 2008). In addition, companies providing WPM to DoD are required to comply
21 with a quality control program administered by the American Lumber Standard Committee, Inc.,
22 through an agreement with APHIS (ALSC 2010). The purpose of this program is to ensure proper
23 treatment application and record keeping through audits and oversight.

24 While this is a laudable policy, DoD has large amounts of stores inside and outside of the United States
25 packaged on or in old WPM not compliant with ISPM No. 15. We do not know if this WPM will be moved
26 to Guam and other parts of the Micronesia Region; we also do not know if and how this WPM is
27 inspected by DoD. Regardless, a certain percentage of WPM—both military and commercial shipments—
28 will always bypass existing regulations and guidelines. While we do not know how large this percentage
29 is, random inspections carried out by USDA revealed that approximately 1% of the WPM accompanying
30 maritime shipments and approximately 5% of the WPM in air shipments arrived without the required
31 ISPM No.15 stamp (Meissner et al. 2009).

32 It is generally assumed that WPM marked with the ISPM No. 15 stamp is compliant with ISPM No. 15
33 requirements. However, treatments may be applied incorrectly or treatment stamps may be used
34 fraudulently. For example, in 2008, CBP found live wood borers in the ISPM No. 15-stamped WPM
35 accompanying 14 separate shipments from a single shipper and concluded that the shipper was using
36 the stamp fraudulently (CBP 2008) (Figure A3-7).

1 **Figure A3-7: ISPM No. 15-stamped WPM with live cerambycid larvae (A) and *Monochamus***
2 **sp. detected in dunnage (B)**



3
4 Source: Photo A courtesy of CBP. Photo B courtesy of M. Hitchcox

5 There is general agreement that non-compliant WPM carries a considerable pest risk. For example, in a
6 USDA pest risk assessment, Pasek (2000) rated 19 insects and fungi known to be associated with WPM
7 and assigned a high pest risk potential to 17 of them. A New Zealand Ministry of Agriculture and
8 Forestry review of sea containers prior to the implementation of ISPM No.15 found that of 5,000
9 containers with WPM, about 30% contained WPM infested with pests (Border Management Group
10 2003). Before China implemented regulations according to ISPM No. 15, a survey focusing on
11 nematodes, conducted between 2000 and 2005, found that batches of WPM imported into China from
12 Japan, the United States, Korea, and the European Union exhibited infestation with various species of
13 nematodes of 21, 17, 24, and 17%, respectively; 6% of batches were infested with species of
14 *Bursaphelenchus* (Nematoda: Aphelenchoididae)—serious plant pests known for their longevity in dead
15 wood (Gu et al. 2006). Finally, Allen and Humble (2002) examined dunnage entering Canada from
16 Norway and recovered over 2,500 adult insects representing more than 40 species of bark beetles,
17 wood borers and their associated parasitoids, predators and scavengers, blue-stain fungi, and
18 nematodes from 29 log bolts. These studies underscore the significant pest risk associated with non-
19 compliant WPM that may enter Guam.

20 In addition to the pest risk presented by non-compliant WPM, live pests are also found on a regular
21 basis on WPM bearing the ISPM No. 15 stamp. Subsequent to implementing ISPM No.15, the Australian
22 Quarantine and Inspection Service sampled close to 20,000 pieces of WPM and found about 0.5%
23 infested with live, wood-boring insects and 0.5% had fungi and/or mold (Biosecurity Australia 2006). A
24 survey carried out at several U.S. ports of entry concluded that 0.1% of all WPM marked with the ISPM
25 No.15 stamp was infested with live wood-boring insects (Haack 2006). Apart from the possibility of
26 incorrectly applied treatments and fraudulent use of the seal, pests may be present in the WPM because
27 the prescribed treatments are not completely effective against all pests (Qi et al. 2005), especially plant
28 pathogens, and because WPM may be re-infested by pests after treatment (ALSC 2009; Haack and
29 Petrice 2009).

1 Pest interception records from routine port-of-entry inspections are not statistically rigorous enough to
2 be used for quantifying pest risk, but they can provide qualitative information on the types of pests
3 found on WPM. Pests intercepted on WPM at U.S. ports of entry between July 5, 2006 (date of full
4 enforcement of ISPM No.15) and February 26, 2010, include a large variety of taxa. More than 2,200
5 specimens were collected in about 1,000 interceptions. The majority of the interceptions were insects,
6 most frequently cerambycid and curculionid woodborers. Many other taxa were also found. Overall, 80
7 families of insects from seven different orders, seven families of mollusks, seeds of 27 plant families, as
8 well as mites, spiders, and a scorpion were intercepted (USDA-APHIS-PPQ 2010a); most of the
9 intercepted specimens were not identified to the family level. The pest taxa intercepted no doubt
10 represent a subset of the taxa actually present in the WPM. Some groups of organisms may be
11 overlooked because of their small size and lack of extraction and identification methods. For example,
12 no nematodes or fungi were intercepted, but these pests are likely to be present on WPM, as shown by
13 Braasch, Gu et al. (2007) and Biosecurity Australia (2006). Similarly, no plant pathogenic bacteria or
14 viruses have been reported from WPM, but it is possible that these types of organisms would also be
15 present.

16 It is important to note that not all species present on WPM truly infest the wood. Many are
17 contaminating pests, which means that they are on the WPM but have no biological association with it.
18 For example, mollusks may seek shelter in WPM, weed seeds may get stuck on WPM, pests may fall
19 from agricultural commodities transported on WPM, and nematodes and soil-borne pathogens may be
20 present in soil on WPM. Outdoor storage of WPM, a common practice at many shipyards and
21 warehouses, facilitates pest infestation, especially if the WPM is stored in direct contact with the soil, if
22 weeds are growing close by, and if nighttime lighting attracts flying insects to the site. Contaminating
23 pests can settle on WPM after treatment and thus may not be affected by ISPM No. 15 measures.

24 Almost any pest species may potentially be present on WPM, and WPM may originate from or may have
25 been in almost any country. To identify species that may present a threat to the Micronesia Region, we
26 compiled a list of species that have been found associated with WPM, are absent from all or some parts
27 of Micronesia, have a distribution range that includes tropical areas, and have host plants that occur in
28 the Micronesia Region. The list is based on the assumption that WPM origin cannot be determined with
29 certainty; thus it encompasses a pest universe of worldwide origin. This list contains numerous species
30 from a variety of taxonomic groups, including wood-boring beetles, ants, fungi, nematodes, and
31 mollusks.

32 While a discussion of the introduction and impact potential for each of these species is beyond the
33 scope of this report, there is little doubt that many of these species, if introduced, could cause severe
34 damage to the native fauna and flora and/or agricultural production of the Micronesia Region. In
35 particular, the introduction of certain ants is extremely worrisome because of their severe ecological
36 and human health impacts (PIAG 2004); similarly, the introduction of terrestrial mollusks, usually
37 generalist feeders, is likely to have very undesirable consequences for agriculture and biodiversity
38 (Cowie 2000); damage caused by wood-boring beetles in many parts of the world is well known; and
39 nematodes and fungi, although knowledge about their biology is very limited, are doubtlessly of
40 concern.

1 As previously stated, some amount of non-compliant WPM will enter Guam, and even compliant WPM
2 presents a pest risk. We found that port-of-entry inspection is the only means by which WPM may
3 currently be monitored, although in actuality WPM seems to be rarely inspected in Guam and the rest of
4 the Micronesia Region due to workload and logistical challenges. When inspection of WPM occurs, it is
5 often limited to a verification of the ISPM No.15 stamp rather than a thorough search for pests. This
6 seems to be true for both military and non-military shipments. If ports of entry in the Micronesia Region
7 are currently understaffed, this situation is only expected to worsen during the military relocation.

8 While port-of-entry inspection is a potentially important safeguarding measure, it is not reliable as a sole
9 measure for preventing pest entry. For a thorough inspection, cargo must be removed from a pallet or
10 crate and repackaged, presenting a considerable logistical challenge. Even thorough inspection will miss
11 many of the pests that are present. Wood-boring pests are usually hidden inside the wood and are very
12 difficult to find. For some pests, such as nematodes and fungi, special extraction methods and
13 identification expertise are needed, and port inspectors are not always sufficiently trained for the
14 detection of wood-boring pests.

15 We know neither the quantity of WPM currently entering Guam and the Micronesia Region nor the
16 quantity that will enter during the military relocation. No precise information on the amount of WPM
17 moved in trade exists, and little information is available to make any estimates.

18 Expected impact of military relocation. The military relocation will lead to a considerable population
19 increase on Guam (see Table A-12). As a result, more consumer goods and construction materials will be
20 imported, often on or in WPM. In addition, the increased workload for inspection personnel during and
21 after the military relocation may place further strain on the safeguarding system. As a result, the
22 frequency of pest introduction through the WPM pathway is likely to increase. However, we do not
23 expect a fundamental change in the types of pests introduced; rather, we expect that the same types of
24 pests will enter Guam more frequently and may thus establish sooner than they would have otherwise.
25 WPM presents a considerable pest risk and strong measures should be taken to protect the Micronesia
26 Region against pests introduced through this pathway.

27 **A3.3.4 Pathway: Construction Materials and Equipment**

28 Construction projects have been implicated in the introduction of exotic species. For example, the
29 introduction of snails into French Polynesia was linked to the construction of a hydro-electric station;
30 and road construction in the Marquesa Islands and water tank construction in the Austral Islands have
31 purportedly led to the introduction of exotic plants to these island groups (Shine et al. 2003). On Guam,
32 the coconut rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae), a devastating pest of
33 coconut palms, is thought to have been introduced on construction material from Asia (Smith and
34 Moore 2008). Seeds of cogongrass, *Imperata cylindrica*, and the giant African snail, *Achatina fulica*
35 (Gastropoda: Achatinidae), both highly invasive species in the Micronesia Region, are known to spread
36 via the movement of construction equipment (Hawley et al. 2006).

37 Apart from construction materials and equipment being a pathway for pest introduction, construction
38 activities create disturbed environments, where the establishment of exotic pests may be more likely

1 (Mulugeta and Stoltenberg 1997). For example, the highly invasive Argentine ant (*Linepithema humile*),
2 a species with potentially devastating consequences to the Micronesia Region, preferentially invades
3 disturbed sites (Mulugeta and Stoltenberg 1997, Kennedy 1998)

4 We do not have precise information on the types and amounts of construction material currently
5 entering Guam or expected to enter Guam in the future. The projected peak housing demand of
6 between 3,500 and 10,000 homes (PB International 2008, U.S. Navy 2009j) cannot be met by the
7 currently available housing on Guam. In addition, a number of utility and training facilities will be built
8 (CMTF 2007), and much of the existing infrastructure (roads, landfills, municipal and port buildings) will
9 be expanded. Significant construction is also planned at Apra Harbor (CMTF 2007). Construction at
10 Andersen AFB alone is estimated to require between 60 and 70 loads of steel weighing approximately
11 22,680 kg (50,000 pounds) per load (PB International 2008). Very few construction materials are
12 available locally on Guam. In spite of plans to reuse soil, rocks, and other materials (U.S. Navy 2009j), the
13 majority of the necessary construction materials such as timber, gravel, sand, steel, tile, granite, cement,
14 and concrete will need to be imported. Construction equipment will also be imported in large quantities.
15 Overall, it is clear that construction material and equipment imports will increase significantly as a result
16 of the relocation and then level off after construction is complete.

17 The majority of construction materials will come from the U.S. mainland (Berthoud 2009), with
18 significant portions also originating in Asian countries (PB International 2008), mainly in China and Japan
19 (Berthoud 2009). Wood has also been imported from Palau in the past (GovGuam 1995), and some
20 materials are being imported from the Philippines and Indonesia (Jimenez et al. 2009). Blocks of cement
21 and concrete currently come from FSM (Berthoud 2009). We do not know whether materials will be
22 imported from any additional countries during the military relocation.

23 Timber pests. A large variety of plant pests are associated with timber. From 2003 to 2009, 106 different
24 species were found in 194 interceptions on wood entering the United States from Asia, including
25 41 families of insects (including wood-boring beetles and ants), 6 families of weeds, 4 families of mites,
26 and 3 families of mollusks (USDA-APHIS-PPQ 2010a). Timber from U.S. locations has been found to
27 harbor pests as well, including the little fire ant, *Wasmannia auropunctata* (Hymenoptera: Formicidae)
28 (Hawley et al. 2006, Berthoud 2009). The little fire ant is currently found on Hawai'i and in other parts of
29 the United States, from where it may be introduced on timber (Hawley et al. 2006). It has demonstrated
30 an ability to establish on Pacific Islands, and is known to occur in New Caledonia, Vanuatu, Tuvalu, and
31 the Cook Islands (Wetterer 2009). Like other fire ants, the little fire ant causes painful stings and harms
32 native biodiversity (ISSG 2010).

33 Certain safeguarding measures are in place to minimize the spread of pests on timber (Table A3-4).
34 Unpeeled saw logs are prohibited from entering Guam, and peeled saw logs and lumber must be
35 inspected and found to be free of termites and wood-boring insects (GDOA 1997). Foreign timber is
36 required to have an import permit detailing the required treatment, which is fumigation (USDA-APHIS
37 2007c). As with any commodity, GDOA has the authority to quarantine, inspect, fumigate, disinfect,
38 destroy, or exclude timber infested with pests (GDOA 1997).

1 **Table A3-4: Regulations Pertaining to Construction Materials and Equipment Entering**
 2 **Guam**

Material	Treatment Requirements
Timber	Peeled saw logs (no bark material) and lumber from domestic locations are permitted to enter Guam after inspection and verification of freedom from termites and wood-boring insects (GDOA 1997); unpeeled saw logs from domestic locations are prohibited from entering Guam. Timber from foreign locations requires fumigation and an import permit, or must be debarked, heat treated or kiln-dried, permanently marked, and kept separate from other shipments (USDA APHIS 2007c). May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Tile/granite	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Cement/concrete	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Sand/gravel	GovGuam requires sand and gravel to be sterilized by approved methods (GEPA 1991, 2009); successful sterilization is verified through testing by the Guam Environmental Protection Agency prior to entry (GEPA 2009). May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Steel	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Construction equipment	The DoD has specific guidelines for the inspection and washing of military equipment and removal of soil and hitchhiker pests (AFPMB 2008). Non-military construction equipment is not generally subject to any cleaning requirements; however, washing or other phytosanitary measures may be required or entry may be refused if construction material is found to be contaminated upon port-of-entry inspection (7 CFR § 330).

3
 4 However, these measures may not be sufficient to mitigate the pest risk posed by timber imports. A risk
 5 assessment determined that similar mitigation measures in New Zealand were not sufficient to prevent
 6 pest introduction (Ormsby 2003). Inspection of wood is often complicated by the size of timber products
 7 and by the fact that wood-boring pests are usually hidden inside the wood. Prescribed quarantine
 8 treatments are not completely effective against all pests, and timber may be recolonized after effective
 9 treatment. For these reasons, and because of the large diversity of pests that may be associated with
 10 timber, there is a significant risk of pest introduction to Guam through this pathway.

11 **A3.3.4.1 Contaminating Pests**

12 Contaminating pests are those that do not have a biological association with the material they are
 13 transported on. For example, a snail does not feed or otherwise depend on steel tubes, but may still be
 14 transported on them. Most construction materials have the potential to transport pests as
 15 contaminants. For example, a recent shipment of insulation and housing beams entering Guam from
 16 South Korea was found to be infested with thousands of spiders belonging to at least two different
 17 species (University of Guam ANRP 2010). From 2003 to 2009, U.S. port-of-entry inspectors intercepted
 18 355 species on some 1,300 shipments of tile and granite from Asia. These interceptions comprised 96
 19 families of insects, 25 families of weeds, 8 families of mollusks, 7 families of mites, and 1 family of plant

1 pathogens (USDA-APHIS-PPQ 2010a). Among the interceptions was the highly invasive cogongrass,
2 *Imperata cylindrica*, (USDA-APHIS-PPQ 2010a), which has become widespread on Guam, and is under
3 eradication in Palau and Yap (LaRosa 2010). While we have no interception records for cement or
4 concrete blocks, they presumably have the same types of contaminating pests associated with them as
5 tiles or granite.

6 Sand and gravel are also known to harbor pests. For example, seeds of the Siam weed, *Chromolaena*
7 *odorata* (*Asteraceae*), which is currently found in CNMI, Guam, Palau, and Yap, have been detected in
8 sand and gravel used in road construction, and can survive for long periods in this medium (Hawley et al.
9 2006). Over 130 different plant pest species were found in 394 interceptions on quarry products from
10 Asia at U.S. ports from 2003 to 2009 (USDA-APHIS-PPQ 2010a). Similarly, 55 different species were
11 found in 79 interceptions on steel and steel bars at U.S. ports of entry from 2003 to 2009, including 19
12 families of insects, 6 families of weeds, 2 families of mollusks, and 1 plant pathogen family (USDA-APHIS-
13 PPQ 2010a).

14 Construction equipment and machinery are also well-known carriers of contaminating pests (AFPMB
15 2008); several exotic species in the Micronesia Region have been introduced as contaminants on
16 construction equipment (Hawley et al. 2006). Of 271 interceptions from Asia on general equipment,
17 machinery, and vehicles at U.S. ports of entry from 2003 to 2009, there were 49 families of insects, 13
18 families of weeds, 6 families of mollusks, 3 families of plant pathogens, and 1 family of nematodes
19 (USDA-APHIS-PPQ 2010a). Weed contamination is of particular concern on construction equipment; a
20 recent Australian study found that 25% of the machinery evaluated (including tractors, graders, and
21 other equipment used for local land management) was contaminated with weed seeds (Moerkerk
22 2006).

23 No USDA regulations specifically address sand or gravel. GovGuam does have quarantine measures in
24 place for timber, sand and gravel, and construction equipment (see Table A3-4); federal regulations give
25 GCQA the authority to require phytosanitary treatment (including washing) of construction materials
26 found to be contaminated with pests or soil through port-of-entry inspection. However, it is unclear how
27 efficacious these measures are at preventing pest entry and how consistently they are applied.

28 **A3.3.4.2 Expected Impact of Military Relocation**

29 The planned military relocation on Guam will lead to a significant increase in construction activity, and
30 thus to an increase in construction material and equipment imports. These imports will increase
31 dramatically during the relocation phase and then level off after most construction is complete.
32 Imported materials will comprise a large diversity of items, many of which are likely to be contaminated
33 with plant pests. Inspection of these items is difficult and existing safeguards are not sufficient to
34 prevent pest introduction. There is little doubt that this pathway will present a significant plant pest risk
35 for the duration of the relocation phase. After the relocation, the pest risk is expected to be slightly
36 higher than its current level.

1 **A3.3.5 Pathway: Plant propagative material**

2 Propagative material used for landscaping on Guam is mainly imported from the United States
3 (GovGuam 2002, McConnell 2010). Other countries of origin include Thailand, Taiwan, Philippines, Costa
4 Rica, Ecuador, and Puerto Rico (Campbell 2010d). In addition to importing, Guam also exports plants to
5 CNMI and FSM, providing a mechanism for pest spread from Guam to other parts of the Micronesia
6 Region (GovGuam 2010).

7 **A3.3.5.1 Pathway for Plant Pests**

8 Movement of plant propagative material (whole plants, buds, bulbs, tubers, or seeds) is a primary
9 means by which plant pests invade new areas (Palm and Rossman 2003, Brasier 2008). Propagative
10 materials are usually planted in areas conducive to their growth, greatly facilitating their establishment
11 and that of any associated pests. A large variety of pests are intercepted on propagative materials
12 arriving at U.S. ports of entry (USDA-APHIS-PPQ 2010a). For example, from March 2009 to March 2010,
13 over 16,000 pest specimens were found in some 5,600 interceptions, including insects (86 families),
14 mollusks (16 families), mites (5 families), weeds (13 families), as well as viruses, fungi, bacteria, and
15 nematodes. Mites, plant pathogens, and nematodes only accounted for 23% of interceptions. However,
16 this is almost certainly not due to a low prevalence of these pests on propagative materials; rather, it is
17 likely due to the difficulty of detecting these types of pests. This is supported by a study of Childers and
18 Rodrigues (2005), who washed propagative plant materials in ethanol, and found 81 mites from 11
19 families on only 12 shipments of propagative materials arriving at Miami International Airport. By
20 comparison, routine port-of-entry inspections at the same airport detected only one species of mite in
21 over 40,000 propagative material shipments. Similarly, plant pathogens are often not detected, because
22 the infected plant material may not express noticeable symptoms and appropriate diagnostic tools do
23 not exist or are not feasible or affordable for plant quarantine purposes (Schaad et al. 2003).

24 Damaging arthropods have been or may be introduced into the Micronesia Region via the propagative
25 materials pathway. The Asian cycad scale, *Aulacaspis yasumatsui* (Homoptera: Diaspididae), was first
26 introduced into Florida through the importation of cycad plants by a botanical garden; from Florida it
27 was introduced into Hawai'i and from there into Guam through the plant trade (Moore et al. 2005). The
28 scale attacks *Cycas micronesica* (Cycadaceae), a plant endemic on Guam and the Micronesia Region.
29 Since the scale's introduction, populations of *C. micronesica* have declined to the point where the
30 situation has been described as an environmental disaster akin to that caused by the brown treesnake
31 (University of Guam 2007). Another exotic insect pest, the coconut rhinoceros beetle, *Oryctes rhinoceros*
32 (Coleoptera: Scarabaeidae), is devastating betelnut, coconut, and ornamental palms on Guam (Smith
33 and Moore 2008). While this pest was likely introduced on construction materials from Asia, movement
34 of live host plants may further spread it throughout the Micronesia Region (Smith and Moore 2008);
35 improper disposal of infested plants may also spread this pest to new locations on Guam. Movement of
36 propagative material has contributed to the dramatic spread of the red palm mite, *Raoiella indica* (Acari:
37 Tenuipalpidae), into and throughout the Caribbean region, where it attacks numerous palm species
38 (Welbourn 2009). The red palm mite is not known to occur in the Micronesia Region and could have a
39 significant impact if introduced.

1 Movement of propagative material is also linked to the spread of numerous plant pathogens, such as
2 the banana bunchy top virus (Thomas et al. 1994) and the causal agent of the citrus disease
3 Huanglongbing (Wang 2009). Finally, Cowie et al. (2008) identified the importance of the horticultural
4 trade pathway in facilitating the spread of mollusks, listing 29 non-native species of terrestrial snails and
5 slugs found during a survey of nurseries in Hawai'i. Terrestrial mollusks can damage nursery crops,
6 displace native species, and vector human and animal diseases (Cowie 2001, Cowie et al. 2009). The
7 polyphagous mollusk *Succinea tenella* (Succineidae), invasive in Hawai'i (Cowie et al. 2008), has been
8 intercepted multiple times on orchid plants at Guam ports of entry (USDA-APHIS-PPQ 2010a).

9 **A3.3.5.2 Plant Propagative Material as Invasive Species**

10 Plant propagative material may become invasive when introduced into a new location. Certain
11 characteristics that are desirable in landscape plants, such as rapid growth, high reproductive capacity,
12 and the ability to withstand a range of environmental conditions (Peters et al. 2006), also predispose
13 plants to being invasive (SPREP 2000; Richardson et al. 2004). Invasive plants can have devastating
14 effects on ecosystems by displacing native species (ISSG 2010), altering the frequency and intensity of
15 fires (Brooks et al. 2004), changing the erosion properties of soil (SPREP 2000), and clogging waterways
16 (Opande et al. 2004; FLDEP 2009; ISSG 2010), among other impacts.

17 There are many examples of plants that have become invasive after being deliberately introduced into
18 an area; in fact, most invasive exotic plant species were probably intentionally introduced. Waugh
19 (2008) reports that of the 191 invasive plants examined in the insular Caribbean, 66% were introduced
20 deliberately through the horticulture pathway; and Frank and McCoy (1995) state that approximately
21 one quarter of Florida's flora comprises non-indigenous species, almost all of them introduced
22 deliberately.

23 *Lantana camara* (Verbenaceae) was deliberately introduced into the Micronesia Region for use as an
24 ornamental plant. However, it is poisonous to livestock (McGinty and Machen 1993) and is now
25 considered a damaging invasive species (ISSG 2010). Similarly, *Miconia calvescens* (Melastomataceae)
26 was introduced into Hawai'i as an ornamental tree; because of its aggressive growth and interference
27 with watershed functions, this species is now listed as a noxious weed (Loope 1997).

28 **A3.3.5.3 Potting Media**

29 Demand for potting media, sometimes referred to as potting soil, is directly related to landscaping
30 activity. Movement of potting media, whether intentional or unintentional, is a well-known pathway for
31 a wide variety of potentially dangerous organisms.

32 In New Zealand, 25 species of exotic weeds were found in imports of coco peat, widely used as a
33 growing medium in the nursery and horticulture industries (Biosecurity New Zealand 2009b). Live
34 arthropods and weeds have been found in potting media sold at a Garden Center in Guam (Moore 2010)
35 (Figure A3-8). Similarly, Cloyd and Zaborski (2004) found a total of 1,245 arthropods in 23 of 96 bags of
36 potting media from wholesale distributors in the United States. Cartwright et al. (1995) reported that
37 commercial potting media were the source of *Pythium* infecting tobacco seedlings. Commercially

1 packaged potting media can also harbor organisms harmful to humans (Steele et al. 1990; Casati et al.
2 2009; Norcini et al. 2010).

3 **Figure A3-8: Commercial Potting Soil Packaged In Plastic Bags (A) and Plants Growing Out Of**
4 **a Closed Bag of Commercial Potting Soil in Guam (B)**



5
6 Source: Aubrey Moore
7

8 **A3.3.5.4 Safeguards**

9 All plant propagative material imported into Guam, including transshipments to the CNMI, Palau, and
10 FSM, is inspected at the Plant Inspection Station operated by GDOA (Campbell 2010d).

11 Plants imported for planting must be free of soil. In addition, plants entering Guam from Hawai'i must
12 be treated with hot water drench or citric acid solution prior to shipment (mainly to prevent the
13 introduction of coqui frogs), and must be inspected for pests of concern to Guam (GDOA 2004). While
14 this regulation may help reduce the plant pest risk posed by propagative material from Hawai'i, the
15 costs associated with the required treatment have caused a shift towards imports from Florida and the
16 Caribbean (Campbell 2010d); no treatment requirements are currently in place for plants from these
17 locations.

18 Both federal and GovGuam regulations prohibit the entry of certain types of plant propagative material
19 from certain locations to prevent the introduction of specific pests of concern. For example, the
20 importation of citrus, coconut, banana, taro, and sweet potato planting material is highly restricted; the
21 same is true for certain plants from areas infested with the European corn borer, *Ostrinia nubilalis*
22 (Lepidoptera: Pyralidae) (GDOA 1997). While these regulations provide some protection against the
23 introduction of pests, the number of regulated pests pales in comparison to all pest species potentially
24 associated with propagative materials entering Guam. The invasiveness potential of the propagative
25 material itself is not considered in any of the existing regulations.

26 DoD drafted a landscape plan for Guam that includes a list of recommended plant species for military
27 lands (NAVFAC 2010). It is not clear whether compliance with this plan is mandatory and, if so, how
28 compliance will be enforced. The majority of species recommended in this landscape plan are native or

1 non-invasive and commonly used in landscapes in Guam. However, the plan also contains some species
 2 that are invasive in parts of the Micronesia Region (Table A3-5). For example, *Pseuderanthemum*
 3 *reticulatum* (Acanthaceae) is invasive in Palau, and Space et al. (2003) discourage further planting.
 4 Another species, *Cynodon dactylon* (Poaceae), is considered one of the most aggressive grasses that has
 5 been introduced into the Micronesia Region (Space and Falanruw 1999). In addition, the landscape plan
 6 lists at least 11 species that are potentially invasive. For example, *Duranta repens* (Verbenaceae) is
 7 believed to have a high potential for invasiveness in the Micronesia Region because it has established
 8 beyond its natural range in other locations (PIER 2010).

9 **Table A3-5: Plants Recommended in the DoD Landscape Plan That Are Invasive in the**
 10 **Micronesia Region or Information Is Insufficient to Determine Invasive Potential**

Scientific name	Comments on invasiveness
<i>Duranta repens</i> (syn. <i>Duranta erecta</i>)	High risk of becoming invasive (PIER 2010)
<i>Hedychium coronarium</i>	High risk of becoming invasive (PIER 2010); Space et al. (1999) suggest monitoring <i>Hedychium</i> sp. for invasive behavior; invasive or potentially invasive in Palau (Space et al. 2009)
<i>Heliconia psittacorum</i>	High risk for becoming invasive (PIER 2010)
<i>Paspalum vaginatum</i>	High risk of becoming invasive (PIER 2010)
<i>Pennisetum clandestinum</i>	High risk of becoming invasive (PIER 2010)
<i>Thevetia peruviana</i>	High risk of becoming invasive (PIER 2010); species of concern in Palau (Space et al. 2009)
<i>Alpinia purpurata</i>	Evaluation of invasiveness recommended (PIER 2010)
<i>Chrysalidocarpus lutescens</i> (syn. <i>Dyopsis lutescens</i>)	Evaluation of invasiveness recommended (PIER 2010)
<i>Clusia rosea</i>	Evaluation of invasiveness recommended (PIER 2010)
<i>Cynodon dactylon</i>	Weedy in Micronesia (Space and Falanruw 1999); Evaluation of invasiveness recommended (PIER 2010)
<i>Livistona chinensis</i>	Evaluation of invasiveness recommended (Space et al. 2009, PIER 2010)
<i>Chlorophytum bichetti</i>	Potential invasiveness unknown
<i>Cordyline fruticosa</i>	Potential invasiveness unknown
<i>Philodendron selloum</i>	Potential invasiveness unknown
<i>Pseuderanthemum reticulatum</i> (syn. <i>Pseuderanthemum carruthersii</i>)	Invasive in Palau; further planting is discouraged (Space et al. 2003)

11
 12 In addition to regulated commerce, smuggled propagative material presents a potentially serious risk. Of
 13 particular concern are live plants sent through the mail or carried in passenger baggage. Various military
 14 guidelines for relocating personnel do not mention restrictions concerning plants and plant products. A
 15 DoD website for personnel assigned to foreign duty stations explicitly states that there are “No
 16 restrictions identified” for plant movement into Guam (DoD 2010d).

17 **A3.3.5.5 Expected Impact of Military Relocation**

18 The demand for plant propagative material, particularly plants for landscaping, will likely increase during
 19 the military relocation due to landscaping needs around newly constructed civilian and military housing,
 20 hotels, and commercial businesses. Apart from plantings on DoD lands, garden centers may increase

1 their supply of ornamental plants to meet demands from a larger consumer base (including
 2 homeowners, hotels, and commercial businesses). Depending on consumer demand, garden centers
 3 may also increase their supply of novel ornamentals, including plants that have not been tested in
 4 Guam’s landscapes and that could become invasive. Increased sales of commercial potting soil may also
 5 introduce and facilitate spread of pests from the U.S. mainland on Guam (Berringer 2010a). Increases in
 6 plant propagative imports will place additional strain on existing safeguarding staff and infrastructure,
 7 limiting their ability to prevent pests from entering the Micronesia Region.

8 **A3.3.6 Pathway: Mail**

9 Mail is a known pathway for the movement of exotic organisms. Almost two decades ago, a report of
 10 the U.S. Congress specifically identified mail as a source of invasive species (OTA 1993) and pointed out
 11 concerns about the potential spread of nematodes, mites, diseases, and parasites in shipments of bee
 12 and bumble bee colonies.

13 Larvae of the Mediterranean fruit fly, *Ceratitis capitata*, the melon fly, *Bactrocera cucurbitae*, the
 14 Oriental fruit fly, *B. dorsalis*, and the Malaysian fruit fly, *B. latifrons* (Diptera: Tephritidae), among other
 15 quarantine pests were found during an examination of first-class USPS and United Parcel Service
 16 packages arriving in California in 1990 to 1991 (McDowell and Krass 1992). Prohibited materials seized in
 17 public and private mail entering the United States include seeds, fresh fruits and vegetables, propagative
 18 plant parts, nuts, live insects, and soil (USDA-APHIS-SITC 2005; 2006; 2007; DHS CBP and USDA-APHIS-
 19 SITC 2008; USDA-APHIS-SITC 2009b; c). Indeed, the relatively low cost of mailing and lax enforcement of
 20 the regulations make the mail an attractive way of moving plant products, legally or otherwise.

21 Specific information about the significance of the mail pathway in Guam and the Micronesia Region is
 22 scarce, but interceptions from mail packages sent from the Micronesia Region to Hawai’i demonstrate
 23 the possibility of pests making their way from the Micronesia Region to Hawai’i via the mail pathway
 24 (Table A3-6). Pests of betelnut, *Areca catechu*, may be of special concern, because betelnuts seem to be
 25 sent frequently in the mail.

26 **Table A3-6: Pest Insects Intercepted From Packages Mailed From the Micronesia Region**
 27 **Destined to Hawai’i between 2003 and 2008**

Country of origin	Inspected host	Pest
Guam	<i>Mangifera indica</i> (fruit)	<i>Sternochetus</i> sp. (Curculionidae)
Guam	Unknown seeds	Curculionidae, species of
Guam	<i>Areca</i> sp. (fruit)	<i>Chrysomphalus aonidum</i> (Diaspididae)
RMI	<i>Areca catechu</i> (seeds)	Pseudococcidae, species of
FSM	<i>Psidium</i> sp. (fruit)	<i>Bactrocera</i> sp. (Tephritidae)
FSM	<i>Citrus</i> sp. (fruit)	<i>Lepidosaphes beckii</i> (Diaspididae)
FSM	<i>Citrus</i> sp. (fruit)	Tarsonemidae, species of
FSM	<i>Areca catechu</i> (fruit)	Pseudococcidae, species of
FSM	<i>Areca catechu</i> (fruit)	Diaspididae, species of
FSM	<i>Areca</i> sp. (fruit)	<i>Lepidosaphes similis</i> (Diaspididae)
Palau	<i>Areca</i> sp. (fruit)	<i>Pinnaspis</i> sp. (Diaspididae)

28 Source: USDA-APHIS-PPQ 2010a

1 A rise in e-commerce has caused an increase in the number of packages sent through the mail
 2 worldwide (Hafner 2006). While e-commerce is currently less utilized in the Micronesia Region than in
 3 other parts of the world, technological advancement and an influx of a large number of people from the
 4 United States, many of whom are accustomed to online shopping, may lead to increased e-commerce
 5 activity over time. Internet retailers and online auction sites are easily accessible sources of plants and
 6 other live organisms (Kay and Hoyle 2001; Derraik and Phillips 2010). Organisms sold online are often
 7 not identified to the species level or are misidentified (Walters et al. 2006; Keller and Lodge 2007), and
 8 consumers tend to be unaware of the phytosanitary risks and regulations associated with mail-order
 9 organisms.

10 In spite of steps taken by some Internet auction sites to curb the sale of invasive plants and plant pests
 11 (eBay 2009), such items, ordered online, are seized in the United States on a regular basis (Table A3-7)
 12 (USDA-APHIS-SITC 2009a, d). Seeds are the most common type of intercepted material, demonstrating
 13 the potential for exotic plant species to be mailed into the Micronesia Region from anywhere in the
 14 world; seeds and other types of mailed propagative material also pose the threat of introducing plant
 15 pests and diseases. It is worth noting that many of the plants listed in Table A3-7 are already established
 16 throughout much of Micronesia and the State of Hawai'i and most likely available from local sources (at
 17 least some varieties).

18 **Table A3-7: Examples of Prohibited Items Purchased from Online Auction Sites Seized In**
 19 **International Mail Entering the United States in 2009**

Country of origin	Organism intercepted	Organism type
Australia	<i>Zea mays</i>	seeds
China	bonsai tree	plant
Germany	bamboo	seeds
Malaysia	<i>Ipomoea aquatica</i>	seeds
Malaysia	<i>Zea mays</i>	seeds
Malaysia	Cucurbitaceae, species of	seeds
Malaysia	<i>Vigna sesquipedalis</i>	seeds
Malaysia	<i>Citrus</i> sp.	seeds
Singapore	<i>Ipomoea aquatica</i>	seeds
Singapore	<i>Citrus</i> sp.	seeds
Thailand	<i>Cycas</i> sp.	plant
Thailand	<i>Citrus hystrix</i>	seeds and plants
Thailand	<i>Oryza</i> sp.	seeds
Thailand	<i>Plumeria</i> sp. ^b	plant
Thailand	<i>Euphorbia</i> sp. ^b	plant
Thailand	dwarf bamboo	plant
Thailand	<i>Oryza</i> sp.	seeds
Thailand	<i>Ipomoea aquatica</i>	seeds
Thailand	<i>Citrus aurantifolia</i>	seeds
Thailand	<i>Fortunella</i> sp.	seeds
Thailand	<i>Tacca chantrieri</i>	tubers
Thailand	<i>Jatropha</i> sp.	seeds
Thailand	<i>Nephelium lappaceum</i>	seeds
Thailand	<i>Hylocereus</i> sp.	seeds

Country of origin	Organism intercepted	Organism type
Thailand	<i>Citrus</i> sp.	seeds
Thailand	Thai eggplant	seeds
Thailand	<i>Piper nigrum</i>	seeds
Thailand	<i>Capsicum annuum</i>	seeds
Thailand	<i>Ocimum tenuiflorum</i>	seeds
Thailand	<i>Cucumis sativus</i>	seeds
Thailand	<i>Coriandrum sativum</i>	seeds
Thailand	<i>Citrus amaruensis</i>	seeds
Thailand	<i>Ipomoea aquatica</i>	seeds
USA (GA/LA)	<i>Citrus</i> sp.	plants
USA (FL)	<i>Citrus aurantifolia</i>	plant
USA (FL)	<i>Citrus</i> sp.	seeds and plants
USA (FL)	<i>Fortunella</i> sp.	seeds
USA (FL)	<i>Marisa cornuarietis</i>	snails
Unknown	<i>Coco nucifera</i>	plant
Unknown	<i>Pomacea caniculata</i>	snail
Unknown	<i>Marisa cornuarietis</i>	snail
Unknown	<i>Annona squamosa</i>	seeds
Unknown	<i>Citrus</i> sp.	plants
Unknown	<i>Zea mays</i>	seeds
Unknown	<i>Acer buergerianum</i>	Bonsai plant
Unknown	orchids	plants

1 Source: USDA-APHIS SITC 2009a, d.

2 ^a Both plants were infected with *Ceratocystis* sp.

3 Mail service to Guam and the Micronesia Region is provided by the USPS and several private shipping
4 companies. Military mail is handled by the Military Postal Service Agency. The Military Postal Service
5 Agency is the single DoD point of contact with the USPS and is required to adhere to USPS rules, federal
6 laws, and various international laws and agreements for movement of military mail. The Military Postal
7 Service Agency uses USPS mail handling and distribution networks where they exist (MPSA 2010).

8 Guam's Main Post Office, located in Barrigada, is the Micronesia Region's mail service hub, serving as a
9 processing facility and staging area for civilian and military mail entering the Region (Ericksen 2010). In
10 addition to delivering mail to people on Guam, this facility processes domestic and international mail for
11 CNMI, RMI, Palau, and FSM (Murphy 1983; Jimenez et al. 2009). Mail inspection also takes place at this
12 facility. Thus, this facility's capacity directly affects the entire Region's biosecurity.

13 The Military Postal Service Agency educates military personnel about items that are prohibited in mailed
14 packages, and the Guam Post Office displays educational posters describing prohibited mail items
15 (Ericksen 2010).

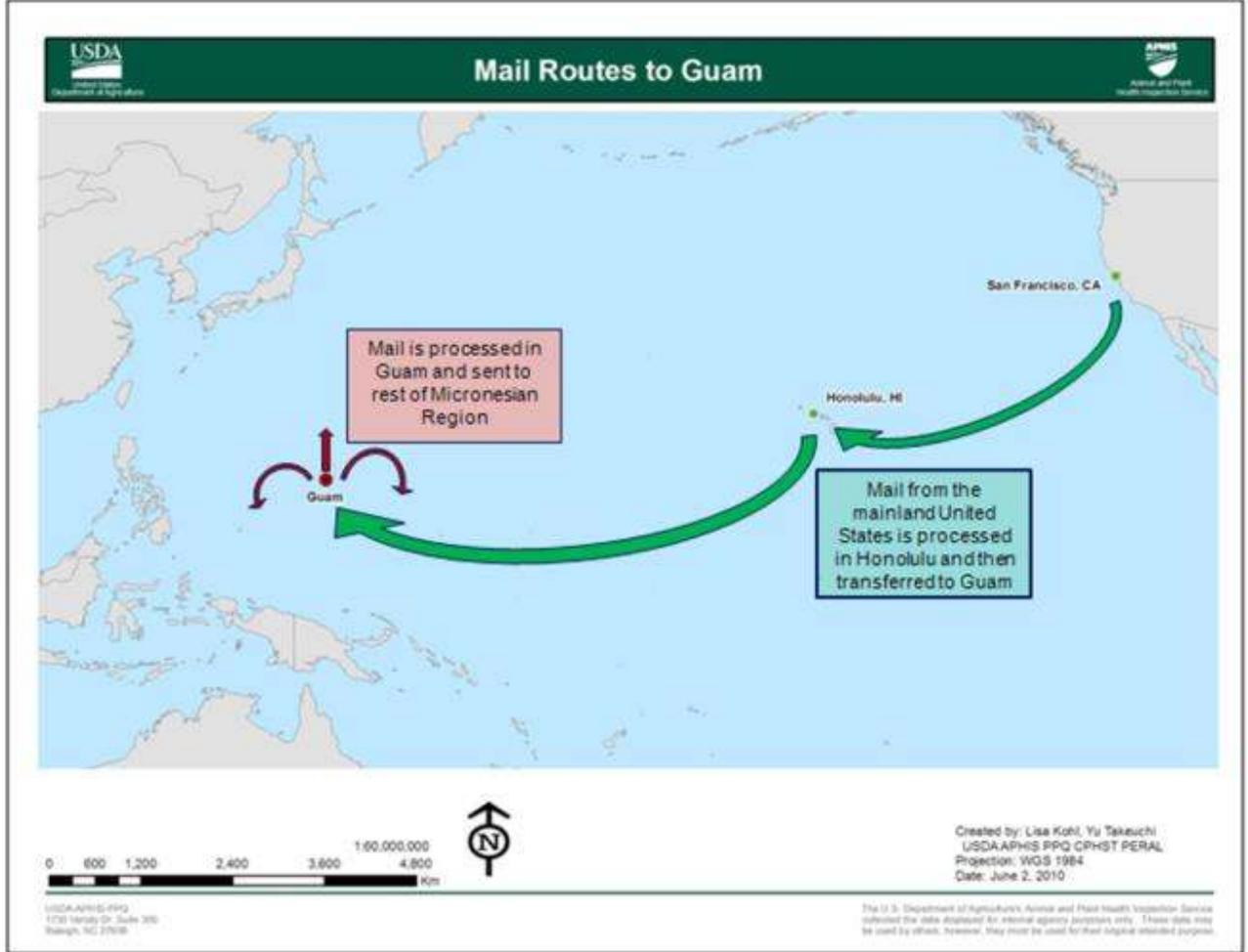
16 Mail sent between the United States, Guam, CNMI, RMI, Palau, and FSM through the USPS is considered
17 U.S. domestic mail (USPS 2009), which means that standard domestic rates apply. This makes the USPS a
18 relatively inexpensive shipping option (USPS 2010b) compared to private shipping companies, which
19 charge international rates on packages sent between the United States and areas in the Micronesia
20 Region (FedEx 2010; UPS 2010). Thus, most packages sent to the Micronesia Region from the United
21 States are sent through the USPS rather than private companies (Ericksen 2010).

1 First-class mail sent via the USPS has legal protection under the Fourth Amendment to the Constitution
2 of the United States, making it illegal to delay such mail or to open it without either a search warrant or
3 permission from the addressee (DoD 2002; USPS 2007). These protections apply also in Guam, the
4 CNMI, RMI, Palau, and FSM. However, of these locations, Guam is the only one where inspection of mail
5 takes place. In order to obtain a search warrant for inspecting first-class mail, the Postal Inspector must
6 establish probable cause. For this purpose, screening of the mail by detector dogs would be useful;
7 however, detector dogs are not being used in the Guam postal facility (Meissner et al. 2010). The actual
8 opening and inspection of the mail is carried out by GCQA officers, but a Postal Inspector must be
9 present at the time of inspection. Because the postal facility cannot legally slow down the flow of
10 domestic mail (39 CFR Title 39), the number of packages that can be inspected with the available
11 workforce is very limited.

12 In contrast to USPS first-class mail, parcels shipped through private mail are considered cargo and are
13 regulated and inspected as such. GCQA has the authority to inspect these packages, and no search
14 warrant is needed. Privately shipped mail (with the exception of diplomatic parcels) may be x-rayed by
15 GCQA (Shimizu 2010a).

16 All mail originating in the United States and most international packages destined for the Micronesia
17 Region are processed in Honolulu, Hawai'i, before being sent to Guam (Figure A3-9). The postal facility
18 of Honolulu has a compliance agreement in place that facilitates inspection of first-class USPS domestic
19 packages. However, it is unclear to what degree mail destined for Guam is actually inspected in
20 Honolulu. While Guam postal officials seem to rely on Hawai'i Department of Agriculture inspectors to
21 inspect this mail (Ericksen 2010; Shimizu 2010a), postal officials in Hawai'i seem to believe that GCQA is
22 carrying out these inspections (Gonzalez 2010). The Hawai'i Department of Agriculture recently
23 experienced a drastic decrease in agricultural inspectors due to budget cuts (Advertiser Staff 2009),
24 creating a general workforce shortage which also affects postal inspections.

1 **Figure A3-9: Route for Packages Sent from the U.S. Mainland to the Micronesia Region**



2
3 Source: Murphy 1983; Ericksen 2010

4
5 Approximately 1.5 million packages currently arrive in Guam; of these, some 100,000-150,000 packages
6 arrive from international locations, mainly Japan and the Philippines (Ericksen 2010). The remainder
7 arrives from domestic locations (Ericksen 2010). The USPS does not keep records of mail volumes for
8 anywhere else in the Micronesia Region (USPS 2010a).

9 In addition to mail arriving from outside the Region, plant pests may also be mailed from Guam to areas
10 within the Micronesia Region. Outgoing packages are not inspected on Guam, and other locations in the
11 Region do not seem to inspect incoming mail (Ericksen 2010).

12 Expected impact of the military relocation. The military relocation is expected to increase mail volumes
13 to Guam. An estimated additional 900,000 packages annually may be delivered to military personnel
14 alone (Ericksen 2010). While we have no data to determine the percentage of packages entering Guam
15 that contain plant quarantine materials, a value of 1% previously calculated based on randomly sampled
16 international mail entering the United States (Meissner et al. 2009) serves as a reasonable estimate.

1 Based on this estimate, an additional 10,000 packages containing plant quarantine material may arrive
2 annually in military mail. In addition, packages mailed to the large expected temporary workforce from
3 Southeast Asia also present a risk.

4 **A3.3.7 Pathway: Agricultural Commodity Imports**

5 Most of the agricultural commodities consumed on Guam are imported, and most of these imports
6 come from the United States. In 2002, the United States supplied 92% (based on weight) of Guam's
7 agricultural imports, and 14 other trading partners provided the remaining 8% (Table A3-8). Some 160
8 types of agricultural commodities were imported from the United States, while Korea provided 90 types,
9 and FSM provided 11 types.

10 **Table A3-8: Percentage of Agricultural Commodity Imports to Guam by**
11 **Country of Origin in 2002**

Country of origin	Percentage of imports ^a
United States	92
Korea	3
FSM	2
New Zealand	1
All other countries ^b	<1

12 Source: GovGuam 1995; 1999; 2000; 2002.

13 ^a Fresh agricultural commodity imports exclude animal-based products.

14 ^b All other countries: Australia, China, CNMI, Japan, Malaysia, Netherlands,
15 Philippines, Singapore, Taiwan, Thailand, and Palau.
16

17 USDA regulations regarding the importation of fresh fruits and vegetables into the United States
18 (including Guam and CNMI) are detailed in 7 CFR (7 CFR § 319; 7 CFR § 318). For any fresh fruits and
19 vegetables from foreign countries, USDA requires pest risk assessments detailing the likelihood and
20 potential consequences of exotic plant pest introduction before permitting importation into the United
21 States. Guam is almost never explicitly considered in these pest risk assessments; however, all fruits and
22 vegetables approved for entry into any part of the United States are also permitted to enter Guam,
23 unless they are specifically designated as not approved (which is rare). This leaves Guam vulnerable to
24 pest introductions from foreign countries. In addition, commodities prohibited from entering Guam may
25 be imported into the continental United States and sent from there to Guam as domestic shipments.

26 Domestic shipments from Hawai'i are governed by GovGuam regulations and 7 CFR § 318 federal
27 regulations. GovGuam restricts the entry of certain agricultural commodities from domestic locations
28 (GDOA 1997); e.g., hosts of the European corn borer from infested U.S. States and hosts of the oriental
29 fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), from infested areas in Hawai'i are prohibited.
30 However, the majority of commodities from the United States are allowed to enter Guam without any
31 phytosanitary restrictions, but subject to inspection.

32 In 2009, GDOA intercepted pests in agricultural shipments from the mainland United States (Campbell
33 2010c), including mites, aphids, thrips, beetles, flies, Hemiptera, Homoptera, Lepidoptera, fungi, and
34 mollusks. Since most of the pests were not identified to the genus level, we were unable to determine

1 their quarantine status. A wider variety of pests not known to occur or of limited distribution in the
 2 Micronesia Region have been found in agricultural shipments entering Hawai'i from the mainland
 3 United States, further demonstrating the potential of introducing pests from the mainland United States
 4 into the Micronesia Region (Table A3-9) (HDOA 2007).

5 **Table A3-9: Pests Not Known To Occur or of Limited Distribution in the Micronesia Region**
 6 **that Were Intercepted in Hawai'i on Domestic Shipments of Agricultural Commodities From**
 7 **the Continental United States**

Coleoptera: Chrysomelidae
<i>Diabrotica balteata</i>
<i>Diabrotica undecimpunctata</i>
<i>Microtheca ochroloma</i>
Hemiptera: Aphididae
<i>Aphis coreopsidis</i>
<i>Aphis nasturtii</i>
<i>Aphis menthaeradidis</i>
<i>Aulacorthum magnolia</i>
<i>Greenidea mangiferae</i>
<i>Hyadaphis foeniculi</i>
<i>Macrosiphum euphorbiae</i>
<i>Macrosiphum rosae</i>
<i>Melanaphis sorghi</i>
<i>Myzus ascalonicus</i>
<i>Rhopalosiphum padi</i>
Hemiptera: Diaspididae
<i>Aonidiella aurantii</i>
<i>Chrysomphalus aonidum</i>
Hemiptera: Miridae
<i>Lygus hesperus</i>
<i>Lygus lineolaris</i>
Hemiptera: Triozidae
<i>Bactericera cockerelli</i>
Hemiptera: Pseudococcidae
<i>Dysmicoccus</i> sp. nr. <i>bispinosus</i>
<i>Dysmicoccus texensis</i>
<i>Ferrisia malvastra</i>
<i>Planococcus ficus</i>
<i>Rhizoecus americanus</i>
<i>Rhizoecus cacticans</i>
<i>Rhizoecus falcifer</i>
Lepidoptera: Gracillariidae
<i>Marmara gulosa</i>
Lepidoptera: Noctuidae

<i>Autographa californica</i>
Mollusca: Agriolimacidae
<i>Deroceras reticulatum</i>
Mollusca: Succineidae
<i>Succinea tenella</i>

Source: HDOA 2007

1
2

3 Expected impact of the military relocation. The military relocation will lead to a considerable population
4 increase on Guam. As a result, larger amounts of agricultural commodities will be imported. The
5 increased workload for inspection personnel during and after the military relocation may place further
6 strain on the safeguarding system. As a result, the frequency of pest introduction through the
7 agricultural commodity pathway is likely to increase. However, we do not expect a fundamental change
8 in the types of pests introduced; rather, we expect that the same types of pests will enter Guam more
9 frequently and may thus establish sooner than they would have otherwise. In addition to legal imports,
10 increased smuggling of agricultural commodities into Guam may occur, especially via mail or in
11 passenger baggage.

12 **A3.3.8 Pathway: Regulated Garbage**

13 Garbage is defined as waste derived from fruits, vegetables, meats, or other plant or animal material.
14 This may include unconsumed meals, food scraps, table refuse, galley refuse, food wrappers or
15 packaging materials, and other waste material from stores, food preparation areas, passengers' or
16 crews' quarters, or dining rooms in ships or airplanes. Garbage is regulated if it is on or removed from
17 any conveyance that has been in any port outside the United States and Canada in the past 2 years (9
18 CFR § 94; 7 CFR § 330.400).

19 Regulated garbage may not be disposed of or removed from a conveyance except in accordance with
20 federal Regulations. All regulated garbage must be contained in tight, covered, leak-proof receptacles
21 during storage on board the conveyance while in the territorial waters, or while otherwise within the
22 legal jurisdiction of the United States. If unloaded, regulated garbage must be moved under the
23 direction of an inspector to an approved facility for incineration, sterilization, or grinding into an
24 approved sewage system. Any person engaged in the handling or disposing of regulated garbage must
25 first enter into a compliance agreement with APHIS (9 CFR § 94; 7 CFR § 330.400). The offloading of
26 regulated garbage from all foreign countries except Canada into the United States is prohibited. Hawai'i,
27 Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin Islands, RMI, and Palau fall under the
28 domestic quarantine notices restricting the offloading of regulated garbage into other States or
29 territories.

30 Expected impact of the military relocation. If the above regulations are followed, regulated garbage
31 poses little to no phytosanitary risk to Guam and the Micronesia Region; thus, changes in this pathway
32 resulting from the military relocation are not likely to negatively affect the Micronesia Region.

1 **A3.3.9 Overview of Pathways and Associated Safeguarding Challenges**

Pathway	Significance of pathway	Safeguarding challenges
People	People may introduce plant pests intentionally or accidentally. Outdoor activities facilitate pest spread. More people will travel to and around the Region.	<ol style="list-style-type: none"> 1. Lack of education about phytosanitary risks and prevention measures 2. Inadequate agricultural inspection staffing and equipment 3. Insufficient agricultural training and focus (inspectors) 4. Smuggling
Personal effects of military personnel	May be contaminated with pests, especially if it has been used or stored outdoors (bicycles, barbecue grills, outdoor furniture, etc.)	<ol style="list-style-type: none"> 1. Lack of education about phytosanitary risks and prevention measures 2. Insufficient agricultural training and focus (military personnel conducting inspections) 3. Smuggling 4. Lack of compliance checks and quality assurance program
Shipping containers	External and internal contamination is common. Transported to multiple ports. Storage practices leading to recontamination. Loading practices may attract pests.	<ol style="list-style-type: none"> 1. Insufficient equipment, space, and resources for agricultural inspection 2. Inspection of containers is rare 3. Cleaning is difficult and often not feasible
Wood packaging material	Wood-boring pests, contaminating pests, and soil contamination are common. Routinely reused and recycled. Inspection is difficult and rarely occurs.	<ol style="list-style-type: none"> 1. Domestic WPM not subject to U.S. phytosanitary regulations 2. Inadequate agricultural inspection staffing and equipment 3. Recontamination due to outdoor storage
Construction materials: wood	Wood-boring pests and contaminating pests are common. Storage practices can lead to recontamination. Contact with disturbed sites facilitates pest establishment.	<ol style="list-style-type: none"> 1. Phytosanitary treatment not required for some types of timber
Construction materials: concrete, sand, steel, etc.	Frequently contaminated with pests and soil. Storage practices can lead to recontamination. Inspection is difficult and rarely occurs. Movement to disturbed sites facilitates establishment.	<ol style="list-style-type: none"> 1. Enforcement of existing regulations is lax 2. Insufficient inspection of incoming materials 3. Lack of phytosanitary procedures at construction sites

Pathway	Significance of pathway	Safeguarding challenges
Construction and other equipment	External and internal contamination with pests and soil very common. Contact with disturbed sites facilitates pest establishment.	<ol style="list-style-type: none"> 1. Enforcement of existing regulations is lax 2. Insufficient inspection of incoming equipment 3. Lack of phytosanitary procedures at construction sites
Soil contamination	Soil that contains plant pests can adhere to containers, machinery, personal effects, agricultural commodities, shoes, and construction equipment. Numerous pests can be found and can survive for a long time in contaminating soil.	<ol style="list-style-type: none"> 1. Insufficient resources for agricultural inspection staff 2. Lack of education about phytosanitary risks and prevention measures 3. Soil-cleaning procedures not in place for equipment moving from Guam to CNMI
Aircraft	Often visit multiple ports in short timeframe. Loading practices can attract pests.	<ol style="list-style-type: none"> 1. Inadequate agricultural inspection staffing and equipment 2. Pest entry and contamination during loading/storage of aircraft 3. Inspection very difficult due to large size of aircraft
Maritime vessels	Often visit multiple ports in short timeframe. Loading practices can attract pests.	<ol style="list-style-type: none"> 1. GCQA officers not allowed to board/inspect military vessels 2. Inadequate agricultural inspection staffing and equipment 3. Inspection is very difficult due to large size of ships
Propagative material	Plant material may become invasive itself or may be infested with pests. Increased landscaping needs of military and civilian population will likely increase imports of propagative materials. Landscaping activities may also facilitate further spread of already established exotic pests.	<ol style="list-style-type: none"> 1. Inadequate agricultural inspection staffing and equipment 2. No weed risk assessment is required for plant importation 3. No code of conduct for nurseries, landscaping businesses, or other entities to promote responsible phytosanitary practices 4. Lack of education about phytosanitary risks and prevention measures 5. Smuggling 6. Very few phytosanitary requirements in place for domestic imports

Pathway	Significance of pathway	Safeguarding challenges
Mail	Plant pests are frequently transported through the mail, both intentionally and accidentally. Internet sales facilitate the movement of pests in the mail. Domestic mail volumes will increase as population of Guam increases.	<ol style="list-style-type: none"> 1. Majority of domestic mail is not inspected 2. Lack of education about risks of sending agricultural materials in the mail 3. No existing mail inspection system in some parts of the Micronesia Region 4. Inadequate agricultural inspection staffing and equipment 5. Smuggling 6. Federal regulations hinder the inspection of domestic mail
Potting media	Direct contact with landscapes facilitates spread of pests.	<ol style="list-style-type: none"> 1. Enforcement of existing regulations (sterilization)
Agricultural commodities	Most of the fruits and vegetable consumed on Guam are imported; most of these imports are domestic imports from the continental United States. May be contaminated with a multitude of pests. Agricultural commodity imports will increase as the population of Guam increases.	<ol style="list-style-type: none"> 1. No phytosanitary requirements for most domestic imports.
Regulated garbage	Contamination with pests possible. Not a big phytosanitary concern if existing regulations are followed.	<ol style="list-style-type: none"> 1. Enforcement of existing regulations

1

2 **A3.3.10 Safeguarding Challenges–General Observations**

3 Based on our risk assessment, we identified a number of overarching safeguarding challenges that
4 pertain to all of the pathways discussed. Most of these challenges are not specific to Guam, but exist to
5 some degree in any location where safeguarding activities take place.

6 **A3.3.10.1 Regulations, Guidelines, and Standard Operating Procedures**

7 Within the federal regulatory framework, Guam (and CNMI) are often considered part of the United
8 States and fall under APHIS domestic quarantines (7 CFR § 318) as well as foreign quarantine regulations
9 (7 CFR § 319). For example, commodity imports into Guam are subject to the federal risk assessment
10 process; mail sent to Guam from the United States is considered domestic mail; and the movement of
11 WPM between Guam and any part of the United States is considered domestic movement. This
12 approach does not take into account Guam’s special geographic, biological, and political reality and
13 leaves Guam vulnerable to exotic pest introductions. While Guam has the authority to protect itself
14 through its own regulations, this is neither economically nor political feasible.

15 In addition, regulations do not always sufficiently address existing pest threats, in part because the
16 regulations are out of date, and in part because they are not based on an accurate assessment of pest

1 risk. Moreover, regulations usually do not provide specific guidance on safeguarding actions. For
2 example, regulations give GCQA and APHIS the authority to carry out inspections, but do not specify
3 what exactly an inspection entails or how it should be conducted. Such details must be provided by
4 separate guidelines or standard operating procedures (SOPs); however, guidelines or SOPs do not
5 always exist where they are needed. In addition, the language of some guidelines or SOPs is vague
6 enough to allow for a broad interpretation.

7 **A3.3.10.2** *Phytosanitary Inspection*

8 Inspection presents an immense challenge in a number of different ways. First, the number of incoming
9 items and the time required for their inspection do not permit thorough inspection of all incoming
10 items. Second, inspection is hindered by logistical challenges, such as the necessity to unload cargo
11 containers for thorough inspection and the lack of the necessary space and equipment for inspection.
12 Third, the detection of plant pests is inherently difficult, as these pests tend to be minute, hidden, or
13 both. Plant pathogens are practically impossible to detect if the infected plant material is asymptomatic,
14 which is frequently the case. Also, inaccurate or imprecise information provided on import manifests
15 sometimes makes it difficult for inspectors to identify shipments that contain materials of plant
16 quarantine significance. Given these shortcomings, a majority of incoming plant pests routinely escape
17 detection, and phytosanitary inspection tends to be overrated as a safeguarding tool.

18 **A3.3.10.3** *Collaboration*

19 As in other locations, various entities work together to safeguard Guam against the introduction of
20 exotic plant pests. GCQA and USDA-APHIS-PPQ collaborate not only with each other, but also with port
21 management, the USPS, various other agencies, and industry on the island. Safeguarding success
22 depends on productive and efficient collaboration, and there is considerable opportunity for improving
23 existing working relationships. Especially regarding the mail pathway, an effort towards improved
24 collaborations seems to be advisable.

25 **A3.3.10.4** *Education*

26 Education on several levels is an important component of any safeguarding system: safeguarding
27 personnel must receive the necessary training to be effective at their job (e.g., training in pest detection
28 and pest identification); military personnel must receive adequate training on the potential impact of
29 exotic plant pests and on ways to prevent their introduction and spread; similarly, the general public
30 must be made aware of the exotic species problem and of opportunities to support safeguarding efforts.

31 **A3.3.10.5** *Data*

32 Reliable data is necessary for assessing pest risk, evaluating the efficacy of safeguarding programs,
33 weighing costs and benefits of safeguarding actions, and allocating resources. Lack of reliable data is a
34 common problem in the United States; however, in Guam and the Micronesia Region this problem is
35 much more pronounced. Pest interception data are not consistently recorded; especially on the side of
36 the DoD, no pest interception records seem to exist. Import data often do not distinguish Guam from
37 the mainland United States, and reliable import data don't exist for the other Micronesian Region
38 countries. There is little information on the number of conveyances and containers processed at the

1 ports of entry, and data on mail volumes are lacking. The number and type of inspections performed is
2 generally unknown.

3 **A3.4 RECOMMENDATIONS**

4 **A3.4.1 Staffing and Infrastructure**

- 5 • Ensure sufficient staffing (e.g., plant safeguarding specialists, identifiers, surveyors) to
6 accomplish all necessary inspection and quarantine activities in the Micronesia Region.
7 Already insufficient staffing levels will become further strained as a consequence of the
8 military relocation as the workload at airports, maritime ports, the mail facility, and the
9 Plant Inspection Station increases. Quarantine officers with plant health expertise should be
10 on duty to clear cargo and conveyances whenever aircraft or maritime vessels arrive.
11 Quarantine officers must be adequately trained in all aspects of their work and should
12 receive periodic refresher training.
- 13 • Ensure availability of necessary equipment. Equipment necessary for effective safeguarding,
14 such as hand lenses, microscopes, and computers, must be available to quarantine officers.
15 X-ray machines or other appropriate scanning technology and cleaning equipment such as
16 power washers must be provided where needed. A sufficient number of lifts must be
17 available for sea cargo container inspections. All equipment must be maintained in working
18 order over the long term. APHIS manuals provide detailed guidance on necessary
19 equipment.
- 20 • Establish decontamination sites for cleaning military and other equipment. Such sites must
21 be available at all locations where military training exercises will take place and at the ports
22 of entry. Sites should contain a quarantine area for storing contaminated equipment prior to
23 cleaning. Precautions must be taken to prevent contaminated water to run off into the soil.
24 Ensure that wash systems used are effective (see Balbach et al. 2008, Flemming 2008).
- 25 • Deploy detector dogs and handlers a) to mail facility for efficient screening of mail for plant
26 pests and to establish probable cause for inspection of domestic mail, and b) to airports for
27 screening baggage for plant pests.

28 **A3.4.2 Point-of-entry Activities (Cleaning, Inspection, Treatment)**

- 29 • Conduct phytosanitary inspection of all arriving conveyances, military and non-military, for
30 contaminating plant pests. Inspection must include a thorough search for contaminating
31 pests on the exterior and the interior of the conveyance. In the case of military vessels,
32 either PPQ safeguarding specialists must be made available to inspect military vessels, or
33 GCQA officers must be allowed to inspect military vessels instead of PPQ safeguarding
34 specialists.
- 35 • Conduct phytosanitary inspection of WPM. An adequate percentage of all domestic and
36 foreign, military and non-military, WPM accompanying agricultural and non-agricultural
37 cargo must be thoroughly inspected for pests. The help of a statistician should be enlisted to
38 determine adequate sample size and inspection protocol. SOPs should be developed to

- 1 ensure consistent inspection methods. All inspections and pest interceptions should be
2 carefully documented. Pest interceptions should also be recorded in the relevant APHIS
3 database to be available for analysis that may contribute to safeguarding improvements and
4 quality control.
- 5 • Conduct phytosanitary inspection of all incoming construction materials for contaminating
6 pests, including materials that have been previously treated or cleaned (due to high chance
7 of recontamination after treatment) and including construction material from the United
8 States.
 - 9 • Clean and disinfect containers and conveyances that arrive in the Micronesia Region
10 contaminated with soil or exotic plant pests. Follow all current APHIS policies and guidelines.
11 Evaluate the effectiveness of current cleaning methods and improve effectiveness as
12 appropriate.
 - 13 • Properly clean all equipment (construction and military) according to APHIS guidelines prior
14 to entry into any part of the Micronesia Region to remove hitchhiker pests and soil
15 contaminations. Equipment must also be cleaned before moving within the Micronesia
16 Region (between countries, between islands of the same country, and, where appropriate,
17 between areas of the same island).
 - 18 • Establish an effective mail inspection system on Guam. Follow a similar model as Hawai'i to
19 use detector dogs for establishing probable cause for inspection of first-class USPS packages.
20 Use appropriate scanning technology for all other incoming mail. For mail arriving via
21 Hawai'i, either ensure adequate level of inspection in Hawai'i or else carry out inspection in
22 Guam. Establish effective working relationships to ensure that safeguarding personnel can
23 carry out their responsibilities. Safeguarding personnel must have sufficient access to the
24 postal facility.
 - 25 • Treat storage areas with molluscicides or install mollusk barriers to prevent mollusks from
26 infesting WPM and shipping containers. Remove weeds and other contaminants from
27 container and WPM storage areas. Storage areas should be hard surface or gravel.

28 **A3.4.3 Regulations, Guidelines, and Compliance**

- 29 • Strengthen existing regulations and guidelines for all jurisdictions and consider options for
30 improving pre-border activities that may assist in reducing risks.
- 31 • Require mandatory training of all construction and contracting companies used by both DoD
32 and public sector developers hired by the Military.
- 33 • Systematically review all guidelines and SOPs of phytosanitary relevance. Ensure that they
34 are clear, complete, and detailed. Develop guidelines or SOPs where they are lacking.
- 35 • Enforce full compliance with all applicable existing federal, GovGuam, and military
36 regulations, guidelines, and SOPs. Issue adequate fines for violations.

- 1 • Require treatment of all WPM according to ISPM No. 15. All domestic and foreign, military
2 and non-military, WPM entering the Micronesia Region should be required to be compliant
3 with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help
4 reduce the presence of pests, especially wood-boring pests.
- 5 • Require phytosanitary treatment of all imported timber, including timber from domestic
6 locations in order to mitigate the risk of pest entry on this pathway. Required treatments
7 should have been scientifically shown to be effective in removing pests.
- 8 • Require weed risk assessment for the importation of exotic plant species. Prohibit the
9 importation of all plant species exotic to and not yet naturalized on Guam unless they have
10 been deemed unlikely to become invasive by a weed risk assessment. Exceptions may be
11 made for plants that have been historically imported without becoming invasive.
- 12 • Develop best management practices for contractors and construction sites. Work with
13 industry and gain their support in helping to prevent the introduction and spread of exotic
14 plant pests. Implement “clean” practices at construction sites to minimize land disturbance
15 and spread of plant pests.
- 16 • Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other
17 businesses as appropriate to promote the sale and use of native and non-invasive plants.
18 This code of conduct should stipulate that the businesses:
 - 19 o ensure that their staff is knowledgeable on the subject of invasive plants
 - 20 o help educate their customers about invasive plants
 - 21 o immediately report any potentially exotic pest organisms found on their premises
 - 22 o use native plants or non-invasive plants locally sourced
- 23 • Revise the DoD landscape plan by removing plant species that are or have the potential to
24 be invasive in the Micronesia Region or Hawai’i. Request technical support from the
25 University of Guam as appropriate.

26 **A3.4.4 Education and Training**

- 27 • Provide adequate education about the potential negative consequences of spreading plant
28 pests and about ways to prevent pest spread. Provide a list of enterable and prohibited
29 materials. Create awareness of the potential legal consequences of violating the law.
30 Educate people on how they can actively contribute to exotic species prevention efforts.
31 Educate military personnel and dependents; non-military workforce; tourists; the general
32 public; and private industry.
- 33 • Provide training to increase inspection and identification expertise. Safeguarding inspectors
34 (both non-military and military) should receive adequate training on a regular basis teaching
35 them the proper techniques for detecting, extracting, recognizing, and identifying pests. A

1 communication network for continuously sharing relevant new information is also
2 recommended.

- 3 • Provide specific and detailed guidance to military personnel on how to inspect clothing and
4 personal effects for plant pests.

5 **A3.4.5 Additional Safeguarding Practices**

- 6 • Implement systematic surveillance for exotic pests, following the model of the Cooperative
7 Agriculture Pest Survey. Surveillance should take place both on and outside of military lands.
8 A transparent and well-documented process of pest prioritization, surveillance, data
9 collection, and record keeping must be followed. Communication of survey results
10 throughout the Micronesia Region would be an essential part of any survey program. Early
11 detection of new pests increases the chances that these pests can be eradicated or
12 controlled. Consider employing the help of qualified volunteers, such as amateur
13 taxonomists or university students to reduce costs.
- 14 • Improve record keeping including recording types and quantities of inbound materials for all
15 jurisdictions, such as agricultural products and origins of such products.
- 16 • Conduct periodic surveys of ethnic markets and grocery stores to intercept prohibited plant
17 products, following the model of or cooperating with USDA-APHIS-PPQ Smuggling,
18 Interdiction and Trade Compliance.
- 19 • Preferentially load conveyances in a way that minimizes pest entry. For example, avoid
20 nighttime loading because lights attract insects.
- 21 • Minimize pest contamination of containers and WPM by:
 - 22 o minimizing storage outdoors
 - 23 o sealing surfaces of storage sites
 - 24 o keeping storage sites clean
 - 25 o controlling pests around storage sites
 - 26 o limiting the use of nighttime lighting around storage sites
- 27 • Re-export infested or non-compliant WPM (as opposed to chipping it). Chipped WPM may
28 present a pest risk when the chips are re-used or improperly disposed of.
- 29 • Carefully inspect plant material recovered from construction sites for plant pests prior to
30 replanting.

31 **A.3.5 ACKNOWLEDGMENTS**

32 We gratefully acknowledge the individuals listed below for their assistance during this project.

- 1 Reviewers from USDA-APHIS:
- 2 Leslie Newton, Rob McDowell, Mitch Nelson, Jim Warren, Maria Borja, and Gary Cave
- 3 We also thank the numerous people who met with us on our site visits to the Micronesia Region to
- 4 share their expertise and answer our questions.
- 5

1 **A4 TERRESTRIAL VERTEBRATES**

2 This section of Micronesian Biosecurity Plan—*Methods and Strategies to Manage Invasive Species*
3 *Impacts to Agriculture, Natural Resources, and Human Health and Safety Project*—was prepared by
4 APHIS-WS, National Wildlife Research Center, Hawai'i Field Station.⁶ The suggested citation for this
5 section is: Wildlife Services, National Wildlife Research Center, Hawai'i Field Station, *Methods and*
6 *Strategies to Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and*
7 *Safety Project*. 2010. Terrestrial vertebrates. *In* Terrestrial plant and animal health risks associated with
8 the U.S. military relocation in the Micronesia Region. United States Department of Agriculture, Animal
9 and Plant Health Inspection Service. Washington, D.C.

10 **A4.1 UNINTENTIONAL PATHWAYS**

11 **A4.1.1 Summary**

12 The movement of the 3rd Marine Expeditionary Unit from Okinawa to Guam and associated actions will
13 greatly increase maritime and air traffic, cargo movement, and military training exercises. As a result,
14 the potential for the unintentional (Section A4.1) and intentional (Section A4.2) transport and
15 introduction of terrestrial vertebrate species will also increase. A high management priority is
16 preventing movement of the brown treesnake (*Boiga irregularis*) (hereafter, BTS) from Guam and
17 Saipan; hence air and seaport biosecurity measures include screening of departing aircraft and cargo
18 exports. The transport and introduction of terrestrial vertebrate species within the Micronesia Region
19 has the potential to negatively impact the region's human health and safety, economy, and ecology.

20 In this section, we conducted a pathway-based risk assessment to determine the means by which
21 terrestrial vertebrate species are unintentionally transported from one location to another in
22 association with the military relocation. We used methods developed by the National Invasive Species
23 Council and the Aquatic Nuisance Species Task Force to identify routes of transport that were related to,
24 and affected by, the military mission; these routes were organized as pathways involving air
25 transportation (the aircraft itself), water transportation (the vessel itself), cargo and cargo conveyance
26 transportation, and transportation of people and baggage. We quantitatively ranked pathways based on
27 the numbers and types of species they could transport, frequency of pathway use, species control
28 measures currently used, characteristics of the pathway or species, and regulatory procedures currently
29 in place governing the specific pathway. Each pathway was assigned to an impact category based on
30 whether the species involved could harm human health and safety, the economy, or the ecology of the
31 region.

32 Most pathways evaluated were rated as high risk because they all had the potential to transport species
33 that could harm human health and safety. Species of particular concern are BTS and rodents because
34 these species could be transported in the majority of the pathways. Pathways with the highest risks

⁶ We gratefully acknowledge the following reviewers from USDA-APHIS for their assistance during this project: Leslie Newton, Rob McDowell, Mitch Nelson, Jim Warren, Maria Borja, and Gary Cave. We also thank the numerous people who met with us on our site visits to the Micronesian Region to share their expertise and answer our questions.

1 were related to the transport of military cargo that is associated with the relocation and for use in
2 training exercises and deployment missions; military field missions and training exercises have the most
3 potential to place gear and personnel in areas where the BTS occurs or could likely establish if
4 introduced. Additionally, there are insufficient resources to meet current inspection requirements and
5 demand, and military activities are expected to exacerbate the problems of an already burdened
6 biosecurity system. For example, even if communications occur, either formal or informal, between the
7 military, customs officials, and agricultural officials on Tinian when an inspection is required, the
8 response capabilities do not exist, thereby preventing adequate inspections from occurring. Inspections
9 of aircraft and vessels are focused on preventing the movement of agricultural pests and vectors of
10 disease; therefore the likelihood of detecting terrestrial vertebrate species is decreased. Short
11 transportation durations such as on aircraft and military high-speed vessels increase the probability of
12 species survival during transport. Currently, GCQA can inspect military vessels and aircraft, unless the
13 craft is carrying classified cargo, is actively engaged in warfare, or has already been pre-cleared. The
14 least amount of risk was associated with fruits and vegetables as these are inspected closely, although
15 only a portion of each shipment gets inspected.

16 Preventing the transport and introduction of terrestrial vertebrate species in the Micronesia Region will
17 require a high degree of cooperation among agencies and increased awareness of the risks associated
18 with invasive species. Additional resources like funding and enforcement are necessary to improve
19 inspection procedures, maintain efficiency in current control measures, and allow for a higher level of
20 biosecurity for the region. It is far more cost-effective to prevent the movement of species in the first
21 place, than to implement management for the control and eradication of species that become
22 established.

23 **A4.1.2 Introduction**

24 **A4.1.2.1 *Methods***

25 The risk analysis process we used was developed jointly by the NISC Prevention Committee and the
26 Aquatic Nuisance Species Task Force (ANSTF) collaborating as the Pathways Work Team in support of
27 the NISC Management Plan (ANSTF and NISC 2007). Although some details of this risk analysis method
28 did not always fit well with data on terrestrial vertebrate invasive species, the stepwise analysis allowed
29 us to elucidate all of the potential risks. Thus, the absolute value of the risk score was not as important
30 as the relative evaluation compared to other pathways and the identification of risk factors. Our risk
31 analysis is pathway-based, meaning it focused primarily on the means by which species are transported
32 and introduced, as well the species being moved. We identified the mission-related pathways in the
33 Micronesia Region (associated with the military relocation), and then assessed those pathways based on
34 the species likely to be transported in each.

35 The risk of transporting and introducing terrestrial vertebrate species for each pathway is evaluated
36 based on a three-step nested process that assigns a risk factor based on aspects like the type of
37 pathway, the species that may be transported, and current biosecurity measures in place in the region.
38 First, mission-related pathways are identified, and each is then assessed based on a list of potentially
39 invasive species that have been, or are likely to be, transported through each pathway. Impact category

1 rating for a pathway depends upon the species that may be transported in that pathway; impacts, in
 2 descending order, are to human health and safety (Impact Category A), the economy (Impact Category
 3 B), and the ecology (Impact Category C). Thus, a species that poses a human health risk is assigned the
 4 highest category even though the number of people that are affected by the health risk is small
 5 compared to those affected economically (ANSTF and NISC 2007). Second, pathway scope level is
 6 evaluated based on the geographic area potentially affected by species transport and introduction. This
 7 ranking uses the number of incidents that may occur and how large an area may be affected. A pathway
 8 that provides for multiple invasive species across international boundaries is ranked the highest,
 9 whereas a pathway limited to a single potential event in a localized area is ranked the lowest. For
 10 example, risk could be intra-island (Pathway Scope I), inter-island (Scope II), between island groups
 11 (Scope III), between regions (Scope IV), and international (Pathway Scope V).

12 Third, the pathways are then evaluated according to a fixed set of criteria (16 questions) that capture
 13 the capacity of the pathway to transport invasive species and the likelihood that the invasive species will
 14 move through the pathway undetected in sufficient numbers to establish an incipient population. The
 15 16 questions addressed issues pertaining to a) probability of species transport, b) invasiveness of
 16 species, c) the attributes of the pathway related to species movement, and d) control-interdiction-
 17 eradication methods. Each question was rated on a whole number scale of 0-10 (0 = No Risk) (Table A4-
 18 1). Risk ratings were science based and supported by quantitative datasets, peer-reviewed scientific
 19 literature, and expert opinion and expertise (NISC 2005; ANSTF and NISC 2007). Information content was
 20 evaluated in risk assessments by criteria such as if it was out of date, scant in detail, or not available,
 21 and/or if information was lacking for a pathway, or for a species not typically targeted for detection,
 22 able to escape detection and/or interdiction methods in use, or detected incidentally and never
 23 reported. Where species- and pathway-specific information was lacking, indirect information was used
 24 to supplement assessments. Such information included temperature-monitored shipments of laboratory
 25 mice in experimental studies on survival rates during air transport, as an indication of thermal conditions
 26 experienced by a hitchhiker (Syversen et al. 2008), or experiments determining ship stowaway rates of
 27 rodents within a specific commodity (Baker 1994).

28 **Table A4-1: Whole Number Risk Level Determination Used For Assessing Each of the 16**
 29 **Evaluation Criteria**

Whole number level determination	Level descriptor
Level 0	No Risk
Level 1-2	Extremely Low Level of Risk
Level 3-4	Moderately Low Level of Risk
Level 5-6	Medium Level of Risk
Level 7-8	Moderately High Level of Risk
Level 9-10	Extremely High Level of Risk

30
 31 Critical to the evaluation process was rating uncertainty, which exists to varying degrees in any risk
 32 assessment and thus was included in the analyses (Caley et al. 2006; ANSTF and NISC 2007). If there
 33 were unknowns, we could not be 100% certain of the risks involved; therefore, ratings represented how
 34 certain we were in our assessment of risks. Uncertainty was rated on a whole number scale of 1-5 (1 =

1 slightly uncertain) (Table A4-2). A general rationale for the uncertainty rating, such as flaws in
 2 methodology (Table A4-3), was coupled with specific details to provide justification. For example, the
 3 increased use of technologically advanced military vessels and aircraft in the region is a political
 4 impediment because biosecurity resources are already taxed, and a reason for biological unknowns
 5 because pathways are new, hence they lack information such as species-interception data.

6 **Table A4-2: Whole Number Ratings of Uncertainty in Risk Assessments**

Whole Number Uncertainty Level	Uncertainty Descriptor
Level 1	≥ 95 percent confident of assessment (slightly uncertain)
Level 2	80 percent – 94 percent confident of assessment
Level 3	65 percent – 79 percent confident of assessment
Level 4	50 percent – 64 percent confident of assessment
Level 5	≤ 49 percent confident of assessment (highly uncertain)

7

8 **Table A4-3: General Basis for Uncertainty in Risk Assessment Ratings**

Basis of Uncertainty
Flaws in methodology
Lack of expertise
Lack of issue coherence
Biological unknowns
Insufficient information
Political impediments
Other–Define

9

10 Numerical scores for the 16 questions were averaged for pathway risk rank; uncertainty ratings were
 11 also averaged and factored into risk ratings. Each pathway receives a risk score based on the
 12 combination of these three steps: a risk impact category (to human health, economy, ecology), a
 13 pathway scope level (local to international), and pathway risk ranking, which were used to determine
 14 the scale of invasiveness from a tabulated scoring ranging from 1 to 200; scores below 50 were assumed
 15 to have no harmful impact, from 51 to 100 were considered to be ecologically significant, from 101 to
 16 150 economically significant, and from 151 to 200 significant to human health and safety (ANSTF and
 17 NISC 2007). The final numerical score provides a rough index to prioritize the pathways for significance.
 18 Rationale for each final risk rating was given in brief narrative format, followed by a list of specific risks
 19 identified for that pathway.

20 The Pathways Work Team grouped pathways under three umbrella categories of Transportation (T),
 21 Living Industry (L), and Miscellaneous (M). Pathways were assessed for the potential to unintentionally
 22 transport terrestrial vertebrate hitchhikers, defined as terrestrial vertebrate species unintentionally
 23 moved to a different location in cargo, packing material, or a shipping container used for transport, or
 24 on/in the conveyance of transport (Meissner et al. 2009). These pathways have been linked to the rapid,
 25 worldwide movement and spread of invasive species (Burgiel et al. 2006; Meyerson and Mooney 2007;
 26 Westphal et al. 2008; Hulme 2009; Osborn 2010). We defined an invasive species as a nonnative species
 27 whose establishment causes or is likely to cause harm to human health and safety, the economy
 28 including agriculture, or the ecology of places where they have been introduced (NISC 2005). Expected

1 increased activities in these pathways during and following the proposed military relocation further
2 increases the probability of unintentionally transporting invasive terrestrial vertebrate species
3 throughout the Micronesia Region (Westphal et al. 2008).

4 Unintentional transport of hitchhiking terrestrial vertebrate species occurs in a number of ways.
5 Hitchhiking species may initially become attracted to certain physical or chemical conditions. Examples
6 include rats (*Rattus spp.*) nesting in aircraft wheel wells (Vice 2010c), BTS sheltering inside shipping
7 containers (Fritts et al. 1999), amphibians such as coqui frog (*Eleutherodactylus coqui*) laying eggs
8 among nursery plants and associated materials (Christy et al. 2007c), and mice (*Mus spp.*) feeding on
9 grain and garbage shipments transported overseas (Baker 1994). Hitchhiking might also result when
10 intentionally transported species escape en route from cargo holds (Graglia 2003; TMG 2009). The
11 swimming ability of some hitchhiking species, like rats and lizards, enables them to jump ship in
12 favorable scenarios, such as when the vessels are close to shore (Perry et al. 2006; Russell et al. 2007;
13 Peacock 2010).

14 Species lists were generated using those species known to be successful invaders. Only those species
15 present at the origin site but not present at the destination site were used except for rodents, which can
16 be exposed to a disease present at the origin site that is absent at the destination site, and therefore
17 have the potential to spread disease if they reach the destination site. Species presenting a human
18 health impact are considered high priority. Species of snakes, particularly BTS, and rodents like rats were
19 included due to their impacts on human health, economic interests, and the ecology (Brennan 1980;
20 Baker 1994; Stenseth et al. 2003; Kurle et al. 2008; Vidal 2008; CDC 2010e).

21 A primary management objective in the Micronesia Region is to prevent the spread of BTS from Guam
22 (Vice et al. 2009). The risk assessment accounted for the potential to transport and spread BTS within
23 the Micronesia Region (Engeman et al. 1998b; Fritts et al. 1999; Wiles et al. 2003; Rödder and Lötters
24 2010; Shwiff et al. 2010). BTS presents a unique circumstance in terms of biosecurity; whereas most
25 customs and quarantine inspections occur upon arrival and importation of goods into a country, BTS
26 inspections take place upon departure and export of goods (Vice et al. 2009). Many of the small
27 amphibians and lizards that could also be potentially transported can also become a prey base for BTS
28 (Pitt et al. 2005, Christy et al. 2007a, Christy et al. 2007c).

29 Information is gravely lacking on the science of species survival, or the physical environment
30 experienced by species during varying transport situations, primarily because the science of biological
31 invasions is relatively new (Wonham 2006), the research of species survival is complex in considering
32 myriad factors and their combinations (Meyerson and Mooney 2007), and because the global
33 movement of species is increasing faster than our ability to understand the consequences (Hulme 2009).
34 Assessment of species movement was associated with pathway and species aspects such as the
35 conduciveness of a pathway to transport species, the probability of species survival during transport,
36 probability of survival in the introduced ecosystem, and the biosecurity measures in place. For example,
37 species survival during transport depends upon several factors, including the type of species, an
38 individual's fitness, the duration of transport, and the thermal environment experienced by the
39 hitchhiker (Syversen et al. 2008; Vice and Pitzler 2008). The type of species and its fitness will determine

1 the animal's ability to deal with stressors like temperature extremes, starvation, and dehydration, as
2 observed in a cat (*Felis catus*) that survived 17 days in a goods container shipped overseas from Israel to
3 Britain (Associated Press 2006). Reptiles can endure long durations without food and water, as
4 evidenced by a BTS that survived 7 months in a crate of household goods on a cargo ship from Guam to
5 Texas (USGS 2005a).

6 Temperature variations and extremes during transport influence species survival. For ocean transport,
7 thermal fluctuations and extremes are more likely in surface-shipped freight than for freight transported
8 below decks out of the elements, the latter being more conducive to species survival (Vice and Pitzler
9 2008). Monitored air shipments of laboratory mice indicated that temperature variations and extremes
10 were more common during international versus domestic flights, when freight handlers used
11 commercial over private aircraft, and on transport routes with stopovers (Syversen et al. 2008). Survival
12 also depends upon the availability of food and shelter during transport. For example, feral mice can
13 stow away in garbage, hay, grain, household goods, dog food, mattresses, and tires (Baker 1994). A
14 combination of these factors likely influences the probability of species survival (Vice and Pitzler 2008).

15 Several of the species listed in this risk assessment have characteristics that would allow them to survive
16 during transport, e.g., the ability to survive periods without food or water, or endure varying thermal
17 environments during transport, such as the cold temperatures of aircraft cargo holds. House mice can
18 survive short durations without food, and can adapt to gradual, rather than sudden, decreases of water
19 intake (Haines et al. 1973; Newsome et al. 1976). In laboratory experiments, musk shrews (*Suncus*
20 *murinus*) survived 32 hours of fasting and lived up to 25 days on 25% of their normal daily food
21 consumption (Wayne et al. 1991; Yasuhara et al. 1991).

22 For the frog species *Hyla cinerea* (American green tree frog), the presence of a cutaneous barrier
23 prevents excessive water loss (Wygoda and Williams 1991; Wygoda and Garman 1993); in laboratory
24 experiments, this species endured a week of starvation and a 37% loss of body water (Layne Jr. et al.
25 1989). Arboreal frogs of the genus *Litoria* have lower rates of evaporative water loss than arboreal frogs
26 in North America, also due to a cutaneous lipid barrier (Main and Bentley 1964; Buttemer 1990;
27 Christian and Parry 1997). For *Rana sylvatica* (wood frog), a terrestrial hibernator, the ability to survive
28 temperatures ranging from 1.5°C to 15°C and withstand long periods submerged in ice water (Light
29 1991; Muir et al. 2007) demonstrates the variable thermal environments tolerated by this species during
30 transport.

31 The green anole (*Anolis carolinensis*) can also endure periods of starvation. In one laboratory
32 experiment, the species was able to withstand up to 12 days of starvation (Windell and Sarokon 1976;
33 Brown and Griffin 2005), and in another, they survived a very restrictive food intake regime for 4 weeks
34 (Speedy and Mumme 1994). Other laboratory studies indicate green anoles are able to acclimate to and
35 withstand temperatures ranging from 10°C to 35°C (Ragland et al. 1981; Art and Claussen 1982). In
36 response to conditions of low humidity, the green anole can decrease the rate of cutaneous evaporative
37 water loss, possibly through the deposition of lipids in the skin (Kobayashi et al. 1983; Kattan and
38 Lillywhite 1989). In laboratory experiments, BTS were able to survive temperatures as low as -5°C for 1
39 hour, with half of those surviving temperatures up to 39°C (Christy et al. 2007b). Boa constrictors (*Boa*

1 *constrictor*) were able to survive up to 168 days without food in the laboratory (McCue 2008). Southern
2 ringneck snakes (*Diadophis punctatus*) withstood temperatures ranging from 3°C to 36°C, but could not
3 survive for extended periods of time at 36°C (Henderson 1970). Burmese pythons (*Python molurus*
4 *bivittatus*) can go up to a year without eating (Starck and Beese 2001, 2002). Red-sided garter snakes
5 (*Thamnophis sirtalis parietalis*) survived for a month without food at 25°C in the laboratory (Starck and
6 Beese 2002). Two species of habu (*Trimeresurus elegans* and *Trimeresurus flavoviridis*) have been
7 reported to go for 2 to 3 years without food (Kamura and Nishimura 1992).

8 We factored in the likelihood of species establishing populations at arriving destinations, or the
9 opportunity for species to establish extralimital populations in assigning risk ratings (Livo et al. 1998;
10 Christy et al. 2007c). The likelihood of species establishing populations focused on either species-related
11 or pathway-related aspects. Species-related aspects included assessments of the numbers, types, and
12 frequency rates of species being moved, the viability of transported individuals, if species are difficult to
13 detect within introduced ecosystems, if species are habitat generalists, and if species are further spread
14 by human activity. Pathway-related factors included whether introductions are possible at multiple
15 points of entry, frequency of pathway use, the types of screening procedures in practice at an entry or
16 departure point, and also whether the pathway itself was conducive to moving the species.

17 Risk assessments accounted for cumulative effects of species transport and introduction. Although the
18 cumulative effects of species introductions remain largely unknown (Baker 1994; Wonham 2006;
19 Ricciardi 2007; Caut et al. 2008; Vidal 2008), repeated releases over an extended time period will
20 increase the chance of successful invasion simply because the release “experiment” is repeated many
21 times under different biotic and abiotic conditions, including different climates and seasons, fitness
22 condition of released animals, and numbers of natural enemies present (Bomford 2008). Cumulative
23 effects include invasive genes that spread among native populations rapidly and insidiously; invasive
24 species hybridizing with native species can have biological, aesthetic, and legal implications. For
25 example, populations of threatened California tiger salamanders (*Ambystoma californiense*) are at risk
26 of losing federal protection as a listed species and becoming genetically extinct because of the rapid
27 spread and introgression of introduced alleles from barred tiger salamanders (*A. tigrinum mavortium*)
28 (Fitzpatrick et al. 2010). Further, it is expected that global climate change will exacerbate the worldwide
29 problem of species invasions (Zhang et al. 2006b; Ward and Masters 2007; Sommer et al. 2010),
30 resulting in uncertain long-term impacts. Such influence is evident in cane toads (*Rhinella marina*)
31 introduced into Australia; the species is rapidly expanding its range in part because of changing
32 environmental and habitat conditions (Christy et al. 2007c). Range expansion by introduced species
33 allows them the ability to exert greater predation and competition pressures on natural ecosystems
34 (White et al. 2008; Greenlees et al. 2010; Martin and Pfennig 2010).

35 Because preventive measures are touted as best management practices, the risk assessment took into
36 account operational biosecurity measures in place for preventing the introduction of terrestrial
37 vertebrate species (CDF and WWF 2002; MAF 2003; VPC 2007; Bomford 2008; Australian Government
38 2009;, Biosecurity New Zealand 2009a; CDF 2009; Galapagos Conservancy 2010). Risks were highest
39 where efforts to prevent the transport of species were lowest. Risks were associated with gaps in
40 biosecurity measures resulting from factors such as insufficient port screening capabilities (staff,

1 equipment, etc.) (Wonham 2006, pg. 298), and regulatory provisions made for the military. For example,
2 although military aircraft departing Guam undergo APHIS canine inspection for BTS, for urgent or
3 medical missions aircraft may depart immediately without BTS inspection, thereby increasing the risk of
4 species transport. The risk assessment also included aspects such as whether control measures are
5 known, available, and effective, and whether control and eradication costs are feasible.

6 There were varying degrees of overlap among pathways. Overlap between military and civilian pathways
7 resulted from the common use of facilities, such as military aircraft using commercial airport facilities
8 (DeGuzman 2009). Overlap can occur when a species is able to access another pathway from the one it
9 is in currently. For example, species may escape from cargo into a craft's recesses, or vice versa, as for
10 escapees from a military aircraft carrier (vessel) to a staged aircraft (cargo). Overlap could also occur if
11 animals are being intentionally transported, such as for research or for the pet trade, or as personal
12 pets, and escape during transport (unintentionally) into a pathway.

13 Limited time and resources dictated the exclusion of some pathway assessment. We chose to focus on
14 pathways associated with the relocation that seemed most likely to unintentionally transport terrestrial
15 vertebrate invasive species. Cargo was not addressed as a single pathway because cargo and cargo
16 conveyance transportation is complex; rather, cargo and conveyances, and their transport means, were
17 addressed as they pertain to military activities in the region. Because of time constraints, not all sources
18 of cargo were considered in each pathway; e.g., for plants transported in food-related pathways, the
19 only source considered was the continental United States. Further, mail was not addressed as an
20 unintentional pathway because it was presumed species moving in mail were most likely being
21 intentionally transported, either legally or illegally; however, mail cargo and conveyance pathways are
22 considered because they are capable of transporting species that escape from other pathways.

23 **A4.1.3 Risk Assessment**

24 **A4.1.3.1 *Air Transportation***

25 The air transportation pathways focus on the aircraft itself as the mode of species transport. The term
26 'aircraft' includes both fixed and rotary-wing aircraft in military, commercial, and private sectors.
27 Different types of military, commercial, and privately owned aircraft currently visit, are home-based, or
28 routinely operate on Guam, with air transportation traffic in all three sectors expected to increase from
29 military activities during and after relocation. Plans for the relocation include training and field exercises
30 conducted on the islands of Tinian, Rota, and Saipan, which involve aircraft operations from Guam and
31 from aircraft carriers.

32 Air transportation pathways are capable of unintentionally transporting mammals, reptiles, amphibians,
33 and birds (Table A4-4). The Department of Transportation estimates that more than 2 million live
34 animals are transported each year in passenger cabins and cargo holds (DOT 2005) as pets, laboratory,
35 or medical research animals, or as a commodity in the wildlife trade, demonstrating the conduciveness
36 of air transportation pathways in moving species and supporting species survival during transport (IATA
37 2010). Military forces may be required to deploy virtually anywhere in the world, with great potential
38 for inadvertently spreading or introducing terrestrial vertebrate species (Dalsimer 2002).

1 **Table A4-4: Invasive Species Transported in the Air Transportation Pathway**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL
	<i>Kaloula pulchra</i>	Asian painted frog	ECL
	<i>Polypedates leucomystax</i>	Common tree frog	ECL
Birds	<i>Padda oryzivora</i>	Java finch	ECN
Mammals	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
Reptiles	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL

2 ^a H = health, ECN = economic, ECL = ecological.

3
 4 Terrestrial vertebrate hitchhikers have been found aboard military and commercial aircraft (Brink 1968,
 5 U.S. Navy 2001). Incidents with military aircraft include BTS, and illustrate the ability of BTS to be
 6 transported over a large geographical region on aircraft (Table A4-5) (Claiborne 1997; USGS 2005a).
 7 Hitchhikers aboard civilian aircraft include rodent pups discovered by APHIS-WS inspectors in the rear
 8 wheel well of an aircraft that had landed on Guam in March 2010 (Vice 2010c). Both live and dead mice
 9 have been found within aircraft cabins (Michaels 2005; Bodry 2008; Moriarty 2010). Java finches (*Padda*
 10 *oryzivora*) were found within an aircraft cargo hold (Vice 2009). Four, 6-inch-long pythons escaped from
 11 an “appropriate” shipping container during a domestic Qantas flight over Australia and were never
 12 found upon arrival by luggage handlers or afterwards by fumigators (TMG 2009). Birds common around
 13 airport facilities such as house sparrows (*Passer domesticus*), starlings (*Sturnus vulgaris*), pigeons
 14 (*Columba spp.*), and mynahs (*Acridotheres spp.*) attract predatory reptiles and rodents that may then
 15 enter aircraft (Brink 1968; Christy et al. 2007c; Gandhi 2009; Cohen 2010).

16 **Table A4-5: Examples of BTS Transport in Military Aircraft**

Location	Year	Number of snakes found	Aircraft type
Kwajalein Atoll	1979	1	Cargo plane
Darwin, Australia	1984	1	B-52 bomber
Kadena AFB, Okinawa	1992	1	unknown
Hickham AFB, Hawai'i	1997	1	Cargo plane

17 Source: Claiborne 1997; Rodda et al. 1999b; USGS 2005a

18
 19 Guam’s population is expected to increase due to the military relocation in both military and
 20 commercial sectors, thereby increasing air transportation activity throughout the region. Such activity
 21 includes military travel for training and services deployment. An increase is expected in military and
 22 civilian inter-island travel for recreation and tourism in the region, the latter necessary for regional
 23 economic growth. Travel may also increase for family visits to and from abroad. On Saipan, tourism is an
 24 economic driver alongside manufacturing. Rota boasts increasing economic development and legalized
 25 gambling, and has an emerging tourism industry that targets service members. Tinian’s primary
 26 community, San Jose, is agricultural. From 2000 to 2005, 90% of tourists visiting CNMI came from East
 27 and Southeast Asia (NOAA 2005). The expected increase in commercial air transportation traffic is
 28 evident in the scope of improvements underway at airports on Saipan, Tinian, Rota, and Guam (CPA
 29 2007a, b; Todeno 2009; Deposa 2010; Guam ABWPIA 2010; Saipan Tribune 2010). Increased air traffic
 30 will increase the risk of vertebrate invasive species being transported on aircraft.

1 **A4.1.3.1.1 Commercial Air Traffic**

2 Commercial aircraft arrive and depart Guam at A.B. Won Pat International Airport, hereafter Guam
 3 International Airport, which serves “over 300 flights per week” (Guam ABWPIA 2010). These flights
 4 consist of daily international cargo and passenger transport. Traffic consists mainly of local aviators and
 5 inter-island taxi traffic, combined and referred to herein as commuter traffic (Table A4-6). Seven
 6 international airlines and six air freight couriers operate out of the Guam International Airport (WPIAA
 7 2010b, a). Guam’s commuter airlines include Freedom Air, Cape Air, and Pacific Island Aviation. Private
 8 jet planes traveling through the area are provided with full executive jet service and maintenance
 9 through Aviation Concepts, Airport Group International, and Guam flight services. The airport has 21
 10 aircraft parking positions with 18 common use terminal gates (GEDA 2010). GCOA is available during
 11 scheduled aircraft operations and upon prior arrangement with field supervisors.

12 **Table A4-6: Airport Operational Statistics for Guam and CNMI International Airports**

	Guam ^a	Tinian ^b	Saipan ^c	Rota ^d
Aircraft based on the field	83	6	22	- ^e
Single engine airplanes	20	4	14	-
Multi-engine airplanes	10	2	8	-
Jet airplanes	52	-	-	-
Helicopters	1	-	-	-
Average aircraft operations/day	108	36	108	127
Percent commercial flights	55	<1	18	27
Percent air taxi flights	24	98	61	69
Percent local general aviation flights	21	1	2	3
Percent transient general aviation flights	<1	<1	16	<1
Percent military flights	<1	<1	1	<1

13 ^a For the 12-month period ending 04 May 2007 (AirNav 2010b).

14 ^b For the 12-month period ending 04 May 2009 (AirNav 2010d).

15 ^c For the 12-month period ending 31 December 2007 (AirNav 2010a).

16 ^d For the 12-month period ending 08 May 2008 (AirNav 2010c).

17 ^e Data unavailable.

18
 19 The Francisco C. Ada Saipan International Airport houses several major airlines and a commuter
 20 terminal. Commuter traffic makes up the majority of the flights to and from Saipan (see Table A4-6). The
 21 major airlines are Asiana, Delta, United Airlines, Northwest Airlines, China Southern, Air China, Shanghai
 22 Airlines, China Eastern, and All Nippon Airways. They provide direct flights from Guam, Japan, Korea,
 23 Hong Kong, Manila, and China. Cape Air, Star Marianas, and Freedom Air provide commuter services to
 24 Tinian, Rota, and Guam (CPA 2007b; Deposa 2010; FlightStats 2010; POI 2010). The airport operates 24
 25 hours, 7 days a week and has 24-hour availability of operating aircraft rescue personnel and equipment
 26 (CPA 2007b). Ground-handling services are provided by POI Aviation Services which is affiliated with Tan
 27 Holdings Company (POI 2010). Immigration and customs officials are available during scheduled
 28 operations, or by prior arrangements with the chief of Immigration Saipan (AirNav 2010a).

29 The majority of flights to and from Tinian are commuter flights (see Table A4-6). Tinian is serviced by
 30 Freedom Air, operating daily flights, and the privately chartered Star Marianas Air that provides services
 31 for the Tinian Dynasty Hotel & Casino customers (CPA 2005). Construction of a high-speed taxiway is

1 currently being advertised for bid and is expected to increase traffic (AirNav 2010d). Ongoing
 2 construction of a new departure terminal is slated to be finished in September 2010 (Saipan Tribune
 3 2010). The airport is equipped for night operation, with night flights from Saipan and Guam for the hotel
 4 and casino (CPA 2005). Immigration and customs officials are available during scheduled operations, or
 5 by prior arrangements with the chief of Immigration Saipan. The airport is also closed to unscheduled
 6 flights of carriers with more than 10 passenger seats without 24 hours' written notice to the airport
 7 manager (AirNav 2010d).

8 Traffic at the Rota International Airport also consists mainly of commuter flights, primarily from Saipan
 9 and Guam (see Table A4-6). Commuter airlines include Freedom Air and Cape Air, the latter a United
 10 Airlines Connection partner. Cape Air is suspending flights to Rota as of 5 October 2010 due to required
 11 scheduled maintenance on the ATR aircraft currently in service (PNC 2010). The airport is equipped for
 12 nighttime operations (CPA 2007a). Immigration, customs, and quarantine officials are available during
 13 scheduled aircraft operations and upon prior arrangements with field supervisors (AirNav 2010c).

14 United Airlines and its affiliates were selected as representative of these pathways, although other
 15 carriers provide similar services (Table A4-7) (United Airlines 2010). The flights listed in Table A4-7 are
 16 the flights that were evaluated and are by no means the only flights to and from Guam. Additionally,
 17 there are other carriers in the region other than United Airlines; however, many of their flights are
 18 similar to United's and are not listed here. From the continental United States, all other major carriers
 19 route through either Hawai'i or Japan.

20 **Table A4-7: Representative Flights to and From Guam on**
 21 **United Airlines and Its Affiliates**

Flight origin	Flight destination	Number of flights/day
Guam	Tokyo, Japan	3
Honolulu, Hawai'i	Guam	2a
Guam	FSM and RMI	1b
Guam	Palau	1
Guam	Saipan	6

22 ^a One flight is nonstop. The other flight makes five stops in Majuro (RMI), Kwajalein (RMI),
 23 Kosrae (FSM), Pohnpei (FSM), and Chuuk (FSM).

24 ^b Stops in Chuuk (FSM), Pohnpei (FSM), Kosrae (FSM), Kwajalein (RMI), and Majuro (RMI).
 25

26 **A4.1.3.1.2 Military Air Traffic**

27 Military air traffic is expected to increase during and after the relocation as personnel are moved and
 28 training exercises increase. Military activities using air transportation pathways include those by the U.S.
 29 Transportation Command which oversees the movement of military personnel and equipment via
 30 aircraft, the U.S. Air Force Air Mobility Command that provides strategic and tactical airlift support for
 31 military operations by moving personnel and cargo, and the movement of military cargo not consigned
 32 to commercial carriers that would be transported by Air Mobility Command aircraft. Aircraft arrivals at
 33 Andersen AFB on Guam include both military and civilian flights resulting from training exercises,
 34 transporting military dependents, and moving cargo. Military aircraft are used in medical or other types

1 of emergency missions, and these aircraft can depart Guam with little or no advance notice or BTS
 2 inspection. Aircraft operations for military training purposes are conducted by the Army, Marine Corps,
 3 Air Force, and Navy (U.S. Navy 2009j). Additional aircraft will be housed on Andersen AFB by the Marine
 4 Corps associated with the relocation, and additional training activities will occur (U.S. Navy 2009a).

5 On Tinian, the Marianas Island Range Complex draft EIS/Overseas EIS (U.S. Navy 2009j) identifies three
 6 range activities (strike warfare and two amphibious warfare activities) that presently include aircraft
 7 training (Table A4-8). Aircraft for these activities may come from the airfield or be staged on an aircraft
 8 carrier. The North Field on Tinian is an abandoned and unmaintained World War II era airfield with four
 9 runways. Two are abandoned and overgrown, one is used for military fixed-wing and helicopter
 10 activities, and the other is used for parachute drops and helicopter activities.

11 **Table A4-8: Range Activities on Tinian Utilizing Aircraft**

Training exercise	Type of aircraft utilized	Number of sorties/year ^a
Strike warfare (combat search and rescue)	SH-60, MH-60, HH-60, CH-53, C-17, C-130, V-22	≤ 75
Amphibious assault warfare	H-53, H-46, MV-22, UH-1, AH-1, AV-8	≤ 5
Amphibious raid warfare	H-53, H-46, MV-22, UH-1, AH-1, AV-8	≤ 2

12 ^a A sortie is defined as an operational flight by a single aircraft, as in a military operation.

13
 14 Training missions associated with various aircraft staged on a carrier are identified in the Marianas
 15 Island Range Complex draft EIS/Overseas EIS, but actual numbers are difficult to come by (U.S. Navy
 16 2009j). Should the carrier transit from Guam to CNMI, aircraft can redeploy rapidly with little time for an
 17 invasive species to leave the aircraft, particularly if this transfer occurs during daylight. Aircraft that are
 18 unloaded from the carrier while in port are considered cargo (U.S. Navy 2009b).

19 **A4.1.3.1.3 Aircraft Inspection**

20 Currently, biosecurity inspection procedures differ for military and commercial aircraft, between arriving
 21 and departing crafts, among the region’s airport security systems, and according to species of concern.
 22 Because inspections of any aircraft departing Guam, commercial or military, are primarily designed to
 23 detect BTS (BTS CEC 1996; USAF 2007), other species not specifically targeted have the potential to be
 24 missed or overlooked. Arriving military and commercial aircraft are not usually inspected for terrestrial
 25 vertebrate species by APHIS-WS unless an incident has been reported aboard (Vice 2010a).

26 **Inspections for BTS**

27 A Brown Treesnake Control and Interdiction Plan was developed by the Navy to prevent the movement
 28 of BTS off of Guam in response to Executive Order 13112, Invasive Species (The White House 1999; U.S.
 29 Navy 2005b). Executive Order 13112 made it the responsibility of all federal agencies to prevent the
 30 introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires
 31 the military to cooperate fully with federal authorities during observations and inspections of cargo
 32 destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to
 33 effectively implement the plan. The plan directs the Department of the Interior and USDA to go through
 34 a rulemaking process on BTS inspections.

1 In general, all aircraft undergo similar inspection processes for BTS, regardless of the aircraft type and
2 use. Planes that are not "quick turns" (on the ground for 3 hours or less) are inspected exteriorly using
3 both detector dog and visual inspection. Very rarely are internal inspections of planes undertaken. It is
4 highly unusual for a plane door to be left open if there is not someone immediately around the aircraft.
5 If a plane is down for extended service, it is more likely to have hatches, doors, or exterior
6 compartments open for extended periods. Depending upon circumstances, an internal inspection on
7 such a plane may be done, but is not the norm (Vice 2010d). Additionally, if cargo is loaded onto a plane
8 without prior inspection, an internal inspection of the craft may be conducted. In 2008 APHIS-WS
9 inspected 88.6% of all departing commercial aircraft, and more than 98% of all departing military aircraft
10 (USDA-APHIS WS 2008a).

11 All aircraft departing Guam are required to be inspected by APHIS-WS (U.S. Navy 2005b). APHIS-WS
12 maintains dogs and equipment necessary to implement BTS control plans. During major exercises,
13 commanders are to work with both Andersen AFB and APHIS-WS personnel to develop an aircraft
14 parking plan to minimize BTS entry into aircraft. If APHIS-WS inspects an aircraft which subsequently is
15 delayed in scheduled departure (after hours of darkness), WS may require another inspection prior to
16 departure. Authority is given to APHIS-WS to stop the departure of aircraft from Guam, with some
17 exceptions, if it is suspected to be harboring BTS; e.g., BTS inspections cannot delay medical emergency
18 departures.

19 Military flight crews are instructed to keep doors of aircraft closed when the aircraft is idling to prevent
20 entry of BTS, and to be aware of the potential for BTS presence during pre-flight inspections (U.S. Navy
21 2005a). All vehicles being shipped are required to be cleaned prior to departure from Guam. High-risk
22 aircraft, such as those used in field exercises, may require additional measures. Such measures may
23 include high-pressure washing, steam-cleaning, fumigation, or other methods required by DoD policy.

24 ***Military Aircraft Inspections***

25 The Quarantine Regulations of the Armed Forces were written to allow the military to comply with the
26 regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, Homeland
27 Security, Interior, and Commerce (DoD 1992). This was superseded by OPNAVINST 6210.2. The
28 regulations are designed to prevent the introduction and spread of disease agents (human, animal, and
29 plant), arthropod vectors, and pests of health or agricultural importance. The documents state that the
30 military is to cooperate with the agencies listed above to comply with regulations. Inspectors from these
31 agencies are authorized to board and inspect aircraft. However, inspectors from foreign countries are
32 not allowed aboard aircraft, even to observe an inspection. In these cases, commanding officers certify
33 compliance with the quarantine regulations of the foreign country to foreign officials. Certification may
34 include a general description of the measures taken to be in compliance.

35 Section II, Subsection B of the Quarantine Regulations of the Armed Forces and Section 9b of
36 OPNAVINST 6210.2 specifically govern aircraft (DoD 1992). Measures are to be taken prior to departure
37 to minimize movement of human disease vectors and arthropod vectors of medical importance. Aircraft
38 commanders are to comply with the medical and agricultural quarantine regulations of the destination
39 country that are published in the U.S. Air Force Foreign Clearance Guide (AFR 8-5 and OPNAVINST

1 3710.2E). Aerosol disinfectants are required when leaving areas known to harbor yellow fever, malaria,
2 or plague, unless a World Health Organization (WHO)- or DoD-approved disinfectant has been used and
3 the aircraft contains certification to that effect. Commanding officers at the point of departure
4 (embarkation) are required to determine whether mosquitoes or other vectors and pests of medical
5 importance are near the airport. In addition, officers are required to undertake pest control measures to
6 eliminate such pests, and minimize their access to aircraft. Commanding officers at the point of entry
7 (debarkation) are required to eliminate breeding places that could be readily accessible to vectors or
8 pests of medical importance, and to conduct routine surveillance for such pests.

9 Section II, Subsection C of the Quarantine Regulations of the Armed Forces and Section 10 of
10 OPNAVINST 6210.2 cover the USDA requirements. These sections govern the movement of animal and
11 plant diseases and pests. Aircraft moving between Hawai'i, Guam, Puerto Rico, the U.S. Virgin Islands,
12 and the continental United States are required to undergo USDA inspection by a USDA inspector or
13 representative. GCQA officers collaborate with USDA-APHIS to enforce federal regulations and have the
14 authority to board military aircraft, provided cargo is not classified and the aircraft are not actively
15 engaged in warfare (Taijeron 2010c), despite recent military questioning of the authority of GCQA to
16 conduct inspections of military aircraft and ships (Delgado 2009, U.S. Navy 2009k). The disinfection
17 measures currently available target primarily disease organisms and insects and may not be effective on
18 many of the invasive species transported in aircraft. Subsection C requires surveillance aboard aircraft
19 that includes spot checking and routine collection and identification of pest organisms.

20 The Defense Transportation Regulations, Part V establishes the requirements for agricultural cleaning
21 and inspection, and the assignment of DoD personnel as agricultural and customs inspectors for pre-
22 clearance programs. USDA-APHIS is responsible for providing DoD with guidance, information, and
23 training to perform pre-clearance inspections (DoD 2009a). APHIS remains the final authority on the
24 pest risk status of material or equipment. Stores and in-flight meals may not enter the United States and
25 garbage must be placed in tight, leak-proof, covered containers and disposed of according to port
26 procedures (DoD 2009a).

27 To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for
28 cargo and equipment returning to the Customs territories of the United States (CTUS) (DoD 2009c). Pre-
29 clearance inspections may be requested for redeployment from major exercises or contingencies, and
30 are performed at the point of origin. Requests for pre-clearance inspections must be submitted no later
31 than 75 days prior to when the inspection is needed. Requests must contain the following information:
32 dates, times, and place of departure from a foreign country; date, time, and place of arrival in the CTUS;
33 number and type of aircraft; identification of all stops between the point of departure and arrival; and
34 whether the border clearance integrity of the aircraft will be maintained during en route stops.
35 Examples of clearance integrity being breached are the addition or removal of cargo or passengers at
36 any stop, crew member changes, off-loading of crew and passengers, or the aircraft remaining in a
37 location overnight. Such breaches of integrity will void the pre-clearance authority.

38 Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military
39 (DoD 2009c). When the planned destination is in the CTUS, Customs Border Clearance Agents inspect

1 aircraft to ensure it is free of plants, animals, or plant and animal products. Equipment must be stored in
2 a way that prevents re-infestation by pests. In addition, CBP can establish a Military Customs
3 Inspectors–Excepted program at a DoD installation (DoD 2009d). Such a program allows DoD personnel
4 to perform the same functions as CBP agents in connection with arriving military or military-chartered
5 aircraft from overseas areas. Inspection duties of the DoD personnel under this program include
6 customs, immigration, and agricultural inspections or functions.

7 The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning
8 and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Large aircraft
9 that remain on the flightline are to have protected areas, such as wheel wells and around cargo and
10 passenger doors, cleaned. A visual inspection of cargo and the flight deck is performed to determine
11 whether further cleaning is needed. For fixed and rotary wing aircraft, the following areas are cleaned:
12 cabin area, cockpit, wheels, wheel wells, skid/runner bars, under deck plates, panels, in flap wells, and
13 all other areas where debris may lodge. Cleaning may consist of a water wash or steam as determined
14 by the inspector on site. Washing and inspection of aircraft may only occur during daylight hours. We
15 had hoped to see the cleaning of aircraft performed while we were on Guam, and specifically requested
16 this, but were unable to schedule a demonstration.

17 ***Commercial Aircraft Inspections***

18 The CFR provides some guidance on aircraft inspection and disinfection as it pertains to movement of
19 regulated articles from Hawai'i and the territories, and movement of animals or animal parts. The
20 pertinent portions are Title 7 (regulated articles from Hawai'i and the territories), Title 9 (movement of
21 animals and animal parts), and Title 42 (public health). Title 7 (Subtitle B, Volume 5, Chapter 3, Part
22 3A.13-9 and Part 330.111) requires inspectors be notified prior to departure or arrival of aircraft on
23 Guam, giving ample opportunity for the inspection process to occur. Title 9 (Volume 1, Chapter 1,
24 Subchapter D, Part 93) allows the inspection of any aircraft from foreign locations without a warrant to
25 determine whether the aircraft is carrying any animal or animal part subject to disposal to prevent the
26 spread of disease. If the aircraft is found to be contaminated, the operator of the aircraft is responsible
27 for disinfection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) also requires the disinfection of an
28 aircraft if it has transported restricted items that were not contained in leak-proof containers. The
29 method of cleaning prescribed in Title 9 (Part 95) includes the collection of litter and refuse, and
30 disposal of that refuse by incineration or other approved method. This is to be followed by cleaning of
31 the areas of the aircraft that were exposed to the contaminant and saturation of the contaminated
32 surface with an approved disinfectant. The approved disinfectants are sodium carbonate solutions,
33 sodium hydroxide solutions, or liquefied phenol. These disinfectants are specifically designed to target
34 foot-and-mouth disease, rinderpest, and ticks. Title 42 (Part 71, Subpart E, Section 71.41) of the CFR
35 states that carriers arriving at U.S. ports are subject to sanitary inspections to look for rodent, insect, or
36 vermin infestation that may spread disease.

37 The APHIS-PPQ Manual for Agricultural Clearance contains information on the inspection of aircraft
38 (USDA-APHIS-PPQ 2013). The manual instructs inspectors to look for "hitchhiking pests" on the aircraft,
39 but does not specify whether this only refers to insects or also includes vertebrates. Inspectors are to

1 board the aircraft after passengers have deplaned but prior to airline personnel, such as caterers and
2 cleaners, to conduct their inspections. The areas to be inspected are the galley area and areas where
3 stores are kept, passenger and crew areas, and cargo holds for cargo and military flights. The manual
4 specifically instructs inspectors to look for hitchhiking insects in cargo holds, but does not mention
5 vertebrate invasive species. Cargo holds are also to be inspected for plant and animal contamination and
6 soil. If contamination or live pests are found, the aircraft must be disinfected. Disinfection procedures
7 for animal contamination include treatment with Virkon®S or sodium carbonate with sodium silicate.
8 Disinfection procedures for live pests are to be determined by a CBP Agricultural Specialist according to
9 the APHIS-PPQ Treatment Manual. The treatment manual only contains guidance for treatment when
10 khapra beetles, fruit flies, and soft bodied insects are found (USDA-APHIS-PPQ 2008). State aircraft are
11 exempt from inspection unless there is a specific agreement in place that allows inspection. State
12 aircraft are aircraft that have been given Diplomatic Overflight and Landing Clearance by the
13 Department of State, Bureau of Political-Military Affairs, and Office of International Security Operations.

14 On July 18, 2007, the United States became a party to the International Health Regulations adopted by
15 the WHO to mitigate public health risks associated with international travel (WHO 2005b). In 2009, the
16 WHO published an updated guideline for hygiene and sanitation practices in aviation to protect
17 passengers from serious illnesses (WHO 2009b). These regulations prescribe measures for routine
18 cleaning of aircraft and procedures to be used when specific disinfection is required due to a known or
19 suspected infected person traveling aboard the aircraft. All procedures in this guideline are focused on
20 the spread of human disease primarily by humans or contaminated food and water.

21 ***Guam***

22 GCQA officers clear aircraft, passengers, and cargo at the airport (Taijeron 2010a). There are seven
23 officers at the airport to inspect air freight and 16 officers to process passengers (Taijeron 2010a). In
24 addition to enforcing local regulations, GCQA officers collaborate with USDA-APHIS to enforce federal
25 regulations (Taijeron 2010c). Inspections by the seven GCQA officers are focused on the interior of the
26 plane and its compartments specifically to search for smuggled contraband, live animals, cargo with a
27 manifest, agriculture violations, and abandoned agricultural items (Taijeron 2010b). In addition, GCQA
28 ensures that garbage aboard aircraft meet local and federal requirements. If pests are found aboard the
29 aircraft, the aircraft doors are shut, and appropriate measures are taken to handle the infestation (Reyes
30 2010).

31 ***Commonwealth of the Northern Mariana Islands***

32 Aircraft from foreign countries arriving in Saipan are cleared by two separate agencies, Saipan Customs
33 and Saipan Quarantine. In CNMI, the Customs Service is under the jurisdiction of the Department of
34 Finance, whereas the Quarantine Service is under the Department of Lands and Natural Resources. All
35 commercial aircraft arriving at the airport in Saipan from Guam are inspected by a BTS detector dog
36 team (Pangolinean 2010). No other inspections are made. There are 14 quarantine officers assigned to
37 operate 24 hours a day, 7 days a week. If a BTS is detected in an aircraft or cargo, Saipan Division of Fish
38 and Wildlife is notified. In addition, if any animals or insects are found, the container is closed and
39 APHIS-PPQ is notified. The Department of Land and Natural Resources, Division of Fish and Wildlife is in

1 charge of training BTS detector dogs (Onni 2010). It takes 1 to 2 months to train a dog training 1 day per
2 week. To be a certified BTS detector dog, dogs must be able to find 80% of the BTS present. Currently,
3 there are four BTS detector dogs on Saipan, and one on Tinian. Funding has been obtained to place a
4 BTS detector dog on Rota. There are 50 BTS traps at the airport, operated by the Division of Fish and
5 Wildlife which currently must breed their own mice for the traps, that are serviced twice a week.

6 Currently, the BTS handler on Tinian only has a snake skin to train the single detector dog. Therefore,
7 the dog is accustomed to finding a dead BTS as opposed to a live BTS. Additionally, because there is only
8 one skin, the dog is used to finding only a single snake (Castro 2010). Additional training is provided off
9 island, but it has been difficult to obtain matching funds from CNMI agencies to send personnel to the
10 training. Personnel must breed their own mice for BTS traps, and recently some traps have been
11 removed due to a lack of mice. The mouse colony on Tinian collapsed due to disease, and personnel did
12 not have the resources to purchase new mice. On Tinian there are two issues; first, customs officials
13 there are not always notified when aircraft bound for Tinian depart Guam without a BTS inspection, and
14 second, even when notified, there is little or no response capability. Customs officials need
15 approximately 12 hours prior notice to enable them to conduct the necessary inspections (Ferrell 2010).

16 ***Federated States of Micronesia***

17 According to FSMC Title 18, Chapter 2 § 206, any aircraft entering FSM is subject to inspections by
18 customs, immigration, agriculture, and administrative personnel. We were unable to find any
19 information regarding exactly what these inspections entail. The immigration regulations of FSM state
20 that all aircraft will be inspected for stowaways, presumably human (FSM ORC 2005). FSM developed a
21 National Biosecurity Strategy and Action Plan in 2002 (FSM 2002), and each of the four FSM states
22 (Kosrae, Pohnpei, Chuuk, and Yap) provided input for the plan. Overall coordination and support is
23 provided through the Environmental Management and Sustainable Development Council and the
24 Department of Economic Affairs.

25 ***Republic of the Marshall Islands***

26 Aircraft entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public
27 health, or administrative personnel as stated in Title 43, Chapter 2, Section 205 of the Marshall Islands
28 Revised Code (PacLII 2003). According to Title 8, Chapter 1, Section 110 of the Marshall Islands Revised
29 Code, aircraft known or suspected to be harboring insects or agricultural pests are to be sprayed with an
30 insecticide (PacLII 2004a). Any employee of the RMI Ports Authority may enter an aircraft for the
31 purpose of inspection according to Title 22, Chapter 1, Section 153 of the Marshall Islands Revised Code
32 (PacLII 2004c).

33 ***Palau***

34 No information could be accessed regarding inspections of aircraft in Palau.

35 ***Japan***

36 No information could be accessed regarding inspections of aircraft in Japan.

1 **Hawai'i**

2 Aircraft inspections follow the procedures outlined above for commercial aircraft inspections. There is a
3 toll-free pest hotline to call if a BTS or other suspected alien pest is sighted, and various agencies and
4 offices throughout Hawai'i have trained responders available.

5 Summary of Findings

6 All aircraft pathways were considered high risk because they can transport BTS and other IAS. In
7 addition, rodent damage, such as gnawing aircraft electrical wiring, can have dangerous consequences
8 (WHO 1995, pg. 7; Song et al. 2003; Moriarty 2010). Risk increased as the probability of species survival
9 during transport increased. Higher risk was associated with planes on routes with few or no stops that
10 travel over relatively short distances and/or durations, due to the increased probability of survival.

11 Risk also increased based on several factors related to the process of inspection. For military aircraft,
12 risks were higher for conveyances not inspected, such as those departing on urgent missions, which are
13 not delayed for BTS (or other terrestrial vertebrate) inspections. The risk of inspectors missing an
14 invasive species increased as time constraints and equipment unavailability (broken or nonexistent
15 equipment) increased, or the number of inspectors decreased. Risk rankings also reflected increased
16 commercial air traffic without adequate increases in biosecurity needs, such as additional staffing for
17 inspections and enforcement, updated equipment and facilities, continued training, and easier reporting
18 capabilities.

19 **A4.1.3.1.4 Specific Risk Factors**

20 The specific risk factors we found to be associated with the air transportation pathways are as follows:

21 **Common Risk Factors**

- 22 • BTS inspections may not address the movement of other potentially invasive species.
- 23 • No rapid response program or formal reporting network exists for introductory detections
24 of vertebrate species other than alien snakes, albeit, the region does utilize informal
25 networking to report potential alien species encounters and to ilicite support from a variety
26 of internal and external resources. Formal reporting mechanisms with jurisdictional and
27 regional coordinating offices established and utilized would be preferable.
- 28 •
- 29 • Agricultural inspections at the port of entry may not adequately detect a vertebrate invasive
30 species moving in aircraft.
- 31 • There are limited control measures for frogs and snakes that could be moved in aircraft
32 pathways.
- 33 • There are no rapid lethal control methods for use to control reptile or amphibian
34 infestations on aircraft.

1 ***Risk Factors Associated With Commercial Aircraft***

- 2 • Inadequate financial resources exist in the CNMI, FSM, RMI, and Palau to maintain
3 expensive control programs.
- 4 • Staffing is inadequate to meet current quarantine demands. Guam needs a total of 100 staff
5 to meet anticipated demands of the relocation (Campbell 2010c). Saipan presently has 14
6 inspectors, and needs a total of 28 to meet demands (Pangolinean 2010). Tinian presently
7 has 4 inspectors, and needs a total of 12 to meet demands (Berringer 2010c).
- 8 • Airports lack adequate screening equipment and facilities for effective and comprehensive
9 inspections.

10 ***Risk Factors Associated With the Military***

- 11 • The retrograde washdown and inspection process (AFPMB 2008) is focused on preventing
12 the transport of agriculturally significant pests on vehicles and may not be effective for
13 preventing the transport of vertebrate invasive species.
- 14 • Aircraft used in urgent missions such as search and rescue and medical evacuations are not
15 delayed for BTS (or other terrestrial vertebrate) inspections.
- 16 • Communication is inadequate between the military and officials on Tinian to allow for
17 proper inspections of aircraft associated with military training to occur, and even when
18 notified, there is little or no response capability.

19 **A4.1.3.2 *Water Transportation***

20 The water transportation pathways focus on the vessel itself as the mode of species transport, and
21 include military, commercial, and private sector vessels. Types of vessels are numerous, including but
22 not limited to rigid inflatable boats, long-line fishing boats, sailboats, amphibious landing craft, high-
23 speed catamarans, cruise ships, container ships, cargo ships (bulk, break-bulk, roll-on/roll-off), aircraft
24 carriers, landing craft utility vessels, barges, inter-island ferries, cruise ships and shuttles, platforms, and
25 hovercraft. Different types of military, commercial, and privately owned vessels currently visit, are
26 home-based, or routinely operate on Guam with water transportation traffic in all three sectors
27 expected to increase from military activities during and after relocation. Plans for the relocation include
28 the construction and use of training ranges for field exercises and activities on the islands of Tinian,
29 Rota, and Saipan, which involves water transport of materials, equipment, and vehicles for range
30 construction, operation, and field exercises. Assessment of these pathways excludes evaluating items
31 carried on a ship such as cargo.

32 Water transportation vessels pose several risks in transporting terrestrial vertebrate species. The wide
33 diversity of vessels operating in the Micronesia Region, along with the current and expected increase in
34 vessel traffic due to military relocation, offer a variety of transport opportunities to hitchhiking
35 terrestrial vertebrate pests. For example, on high-speed catamarans with long-distance capabilities in
36 use by the military (Tack 2010), the probability of species survival during rapid transit times is increased,
37 along with the chance for far-ranging spread and dispersal, whereas the same hitchhiker in the hold of a

1 commercial cargo ship would typically experience longer transit durations that decrease survival
 2 probability en route; however, the global trade via the water transportation industry still facilitates the
 3 widespread movement and dispersal of pest species (Burgiel et al. 2006; Meyerson and Mooney 2007;
 4 Westphal et al. 2008; Hulme 2009; Osborn 2010). Vessels that are in direct contact with the ground,
 5 such as vessels in dry storage; are within shipyard facilities; or have technological advances such as
 6 military amphibious vessels, are vulnerable to species access. Vessels vary in their capacity for harboring
 7 species, depending upon the vessel's physical size and configuration. For example, a bulk cargo ship
 8 typically has fewer areas for harboring terrestrial vertebrate species than a break-bulk cargo ship, but
 9 both will have more discrete hiding places than a barge. All of these aspects increase the probability of
 10 successful species transport, including their myriad possible combinations.

11 Rodents have a history of hitchhiking in water transportation pathways (AQIS 2010), and are therefore
 12 considered a concern. Rats are a particular concern because rat species have reached about 80% of the
 13 world's islands and are among the most successful invasive mammals (Caut et al. 2008; Peacock 2010).
 14 Marine port facilities with rodent infestations have a higher likelihood of introducing them into the
 15 water transportation pathways (2005). As much as one-quarter of Chinese seaports have rodent
 16 infestations (Song et al. 2003). Rodent infestations around port facilities can occur from improper
 17 garbage handling and waste disposal and employees feeding the wildlife, combined with inadequate
 18 resources to control or eradicate detected populations or educate port staff (WHO 2007b, 2010h).
 19 Detection systems for rat introductions are lacking overall (Jarrad et al. 2010). Rodents, such as rats, are
 20 capable of swimming to and from shore in favorable scenarios (Peacock 2010). Other species are also
 21 capable of being transported in water transportation pathways (Table A4-9). Because rodents are well-
 22 known vectors of disease and are often well established at ports, this makes their presence on ships a
 23 special concern (WHO 2007b; Meerburg et al. 2009; WHO 2010h). Due to their confined nature, ships
 24 are conducive to spreading disease among passengers and crew (WHO 2007b, 2010h). This, combined
 25 with global travel, presents a risk of spreading infectious diseases to other ports.

26 **Table A4-9: Invasive Species Transported in the Water Transportation Pathway**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Bufo gargarizans</i>	Asiatic toad	ECL
	<i>Kaloula picta</i>	Slender-digit chorus frog	None foundb
	<i>Rana catesbeiana</i>	American bullfrog	ECN, ECL
	<i>Rhinella marina</i>	Cane toad	H, ECN, ECL
Birds	<i>Columba livia</i>	Rock dove	H, ECN, ECL
	<i>Dicrurus macrocercus</i>	Drongo	ECL
	<i>Padda oryzivora</i>	Java sparrow	ECN
	<i>Passer domesticus</i>	House sparrow	H, ECN, ECL
	<i>Passer montanus</i>	Tree sparrow	ECN
	<i>Pycnonotus jocosus</i>	Red-whiskered bulbul	ECN, ECL
	<i>Streptopelia bitorquata dusimieri</i>	Philippine turtle dove	ECL
Mammals	<i>Herpestes javanicus</i>	Small mongoose	H, ECN, ECL
	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL

Class	Scientific name	Common name	Risk type ^a
	<i>Rattus rattus</i>	Black rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Anolis carolinensis</i>	Green anole	ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Dinodon rufozonatum</i>	Red banded snake	None found
	<i>Elaphe carinata</i>	Taiwan stink snake	None found
	<i>Elaphe taeniura friesi</i>	Taiwan beauty snake	None found
	<i>Gehyra mutilata</i>	Mutilating gecko	None found
	<i>Gekko gekko</i>	Tokay gecko	ECL
	<i>Hemidactylus frenatus</i>	Common house gecko	ECL
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found
	<i>Naja kaouthia</i>	Monocled cobra	H
	<i>Trimeresurus elegans</i>	Sakashima habu	H
	<i>Trimeresurus flavoviridis</i>	Habu	H
	<i>Trimeresurus mucrosquamatu</i>	Taiwan habu	H
	<i>Xenochrophis piscator</i>	Asiatic water snake	None found

a H = health, ECN = economic, ECL = ecological.

b No impacts found in the literature, but undocumented impacts may exist.

Both commercial and military maritime traffic are expected to increase due to the relocation, thereby increasing the risk of moving invasive species. Commercial maritime traffic plays a significant role in transporting a majority of commodities moved throughout the Micronesia Region, and maritime traffic in general will transport a majority of the cargo associated with the relocation on Guam (U.S. Navy 2009j, pages 97-112). Military maritime traffic will significantly impact the potential to transport vertebrate invasive species to Guam and CNMI. The complex set of training activities following the relocation on Guam and Tinian combined with the technically advanced types of military vessels used in the region pose significant opportunities for the movement of vertebrate invasive species (U.S. Navy 2009a, j). Vessels calling on the Port of Guam do so at Apra Harbor, which comprises both an outer harbor area (Outer Apra Harbor) and an inner harbor area (Inner Apra Harbor). Most of Outer Apra Harbor and the entire Inner Apra Harbor are under the jurisdiction of the Navy.

Species may stow away in a vessel's hold or on the superstructure of the ship. Five classes of vessels were evaluated: commercial container ships, commercial barges, commercial fishing vessels, cruise ships, military vessels, and privately owned and operated vessels.

A4.1.3.2.1 Commercial Maritime Traffic

The Jose D. Leon Guerrero Commercial Port of Guam is located at the northern end of Apra Harbor, with commercial and recreational facilities located in the outer harbor. The commercial port has six berths associated with the main cargo terminal that provide port access to vessels with different draft and cargo container handling requirements. The berths are characterized in the Port of Guam Master Plan (PB International 2008). Commercial shipping activity and annual container traffic, as well as estimated

1 increases due to the military relocation, are also included for both shipping activities and container
2 traffic elsewhere in this document.

3 Guam also has two marinas, Hagatna Marina (Gregorio D. Perez Marina) and Agat Marina, that are
4 administered by the Port Authority of Guam (PB International 2008). Both marinas have chainlink fences
5 on their perimeter, but the fences are in generally poor condition, thereby allowing terrestrial
6 vertebrate species access to port areas and vessels. Private vessels used for recreation, such as fishing,
7 utilize these marinas. There are at least three major recreational fishing events associated with these
8 marinas. These include the Guam Marianas International Fishing Derby, the Fisherman’s Festival, and
9 the Annual Marianas Underwater Fishing Federation Competition (Allen and Bartram 2008). The fishing
10 derby averages around 70 boats and 300 fishermen (Allen and Bartram 2008). A total of 75 teams
11 participated in the derby departing from both the Agat Marina and the Hagatna Marina in 2009. The
12 underwater fishing competition had 13 teams from Guam and two from Saipan in 2005 (Allen and
13 Bartram 2008).

14 The majority of cargo vessels in the region are operated by Matson Navigation Company and Horizon
15 Lines (Horizon Lines 2010b, c, d, a; Matson 2010a, b). The Kyowa Shipping Company also operates in the
16 area, shipping from the ports in Busan, South Korea and Yokohama, Japan into the port on Saipan
17 (Kyowa Shipping Company 2010a, b). Kyowa Shipping is the transshipment service provider for Horizon
18 in the region (PB International 2008). Shipping routes are shown in Figure A2-2 (Section A2). Regional
19 shipping from the ports on Guam and Saipan throughout the region are handled by feeder services
20 provided by Kyowa, Seabridge Marine, and Micronesia Express Service (PB International 2008). Major
21 islands serviced by these providers in the region include Guam; Saipan and Tinian (CNMI); Majuro (RMI);
22 Pohnpei, Chuuk, Kosrae, and Yap (FSM); and Palau. Regional shipping via Seabridge or Matson has a
23 transit time between Guam and Saipan of approximately 12 hours according the Port Authority of Guam
24 Master Plan Update (PB International 2008). We did not attempt to capture every possible shipping
25 route in our analysis, but focused instead on the major routes. Therefore, routes from charter vessels,
26 fuel vessels, and smaller shipping companies are not captured in the analysis.

27 The shipping companies contract with each other and other regional carriers to provide transshipment
28 services throughout the region (PB International 2008). The interconnections between the different
29 international and regional transshipment services make determining actual transit time for a given
30 container difficult to predict. For example, it is possible for a container to be loaded in a port in Asia, be
31 unloaded in Busan, reloaded on a regional ship and shipped to Saipan or transshipped further, on the
32 same vessel to a port “downstream” of Saipan. A more complex route would have a container loaded on
33 a ship in a port on the west coast of the United States, transshipped via Hawai’i to Guam, loaded on a
34 Kyowa vessel and transshipped out of Guam to another port in the region. However, some estimates of
35 shipping times are shown in Table A4-10 (PB International 2008; Horizon Lines 2010b, c, d, a; Kyowa
36 Shipping Company 2010a, b; Matson 2010a, b).

37 **Table A4-10: Estimates of Time in Transit for Various Shipping Companies and Routes**

Carrier	Origination site	Destination site	Estimated transit time (days)
---------	------------------	------------------	-------------------------------

Horizon, Matson	U.S. west coast	Hawai'i	4
Horizon, Matson	Hawai'i	Guam	8
Horizon	China	Oakland, California	21
Matson	China	Los Angeles, California	18
Kyowa, Seabridge, Micronesia Express	Busan, Korea	Saipan, CNMI	10
Kyowa, Seabridge, Micronesia Express	Saipan, CNMI	Guam	<1
Kyowa, Seabridge, Micronesia Express	Guam	Chuuk, FSM	3
Kyowa, Seabridge, Micronesia Express	Chuuk, FSM	Pohnpei, FSM	2
Kyowa, Seabridge, Micronesia Express	Pohnpei, FSM	Kosrae, FSM	3
Kyowa, Seabridge, Micronesia Express	Pohnpei, FSM	Yap, FSM	4
Kyowa, Seabridge, Micronesia Express	Yap, FSM	Koror, Palau	2

1

2

A4.1.3.2.2 Military Maritime Traffic

3

The Marianas Island Range Complex is a major naval training area and includes Guam, as well as the islands of Saipan, Tinian, Rota, Farallon de Medinilla, and the training area W-517 (U.S. Navy 2009j). It includes 501,872 square nautical miles of sea space for naval training, as well as 10,074 hectares (24,894 acres) of land range. Navy ships that may operate in the area during any major training exercise include nuclear aircraft carriers, cruisers, frigates, landing craft utility vessels, high-speed transport vessels, and amphibious support and assault vessels (U.S. Navy 2009j). Exercises involve 3 to 30 ships and last 5 to 21 days. Training events may occur 1 to 5 times per year. The types of ships currently operating in the area attached to the U.S. Navy Military Sealift Command include tanker ships and ships carrying break bulk and containers (U.S. Navy MSC). The southern end of Apra Harbor on Guam has four major wharves available for docking ships: Victor Wharf, Sierra Wharf, Polaris Point, and Kilo Wharf. Navy waterfront facilities are located in both the outer harbor and the inner harbor. Waterfront facilities for the U.S. Coast Guard are located in the inner harbor.

15

A4.1.3.2.3 Ship Inspection Procedures

16

World Health Organization Regulations

17

On July 18, 2007, the United States became a party to the International Health Regulations adopted by the WHO to mitigate public health risks associated with international travel (WHO 2005b). Article 27 of these regulations states that if a source of contamination or infection is found or suspected on board a ship, authorities are allowed to decontaminate the ship which may include deratting. Article 28 states that, if an infected ship wishes to enter a port that is not equipped to deal with the infection, the port authorities may order the ship to proceed to the nearest suitable port for inspection. Port authorities are required to notify the next known port of entry of the infection.

24

Article 39 of the International Health Regulations governs Ship Sanitation Control Certificates and Ship Sanitation Control Exemption Certificates. Formerly, these certificates were referred to collectively as a

25

1 Deratting/Deratting Exemption Certificate. With the publication of the 2005 International Health
2 Regulations, these certificates were changed to include all public health risks, not just those pertaining
3 to rodents (WHO 2007a). Certificates are only valid for 6 months, after which inspection is required for
4 renewal. If a port is unable to perform an adequate inspection at the time of renewal, the certificate
5 may be renewed for up to 1 month to allow the necessary inspection to be performed. Inspections for
6 certification are to be conducted when the ship and holds are empty. Ship Sanitation Control Exemption
7 Certificates are issued when an inspection reveals no evidence of a public health risk, and authorities are
8 satisfied the ship is free of contamination or disease vectors (WHO 2007a). A Ship Sanitation Control
9 Certificate is issued when an inspection reveals evidence of a public health risk or sources of
10 contamination and appropriate control measures have been undertaken. If appropriate control
11 measures cannot be performed at the port of inspection, this is to be noted on the Ship Sanitation
12 Control Certificate and the next port of call notified; this does not guarantee response by officials
13 receiving notification.

14 The third edition of the International Health Regulations Guide to Ship Sanitation was published in
15 October 2007. The guide contains both general and specific recommendations to be considered in the
16 construction of ship facilities, as well as measures that can be undertaken to minimize problems in ships
17 that have already been constructed (WHO 2007b, 2010c). Section 10.7 of the ship sanitation guide
18 contains specific recommendations for controlling insect and rodent disease vectors. Essentially, any
19 openings larger than 1.25 centimeters (cm) (0.5 inches [in]) should be obstructed with rat-proof
20 materials. Insulation that is thicker than 1.25 cm (0.5 in) must also be protected against gnawing by rats.
21 The rat-proof materials mentioned in the guide include steel plates, sheet iron or steel, sheet aluminum
22 or metal alloy, perforated sheet metal, expanded metal, flattened expanded metal, wire mesh, or
23 hardware cloth. These materials must not contain openings greater than 1.25 cm (0.5 in). Non-rat-proof
24 materials may be used in rat-proof areas as long as boundaries and gnawing edges are protected. Rat-
25 proof material is defined as a material having surfaces and edges that are resistant to gnawing by rats. A
26 rat-proof area is defined as an area that is completely isolated from other areas by means of rat-proof
27 material. Examples of rat-proof areas include galleys, pantries, cargo holds, storage spaces, and
28 shaftways. A rat-tight area is an area bounded by material that contains no hole large enough for the
29 passage of rats, and is sufficient only in more frequented areas where rats cannot gnaw undisturbed.
30 Examples of rat-tight areas include quarters, dining rooms and mess rooms, and public spaces such as
31 lounges, radio rooms, and wheelhouses.

32 The ship sanitation guide also recommends delegating at least one person on board a ship to be
33 responsible for a rodent trapping program. Traps are to be set after leaving a port where rats could
34 possibly have come on board directly or with cargo. If, after 2 days, no rats are caught, the traps can be
35 removed. Otherwise, traps are to be left in place until no more rats are caught. Records of when and
36 where traps were set along with catch records should be recorded in the ship's log to be available for
37 port health inspectors. In addition to trapping, regular inspections should be performed to look for
38 evidence of rats, such as droppings. In particular, these inspections should focus on areas where food is
39 prepared and garbage is stored, as well as any place rats might potentially hide. Port authority officials
40 conduct inspections of the ship to ensure the ship has adequately assessed and addressed potential

1 health risks. For larger ships that have monitoring and management programs in place, inspection at the
2 port may consist only of auditing records to ensure compliance. Ships that have had an outbreak of
3 disease or pests will be inspected by authorities to determine the cause.

4 The U.S. government does not require ships to hold a Ship Sanitation Control Certificate or Ship
5 Sanitation Control Exemption Certificate (CDC 2009). The authority for compliance with the
6 International Health Regulations in the United States is the U.S. Department of Health and Human
7 Services. Most of the responsibilities associated with the International Health Regulations are assigned
8 to the Centers for Disease Control and Prevention. The United States currently does not provide ship
9 sanitation inspections of commercial cargo carriers, and is awaiting further guidance from the WHO
10 regarding these inspections (CDC 2009; WHO 2010e).

11 ***Federal Regulations***

12 The CFR provides some guidance on ship inspection and disinfection. The pertinent portions are Title 7
13 (regulated articles from Hawai'i and the territories), Title 9 (movement of animals and animal parts), and
14 Title 42 (public health). Title 7 (Subtitle B, Volume 5, Chapter 3, Part 3A.13-9 and Part 330.111)
15 specifically requires notification of inspectors prior to departure or arrival of ships on Guam, giving the
16 inspector the opportunity to conduct an inspection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93)
17 allows the inspection of any ship from foreign locations without a warrant to determine whether the
18 ship is carrying any animal or animal part subject to disposal to prevent the spread of disease. If the ship
19 is found to be contaminated, the operator of the ship is responsible for disinfection. Title 9 (Volume 1,
20 Chapter 1, Subchapter D, Part 95) also requires the disinfection of a ship if it has transported restricted
21 items that were not contained in leak-proof containers. The method of cleaning prescribed in Title 9
22 (Part 95) includes the collection of litter and refuse, and disposal of that refuse by incineration or other
23 approved method. This is to be followed by cleaning of the areas of the ship that were exposed to the
24 contaminant and saturation of the contaminated surface with an approved disinfectant. The approved
25 disinfectants are sodium carbonate solutions, sodium hydroxide solutions, or liquefied phenol. These
26 disinfectants are specifically designed to target foot and mouth disease, rinderpest, and ticks. Title 42
27 (Part 71, Subpart E, Section 71.41) of the CFR states that carriers arriving at U.S. ports are subject to
28 sanitary inspections to look for rodent, insect, or vermin infestation that may spread disease.

29 The APHIS-PPQ Manual for Agricultural Clearance contains information on the inspection of ships
30 (USDA-APHIS-PPQ 2013). The manual provides a table for determining whether a ship needs to be
31 boarded on arrival, boarding can be deferred, or the ship only needs to be monitored. Ships that need to
32 be boarded on arrival are generally from known infected areas, have a history of violations, or are
33 foreign ships. Ships in the deferred boarding category are usually U.S. Armed Forces vessels not boarded
34 on arrival, U.S. flag ships, private ships, or ships that frequent the port and have a low pest risk. Ships
35 are monitored on an unannounced, spot-check basis for compliance with garbage regulations and
36 adequate safeguarding of stores. Ships that were not previously boarded are monitored when feasible,
37 and at least 50% of ships that were previously boarded will also be monitored.

38 There are three factors that determine the focus and extent of ship inspections (USDA-APHIS-PPQ 2013),
39 the location of the port, where the ship has traveled and taken on cargo, and whether the ship is on a

1 watch list for previous violations or known pest outbreaks. The areas to be inspected include the galley
2 and stores, quarters, and deck. These areas are inspected for fresh fruits and vegetables, evidence of
3 pests, and compliance with garbage regulations. The manual specifically instructs inspectors to focus
4 their inspections of barges on the deck areas. If live or dead animals, contamination, or leaking garbage
5 is found, the area is to be cleaned and disinfected. Disinfection procedures for animal contamination
6 include treatment with Virkon®S or sodium carbonate with sodium silicate. Disinfection procedures for
7 live pests are to be determined by a CBP Agricultural Specialist according to the APHIS-PPQ Treatment
8 Manual. The treatment manual only contains guidance for treatment when khapra beetles, fruit flies,
9 and soft bodied insects are found (USDA-APHIS-PPQ 2008).

10 CBP published a Vessel Inspection Guide in 2009. However, this guide does not contain information on
11 inspection of ships per se. The guide contains instructions for checking the paperwork of crew members
12 and passengers, signs of human trafficking, and how to handle human stowaways (CBP 2009).

13 ***Commercial Vessel Inspections***

14 The Centers for Disease Control and Prevention published a Vessel Sanitation Program Operations
15 Manual in 2005. This manual also provides guidance to the cruise ship industry on methods to minimize
16 public health risks (CDC NCEH 2005). Compliance with the program is voluntary. However, the U.S.
17 Public Health Service has the authority under the Public Health Service Act (Title 42, Part G) to make
18 regulations and take actions to prevent the spread of communicable diseases (FDA 1999a, b). Title 42 of
19 the CFR also gives the Public Health Service the authority to conduct sanitary inspections. The National
20 Center for Environmental Health at the Centers for Disease Control and Prevention became responsible
21 for administering the program in 1986. A fee is charged for the service depending on the size of the ship.
22 The manual contains guidance on keeping food areas free of rodents and other pests, such as using
23 tight-fitting lids on garbage containers. Incoming food supplies are to be inspected for signs of insect,
24 rodent, or other pest infestation. Areas of the ship that are inspected include medical facilities, potable
25 water systems, swimming pools, whirlpools, galleys, dining rooms, child activity centers, hotel
26 accommodations, ventilation systems, and common areas. The manual recommends that any vessel
27 with a foreign itinerary carrying more than 13 passengers be inspected twice yearly for food safety and
28 environmental sanitation. However, inspections do not occur every 6 months (WHO 2010e). These are
29 to be unannounced inspections if the vessel is available. Inspection reports or summary reports are
30 published on the Vessel Sanitation Program website.

31 ***Military Vessel Inspections***

32 The Quarantine Regulations of the Armed Forces were written to allow the military to comply with the
33 regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, Homeland
34 Security, Interior, and Commerce (DoD 1992). This was superseded by OPNAVINST 6210.2. The
35 regulations are designed to prevent the introduction and spread of disease agents (human, animal, and
36 plant), arthropod vectors, and pests of health or agricultural importance. The documents state that the
37 military is to cooperate with the agencies listed above to comply with regulations. Military vessels are
38 exempt from inspections by foreign officials, although they must meet the quarantine requirements of
39 each entry port that are published in the U.S. Air Force Foreign Clearance Guide (AFR 8-5 and

1 OPNAVINST 3710.2E). Commanding officers may certify compliance to foreign health officials, which
2 may include a general description of the measures taken to be in compliance. Foreign officials are not
3 allowed to board a U.S. Armed Forces ship, even to observe inspections.

4 Section II, Subsection A of the Quarantine Regulations of the Armed Forces and Section 9a of
5 OPNAVINST 6210.2 specifically govern vessels (DoD 1992). Measures are to be taken prior to departure
6 to minimize movement of human disease vectors, including insects and rats. As soon as a vessel is
7 berthed at a pier, and for the remainder of its stay at the pier, certain preventive measures must be
8 taken to minimize the likelihood of rats gaining access to the ship. Ships must be moored at least 6 feet
9 from the pier. Gangways and other access points to the ship are to either be well lit and guarded, or
10 separated from the shore. Cargo nets or similar devices extending between the ship and the shore will
11 be raised or removed unless actually in use. All connecting lines are to be fitted with rat guards. The
12 International Health Regulations no longer require the use of rat guards on mooring lines unless the ship
13 is berthed in a port where plague is endemic. However, commanding officers or medical department
14 representatives can still require their use in ports with a large rodent population. Cargo is only to be
15 loaded after it has either been found to be free of rodents or has been treated to remove all rodents.
16 Before the ship departs the port, it must be inspected for fleas and rodents and treated to remove these
17 pests if found.

18 All naval ships are required to have current Ship Sanitation Control or Ship Sanitation Control Exemption
19 certificates because they can be deployed anywhere in the world on short notice (U.S. Navy 2001).
20 These may be issued either by the U.S. Public Health Service or by a Public Health Service designated
21 military quarantine representative (DoD 1992; OPNAVINST 6210.2). According to BUMED 6210, the
22 primary medical personnel that are authorized to issue ship sanitation certificates are Navy preventive
23 medicine technicians (U.S. Navy 2010b), and inspectors are not allowed to inspect or issue a ship
24 sanitation certificate for a vessel where they are part of the ship's company (U.S. Navy 2001, 2010b).
25 Navy medical personnel are authorized to issue ship sanitation certificates for Navy, Army, Military
26 Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels. Qualified
27 inspectors are issued an official seal from the U.S. Public Health Service to be used in the issuance of
28 ship sanitation certificates (U.S. Navy 2010b). According to BUMED 6250.14A, rodent inspections for
29 ship sanitation certificates are to be conducted during daylight hours with an empty hold or a hold
30 containing only material unattractive to rodents (U.S. Navy 2010b). If rodents are found, BUMED
31 6250.14A instructs personnel to continue to conduct control operations for 3 to 5 days after signs of an
32 active infestation have ceased before requesting a re-inspection. Deratting should be conducted when
33 holds are empty if possible. Ship sanitation certificates are to be issued in duplicate, with one copy going
34 to the ship and the medical department retaining the other. Specifications and directions for rat guards
35 are also given in BUMED 6250.14A.

36 Section II, Subsection C of the Quarantine Regulations of the Armed Forces and Section 10 of
37 OPNAVINST 6210.2 cover the USDA requirements. These sections govern the movement of animal and
38 plant diseases and pests. Ships moving between Hawai'i, Guam, Puerto Rico, the U.S. Virgin Islands, and
39 the continental United States are required to undergo USDA inspection by a USDA inspector or
40 representative. GCQA officers collaborate with USDA-APHIS to enforce federal regulations (Tajjeron

1 2010c). The disinfection measures currently available target primarily disease organisms and insects and
2 may not be effective on many of the invasive species transported in ships. Subsection C requires
3 surveillance aboard ships that includes spot checking and routine collection and identification of pest
4 organisms.

5 The Defense Transportation Regulations, Part V establishes the requirements for agricultural cleaning
6 and inspection, and the assignment of DoD personnel as agricultural and customs inspectors for pre-
7 clearance programs. USDA-APHIS is responsible for providing DoD with guidance, information, and
8 training to perform pre-clearance inspections (DoD 2009a).

9 To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for
10 vessels returning to the CTUS (DoD 2009c). Pre-clearance inspections may be requested for
11 redeployment from major exercises or contingencies, and are performed at the point of origin. Requests
12 for pre-clearance inspections must be submitted no later than 75 days prior to when the inspection is
13 needed. Requests must contain the following information: dates, times, and place of departure from a
14 foreign country; date, time, and place of arrival in the CTUS; number and type of ships; identification of
15 all stops between the point of departure and arrival; and whether the border clearance integrity of the
16 ship will be maintained during en route stops. Examples of clearance integrity being breached are the
17 addition or removal of cargo or passengers at any stop, crew member changes, or off-loading of crew
18 and passengers. Such breaches of integrity will void the pre-clearance authority. Both CBP and USDA
19 provide and approve training of Customs Border Clearance Agents for the military (DoD 2009c). When
20 the planned destination is in the CTUS, Customs Border Clearance Agents inspect ships to ensure they
21 are free of plants, animals, or plant and animal products. Equipment must be stored in a way that
22 prevents re-infestation by pests.

23 The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning
24 and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Decks of
25 ships that held vehicles or equipment are required to be thoroughly cleaned. In particular, recessed
26 areas, underneath shelving, corners, and hard to reach places should be cleaned to remove soil.
27 Causeways on naval vessels are to be washed with either fresh or salt water during back loading.
28 Vessels, such as the Captain's launch or a liberty launch, are not required to be cleaned unless they are
29 contaminated. Although the guide recommends that operators of these vessels conduct a thorough
30 inspection, it does not require it.

31 NAVMED P-5010-8 is the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest
32 Control Technology (U.S. Navy BMS 2004). This manual covers the use of preventive measures and oral
33 bait stations and anticoagulants for rodent control. The species of concern that are listed in the manual
34 are the Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*), and house mouse (*Mus musculus*). Some
35 general characteristics of each are described to aid in identification. Measures that are mentioned to
36 control and prevent rodent infestations include the elimination of food and shelter, rodent proofing
37 when feasible, rodenticides, snap traps, and glue boards. The manual contains a specific section on
38 controlling and preventing rodents aboard ships which include proper sanitation, pierside inspections,
39 rat guards, illumination and movement restrictions, glue boards, and snap traps. Pierside inspections for

1 signs of rodents (droppings, hair, gnawing) should be conducted on all subsistence items and cargo. Rat
2 guards are required to be a minimum of 91 cm (36 in) in diameter and be mounted at least 1.8 m (6
3 feet) from shore or 0.6 m (2 feet) from the ship. Access points to the vessel, such as gangways, are to be
4 separated from the shore by at least 1.8 m (6 feet), and cargo nets or similar devices extending between
5 ship and shore are to be raised or removed when not in use. Vessels departing from ports where certain
6 diseases such as yellow fever, malaria, and plague are endemic or epidemic in the port area must be
7 disinfected.

8 The U.S. Navy Shipboard Pest Control Manual, NAVMED P-5052-26, provides guidance on inspection and
9 deratting procedures to be carried out on ships (U.S. Navy 2008). This manual also lists the Norway rat,
10 roof rat, and house mouse as the most common rodents of concern. The commanding officer of a ship is
11 to ensure that medical department personnel are trained and certified in shipboard pest control. The
12 medical department representative ensures that there is an ongoing pest control program on board the
13 ship. This includes maintaining current ship sanitation certificates, conducting inspections, and keeping
14 records of pest control activities. Records of activities include pierside and onboard inspection records,
15 ship sanitation certificates, and pesticide use records.

16 According to the U.S. Navy Shipboard Pest Control Manual, inspections occur pierside for incoming food,
17 and surveillance on a ship is to occur at least every 2 weeks (U.S. Navy 2008). If control measures are
18 implemented, they should be followed up with surveillance to determine efficacy. Rodent signs to look
19 for during inspections include runways and rub marks, tracks, gnawing, droppings, urine, and hairs.
20 Prevention measures listed are similar to those provided in NAVMED P-5010-8. In addition to the rat
21 guard requirements listed in NAVMED P-5010-8, the pest control manual requires rat guards to have a
22 cone angle of 30 degrees and be made of 18 gauge steel or aluminum. Gaps are to be plugged with rags
23 that are tightly secured to prevent rodents from pulling them apart. Stray lines are to be kept out of the
24 water, and if two lines are close to each other, they are either to be installed through the same rat guard
25 or have rat guards installed side by side to prevent rats from jumping from line to line. The U.S. Navy
26 Shipboard Pest Control Manual also reiterates the guidelines in the CFR listed above.

27 In addition to the U.S. Navy Shipboard Pest Control Manual, MIL-STD-904B provides guidance on the
28 detection, identification, and prevention of pest infestations. This standard is provided in full in
29 Appendix G of the U.S. Navy Shipboard Pest Control Manual (U.S. Navy 2008). The standard applies not
30 only to insects and rodents, but to birds and other animals as well. For preventing cross-contamination
31 of pathways (cargo to vessel), the standard requires samples be taken of subsistence items that have a
32 history of contamination or infestation or items that have been stored near contaminated or infested
33 items. Samples should be taken from the area most likely to be infested, such as the outermost
34 containers of a stack, or the area closest to the contaminated or infested items. Closed packages are to
35 be inspected for holes made by insects, and rodent, bird, or other animal contamination or damage. If
36 signs of contamination or damage are found, the package is to be opened. Opened packages weighing
37 less than 4.5 kg (10 pounds) are to be inspected in their entirety. If the opened package weighs more
38 than 4.5 kg (10 pounds), a 1.4 kg (3 pounds) sample is to be taken from the top and bottom of the unit
39 and adjacent to tears or holes. Subsistence items shipped from tropical environments are to be paid
40 special attention and inspected thoroughly. Stored subsistence items are to be inspected at least once

1 monthly, as are storage areas. Items are to be stored off the floor on pallets or shelves and be at least
2 0.5 m (18 in) from the wall to minimize hiding areas available to rodents, birds, and other animals.

3 ***Guam***

4 Commercial ships providing a ship sanitation certificate that arrive in the Port of Guam will have
5 acquired it from a previous port of call on the identified list of ports identified by the WHO (Ames 2010).
6 Guam is listed in the WHO International Health Regulations Authorized Ports List as being able to issue
7 ship sanitation certificates (WHO 2010e). All vessels tying up at the dock must place rodent barriers on
8 mooring lines (Merfalen 2010). All commercial cargo is subject to inspection and is selected based on
9 the manifest associated with the shipment (Merfalen 2010). The process for inspecting the vessel will
10 follow the guidelines established in the International Health Guidelines interim technical advice, but will
11 vary procedurally by the country of issuance (WHO 2007a). Title 10 Chapter 37 of the Guam Code
12 requires docks and wharves to be constructed so as to prevent rodents from gaining access to them
13 during low and high tides. Food stored at docks and wharves must be stored in such a manner to
14 prevent access by rodents. The Director of Public Health and Social Services is to enforce international
15 quarantine regulations for controlling rodents for all vessels and watercraft arriving on Guam (GCA).
16 Perimeter fencing supports traps for BTS (PB International 2008).

17 ***Commonwealth of the Northern Mariana Islands***

18 Privately owned vessels returning to Saipan are inspected by CNMI Customs and Quarantine officers for
19 rodents and BTS by the detector dog teams. The BTS detector dog teams are part of the CNMI Division
20 of Fish and Wildlife, which is a separate agency from the CNMI Customs and CNMI Quarantine agencies.
21 Customs personnel accompany the dog detector team aboard the vessel (Guerrero 2010). Saipan is
22 listed in the WHO International Health Regulations Authorized Ports List as being able to issue ship
23 sanitation certificates (WHO 2010e). We observed perimeter fencing supporting traps for BTS during our
24 site visit to the Port of Saipan in January 2010. The Port of Tinian receives cargo ships routed from
25 Saipan or Guam and inter-island ferry traffic. We observed perimeter fencing supporting traps for BTS
26 during our site visit to the Port of Tinian in January 2010. During the site visit on Tinian there were no
27 mice available to use in BTS traps due to collapse in the species' population on the island, and
28 insufficient funding to purchase new mice (Castro 2010).

29 ***Federated States of Micronesia***

30 According to FSMC Title 18, Chapter 2 § 206, any ship entering FSM is subject to inspections by customs,
31 immigration, agriculture, and administrative personnel. We were unable to find any information
32 regarding exactly what these inspections entail. The immigration regulations of FSM state that all ships
33 will be inspected for stowaways, presumably human (FSM ORC 2005). FSM is a party to the WHO, and
34 therefore is bound by the International Health Regulations.

35 ***Republic of the Marshall Islands***

36 Vessels entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public
37 health, or administrative personnel as stated in Title 43, Chapter 2, Section 205 of the Marshall Islands
38 Revised Code (PacLII 2003). According to Title 8, Chapter 1, Section 110 of the Marshall Islands Revised

1 Code, vessels known or suspected to be harboring insects or agricultural pests are to be sprayed with an
2 insecticide (PacLII 2004a). Any employee of the RMI Ports Authority may enter a vessel for the purpose
3 of inspection according to Title 22, Chapter 1, Section 153 of the Marshall Islands Revised Code (PacLII
4 2004c). RMI is a party to the WHO, and therefore is bound by the International Health Regulations.

5 ***Palau***

6 No information could be accessed regarding ship inspections in Palau. However, Palau is a party to the
7 WHO, and therefore is bound by the International Health Regulations.

8 ***China***

9 China is a member state of the WHO, and therefore is bound by the International Health Regulations,
10 and according to the WHO International Health Regulations Authorized Ports List, can issue ship
11 sanitation certificates (WHO 2010e). Chapter 4 of the Rules for the Implementation of Frontier Health
12 and Quarantine Law of the People’s Republic of China covers seaport quarantine (Chinese Ministry of
13 Public Health 1989). Both entry and exit quarantine inspections are conducted, although what these
14 inspections actually entail is not explained. Article 29 states that inspections will occur between sunrise
15 and sunset only, unless the port is equipped for night navigation. Inspections will not occur at night if
16 the ship is from an area with a known infestation. Ship Sanitation Control Certificates are required for
17 entry to ports in China according to Article 30.

18 ***Korea***

19 Korea is not listed as a member state of the WHO, and therefore may not follow the International Health
20 Regulations. However, the Republic of Korea is listed in the WHO International Health Regulations
21 Authorized Ports List as being able to issue ship sanitation certificates (WHO 2010e). No information
22 could be accessed regarding ship inspections in Korea.

23 **A4.1.3.2.4 *Summary of Findings***

24 All water transportation pathways were considered high risk due to their ability to transport species,
25 such as BTS and rodents, with potential impacts to human health. Risk increased as the probability of
26 species survival during transport increased, such as for high-speed vessels and vessels transiting short
27 distances. Risk also increased based on several factors related to the process of inspection. Risk
28 increased in ports where the International Health Regulations are not enforced. The risk of inspectors
29 missing an invasive species increased as time constraints and equipment unavailability (broken or
30 nonexistent equipment) increased, or the number of personnel decreased. Risks basically reflected an
31 increase in commercial ship traffic without adequate increases in biosecurity needs, such as additional
32 staffing for inspections and enforcement, updated equipment and facilities, continued training, and
33 easier reporting capabilities.

34 **A4.1.3.2.5 *Specific Risk Factors***

35 The specific risk factors we found to be associated with the water transportation pathways are as
36 follows:

1 **Common Risk Factors**

- 2 • Rat guards may not be required or used for prevention in all ports of call on vessels
3 transiting to Guam or the Micronesia Region.
- 4 • Rat guards may not prevent BTS from accessing the ship by crawling up a mooring line.
- 5 • The ability of the canine inspection to locate BTS in a complex environment may be
6 compromised.
- 7 • An inspection/management program focused on preventing introduction of an agricultural
8 pest may not detect or prevent the movement of a vertebrate invasive species to another
9 pathway.
- 10 • Regulations pertaining to ships are primarily focused on insects, rodents, and the prevention
11 of spreading human disease. Invasive species that do not fall under one of these categories,
12 such as amphibians, may be missed during inspections.
- 13 • Inadequate financial resources exist in CNMI, FSM, RMI, and Palau to maintain expensive
14 control programs.

15 **Risk Factors Associated With Commercial Maritime Traffic**

- 16 • Commercial carrier vessels from the major shipping lines are cleared rapidly (approximately
17 30 minutes) by customs and quarantine officers (Merfalen 2010). Emphasis is on regulated
18 waste inspections and reviewing cargo manifests.
- 19 • Cruise ships are not required to comply with the Vessel Sanitation Program and only need to
20 supply ship sanitation certificates if it is required for a port at which the vessel is docking.
- 21 • Staffing on Guam and CNMI is inadequate to meet current quarantine demands.

22 **Risk Factors Associated With Military Maritime Traffic**

- 23 • Retrograde washdown procedures primarily target soil and may not remove invasive species
24 hidden in areas not targeted for washing.
- 25 • Captain’s launches and liberty launches are not required to be inspected or cleaned upon
26 return to a ship unless they are contaminated, increasing the likelihood of moving invasive
27 species undetected.

28 **A4.1.3.3 Military Cargo and Vehicles Used In Training Exercises**

29 The pathways we evaluated in this analysis are focused on the risk of moving invasive species on cargo
30 associated with military training. Cargo includes equipment, gear, vehicles, vessels, aircraft, and supplies
31 used in training exercises. Current training activities are presented in the Marianas Island Range
32 Complex draft EIS/Overseas EIS (U.S. Navy 2009j). Future training activities following the relocation of
33 the 3rd Marine Expeditionary Unit from Okinawa to Guam are presented in the second and third
34 chapters of Volume 2 of the draft EIS/Overseas EIS (U.S. Navy 2009f, Vol 2, Chap 2, 2009g, Vol 2, Chap
35 3).

1 Various species can be moved in cargo (Table A4-11). The Marianas Island Range Complex EIS specifically
 2 lists tent and camp setup as activities that will occur during field training and force protection exercises
 3 at Northwest Field and Andersen South (U.S. Navy 2009j). There have been documented reports of the
 4 transport of invasive species of concern in cases of munitions (Vice et al. In preparation). Therefore, we
 5 evaluated munitions being brought to Guam and spent munitions being shipped from Guam as a result
 6 of training. Vehicles, such as trucks and tanks, amphibious assault and support vessels, and high-speed
 7 vessels will be used in training exercises to transport troops and supplies (U.S. Navy 2009j, f).

8 **Table A4-11: Invasive Species Transported In Military Cargo and Equipment**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Bufo gargarizans</i>	Asiatic toad	ECL
	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL
	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL
	<i>Fejervarya cancrivora</i>	Crab-eating frog	ECL
	<i>Fejervarya limnocharis</i>	Asian cricket frog	ECL
	<i>Kaloula pulchra</i>	Asian painted frog	ECL
	<i>Litoria fallax</i>	Dwarf tree frog	ECL
	<i>Microhyla pulchra</i>	Marbled pygmy frog	ECL
	<i>Polypedates leucomystax</i>	Common tree frog	ECL
	<i>Polypedates megacephalus</i>	Spot-legged tree frog	ECL
	<i>Rana catesbeiana</i>	American bullfrog	ECN, ECL
	<i>Rana guentheri</i>	Guenther's frog	H, ECL
	<i>Rhinella marina</i>	Cane toad	H, ECN, ECL
Birds	None likely	None likely	
Mammals	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
	<i>Rattus rattus</i>	Black rat	H, ECN, ECL
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Anolis carolinensis</i>	Green anole	ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Dinodon rufozonatum</i>	Red banded snake	None found ^b
	<i>Elaphe carinata</i>	Taiwan stink snake	None found
	<i>Elaphe taeniura friesi</i>	Taiwan beauty snake	None found
	<i>Gehyra mutilata</i>	Mutilating gecko	None found
	<i>Gekko gekko</i>	Tokay gecko	ECL
	<i>Hemidactylus frenatus</i>	House gecko	ECL
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found
	<i>Naja kaouthia</i>	Monocled cobra	H
	<i>Trimeresurus elegans</i>	Sakashima habu	H
	<i>Trimeresurus mucrosquamatu</i>	Taiwan habu	H
	<i>Xenochrophis piscator</i>	Asiatic water snake	None found

^a H = health, ECN = economic, ECL = ecological.

^b No impacts found in the literature, but undocumented impacts may exist.

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1 **A4.1.3.3.1 *Military Cargo and Vehicle Inspection***

2 A Brown Treesnake Control and Interdiction Plan was developed by the Navy to prevent the movement
3 of the BTS off of Guam in response to Executive Order 13112, Invasive Species (The White House 1999;
4 U.S. Navy 2005b). Executive Order 13112 made it the responsibility of all federal agencies to prevent the
5 introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires
6 the military to cooperate fully with federal authorities during observations and inspections of cargo
7 destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to
8 effectively implement the plan. The plan directs the Department of the Interior and USDA to go through
9 a rulemaking process on BTS inspections.

10 The plan requires that 100% of all outbound cargo is to be inspected for BTS using canine detection
11 methods; however, the plan also states that military commanders and APHIS-WS personnel must jointly
12 decide the extent of inspections based on the nature of the training exercise and the volume of cargo to
13 be transported. On Guam, APHIS-WS maintains dogs and equipment necessary to implement BTS
14 control plans. APHIS-WS may recommend holding a cargo carrier from departing Guam if it is suspected
15 to harbor BTS, and allow commanders to make the decision whether to release the cargo (Vice 2010a).

16 Prior to establishing bivouac sites on Guam, APHIS-WS personnel are to be consulted so they can
17 recommend areas that have a lower BTS risk. Cargo shipped to Tinian from Guam is tagged following
18 inspection and clearance by APHIS-WS and this tag is subject to confirmation by CNMI Quarantine
19 inspectors. Untagged cargo may be refused entry and reloaded aboard the conveyance for return to
20 Guam. Vehicles are to be cleaned and inspected prior to being moved to an approved cargo staging
21 area. Vehicles and equipment that are considered to be higher risk for BTS infestation may be required
22 to undergo additional cleaning measures such as high pressure washing, steam-cleaning, or fumigation.
23 Once cargo is cleaned and inspected, it is to be immediately loaded onto a vessel or aircraft. If a delay
24 will occur between inspection and loading, cargo may be placed in a APHIS-WS approved staging area
25 and re-inspection may be required. Cargo staging areas are to be chosen to minimize the likelihood that
26 BTS can access cargo. APHIS-WS is to be given complete access to staged cargo and equipment for the
27 purposes of BTS inspections. Prior to breaking camp, all personal belongings and tents used in a bivouac
28 area are to be inspected by APHIS-WS for the presence of BTS.

29 Inspections of baggage and personnel are focused on preventing the movement of drugs, firearms, plant
30 and animal products, and undeclared items (DoD CBCPP 2009c). All DoD cargo is to be made available
31 for inspection by CBP upon entry to the United States. It is up to the discretion of CBP personnel to
32 determine what level of inspection is required.

33 To facilitate redeployment operations, the DoD can request pre-clearance inspections by CBP and USDA
34 for cargo and equipment returning to the CTUS (DoD 2009c). The Defense Transportation Regulations,
35 Part V establishes the requirements for agricultural cleaning and inspection, and the assignment of DoD
36 personnel as agricultural and customs inspectors for pre-clearance programs. USDA-APHIS is responsible
37 for providing the DoD with guidance, information, and training to perform pre-clearance inspections
38 (DoD 2009a). APHIS remains the final authority on the pest risk status of material or equipment.

1 Pre-clearance inspections may be requested for redeployment from major exercises or contingencies,
2 and are performed at the point of origin. Requests for pre-clearance inspections must be submitted no
3 later than 75 days prior to when the inspection is needed. Requests must contain the following
4 information: dates, times, and place of departure from a foreign country; date, time, and place of arrival
5 in the CTUS; amount and type of cargo; identification of all stops between the point of departure and
6 arrival; and whether the border clearance integrity of the aircraft or ship will be maintained during en
7 route stops. Examples of clearance integrity being breached are the addition or removal of cargo or
8 passengers at any stop, crew member changes, off-loading of crew and passengers, or an aircraft
9 remaining in a location overnight. Such breaches of integrity will void the pre-clearance authority.

10 Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military
11 (DoD 2009c). When the planned destination is in the CTUS, CBP agents inspect cargo to ensure it is free
12 of plants, animals, or plant and animal products. Equipment must be stored in a way that prevents re-
13 infestation by pests. In addition, CBP can establish a Military Customs Inspectors–Excepted program at a
14 DoD installation (DoD 2009d). Such a program allows DoD personnel to perform the same functions as
15 CBP agents in connection with arriving military or military-chartered aircraft from overseas areas.
16 Inspection duties of the DoD personnel under this program include customs, immigration, and
17 agricultural inspections or functions. Inspectors under the Military Customs Inspection Excepted
18 program may not conduct searches of personnel.

19 Chapter 511 of the Defense Transportation Regulations Part V states that all cargo entering Guam,
20 regardless of origin, is subject to inspection by GCQA. GCQA requires a packing list for all containers, and
21 will conduct inspections of containers. What these inspections entail is not described, other than to say
22 that inspectors must make sure departing containers are free of BTS. Coordination of inspection
23 activities between the military and foreign governments falls to the U.S. Transportation Command (DoD
24 CBCPP 2009b). Part II of the Defense Transportation Regulations covers cargo, but contains little
25 information regarding inspections (DoD 2008a).

26 OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect cargo to prevent the
27 introduction of plant and animal pests or diseases. No cargo is to be loaded in foreign countries unless it
28 is free of soil or pests. Cargo is to be cleaned to remove soil and pests, and packed in such a way as to
29 prevent access of pests to cleaned cargo. The Quarantine Regulations of the Armed Forces states that
30 cargo is subject to inspection by a representative of USDA to prevent the introduction or spread of
31 animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is
32 considered part of the United States. The CFR provides some guidance on military cargo inspection and
33 disinfection as it pertains to movement of regulated articles from Hawai'i and the territories, and
34 movement of animals or animal parts. Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 3A.13-8 and 3A.13-
35 10) states that cargo moving between Guam, CNMI, Hawai'i, and the continental United States is subject
36 to agricultural inspection.

37 The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning
38 and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Washing and
39 inspection of vehicles and equipment shipped as cargo may only occur during daylight hours. Prior to

1 arriving at a washdown area there are several preparations that must take place on vehicles. Vehicles
2 are to be prepared by having the cab and all storage and tool compartments swept or vacuumed. The
3 battery and battery box should be removed, cleaned, and reinstalled. Outside dual tires and spare tires
4 should be removed and placed in the back of the vehicle. Payloads, seat cushions, detachable
5 sideboards, canvas dies/tops, and person gear are to be removed and left at the mobile staging area for
6 cleaning. Vegetation, insects, or other debris should be removed from the radiator. Trucks that are
7 equipped with collapsible sides should have the sides disengaged, and all recessed areas and ledges
8 cleaned. Engine packs should be removed from tanks and Bradley fighting vehicles prior to washing.
9 Once at the washdown area, vehicles are exposed to either high pressure (minimum 90 psi) fresh water
10 or steam.

11 After vehicles are washed, they are inspected to ensure all soil has been removed (AFPMB 2008).
12 Common areas to be inspected include top and bottom access points, paying particular attention to
13 crevices. Top access points are floor boards; battery boxes; storage and tool compartments; wheels and
14 tires; windshield bases; front and rear bumper hollows and braces; radiator front; and truck beds.
15 Bottom access points are fender wells; rocker panels; fore and aft frames; coil spring wells; transmission
16 support beams; rear suspension A-frames; pivot points; and drain holes; trailer hitch bolt recesses; front,
17 side, and rear body lips; drive shaft tunnels; power take-offs; axle brackets; fuels tanks; transaxle
18 brackets; leaf springs; and air tank braces.

19 The troop compartment, crew area, and the crew's personal equipment on amphibious vehicles are
20 required to be cleaned. All soil packed into the treads, around the rubber cleats, in the tread connectors,
21 and between and behind tread guides and roller supports on tracked vehicles must be removed. The
22 interior of tracked vehicles, including the battery box, must also be free of soil. Bilges can contain some
23 sand as long as it is mixed with salt water and is not being transported on an aircraft. Tracked vehicles
24 can only be cleaned on shore as long as they can be reloaded without recontamination of the treads,
25 otherwise they must be cleaned on the ship's well deck. The problem areas of specific vehicles are
26 shown in the Appendices of Technical Guide Number 31 (AFPMB 2008).

27 Hand brooms, rags, compressed air, and other non-water methods can be used to clean supplies and
28 equipment such as mount-out boxes/Hardigg-like cases, field desks, and communications equipment
29 (AFPMB 2008). In particular, attention should be paid to cracks, crevices, and recesses. Pallets are to be
30 cleaned of soil and vegetation. Tents and canvas should be spread out on a pest free surface and swept
31 down on both sides, paying particular attention to the seam and flaps. No water should be used to clean
32 tents and canvas, but compressed air may be used to aid in the cleaning process.

33 **A4.1.3.3.2 Summary of Findings**

34 With the exception of transporting hazardous waste from the naval base on Guam to the continental
35 United States, all pathways were considered to be high risk due to their potential to transport species
36 that can harm human health and safety. The hazardous waste pathway was only likely to vertebrate
37 species and species that could be transported in this pathway only had ecological effects. Inspections of
38 cargo departing Guam are primarily focused on BTS and pests with agricultural risks; thus, inspections
39 may miss some vertebrate invasive species. Detection of BTS relies on a large degree of cooperation

1 among agencies, particularly APHIS-WS and the military. Resources are limited in CNMI to maintain
 2 expensive prevention and control programs for BTS, increasing the risk that the BTS could become
 3 established there.

4 **A4.1.3.3.3 Specific Risk Factors**

5 The specific risk factors we found to be associated with transport of military cargo used in training
 6 exercises are as follows:

- 7 • BTS inspections may not address the movement of other potentially invasive species.
- 8 • Tent cleaning and inspection processes emphasize agricultural pest risks and may not
 9 adequately address the risk of transporting an invasive vertebrate species.
- 10 • The emphasis on preventing the movement of invasive species associated with tent cities is
 11 on departure from Guam and BTS. No emphasis is placed on the risk of bringing new
 12 invasive species to Guam.
- 13 • No contact networks exist for species other than BTS. This network may be used when other
 14 invasive species are located or captured, but this is not always the case.
- 15 • Agricultural inspections of cargo at the port of entry may not adequately detect a vertebrate
 16 invasive species moving in vehicles, cargo or equipment.
- 17 • There are limited control measures for frogs, toads, lizards, and snakes that could be
 18 transported with military cargo.
- 19 • The retrograde washdown and inspection process is focused on preventing the transport of
 20 agriculturally significant pests on vehicles and may not be effective for preventing the
 21 transport of vertebrate invasive species.
- 22 • Inadequate financial resources exist in CNMI to maintain expensive prevention and control
 23 programs.
- 24 • Communication is inadequate between the military and officials on Tinian, and response
 25 capabilities are lacking on Tinian, to allow for proper inspections of cargo associated with
 26 military training to occur.

27 **A4.1.3.4 Cargo and Container Conveyances**

28 Movement of invasive vertebrate species in containerized cargo and on the container conveyance itself
 29 is a significant pathway, capable of moving many types and a large number of species (Table A4-12).
 30 There is an anticipated increase in the amount of containerized cargo that will be shipped to Guam to
 31 support the relocation and the provisioning of increased military personnel.

32 **Table A4-12: Invasive Species Transported in the Cargo Container Pathway**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Bufo melanostictus</i>	Asian common toad	None found ^b
	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL

Class	Scientific name	Common name	Risk type ^a
	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL
	<i>Hyla cinerea</i>	American green tree frog	ECL
	<i>Kaloula pulchra</i>	Asian painted frog	ECL
	<i>Limnodynastes tasmaniensis</i>	Spotted grass frog	ECL
	<i>Litoria aurea</i>	Green and golden bell frog	H, ECL
	<i>Litoria caerulea</i>	Australian green tree frog	ECL
	<i>Litoria chloris</i>	Red-eyed tree frog	None found
	<i>Litoria ewingii</i>	Whistling tree frog	ECL
	<i>Litoria fallax</i>	Eastern dwarf tree frog	ECL
	<i>Osteopilus septentrionalis</i>	Cuban tree frog	H, ECN, ECL
	<i>Polypedates leucomystax</i>	Common tree frog	ECL
	<i>Pseudacris regilla</i>	Pacific tree frog	ECL
	<i>Rana sylvatica</i>	Wood frog	ECL
Birds	None likely	None likely	
Mammals	<i>Didelphis marsupialis</i>	American opossum	H, ECN, ECL
	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Myotis lucifugus</i>	Little brown bat	H, ECN
	<i>Pipistrellus javanicus</i>	Javan pipistrelle	H, ECN
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
	<i>Rattus rattus</i>	Ship rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN, ECL
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Agama agama</i>	Common agama	None found
	<i>Anolis cristatellus</i>	Common Puerto Rican anole	ECL
	<i>Anolis distichus</i>	Hispaniolan gracile anole	ECL
	<i>Anolis extremus</i>	Barbados anole	ECL
	<i>Anolis porcatius</i>	Cuban green anole	ECL
	<i>Anolis sagrei</i>	Cuban brown anole	ECL
	<i>Boa constrictor</i>	Boa constrictor	H, ECN, ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Calotes versicolor</i>	Eastern garden lizard	ECL
	<i>Chondrodactylus bibronii</i>	Bibron's thick-toed gecko	ECN
	<i>Cnemidophorus lemniscatus</i>	Rainbow lizard	ECL
	<i>Cryptoblepharus carnabyi</i>	Spiny-palmed snake-eyed skink	None found
	<i>Cryptoblepharus peecilopleurus</i>	Mottled snake-eyed skink	ECL
	<i>Cryptoblepharus plagioccephalus</i>	Péron's snake-eyed skink	None found
	<i>Cryptoblepharus virgatus</i>	Cream-striped shinning-skink	None found
	<i>Cyrtopodion scabrum</i>	Rough-tailed gecko	ECL
	<i>Elaphe taeniura friesi</i>	Taiwan beauty snake	None found
	<i>Elgaria multicarinata</i>	Southern alligator lizard	None found
	<i>Emoia cyanura</i>	Bluetail emo skink	ECL
	<i>Eulamprus tenuis</i>	Bar-sided forest skink	None found
	<i>Gehyra mutilata</i>	Mutilating gecko	None found

Class	Scientific name	Common name	Risk type ^a
	<i>Gekko gekko</i>	Tokay gecko	ECL
	<i>Gonatodes albogularis</i>	Yellow-headed gecko	None found
	<i>Hemidactylus frenatus</i>	Common house gecko	ECL
	<i>Hemidactylus garnotii</i>	Indo-Pacific gecko	None found
	<i>Hemidactylus platyurus</i>	Flat-tailed house gecko	None found
	<i>Hemidactylus turcicus</i>	Mediterranean house gecko	ECL
	<i>Hemiphyllodactylus typus</i>	Common dwarf gecko	None found
	<i>Lampropholis delicata</i>	Delicate skink	ECL
	<i>Lepidodactylus aureolineatus</i>	Golden scaly-toed gecko	None found
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found
	<i>Lipinia noctua</i>	Moth skink	None found
	<i>Lycodon aulicus</i>	Common wolf snake	ECL
	<i>Mabuya multifasciata</i>	Rough mabuya	None found
	<i>Python molurus bivittatus</i>	Burmese python	H, ECN, ECL
	<i>Ramphotyphlops braminus</i>	Blind snake	None found
	<i>Sceloporus occidentalis</i>	Western fence lizard	None found
	<i>Sphaerodactylus argus</i>	Ocellated gecko	None found
	<i>Sphaerodactylus elegans</i>	Ashy gecko	None found
	<i>Tarentola mauritanica</i>	Common wall gecko	None found
	<i>Tiliqua scincoides</i>	Common bluetongue	None found
	<i>Trimeresurus flavoviridis</i>	Habu	H
	<i>Uta stansburiana</i>	Northern side-blotched lizard	None found

^a H = health, ECN = economic, ECL = ecological.

^b No impacts found in the literature, but undocumented impacts may exist.

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Cargo and its conveyances originate from numerous sources, and the actual points of origination for much of this traffic have not been identified. The major shipping companies for containerized cargo transport in the Micronesia Region are Horizon, Matson, Kyowa, and Marianas Express Lines (PB International 2008). Information from these companies was used to determine the routes by which cargo is likely to be shipped. The shipping pathways are taken from the current schedules posted on the websites for Horizon, Horizon Lines of Guam, Kyowa, Mariana Express Lines, and Matson (Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Mariana Express Lines 2010a, b; Matson 2010a, b).

Shipping routes were chosen to capture the risks associated with the movement of containerized cargo in the region with emphasis on the most likely sources for material associated with the relocation. We focused on containerized cargo coming from Asia, specifically that shipped through South Korea by Kyowa, and from the continental United States via the West Coast and Hawai'i to Guam by Matson and Horizon.

A4.1.3.4.1 Cargo Container Inspections

International and Federal Regulations

The International Health Regulations contain guidance regarding containers and cargo with respect to public health concerns (WHO 2005b). Chapter 4, Article 34, governs containers and loading areas. Container shippers are responsible for ensuring that containers are kept free of vectors and reservoirs of

1 disease and contamination during the packing process. Loading areas are also to be kept free of disease
2 vectors and reservoirs. If containers are used for multiple types of cargo, shippers must ensure that
3 cross-contamination does not occur. Countries may determine, at their discretion, that a container is
4 sufficiently large to require a sanitary inspection for disease vectors and reservoirs; no guidance is given
5 on what “sufficiently large” means. Inspection facilities are to be available at container loading areas if
6 practical. Chapter 5, Article 23, allows any country to require inspections of cargo and containers prior
7 to departure and arrival if deemed necessary for public health reasons.

8 The CFR provides guidance on cargo and cargo container inspection and disinfection as it pertains to
9 movement of regulated articles from Hawai’i and the territories, and movement of animals or animal
10 parts. Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 3A.13-8 and 3A.13-10) states that cargo moving
11 between Guam, CNMI, Hawai’i, and the continental United States is subject to agricultural inspection.
12 Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) allows the inspection of any shipping containers on
13 aircraft or ships from foreign locations without a warrant to determine whether the aircraft or ship is
14 carrying any animal or animal part subject to disposal to prevent the spread of disease. If the container
15 is found to be contaminated, the operator of the aircraft or ship is responsible for disinfection. Title 9
16 (Volume 1, Chapter 1, Subchapter D, Part 95) also requires the disinfection of a container if it has
17 transported restricted items that were not contained in leak-proof containers. The method of cleaning
18 prescribed in Title 9 (Part 95) includes the collection of litter and refuse, and disposal of that refuse by
19 incineration or other approved method. This is to be followed by cleaning the areas of the container that
20 were exposed to the contaminant and saturation of the contaminated surface with an approved
21 disinfectant. The approved disinfectants are sodium carbonate solutions, sodium hydroxide solutions, or
22 liquefied phenol. These disinfectants are specifically designed to target foot and mouth disease,
23 rinderpest, and ticks.

24 The APHIS-PPQ MAC instructs inspectors to inspect cargo if it is of agricultural interest (USDA-APHIS-PPQ
25 2013). Cargo of agricultural interest will contain either plant or animal material and is inspected
26 primarily for agricultural pests or diseases. The APHIS-PPQ Treatment Manual contains procedures for
27 treating cargo with fumigants, phosphine, methyl bromide, aerosols, or micronized dust (USDA-APHIS-
28 PPQ 2008).

29 ***BTS Inspections***

30 A Brown Treesnake Control and Interdiction Plan was developed by the Navy in response to Executive
31 Order 13112, Invasive Species (The White House 1999, U.S. Navy 2005b), to prevent the movement of
32 BTS off of Guam. Executive Order 13112 made it the responsibility of all federal agencies to prevent the
33 introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires
34 the military to cooperate fully with federal authorities during observations and inspections of cargo
35 destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to
36 effectively implement the plan. APHIS-WS maintains dogs and equipment necessary to implement BTS
37 control plans. The plan directs the Department of the Interior and USDA to go through a rulemaking
38 process on BTS inspections.

1 The plan requires that 100% of all outbound cargo be inspected by BTS detector dog teams. However,
2 the plan also states that military commanders and APHIS-WS personnel must jointly decide the extent of
3 inspections based on the nature of the training exercise and the volume of cargo to be transported.
4 Cargo shipped to Tinian is tagged following inspection and clearance by APHIS-WS, and this tag is subject
5 to confirmation by CNMI Quarantine inspectors; however, the limited resources on Tinian hamper these
6 confirmation inspections. Untagged cargo may be refused entry and reloaded aboard the conveyance
7 for return to Guam. Once cargo is cleaned and inspected, it is to be immediately loaded onto a vessel or
8 aircraft. If a delay will occur between inspection and loading, cargo may be placed in an APHIS-WS
9 approved staging area and re-inspection may be required. Cargo staging areas are to be chosen to
10 minimize the likelihood that BTS can access cargo. APHIS-WS is to be given complete access to staged
11 cargo and equipment for the purposes of BTS inspections.

12 ***Military Regulations***

13 All DoD containerized cargo is to be made available for inspection by CBP upon entry to a U.S. port of
14 entry. It is up to the discretion of CBP personnel to determine what level of inspection is required.
15 Inspections are focused on preventing the movement of drugs, firearms, plant and animal products, and
16 undeclared items (DoD CBCPP 2009c). When the planned destination is in the CTUS, CBP agents inspect
17 cargo to ensure it is free of plants, animals, or plant and animal products. Technically, Guam is not
18 considered a CTUS.

19 To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for
20 containerized cargo and equipment returning to the CTUS (DoD 2009c). The Defense Transportation
21 Regulations, Part V, establish the requirements for agricultural cleaning and inspection and the
22 assignment of DoD personnel as agricultural and customs inspectors for pre-clearance programs. USDA-
23 APHIS is responsible for providing DoD with guidance, information, and training to perform pre-
24 clearance inspections (DoD 2009a). Both CBP and USDA provide and approve training of Customs Border
25 Clearance Agents for the military (DoD 2009c; DoD CBCPP 2009a, c). In addition, CBP can establish a
26 Military Customs Inspectors–Excepted program at a DoD installation (DoD 2009d). Such a program
27 allows DoD personnel to perform the same functions as CBP agents in connection with certain cargo as
28 laid out in a memorandum of understanding between the installation commander and the local CBP port
29 director. Inspection duties of the DoD personnel under this program include customs, immigration, and
30 agricultural inspections or functions.

31 According to the requirements for agricultural cleaning and inspection (Part 5, Chapter 505), no cargo is
32 to be loaded in a foreign country unless it is free from plant and animal contamination or pest
33 infestations (DoD 2009a). Pre-clearance inspections may be requested for redeployment from major
34 exercises or contingencies, and are performed at the point of origin (DoD 2009c). Requests for pre-
35 clearance inspections must be submitted no later than 75 days prior to when the inspection is needed.
36 Requests must contain the following information: dates, times, and place of departure from a foreign
37 country; date, time, and place of arrival in the CTUS; amount and type of cargo; identification of all stops
38 between the point of departure and arrival; and whether the border clearance integrity of the aircraft or
39 ship will be maintained during en route stops. Examples of clearance integrity being breached are the

1 addition or removal of cargo or passengers at any stop, crew member changes, off-loading of crew and
2 passengers, or an aircraft remaining in a location overnight. Such breaches of integrity will void the pre-
3 clearance authority. APHIS remains the final authority on the pest risk status of material or equipment.

4 Chapter 511 of the Defense Transportation Regulations Part V states that all containerized cargo
5 entering Guam, regardless of origin, is subject to inspection by GCQA. GCQA requires a packing list for all
6 containers, and will conduct inspections of containers. What these inspections entail is not described,
7 other than to say that inspectors must make sure containers are free of BTS. Coordination of inspection
8 activities between the military and foreign governments falls to the U.S. Transportation Command (DoD
9 CBCPP 2009b). Part II of the Defense Transportation Regulations covers cargo, but contains little
10 information regarding inspections (DoD 2008a).

11 OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect containerized cargo to prevent
12 the introduction of plant and animal pests or diseases. For the purposes of these regulations, Guam is
13 considered part of the United States. No military cargo is to be loaded in foreign countries unless it is
14 free of soil or pests. Cargo is to be cleaned to remove soil and pests and packed in such a way as to
15 prevent access of pests to cleaned cargo. The Quarantine Regulations of the Armed Forces states that
16 cargo is subject to inspection by a representative of USDA to prevent the introduction or spread of
17 animal and plant diseases or pests (DoD 1992).

18 ***Australia***

19 The Australia Customs and Border Protection Service operates Container Examination Facilities at
20 seaports, which were established to address border risks such as narcotics and terrorism (ACBPS 2009a,
21 b). The Australia Customs and Border Protection Service conducts risk assessments for incoming cargo,
22 and conducts inspections of all high risk cargo using x-ray machines in combination with physical
23 examinations. Containers are x-rayed upon arrival at the port, and a determination is made whether the
24 cargo requires an examination. Those requiring examination are physically inspected.

25 The Australian Quarantine and Inspection Service also conducts inspections of cargo containers.
26 Inspections are designed to exclude exotic pests and diseases, and examine the external and internal
27 cleanliness of containers. Containers from areas where the giant African snail (*Achatina fulica*) is found
28 undergo a mandatory inspection. Containers are also examined for the presence of soil, plant material,
29 and animal products.

30 ***China***

31 China Customs and the Ministry of Agriculture are responsible for import and export inspections. The
32 best information that we could obtain for cargo inspections by China Customs is related to inspection of
33 goods. This information was used because goods may be packaged as cargo in containers. All inspections
34 are conducted by two or more officers in a Customs control area. Goods are inspected to ensure that
35 they match what is listed on the customs declaration. Customs officers have the discretion to determine
36 what level of inspection is required. Inspections may be either thorough or selective, and may take place
37 by either manual inspection, machine inspection, or both. Manual inspection may be of the exterior of
38 packages, the interior of packages, or both (Xinsheng 2005; GAC 2007). Containers may also be

1 inspected under the Import and Export Animal and Plant Quarantine Regulations by Ministry of
2 Agriculture officials (People’s Republic of China State Council 1982). No details could be found as to
3 what quarantine inspections entail.

4 ***Commonwealth of the Northern Mariana Islands***

5 The Saipan Customs Division looks for undeclared items, non-English labeled items, drugs, and weapons
6 during its inspections of cargo (Sabian 2010). Saipan Customs has an x-ray machine for container
7 inspections at the Port of Saipan. There is a BTS barrier at the Port of Saipan for containers, but Customs
8 does not currently have a protocol for using it. Cargo that does not come from the continental United
9 States is put in the barrier area for a minimum of 3 days. Personnel from the Department of Land and
10 Natural Resources place traps around the barrier, and inspect the exterior of the containers with BTS
11 detector dogs (Guerrero Jr. 2010). If a BTS detector dog alerts to a container, the container will stay
12 within the barrier longer than 3 days for further inspection. Detector dog inspections are usually only
13 conducted in the morning because the metal of the containers gets too hot during the middle of the day
14 for the dogs. The BTS detector dog teams are part of the Division of Fish and Wildlife, which is a
15 separate agency from the CNMI Customs and CNMI Quarantine agencies. Customs officials at the Saipan
16 Airport receive training and certification for clearing exports (Pangolinean 2010). Staffing is currently
17 inadequate at the airport, and Customs officials lack the necessary safety equipment to conduct
18 inspections. The x-ray machine that was in use at the airport is nonfunctional because it is so old that
19 replacement parts can no longer be obtained.

20 There is also a BTS barrier at the Port of Tinian (Ferrell 2010). Any containers that come from Guam get
21 put into the barrier until the BTS detector dog can inspect it. Another BTS barrier is needed at the Tinian
22 airport where the military C-130s unload their cargo. The military does not always inform Tinian
23 Quarantine when they are coming with cargo; therefore, not all cargo gets inspected. Further, even
24 when notification does occur, Tinian lacks the necessary response capabilities. Agricultural inspections in
25 CNMI are overseen by APHIS-PPQ.

26 ***Federated States of Micronesia***

27 FSMC Title 54, Chapter 2, Subchapter 3 gives Customs officials the right to examine goods. All cargo
28 entering at an FSM port is required to be reported to FSM Customs within 1 day of arrival. No
29 information could be found regarding Customs inspections of cargo. FSMC Title 22, Chapter 4, governs
30 agricultural inspections of cargo, but no information is contained regarding what inspections entail.

31 ***Guam***

32 Containerized cargo import inspections are to be conducted at designated ports unless otherwise
33 authorized by the Director of GCQA (GCA 2010a). Seals on cargo and containers are not to be broken
34 except by GCQA officials. There are 78 container freight stations on Guam (Merfalen 2010). Because of
35 the volume of traffic, not all containers are selected for inspection. It is unknown how many arriving
36 containers are opened and inspected for vertebrate invasive species. However, GCQA does not routinely
37 open containers unless they lack proper documentation or are from a country Guam has deemed a
38 country of concern (Merfalen 2010). Countries may be considered a concern for a variety of reasons,

1 including whether they harbor an agricultural pest of concern, have had a disease outbreak, or have had
2 previous customs violations.

3 The container freight station at the Guam International Airport currently only has one, two-man team.
4 The freight station needs at least two teams to handle the relocation. GCQA has a new facility at the
5 airport that will be able to handle the increased cargo flow from the relocation once it is fully
6 operational. However, GCQA at the airport is currently understaffed and will need at least 31 additional
7 personnel to handle the increased cargo flow due to the relocation (Shimizu 2010b). Guam Customs has
8 two x-ray machines at the airport; they were inoperable at the time this was document was written and
9 are awaiting replacement RapidScan machines (Berringer 2010b). GCQA relies on a paper trail to identify
10 containers likely to require inspection. For example, in the Port of Guam, a container identified as
11 requiring an inspection will be tagged by a Guam Customs and Quarantine Agent. This container may
12 then be released to a consignee for movement from the port to a container freight station until
13 inspection.

14 ***Hong Kong***

15 Containerized cargo export examination is carried out by the Hong Kong Customs and Excise
16 Department. Selection for examination is done in such a way as to minimize disruption of the shipping
17 process. Hong Kong allows shippers to submit either a paper or an electronic cargo manifest. No specific
18 information could be accessed regarding cargo examination procedures (Hong Kong CED 2010). We
19 were unable to find any information regarding agricultural inspections of cargo.

20 ***Indonesia***

21 No information could be found regarding inspections of cargo in Indonesia.

22 ***Japan***

23 Exporters in Japan must obtain an export permit from Japan Customs, and goods are physically
24 examined (Japan Customs and Tariff Bureau , MoF). Cargo is also subject to agricultural inspections by
25 personnel from the Ministry of Agriculture, Forestry, and Fisheries. We could not obtain information
26 regarding what inspections entail.

27 ***Korea***

28 In order to promote foreign trade, the Korea Customs Service utilizes a paperless system for exporters
29 to file paperwork. Technically, exported goods are exempt from inspection; however, Customs officials
30 use risk selection criteria to select a certain percentage of exported containers to inspect. The risk
31 selection criteria include shippers with past violations and forged goods or documents (MSF 2009). We
32 were unable to find any information regarding agricultural inspections of cargo. The United States
33 military has a manual specifically for customs inspections of military cargo in Korea (USFK CLE 2010).
34 Military inspectors are to coordinate with the Korea Customs Service to conduct inspections and to
35 ensure violations are reported and investigated. Military cargo imports are inspected on a case by case
36 basis, with the emphasis placed on preventing military property from entering the black market. In light

1 of this emphasis, cargo with a high black market value is considered high risk and is targeted for
2 inspection.

3 ***Malaysia***

4 No information could be found regarding inspections of cargo in Malaysia.

5 ***New Zealand***

6 The Ministry of Agriculture and Forestry is responsible for agricultural inspections of cargo, and the New
7 Zealand Customs Service is responsible for customs inspections. The only guidance concerning
8 agricultural inspections of cargo and cargo containers we could find is related to import requirements
9 for companies shipping to New Zealand. The interior of containers is to be inspected prior to being
10 packed for animals, insects and other invertebrates, insect egg casings, animal materials, plant
11 materials, water, and soil (MAF). During loading, containers are not to be contaminated with soil by
12 forklifts or footwear, and are to be loaded on a hard, sealed surface. Containers are not to be left open
13 for extended periods of time or overnight to prevent entry by pests. The exterior of containers are to be
14 inspected for egg masses, grass, insects, pests, nests, seeds, snails, soil, and webs. Importers must file a
15 Quarantine Declaration form that includes information about any treatments the container has
16 received; otherwise it will be considered high risk. It is unknown if exported cargo must meet the same
17 requirements.

18 The New Zealand Customs Service has an online declaration website that exporters can use to clear their
19 exports with Customs. Shippers using this service must first be approved by customs officials as a
20 registered user of the site. No information could be found regarding whether containers and cargo are
21 inspected, how containers and cargo are selected for inspection, or what inspections entail.

22 ***Palau***

23 The Bureau of Agriculture is the NPPO of Palau and maintains the legal authority from the Plant and
24 Animal Quarantine Regulations (1999) as amended in 2008 to inspect containers and their contents for
25 plant pests. The Palau NPPO is not responsible for the issuance of phytosanitary regulations or arranging
26 for phytosanitary certification with the objective of ensuring that exported plants, plant produces,
27 regulated articles, and consignments are in conformity with the certifying statement that the shipment
28 is in compliant IPPC standards (Werner 2012).

29 ***Philippines***

30 The Philippine Bureau of Customs regulates exports, but no information could be found regarding
31 inspections for cargo other than paperwork requirements. Imported cargo agricultural products are
32 inspected by the Bureau of Customs (BOC) control. A cargo manifest for both incoming vessels and
33 airways are shared with the Plant and Animal Quarantine to inform of incoming products. As per
34 agreement in different ports of entry all attached government agencies involved in regulating the
35 imported agricultural products provide clearance prior to BOC release. Upon arrival of agricultural
36 products, BOC notifies plant and animal quarantine section to facilitate inspection and clearance. All
37 documentation have to pass and satisfy both agencies prior to release. For export products, all

1 agricultural products for export has to comply with the import requirement of the importing countries.
2 Plant quarantine will issue a phytosanitary certificate for plants and plant products and international
3 veterinary certificate for animals and animal products along with the inspection, treatment and
4 compliance to any bilaterally agreed protocol required by the importing country. Documentation and
5 treatment requirements of all cargoes with agricultural commodities for export are being done in the
6 exporter's premises prior to transport to the port. For hand-carry baggage and small consignments,
7 there are plant and animal quarantine inspection booths present in all ports of departure to inspect
8 outgoing agricultural products and issue export certifications.

9 ***Republic of the Marshall Islands***

10 The Marshall Islands Revised Code (Title 48, Chapter 2, Section 216) gives Customs officials the authority
11 to examine goods carried on ships and aircraft (PacLII 2004b). No information is given regarding what
12 examinations entail. The Marshall Islands Revised Code (Title 8, Chapter 1, Section 106) authorizes
13 agricultural inspections of cargo to enforce plant and animal quarantine regulations (PacLII 2004a). No
14 detail is given as to what agricultural inspections entail.

15 ***Singapore***

16 Cargo that is to be exported requires a Customs permit and is cleared by Singapore Customs officials
17 (Singapore Customs 2007a, b). No information was available as to what the clearance procedures entail.
18 We were unable to find any information regarding agricultural inspections of cargo.

19 ***Taiwan***

20 The Directorate General of Customs (DOGC) is the authority to regulate cargo container inspections for
21 both imports and exports for non-agriculture items. Importers are required to provide documents that
22 can prove the authenticity of country of origin, eg. certificate of origin, contract of conveyance, the
23 information of manufacturing factory, export goods declaration form, etc. DOGC will check all the
24 related documents for each cargo to ensure that they match with each other. However, physically
25 examination on cargos are randomly sampled. The number of samples is determined based on entities,
26 types, packages, and quantities of commodities. If dangerous cargo is suspected, then police agencies
27 will jointly inspect the cargo with DOGC. Imported fresh fruit and vegetables, live animals, and plants
28 may be exempted from inspection by DOGC. DOGC do not inspect these items for export. The Bureau of
29 Animal and Plant Health Inspection and Quarantine (BAPHIQ), Council of Agriculture, is the authority
30 responsible for both imports and exports of agricultural inspections of cargo. Food and Drug
31 Administration, Department of Health and BAPHIQ are the authorities responsible for inspection of
32 meat for human consumption.

33 ***United States***

34 United States regulations are covered above under federal regulations.

35 ***Vietnam***

36 Vietnam Customs is responsible for government inspections related to national security issues and
37 inspects both imported and exported cargo (Vietnam Customs 2008a, b). Shippers who have been

1 importing goods for 2 years without customs violations are exempt from inspection. It is unknown if this
2 exemption also applies to exporters. In addition, there are certain types of goods that are exempt from
3 inspection such as equipment and machinery. Ten percent of the cargo containers that do not meet one
4 of these two requirements are inspected. Those shippers that have had three or more customs
5 violations in the past 2 years will have the entire shipment of cargo inspected. We were unable to find
6 any information regarding agricultural inspections of cargo.

7 **A4.1.3.4.2 Summary of Findings**

8 All pathways were considered high risk due to their ability to transport species that can harm human
9 health and safety. The primary risk associated with this pathway is that current inspection procedures
10 do not include inspection for vertebrate invasives because they have an agricultural pest or national
11 security emphasis. In addition, containers are generally not opened unless they lack proper
12 documentation or are from a country with a history of transporting invasive species or other violations.
13 Such directed inspections, as opposed to true random inspections, make it more likely vertebrate
14 invasive species could get missed. However, the optimal container selection strategy is a topic of current
15 research (Eiswerth and Johnson 2002, Horan et al. 2002, Batabyal and Beladi 2006, Batabyal and Lee
16 2006, Surkov et al. 2009, Batabyal and Herath 2010).

17 **A4.1.3.4.3 Specific Risk Factors**

18 The specific risk factors we found to be associated with the cargo container pathways are as follows:

- 19 • Customs agencies are constrained by resources to only inspect a portion of containers.
20 These inspections tend to be of material that has insufficient documentation or is from a
21 country of concern.
- 22 • The paperwork associated with arriving containers is not automated which does not allow
23 for more rapid selection of containers for screening.
- 24 • Documentation is lacking with regard to interception of vertebrates in or on cargo
25 containers. Often a species is identified as moving in cargo but the specifics are not
26 available.
- 27 • Container scanners are not available on Guam. They are available on Saipan but not used
28 due to funding limitations.
- 29 • Not all cargo from Asia is required to be inspected prior to export.

30 **A4.1.3.5 Wood Packaging Material**

31 Wood packaging material can be a commodity shipped, used in the shipping process as packing material,
32 and the conveyance used in packing, such as wooden crates. Wood packaging materials are used in
33 almost all major shipments of cargo, and are known pathways for plant pest and pathogen introductions
34 (USDA-APHIS 2003, FAO 2006e). Risk assessments to date have focused primarily on the movement of
35 plant pests and pathogens; however, the WPM pathway can also move terrestrial vertebrates (Table A4-
36 13).

1

Table A4-13: Invasive Species Transported in the Wood Packaging Material Pathway

Class	Scientific name	Common name	Risk type ^a	
Amphibians	<i>Bufo melanostictus</i>	Asian common toad	None found ^b	
	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL	
	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL	
	<i>Hyla cinerea</i>	American green tree frog	ECL	
	<i>Kaloula pulchra</i>	Asian painted frog	ECL	
	<i>Limnodynastes tasmaniensis</i>	Spotted grass frog	ECL	
	<i>Litoria aurea</i>	Green and golden bell frog	H, ECL	
	<i>Litoria caerulea</i>	Australian green tree frog	ECL	
	<i>Litoria chloris</i>	Red-eyed tree frog	None found	
	<i>Litoria ewingii</i>	Whistling tree frog	ECL	
	<i>Litoria fallax</i>	Eastern dwarf tree frog	ECL	
	<i>Osteopilus septentrionalis</i>	Cuban tree frog	H, ECN, ECL	
	<i>Polypedates leucomystax</i>	Common tree frog	ECL	
	<i>Pseudacris regilla</i>	Pacific tree frog	ECL	
	<i>Rana sylvatica</i>	Wood frog	ECL	
	<i>Rhinella marina</i>	Cane toad	H, ECN, ECL	
	Birds	None likely	None likely	
	Mammals	<i>Didelphis marsupialis</i>	American opossum	H, ECN, ECL
		<i>Mus musculus</i>	Common mouse	H, ECN, ECL
		<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
<i>Rattus norvegicus</i>		Norway rat	H, ECN, ECL	
<i>Rattus rattus</i>		Ship rat	H, ECN, ECL	
<i>Suncus murinus</i>		Musk shrew	H, ECN, ECL	
Reptiles	<i>Agama agama</i>	Common agama	None found	
	<i>Anolis cristatellus</i>	Common Puerto Rican anole	ECL	
	<i>Anolis distichus</i>	Hispaniolan gracile anole	ECL	
	<i>Anolis extremus</i>	Barbados anole	ECL	
	<i>Anolis porcatius</i>	Cuban green anole	ECL	
	<i>Anolis sagrei</i>	Cuban brown anole	ECL	
	<i>Boa constrictor</i>	Boa constrictor	H, ECN, ECL	
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL	
	<i>Calotes versicolor</i>	Eastern garden lizard	ECL	
	<i>Chondrodactylus bibronii</i>	Bibron's thick-toed gecko	ECN	
	<i>Cnemidophorus lemniscatus</i>	Rainbow lizard	ECL	
	<i>Cryptoblepharus carnabyi</i>	Spiny-palmed snake-eyed skink	None found	
	<i>Cryptoblepharus peocilopleurus</i>	Mottled snake-eyed skink	ECL	
	<i>Cryptoblepharus plagioccephalus</i>	Péron's snake-eyed skink	None found	
	<i>Cryptoblepharus virgatus</i>	Cream-striped shinning-skink	None found	
	<i>Cyrtopodion scabrum</i>	Rough-tailed gecko	ECL	
	<i>Elaphe taeniura friesii</i>	Taiwan beauty snake	None found	
	<i>Elgaria multicarinata</i>	Southern alligator lizard	None found	
	<i>Emoia cyanura</i>	Bluetail emo skink	ECL	
	<i>Eulamprus tenuis</i>	Bar-sided forest skink	None found	
	<i>Gehyra mutilata</i>	Mutilating gecko	None found	
	<i>Gekko gekko</i>	Tokay gecko	ECL	
	<i>Gonatodes albogularis</i>	Yellow-headed gecko	None found	

Class	Scientific name	Common name	Risk type ^a
	<i>Hemidactylus frenatus</i>	Common house gecko	ECL
	<i>Hemidactylus garnotii</i>	Indo-Pacific gecko	None found
	<i>Hemidactylus platyurus</i>	Flat-tailed house gecko	None found
	<i>Hemidactylus turcicus</i>	Mediterranean house gecko	ECL
	<i>Hemiphyllodactylus typus</i>	Common dwarf gecko	None found
	<i>Lampropholis delicata</i>	Delicate skink	ECL
	<i>Lepidodactylus aureolineatus</i>	Golden scaly-toed gecko	None found
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found
	<i>Lipinia noctua</i>	Moth skink	None found
	<i>Lycodon aulicus</i>	Common wolf snake	ECL
	<i>Mabuya multifasciata</i>	Rough mabuya	None found
	<i>Python molurus bivittatus</i>	Burmese python	H, ECN, ECL
	<i>Ramphotyphlops braminus</i>	Blind snake	None found
	<i>Sceloporus occidentalis</i>	Western fence lizard	None found
	<i>Sphaerodactylus argus</i>	Ocellated gecko	None found
	<i>Sphaerodactylus elegans</i>	Ashy gecko	None found
	<i>Tarentola mauritanica</i>	Common wall gecko	None found
	<i>Tiliqua scincoides</i>	Common bluetongue	None found
	<i>Trimeresurus flavoviridis</i>	Habu	H
	<i>Uta stansburiana</i>	Northern side-blotched lizard	None found

^a H = health, ECN = economic, ECL = ecological.

^b No impacts found in the literature, but undocumented impacts may exist.

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4 WPM encompasses such things as crates, pallets, dunnage, packing blocks, drums, cases, load boards,
5 pallet collars, skids, veneer peeler cores, sawdust, wood wool, wood shavings, raw wood cut into thin
6 pieces, and cable spools. Because WPMs differ and are not likely to transport the same types of
7 terrestrial vertebrates, they were grouped into three broad categories for the risk analysis depending on
8 what they were likely to transport. Cable spools, cases, crates, drums, and pallets were grouped
9 together as being likely to transport a variety of amphibians, mammals, and reptiles because of the
10 availability of hiding places. Dunnage, load boards, packing blocks, pallet collars, raw wood cut into thin
11 pieces, skids, and veneer peeler cores were grouped together because they most likely will only
12 transport tree frogs, geckos, and skinks as these species are capable of clinging to various surfaces.
13 Finally, sawdust, wood shavings, and wood wool were grouped together as being likely to only transport
14 rodents that might be attracted to the material as bedding or nesting habitat.

15 Because of the paucity of documentation specifically relating to the movement of invasive species in
16 WPM, species that were listed as having been moved in cargo were used to generate the species lists,
17 and further, only those that were deemed likely to use a particular type of packing material based on
18 biological information were used. Species selection was based on criteria such as body size, presence of
19 toe pads on amphibians and lizards, ability to walk on vertical surfaces and upside down, whether a
20 species tends to be arboreal or terrestrial, and the resting or nesting sites typically utilized. Many
21 species are listed as having been moved in cargo, but no specific information is given as to where in the
22 cargo they were found. They may have been clinging to the inside of the cargo container itself, clinging
23 to WPM such as dunnage, or have found their way inside packing material such as sawdust. There is
24 likely to be overlap between the species listed in these pathways and those listed in the cargo container

1 pathway. Because no good data exist, there is some uncertainty inherent in the list of species for this
2 pathway.

3 Information from the major shipping companies servicing the Micronesia Region was used to determine
4 the routes by which cargo is likely to be shipped. This information was used because no information
5 exists explicitly on the transport of WPM, and WPM is likely to be used with specific cargo. The major
6 shipping companies used for cargo delivery in the Micronesia Region and their routes are covered
7 elsewhere in this document.

8 **A4.1.3.5.1 Wood Packaging Material Inspections**

9 Wood packaging material can be shipped as cargo to companies that then use those materials in the
10 packing and shipping of cargo goods. The United States began fully enforcing treatment of WPM being
11 shipped as cargo according to the ISPM on July 5, 2006 (USDA-APHIS 2007b). Wood packaging materials
12 themselves are subject to ISPM regulations listed in ISPM 15 that were developed by the IPPC (FAO
13 2006e). The IPPC is an international agreement regarding plant health and the prevention of the
14 movement of plant pests. Currently, it has 173 signatories, making the majority of the countries involved
15 in this pathway subject to ISPM 15 regulations (IPPC 2010). These regulations do not apply to WPM used
16 in the packing and shipping of cargo goods.

17 The regulations allow manufacturers and shippers two options: heat treatment or treatment with
18 methyl bromide. For materials to receive the ISPM 15 quality mark, materials being shipped as cargo
19 must be inspected by an agency accredited by either the American Lumber Standard Committee for heat
20 treatment (ALSC 2009), or the National Wood Pallet and Container Association for methyl bromide
21 fumigation (NWPCA 2009). Inspection procedures by both agencies must follow ISPM 15 regulations.
22 The regulations were developed to prevent the movement of plant pests such as insects, rather than
23 vertebrate invasives. These regulations only apply to pallets, dunnage, crates, packing blocks, drums,
24 cases, load boards, pallet collars, and skids that are transported as cargo and not as a conveyance (FAO
25 2006e). Materials such as veneer peeler cores, sawdust, wood wool, wood shavings, and raw wood cut
26 into thin pieces are not considered pathways of introduction for quarantine pests and thus are not
27 regulated (FAO 2006e). These regulations do not apply to movement within the United States or to
28 export to U.S. Trust Territories (USDA-APHIS 2008a). Also exempt is WPM used in DoD cargo shipments
29 of WPM that are imported for use by the DoD or its contractors, although some contractors may choose
30 to implement ISPM procedures (CBP 2010c).

31 Although heat treatment and methyl bromide may eliminate many insect and plant pests, both
32 treatments are utilized during the manufacturing stage only, and terrestrial vertebrate species may
33 enter treated WPM during the packing process. Heat treatment consists of heating wood until the
34 minimum wood core temperature is 56°C for at least 30 minutes (FAO 2006e). The methyl bromide
35 fumigation procedure is temperature and dosage dependent, but the minimum temperature is not to be
36 less than 10°C and the minimum exposure time is not to be less than 24 hours. Minimum monitoring of
37 the methyl bromide concentration should be conducted at 2, 4, and 24 hours (FAO 2006e).

1 Customs agents clearing WPM imported as cargo rely on quality marks, the labeling required by ISPM 15
2 for WPM. Quality marks allow for clear and easy identification of material that has been properly
3 treated and its country of origin. The country of origin is identified by a two letter ISO (International
4 Organization for Standardization) country abbreviation (FAO 2006e). Quality marks include information
5 such as a trademark, facility identification, and treatment used. The trademark identifies who made the
6 inspection, and is an identifying symbol, logo, or name of the accredited agency that provided inspection
7 services. The facility identification gives the product manufacturer name, brand, or assigned facility
8 number. The treatment used is symbolized as HT for heat treatment and MB for methyl bromide. The
9 quality mark contains an approved international symbol for compliant WPM, and an indication of
10 whether the material is used as dunnage; dunnage can either be spelled out or abbreviated. Dunnage
11 imported as cargo may be specifically singled out for marking because it can be made from wood that
12 has or has had bark on it, or it may be recycled and used to build crates or pallets; therefore, it needs to
13 be especially clear that it has been treated to avoid movement of insect pests (FAO 2006e). Wood
14 packaging material cargo that is recycled must be re-certified and re-marked to ensure that no new
15 pests, particularly insects, have entered the material prior to recycling (FAO 2006e).

16 Accredited inspection agencies periodically audit WPM manufacturer facilities and provide the quality
17 mark to the manufacturer. Audits typically include an inspection of records to ensure compliance with
18 ISPM 15, and may or may not include an inspection of the manufacturing floor or operational
19 procedures. It is incumbent upon the individual manufacturer to maintain proper records and quality
20 assurance procedures. Generally, only representative samples from random lots of material are
21 inspected (ALSC 2009, NWPCA 2009). An obvious invasive species might get detected during this
22 process, but most invasives listed in this pathway are small and may go undetected. In addition, most
23 vertebrate invasives are most likely to enter this pathway when the materials are used post-
24 manufacture to cushion other cargo during transport. This screening does nothing to prevent a species
25 from entering the material while it is being used in the packing process, post-manufacturing.

26 CBP inspects WPM shipped as a commodity for compliance with ISPM 15 and the presence of quality
27 marks indicating inspections were completed by an accredited agency (CBP 2010b). CBP does not
28 validate quality marks which is the jurisdiction of USDA, but it does check to ensure marks are legible
29 and permanent (SAL). Most of the countries involved in this pathway are parties to the IPPC, and require
30 adherence to ISPM 15 regulations (USDA-APHIS 2009b).

31 Title 7 of the CFR governs the treatment and inspection of WPM being shipped as a cargo commodity.
32 Part 305 of Title 7 covers phytosanitary treatments and states that treatments are to occur at APHIS
33 certified facilities and are to be monitored by APHIS officials. Part 319 of Title 7 of the CFR defines
34 regulated WPM as dunnage, crating, pallets, packing blocks, drums, cases, and skids. All regulated WPM
35 are required to have the IPPC quality mark, unless they are a DoD shipment. Regulated WPM is to be
36 inspected at the first port of entry. If pests are found, the shipment can either be cleaned and treated or
37 refused entry. A minimum of 7 days' advance notice to the APHIS officer in charge is required for all
38 regulated WPM coming into a port in the United States.

1 The APHIS-PPQ Manual for Agricultural Clearance directs inspectors to check whether regulated WPM is
2 compliant or non-compliant, but gives no other information on inspections (USDA-APHIS-PPQ 2013).
3 Dunnage on barges is a particular concern because it is more susceptible to becoming flotsam. The
4 APHIS-PPQ Treatment Manual contains specific instructions for the treatment of regulated WPM with
5 heat or methyl bromide (USDA-APHIS-PPQ 2008).

6 The APHIS Miscellaneous and Processed Products Manual contains inspection guidance that also applies
7 to Guam and CNMI (USDA-APHIS-PPQ 2010d). Inspectors are instructed to look specifically for timber
8 pests, other insects, and unspecified hitchhikers. If the WPM came from the United States, including U.S.
9 territories, or from the DoD, it is to be released but may be inspected. Wood packaging material coming
10 from foreign locations is inspected for the proper ISPM 15 quality mark and for timber pests, other
11 insects, and hitchhikers. Inspection is defined in the manual as a review of documentation and articles to
12 determine compliance with regulations. Logs, lumber, wood crating, and dunnage have special
13 inspection instructions that are related to the safety of the inspector. When no special inspection
14 instructions exist, 2% of the shipment is inspected. In addition, these articles are inspected for beetles,
15 borers, nematodes, termites, and weevils. A list of 28 items that routinely use WPM that should be paid
16 special attention to are given in this manual. These include such items as cast iron products, equipment,
17 pottery, and stoneware.

18 It is unknown how many containers are opened and the WPM used in the packing and shipping process
19 are inspected for terrestrial vertebrate invasive species, or the thoroughness of inspections. GCQA does
20 not routinely open containers unless they lack proper documentation or are from a country Guam has
21 deemed a concern (Shimizu 2010b). Countries of concern for Guam tend to be in Asia and on smaller
22 Micronesian islands that have little or no resources for biosecurity, because these were identified as
23 points of origin for cargo and related packing materials, or have had previous violations. Inspection
24 protocols similar to Guam's are in place on Saipan and Tinian (Ferrell 2010; Sabian 2010). We were
25 unable to find information specifically relating to the inspection of WPM by the other countries listed as
26 moving cargo and WPM.

27 **A4.1.3.5.2 Summary of Findings**

28 All pathways were considered high risk because of their ability to transport species that could harm
29 human health and safety. The primary risk associated with this pathway is that current inspection
30 procedures do not include inspection for terrestrial vertebrate species, nor do they prevent the entry of
31 these species into the material during the packing process. Inspections driven solely by proper
32 documentation and country of origin, as opposed to true random inspections, make it more likely to
33 miss terrestrial vertebrate species inadvertently being transported. Risk increased as the resources of
34 customs agencies decreased. The required ISPM 15 quality marks have been counterfeited or
35 fraudulently used (Brindley 2010; WPA 2010). More data are needed on the interception of vertebrates
36 found specifically in WPM upon arrival with cargo.

37 **A4.1.3.5.3 Specific Risk Factors**

38 The specific risk factors we found to be associated with the WPM pathways are as follows:

- 1 • The inspection process for WPM applies to pre-packaged material manufactured at the plant of
- 2 origin and does not apply to vertebrates that have entered the material while it is being used
- 3 post-manufacturing as packing material for cargo shipments.
- 4 • Customs agencies are constrained by resources such as time and finances, to inspect only a
- 5 portion of arriving containers, and may exclude any WPM within.
- 6 • It is unclear how thorough inspection of containers is with regard to WPM.
- 7 • ISPM 15 quality marks may be counterfeited or fraudulently used.
- 8 • Documentation is lacking with regard to interception of vertebrates found in WPM.

9 **A4.1.3.6 Relocation: Household Goods and Personal Vehicles Related to Relocation**

10 In general, household goods and vehicles are well-known pathways for the movement of invasive
11 species (Long 2003, Vice and Pitzler 2008, Kraus 2009). This type of cargo is capable of transporting BTS
12 and rodents among other species (Table A4-14). A large number of military personnel and their
13 dependents will be relocating to Guam as a result of the military relocation (see Section 0). Personnel
14 will be bringing household goods and personal vehicles, increasing the risk of moving vertebrate invasive
15 species. Additionally, military and civilian household goods and vehicles are routinely shipped
16 commercially throughout the Micronesia Region.

17 Military personal property is shipped by the U.S. Transportation Command, who can transport the cargo
18 on a military conveyance or book a commercial contract carrier (DoD 2008b, 2010a). To the extent
19 possible, personal property is shipped using the services of the Air Mobility Command or the Military
20 Sealift Command. Property is commonly packed commercially and moved off base by commercial
21 channels as freight (Vice and Pitzler 2008). Additionally, when service members are relocated they are
22 entitled to have one vehicle transported to their new duty station at government expense (DoD 2009e).
23 Other vehicles may be transported at the service member's expense.

24 Regionally, Guam is a commercial center for the Micronesia Region for commodities such as small
25 appliances, furniture, and other household goods that are often shipped regionally from Guam
26 throughout the region for both private and military purposes. This type of cargo may be containerized or
27 palletized. Personally owned vehicles, particularly used vehicles, are also shipped from Guam, often as
28 bulk cargo.

29 Three major routes for this type of cargo shipment were considered in the analyses: Okinawa to Guam,
30 Guam to the continental United States, and Guam to other parts of the Micronesia Region via Saipan.
31 Household goods and personally owned vehicles can be shipped commercially from Okinawa via Miike
32 Harbor, Japan, once a week. The shipping company is Hueng-A Shipping Company, Limited, and their
33 agents for the Okinawa to the Port of Miike route are either Kaniyaku Corporation or Minami Nihon
34 Kisen (Port of Miike). Containerized cargo can then be transshipped via Busan by Kyowa to Guam or via
35 a port in China to Guam by Matson or Horizon. Arrangements can be made through a freight forwarding
36 company. Cargo shipped commercially off Guam by Matson or Horizon to the continental United States
37 is transshipped through Asia prior to returning to the continental United States (Matson 2006; Horizon

1 Lines 2008). Regional shipping from the ports on Guam and Saipan throughout the Micronesia Region is
 2 handled by feeder services provided by Kyowa, Seabridge Marine, and Micronesia Express Service (PB
 3 International 2008).

4 **Table A4-14: Invasive Species Transported in the Household Goods and Personal Vehicles**
 5 **Pathways**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL
	<i>Kaloula picta</i>	Slender-digit chorus frog	None found ^b
	<i>Kaloula pulchra</i>	Asian painted frog	ECL
	<i>Litoria fallax</i>	Dwarf tree frog	ECL
	<i>Polypedates leucomystax</i>	Common tree frog	ECL
	<i>Rhinella marina</i>	Cane toad	H, ECN, ECL
Birds	None likely	None likely	
Mammals	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
	<i>Rattus rattus</i>	Black rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN, ECL
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Anolis carolinensis</i>	Green anole	ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Elaphe taeniura friesi</i>	Taiwan beauty snake	None found
	<i>Gehyra mutilata</i>	Mutilating gecko	None found
	<i>Gekko gekko</i>	Tokay gecko	ECL
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found

6 ^a H = health, ECN = economic, ECL = ecological.

7 ^b No impacts found in the literature, but undocumented impacts may exist.

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9 **A4.1.3.6.1 Inspection of Household Goods and Personal Vehicles**

10 **Military Regulations**

11 Shipping of military household goods and personally owned vehicles is covered in Part 4 of the Defense
 12 Transportation Regulations. Other regulations that pertain to these items are covered in Section 0.
 13 Personnel are counseled prior to a move as to what is required of them, and they are required to sign
 14 form DD 1797 stating they have been counseled as to moving requirements (DoD). Household goods
 15 that contain engine power driven equipment must be free of dirt and grease (DoD 2010b). Personal
 16 property items are also to be free of soil and pest infestations, such as gypsy moths or BTS (DoD 2010b,
 17 c). Any item that can be scratched, broken, or otherwise damaged during shipment is individually
 18 wrapped (DoD 2010e). Household goods packed on Guam are inspected by APHIS-WS detector dog
 19 teams for BTS during packing for households with more than an estimated 1,814 kg (4,000 pounds) of
 20 personal property (Vice and Pitzler 2008). During fiscal year 2008, approximately 70% of all packed
 21 household goods were inspected by APHIS-WS BTS detector dogs at Andersen AFB, 80% at the naval
 22 base, and 87% at the commercial ports (USDA-APHIS WS 2008a).

1 Shipment of personally owned vehicles is covered in Chapter 408 and Attachment K3. Personnel are
2 responsible for ensuring that all exterior surfaces and the undercarriage of the vehicle are free of soil
3 and foreign matter (DoD 2009e, f). The vehicle processing center at the naval base on Guam advises
4 vehicle owners to make sure their vehicles are free of plants, leaves, seeds, soil, dirt, mud, food,
5 beverages, insects, rodents, and animals (Pepka 2010). An inspection is performed of the vehicle by
6 personnel at the vehicle processing center to note any damage prior to shipping and to ensure the
7 cleanliness of the vehicle (DoD 2009e, f). On Guam, USDA personnel inspect the engine, engine
8 compartment, radiator grill, hood, trunk, hatch, door compartments, wheels, wheel areas, and
9 undercarriage areas (Pepka 2010), and APHIS-WS BTS detector dogs inspect the vehicles prior to
10 shipping. If destined for the United States, vehicles are inspected again upon arrival. GCQA inspects
11 vehicles coming from foreign locations, but does not inspect vehicles coming from the continental
12 United States. During fiscal year 2008, 100% of all vehicles were inspected by APHIS-WS BTS detector
13 dogs at Andersen AFB and the naval base, and 99% at the commercial ports (USDA-APHIS WS 2008a).

14 ***Japan***

15 Exporters of military household goods and personal vehicles in Japan must obtain an export permit from
16 Japan Customs, and goods are physically examined. Cargo is also subject to agricultural inspections by
17 personnel from the Ministry of Agriculture, Forestry, and Fisheries. We could not obtain information
18 regarding what inspections entail.

19 ***Guam***

20 Cargo and vehicles arriving in Guam shipped as commercial freight would be subject to GCQA inspection
21 (Merfalen 2010). Cargo inspections are to be conducted at designated ports unless otherwise authorized
22 by the Director of GCQA (GCA 2010a). Seals on cargo are not to be broken except by GCQA officials.
23 There are 78 container freight stations on Guam where selected containers are moved from the point of
24 entry and staged for inspection (Merfalen 2010). Because of the volume of traffic, not all containers are
25 selected for inspection. It is unknown how many arriving containers are opened and inspected for
26 vertebrate invasive species. However, GCQA does not routinely open containers unless they lack proper
27 documentation or are from a country Guam has deemed a country of concern (Merfalen 2010).
28 Countries may be considered a concern for a variety of reasons, including whether they harbor an
29 agricultural pest of concern, have had a disease outbreak, or have had previous customs violations.

30 The container freight station at the Guam International Airport currently only has one two-person team.
31 The freight station needs at least two teams to handle the relocation. GCQA has a new facility at the
32 airport, which will spatially be able to handle the increased cargo flow from the relocation once it is
33 adequately staffed and equipped and fully operational. Currently, GCQA at the airport is currently
34 understaffed, and will need at least 31 additional personnel to handle the increased cargo flow due to
35 the relocation (Shimizu 2010b). Guam Customs has two x-ray machines at the airport; they were
36 inoperable at the time this was document was written and are awaiting replacement RapidScan
37 machines (Berringer 2010b). GCQA relies on a paper trail to identify containers likely to require
38 inspection. For example, in the Port of Guam, a container identified as requiring an inspection will be

1 tagged by a Customs and Quarantine Agent. This container may then be released to a consignee for
2 movement from the port to a container freight station until inspection.

3 ***Commonwealth of the Northern Marianas Islands***

4 The Saipan Customs Division looks for undeclared items, non-English labeled items, drugs, and weapons
5 during its inspections of household imports (Sabian 2010). Saipan Customs has an x-ray machine for
6 containerized cargo import inspections at the Port of Saipan. There is a BTS barrier at the Port of Saipan
7 for containers, but Customs does not currently have a protocol for using it. Cargo that does not come
8 from the continental United States is put in the barrier area for a minimum of 3 days. Personnel from
9 the Department of Land and Natural Resources place traps around the barrier, and inspect the exterior
10 of the containers with BTS detector dogs (Guerrero Jr. 2010). If a BTS detector dog alerts to a container,
11 the container will stay within the barrier longer than 3 days for further inspection. Detector dog
12 inspections are usually only conducted in the morning because the metal of the containers gets too hot
13 during the middle of the day for the dogs. Customs officials at the Saipan Airport receive training and
14 certification for clearing exports (Pangolinean 2010). Staffing is currently inadequate at the airport, and
15 Customs officials lack the necessary safety equipment to conduct inspections. The x-ray machine that
16 was in use at the airport is nonfunctional because it is so old that replacement parts can no longer be
17 obtained.

18 There is also a BTS barrier at the Port of Tinian (Ferrell 2010). Any containers that come from Guam get
19 put into the barrier until the BTS detector dog can inspect it. Another BTS barrier is needed at the Tinian
20 airport where the military C-130s unload their cargo. The military does not always inform Tinian
21 Quarantine when they are coming with cargo; therefore, not all cargo gets inspected; however, when
22 information is relayed, there is typically little or no response capability to perform inspections.
23 Agricultural inspections in CNMI are overseen by APHIS-PPQ.

24 **A4.1.3.6.2 *Summary of Findings***

25 All pathways were considered high risk due to their ability to transport species that could harm human
26 health and safety. Household goods that are individually wrapped and/or packed are associated with
27 lower risk of transporting vertebrate invasive species because the packing process makes detection
28 more likely (Vice and Pitzler 2008). However, the probability of detecting BTS by canine inspection
29 teams is greatly decreased once household goods are sealed inside containers or wooden crates (Vice
30 and Pitzler 2008). Short shipment times, particularly those within the Micronesia Region, increase the
31 probability of species survival during transport (Vice and Pitzler 2008). Higher risk ratings also resulted
32 because resources for implementing biosecurity measures were inadequate to meet even current
33 demands.

34 **A4.1.3.6.3 *Specific Risk Factors***

35 The specific risk factors we found to be associated with the household goods and personal vehicles
36 pathways are as follows:

- 37 • BTS inspections may not address the movement of other potentially invasive species.

Class	Scientific name	Common name	Risk type ^a
	<i>Rana sylvatica</i>	Wood frog	ECL
Birds	None likely	None likely	
Mammals	<i>Didelphis marsupialis</i>	American opossum	H, ECN, ECL
	<i>Herpestes javanicus</i>	Small Indian mongoose	H, ECN, ECL
	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
	<i>Rattus rattus</i>	Ship rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN, ECL
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Agama agama</i>	Common agama	None found
	<i>Anolis cristatellus</i>	Common Puerto Rican anole	ECL
	<i>Anolis distichus</i>	Hispaniolan gracile anole	ECL
	<i>Anolis extremus</i>	Barbados anole	ECL
	<i>Anolis porcatius</i>	Cuban green anole	ECL
	<i>Anolis sagrei</i>	Cuban brown anole	ECL
	<i>Boa constrictor</i>	Boa constrictor	H, ECN, ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Calotes versicolor</i>	Eastern garden lizard	ECL
	<i>Chondrodactylus bibronii</i>	Bibron's thick-toed gecko	ECN
	<i>Cnemidophorus lemniscatus</i>	Rainbow lizard	ECL
	<i>Cryptoblepharus carnabyi</i>	Spiny-palmed snake-eyed skink	None found
	<i>Cryptoblepharus peocilopleurus</i>	Mottled snake-eyed skink	ECL
	<i>Cryptoblepharus plagioccephalus</i>	Péron's snake-eyed skink	None found
	<i>Cryptoblepharus virgatus</i>	Cream-striped shinning-skink	None found
	<i>Cyrtopodion scabrum</i>	Rough-tailed gecko	ECL
	<i>Elaphe taeniura friesi</i>	Taiwan beauty snake	None found
	<i>Elgaria multicarinata</i>	Southern alligator lizard	None found
	<i>Emoia cyanura</i>	Bluetail emo skink	ECL
	<i>Eulamprus tenuis</i>	Bar-sided forest skink	None found
	<i>Gehyra mutilata</i>	Mutilating gecko	None found
	<i>Gekko gekko</i>	Tokay gecko	ECL
	<i>Gonatodes albogularis</i>	Yellow-headed gecko	None found
	<i>Hemidactylus frenatus</i>	Common house gecko	ECL
	<i>Hemidactylus garnotii</i>	Indo-Pacific gecko	None found
	<i>Hemidactylus platyurus</i>	Flat-tailed house gecko	None found
	<i>Hemidactylus turcicus</i>	Mediterranean house gecko	ECL
	<i>Hemiphyllodactylus typus</i>	Common dwarf gecko	None found
	<i>Lampropholis delicata</i>	Delicate skink	ECL
	<i>Lepidodactylus aureolineatus</i>	Golden scaly-toed gecko	None found
	<i>Lepidodactylus lugubris</i>	Mourning gecko	None found
	<i>Lipinia noctua</i>	Moth skink	None found
	<i>Lycodon aulicus</i>	Common wolf snake	ECL
	<i>Mabuya multifasciata</i>	Rough mabuya	None found
	<i>Python molurus bivittatus</i>	Burmese python	H, ECN, ECL
	<i>Ramphotyphlops braminus</i>	Blind snake	None found
	<i>Sceloporous occidentalis</i>	Western fence lizard	None found
	<i>Sphaerodactylus argus</i>	Ocellated gecko	None found
	<i>Sphaerodactylus elegans</i>	Ashy gecko	None found

Class	Scientific name	Common name	Risk type ^a
	<i>Tarentola mauritanica</i>	Common wall gecko	None found
	<i>Tiliqua scincoides</i>	Common bluetongue	None found
	<i>Trimeresurus flavoviridis</i>	Habu	H
	<i>Uta stansburiana</i>	Northern side-blotched lizard	None found

^a H = health, ECN = economic, ECL = ecological.

^b No impacts found in the literature, but undocumented impacts may exist.

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4 Construction materials are items used in the building process and can consist of packed or containerized
5 cargo goods, and break-bulk items like lumber, wood and metal paneling, molding, plumbing pipes, and
6 fixtures. Construction equipment is items and tools used for building, like generators, compressors,
7 table saws, nail guns, ladders and scaffolding, and machinery parts and accessories. Construction
8 vehicles include earth moving machinery like bulldozers, excavators, and bobcats, as well as forklifts,
9 concrete mixers and their pumps, dump trucks, and all-terrain vehicles. Estimates of construction
10 material, equipment, and vehicle needs were partly based on a projection of the amount of land that
11 would need to be cleared to accommodate military relocation on Guam (Section 0).

12 Construction material shipped as break-bulk cargo is items that exceed the dimensions of a standard
13 cargo container. The carriers Matson and Horizon transport these materials on a 40-foot flat rack system
14 (Matson 2006; Horizon Lines 2008). Cargo that exceeds the dimensions of a flat rack can be
15 accommodated by these carriers by special arrangement. Kyowa uses a similar system but will ship
16 smaller break-bulk cargo as well (Kyowa Shipping Company 2010a).

17 The actual points of origination for much of the construction materials, equipment, and vehicles have
18 not been identified. We assessed risks posed by construction cargo brought to Guam from elsewhere in
19 the United States or Asia. Construction cargo entering the Micronesia Region is shipped in by boat to the
20 Port of Guam or flown in by air to Guam International Airport (commercial) or Andersen AFB (military).
21 The major shipping companies for cargo in the Micronesia Region are Horizon, Matson, Kyowa, and
22 Mariana Express Lines (PB International 2008). Information from these companies was used to
23 determine the routes by which cargo is likely to be shipped (Horizon Lines 2010b, c, d, a; Kyowa Shipping
24 Company 2010a, b; Mariana Express Lines 2010a, b; Matson 2010a, b). All of these companies provide
25 containerized and bulk cargo transport.

26 **A4.1.3.7.1 Inspection of Construction Materials, Equipment, and Vehicles**

27 Because construction supplies and some equipment will be shipped as either containerized or break-
28 bulk cargo, the cargo regulations provided in Section 0 apply. Details of each regulation can be found in
29 that section. Most cargo undergoes both customs and agricultural inspections upon arrival. The
30 International Health Regulations govern inspections related to human health concerns (WHO 2005b).
31 The CFR gives authority for cargo inspections and disinfection in Titles 7 and 9 (7 CFR 318, 9 CFR). The
32 Brown Treesnake Control and Interdiction Plan makes it the responsibility of all federal agencies to
33 prevent the movement of BTS, and covers inspection of cargo (U.S. Navy 2005b). The military is bound
34 to conduct inspections of cargo by Parts 2 and 5 of the Defense Transportation Regulations, the
35 Quarantine Regulations of the Armed Forces, and OPNAVINST 6210.2 (DoD 1992, DoD 2009b). The

1 APHIS-PPQ Manual for Agricultural Clearance contains a chapter on clearing cargo (USDA-APHIS-PPQ
2 2013).

3 Construction vehicle inspections emphasize agricultural risks for transporting invasive plants, insects, or
4 agriculturally significant diseases vectored in soil. Inspection scrutiny increases with equipment arriving
5 from an origin of concern that may pose an agricultural risk. Agricultural inspections are overseen in
6 Guam and CNMI by APHIS-PPQ. Additionally, construction vehicles shipping from Guam are inspected
7 for the presence of the BTS by an APHIS-WS detector dog team (Vice 2010a). Because construction
8 vehicles are so large, searches by BTS detector dogs may not be as effective as for smaller vehicles.
9 Construction vehicles arriving in CNMI will be placed in a BTS barrier and inspected for BTS (Pangolinean
10 2010).

11 **A4.1.3.7.2 Summary of Findings**

12 All pathways were considered to be high risk due to their ability to transport species capable of harming
13 human health and safety. The primary risk associated with this pathway is that current inspection
14 procedures do not include inspection for vertebrate invasives because they have an agricultural pest or
15 human health risk emphasis. Inspections are directed at cargo arriving from an origin of concern or
16 cargo that may pose an agricultural risk. Containers likely to be inspected will have a manifest
17 identifying the cargo as an agricultural product. Bulk cargo containing wood or transported on/in wood
18 conveyances such as pallets will be inspected to ensure the wood complies with ISPM 15 requirements
19 (FAO 2006e). Because almost no specific information could be obtained regarding the needs and
20 acquisition of construction cargo for the military relocation on Guam and CNMI, the risk assessment is
21 incomplete.

22 **A4.1.3.7.3 Specific Risk Factors**

23 The specific risk factors we found to be associated with the construction materials, equipment, and
24 vehicles pathways are as follows:

- 25 • Customs agencies are constrained by resources to inspect only a portion of cargo or
26 vehicles. These inspections tend to be of material that has insufficient documentation, is
27 from a country of concern, or contains agricultural material.
- 28 • The paperwork associated with arriving construction cargo needs to be automated to allow
29 for more rapid selection of cargo to be screened.
- 30 • Documentation is lacking with regard to interception of vertebrates in or on break-bulk
31 cargo, construction materials, and construction vehicles. Often a species is identified as
32 moving in cargo or in a vehicle, but the specifics are not available.
- 33 • X-ray container scanners are not available on Guam. They are available on Saipan but not
34 used due to funding limitations.
- 35 • The actual origin of much of the break-bulk cargo and construction materials associated
36 with the relocation has not been identified.

1 **A4.1.3.8 Plant Pathways: Plant Materials and Plant and Nursery Trade**

2 The plant pathways are well-known routes for the transport and introduction of species such as
 3 amphibians like the coqui and greenhouse frogs to Hawai'i. Soil may transport anuran eggs, and anurans
 4 can be difficult to detect in certain plants such as bromeliads (Kraus et al. 1999; Christy et al. 2007c). The
 5 rapid shipment of live plants, and the cool, moist environment plants are shipped in, make survival of
 6 invasive species more likely (Christy et al. 2007c). Importation of ornamental plants for landscaping and
 7 nursery plants and materials is expected to increase due to the military relocation on Guam. Examples of
 8 the types of plants currently imported into Guam are given in Section O. Although risk assessments to
 9 date have focused primarily on insects and diseases of concern to plants, vertebrate invasives also have
 10 the potential to be spread by this pathway (Table A4-16). The plant pathway covers growing mediums,
 11 fertilizer, and potting soil; bedding and sod; above-ground plant parts; and below-ground plant parts. A
 12 contaminating or hitchhiking pest is carried by a commodity and, in the case of plants and plant
 13 products, does not infest those plants or plant products.

14 **Table A4-16: Invasive Species Transported in the Plant Pathways**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL
	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL
	<i>Osteopilus septentrionalis</i>	Cuban tree frog	H, ECN, ECL
	<i>Pseudacris regilla</i>	Pacific frog	ECL
Birds	None likely	None likely	
Mammals	<i>Clethrionomys rutilus</i>	Northern red-backed vole	H, ECL
	<i>Microtus californicus</i>	California vole	H, ECN, ECL
	<i>Mus musculus</i>	Common house mouse	H, ECN, ECL
Reptiles	<i>Anolis distichus</i>	Hispaniolan gracile anole	ECL
	<i>Anolis sagrei</i>	Cuban brown anole	ECL
	<i>Calotes versicolor</i>	Eastern garden lizard	ECL
	<i>Diadophis punctatus</i>	Southern ringneck snake	None found ^b
	<i>Elaphe guttata</i>	Red corn snake	None found
	<i>Gekko hokouensis</i>	Kwangsi gecko	None found
	<i>Hemidactylus frenatus</i>	Common house gecko	ECL
	<i>Hemidactylus garnotii</i>	Indo-Pacific gecko	None found
	<i>Hemiphyllodactylus typus</i>	Common dwarf gecko	None found
	<i>Lampropholis delicata</i>	Delicate skink	ECL
	<i>Saproscincus mustelina</i>	Weasel skink	None found
	<i>Tarentola mauritanica</i>	Common wall gecko	None found
	<i>Thamnophis spp.</i>	Unknown	None found

15 ^a H = health, ECN = economic, ECL = ecological.

16 ^b No impacts found in the literature, but undocumented impacts may exist.

17
 18 Growing media like potting soils and fertilizers are likely to transport amphibians and their eggs, and the
 19 blind snake, *Ramphotyphlops braminus* (Nussbaum 1980; Crombie and Pregill 1999; Christy et al. 2007c).
 20 *Ramphotyphlops braminus* was not included in the analysis because it is already present in Guam, CNMI,
 21 FSM, and Palau. Although not currently reported to be present in CNMI, fossil records show that it was
 22 once a naturally occurring part of the herpetofauna (Pregill 1998). Sod is not typically imported to
 23 Guam, although grass stolons are (Campbell 2010b). Bedding material is likely to transport a variety of

1 amphibians, mammals, and reptiles, but little of this material is “imported” to Guam because it comes
2 mainly from the continental United States (Campbell 2010b). Above-ground plant parts can transport a
3 variety of amphibians and reptiles (Christy et al. 2007c; Berringer 2010a; Campbell 2010d). Below-
4 ground plant parts are likely to transport primarily mice, and corn snakes.

5 **A4.1.3.8.1 Inspection Procedures**

6 ***International Standards for Phytosanitary Measures***

7 The IPPC is an agreement among countries on plant health and measures taken to prevent the
8 introduction and spread of pests. One of its products is the publication of the ISPM. Several of these are
9 particularly pertinent to the movement of plant materials. Principles outlining how countries should
10 implement phytosanitary measures are discussed in ISPM 1 (FAO 2006f). Thailand began full
11 implementation in 1995, and China began full implementation of ISPM 1 in 2001 (FAO 2006g, j). Japan
12 has mostly implemented this standard (FAO 2007a). New Zealand, the Philippines, and South Korea
13 report that they have fully implemented this standard, but do not give a date when full implementation
14 began (FAO 2006h, i, 2009). No information on the implementation of ISPM 1 in the other countries
15 could be found. However, of the countries listed, only Hong Kong and Taiwan are not signatories to the
16 IPPC.

17 A glossary of phytosanitary terms is given in ISPM 5 (FAO 2010b). Some definitions of particular
18 importance to this pathway are given in the following paragraphs. Thailand began full implementation in
19 1995, and China began full implementation of ISPM 5 in 2005 (FAO 2006g, j). Japan, New Zealand, the
20 Philippines, and South Korea have fully implemented the standard, but give no date when
21 implementation began (FAO 2006h, i, 2007a, 2009). No information on the implementation of ISPM 5 in
22 the other countries could be found.

23 Bulbs and tubers refer to the dormant underground parts of plants intended for planting, and include
24 corms and rhizomes. Commodities refer to types of plants, plant products, or other articles being moved
25 for trade or other purpose. Cut flowers and branches refer to the fresh parts of plants intended for
26 decorative use and not for planting. A growing medium is any material in which plant roots are growing
27 or intended for that purpose. Plants refer to living plants and parts thereof, including seed and
28 germplasm. A regulated article is any plant, plant product, packaging, conveyance, container, soil and
29 any other organism, object or material capable of harboring or spreading pests, deemed to require
30 phytosanitary measures, particularly where international transportation is involved. Seeds refer to a
31 commodity class of seeds for planting or intended for planting and not for consumption or processing.

32 Preventative measures taken within the plant pathways include various treatment methods. Treatment
33 is an official procedure for the killing, inactivation, or removal of pests, or for rendering pests infertile or
34 for devitalization. Fumigation is treatment with a chemical agent that reaches the commodity wholly or
35 primarily in a gaseous state. Heat treatment is a process in which a commodity is heated until it reaches
36 a minimum temperature for a minimum period of time according to an official technical specification.
37 Irradiation is treatment with any type of ionizing radiation.

1 Further preventative measures include screening procedures and regulatory compliance. Clearance
2 refers to the verification of compliance with phytosanitary regulations. An inspection is an official visual
3 examination of plants, plant products, or other regulated articles to determine if pests are present
4 and/or to determine compliance with phytosanitary regulations. A visual examination is the physical
5 examination of plants, plant products, or other regulated articles using the unaided eye, lens,
6 stereoscope, or microscope to detect pests or contaminants without testing or processing.

7 Imports through these pathways are subject to regulations. A certificate is an official document that
8 attests to the phytosanitary status of any consignment affected by phytosanitary regulations. The
9 country of origin is the country where the plants were grown or where regulated articles were first
10 exposed to contamination by pests. An import permit is an official document that authorizes the
11 importation of a commodity in accordance with specified phytosanitary import requirements. A point of
12 entry is an airport, seaport, or land border point officially designated for the importation of
13 consignments, and/or entrance of passengers. A re-exported consignment is a consignment that has
14 been imported into a country from which it is then exported.

15 Equivalence of phytosanitary measures refers to situations where different phytosanitary measures
16 achieve a contracting party's appropriate level of protection for a specified pest risk. Phytosanitary
17 import requirements refer to specific phytosanitary measures established by an importing country
18 concerning consignments moving into that country. A phytosanitary measure is any legislation,
19 regulation, or official procedure having the purpose to prevent the introduction and/or spread of
20 quarantine pests, or to limit the economic impact of regulated non-quarantine pests. A phytosanitary
21 procedure is any official method for implementing phytosanitary measures including the performance of
22 inspections, tests, surveillance, or treatments in connection with regulated pests.

23 An outline for the development of a national system for issuing phytosanitary certificates is described in
24 ISPM 7 (FAO 2006a). Thailand began full implementation in 1997, and China began full implementation
25 of ISPM 7 in 1998 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South Korea all fully
26 implement the standard, but give no date when full implementation began (FAO 2006h, i, 2007a, 2009).
27 Guidelines for preparing and issuing phytosanitary certificates and phytosanitary certificates for re-
28 export are given in ISPM 12 (FAO 2001). Thailand began full implementation in 2001, and China began
29 full implementation of ISPM 12 in 2003 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South
30 Korea all fully implement the standard, but give no date when full implementation began (FAO 2006h, i,
31 2007a, 2009). ISPM 23 outlines the guidelines for conducting inspections of plant materials (FAO 2006c).
32 Both China and Thailand began full implementation of ISPM 23 in 2005 (FAO 2006g, j). Japan, New
33 Zealand, the Philippines, and South Korea all fully implement the standard, but give no date when full
34 implementation began (FAO 2006h, i, 2007a, 2009).

35 Guidelines to assist countries in determining the equivalence of phytosanitary measures is given in ISPM
36 24 (FAO 2006d). China began full implementation of ISPM 24 in 2005, and Thailand began partial
37 implementation in 2008 (FAO 2006g, j). Thailand rates the relevance of ISPM 24 to its phytosanitary
38 procedures as low. Japan, New Zealand, and South Korea fully implement the standard, but give no date
39 when full implementation began (FAO 2006i, 2007a, 2009). The Philippines does not implement ISPM

1 24, and rates its relevance as low (FAO 2006h). The selection of an appropriate sampling scheme for
2 inspection is discussed in ISPM 31 (FAO 2008). No information could be obtained on implementation of
3 ISPM 31 in any of the countries.

4 ***Australia Export Regulations***

5 In Australia, goods that are to be exported have to be free of pests as determined by inspection, and
6 cannot be exported without an export permit. These goods cannot then be loaded after inspection into
7 containers unless the containers are free from pests. Likewise, goods cannot be loaded after inspection
8 with other goods that could cross-infect the prescribed goods (Australia OLDP 2007). A notice of intent
9 to export goods must be given not less than three working days prior to export by ship or in sufficient
10 time to obtain an export certificate for export by aircraft. The notice must contain the following
11 information:

- 12 • Name and address of the consignor and consignee
- 13 • Intended port of loading of the goods
- 14 • Intended ship and voyage number or airline flight number
- 15 • Intended date of departure
- 16 • Intended port of discharge of the goods
- 17 • Country of origin if it is not Australia
- 18 • Country of intended final destination of the goods
- 19 • Place where goods can be inspected
- 20 • Date on which goods can be inspected
- 21 • State or Territory in which application for a certificate with respect to the goods, if sought,
22 will be made
- 23 • Number allotted to the registered establishment in which processing last occurred
- 24 • Shipping or other identifying marks relating to the goods
- 25 • Identification number appearing on a container system unit that will contain the goods if
26 available
- 27 • Number and kind of packages (if different from the number passed for export, list the
28 number passed for export; if all passed for export, the phrase “as submitted”)
- 29 • True description of the goods
- 30 • Quantity of goods available for inspection
- 31 • Any other information required by the Secretary

- 1 • Declaration by the exporter that the orders that apply to the goods have been complied
2 with, information contained in the notice is true and correct, and conditions in the
3 importing country have been complied with

4 If goods do not pass inspection and a treatment exists, the treatment must be applied prior to the
5 issuance of a phytosanitary certificate. Currently, Australia treats plants for export for invertebrate pests
6 rather than vertebrate pests. Only certain plants likely to carry particular invertebrate pests, such as the
7 green snail, are treated (South Australia 2010). Such plants are treated with methyl bromide, a
8 steam/air mixture at 60°C for 30 minutes, or fumigation with Basamid. Only plants that are within 25 km
9 (15.5 miles) of a known green snail infestation are subject to treatment.

10 After inspection, the authorized officer must make sure the identification number appearing on a
11 container system unit is entered on the notice of intent to export if not already present. The officer
12 must also arrange for the number of the official mark, if applied to the container system unit, to be
13 entered on the notice of intent to export next to the number of the container unit. A phytosanitary
14 certificate will also be issued containing the following information:

- 15 • Name of an approved inspector
- 16 • Written declaration of disinfestation or disinfection treatments carried out by the exporter if
17 not supervised by an approved inspector, or ruling out of the appropriate area on the form
18 to indicate such treatments are not required
- 19 • Additional declarations such as free of weed seeds, specific pests, or pest or fumigation
20 treatment applied; if no such declarations are needed, this must be indicated on the
21 certificate
- 22 • Signature of authorized officer and the Departmental seal
- 23 • Description of the consignment (container system unit numbers, import and export permit
24 numbers if known, approved officer has to check off each column entry prior to signing the
25 certificate; if the back of the certificate or an additional sheet is used, it must contain the
26 number of the certificate and name of the exporter and be signed by the officer)
- 27 • Common and botanical name of the goods, or a general term or description if a botanical
28 name is not appropriate
- 29 • Consignee's name and address if known, or "to order" otherwise
- 30 • Point of entry, or actual port of importation if known

31 ***China Export Regulations***

32 Any material exported from China is subject to a quarantine inspection by Ministry of Agriculture
33 personnel. The shipper has to submit, prior to export, an application for quarantine inspection. Plants
34 are quarantined by the port animal and plant quarantine office until an inspection can be performed.
35 Once inspection is passed (or an unspecified suitable treatment applied), material is allowed to leave the
36 country. Customs officials release the shipment on the basis of quarantine certificates or stamps on the

1 customs declaration forms from the port animal and plant quarantine office. Transport of plant material
2 for export is expected to comply with regulations on plant quarantine and epidemic prevention (China
3 2009).

4 After inspection, a phytosanitary certificate is issued to the shipper. The phytosanitary certificate
5 contains the following information:

- 6 • Name and address of both the consignor and consignee
- 7 • Botanical and common names of the products
- 8 • Quantity of product
- 9 • Number and type of packages
- 10 • Place of origin
- 11 • Port of destination
- 12 • Mode of conveyance
- 13 • Date of inspection
- 14 • Any disinfestation or disinfection treatments applied
- 15 • Place and date where the certificate was issued

16 Interception records and patterns indicate a weak enforcement for for export criteria in China.

17 ***Commonwealth of the Northern Mariana Islands Export Regulations***

18 No regulations pertaining to plant export requirements or treatment of plants and plant propagative
19 material could be accessed.

20 ***Federated States of Micronesia Export Regulations***

21 No regulations pertaining to plant export requirements or treatment of plants and plant propagative
22 material could be accessed.

23 ***Guam Export Regulations***

24 The only information that could be found regarding plant exportation from Guam pertains to shipments
25 of nursery stock. The Guam Administrative Rules and Regulations (GARR) state that GDOA certifies
26 nursery stock shipments for export when required, but does not give information regarding what the
27 certification process involves. GDOA issues nursery stock certificates to nurseries complying with their
28 inspection regulations, although these are also not stipulated (GDOA 2007a).

29 ***Hong Kong Export Regulations***

30 No regulations pertaining to plant export requirements or treatment of plants and plant propagative
31 material could be accessed.

1 ***Japan Export Regulations***

2 Exporters must prepare an export declaration for Japan Customs describing the nature, quantity, and
3 value of the goods to be exported. The Plant Protection Station (PPS) conducts inspections of plant
4 material after an application by the shipper for an export inspection. Inspections are carried out at the
5 PPS located at the airport or seaport of export. What these inspections cover depends on the
6 requirements of the importing country. After a physical examination of the goods, an export permit and
7 phytosanitary certificate must be obtained by the shipper. Phytosanitary certificates contain the
8 following information:

- 9 • Name and address of consignor and consignee
- 10 • Number and description of packages
- 11 • Distinguishing marks
- 12 • Place of origin
- 13 • Means of conveyance
- 14 • Declared point of entry
- 15 • Name of produce and quantity declared
- 16 • Botanical name if applicable
- 17 • Disinfestation or disinfection treatment if applied

18 It is unknown whether inspections and phytosanitary certificates apply to plant propagative material.
19 Treatment of infected material is dependent on the pest found in the material. Several of the approved
20 treatments are as follows: hydrogen cyanide fumigation, methyl bromide fumigation, and phosphine
21 fumigation. No information could be found on treatment of plant propagative material prior to export
22 from Japan.

23 ***Korea Export Regulations***

24 The National Plant Quarantine Service conducts export inspections of plant materials and issues
25 phytosanitary certificates in South Korea. Plants being exported to countries not requiring a
26 phytosanitary certificate are not inspected. Inspections and phytosanitary certificates conform to the
27 requirements of the importing country (KNQS 2008). South Korea uses methyl bromide fumigation,
28 chemical treatments, cold, heat, and irradiation to treat plant materials. No information could be
29 accessed for North Korea.

30 ***Netherlands Export Regulations***

31 The Ministry of Agriculture, Nature, and Food Quality transferred responsibility for inspections to four
32 horticultural inspection bodies on September 1, 2007. These agencies are as follows: Netherlands
33 General Inspection Service for Agricultural Seed and Seed Potatoes; Netherlands Inspection Service for
34 Horticulture; Flower Bulb Inspection Service; and Quality Control Bureau for Vegetables and Fruit. These

1 four agencies are responsible for inspecting exported plants for diseases (NMA 2007). No additional
2 information could be found on further export requirements or treatments for plant materials.

3 ***New Zealand Export Regulations***

4 Exporters in New Zealand must meet the phytosanitary requirements of the country to which they wish
5 to ship material. Biosecurity New Zealand delegates authority for export inspections to authorized
6 Independent Verification Agencies (PMACI 2006; Biosecurity New Zealand 2009b). Shipments for export
7 are inspected in accordance with the requirements of the importing country and a phytosanitary
8 certificate is issued. Random samples of homogeneous lots are inspected, with samples being large
9 enough to provide a minimum 95% confidence level that pests do not exceed a specified threshold.
10 Inspections include both the product and the packaging. If pests are found, treatment may be applied
11 prior to shipment (Biosecurity New Zealand 2006). New Zealand uses several different treatments
12 depending on the plant material and the pest involved. These include methyl bromide fumigation, hot
13 water or chemical treatment for dormant material, or chemical treatment with either a spray or a dip
14 (Biosecurity New Zealand 2010).

15 Suppliers are required to maintain inspection records that include the following information:

- 16 • Product type inspected
- 17 • Line/grower/packing period
- 18 • Time of sampling
- 19 • Lot size
- 20 • Sample size
- 21 • Date of inspection
- 22 • Number and type of quarantine pest found per sample
- 23 • Country/crop maximum pest limit, or combination (as appropriate) used in the decision-
24 making process resulting from the inspection
- 25 • Action taken as a result of the inspection
- 26 • Inspector's name and validation

27 In addition, suppliers must maintain records of equipment calibrations where applicable, security checks
28 undertaken while plant products are stored in registered facilities, and non-approved organizations that
29 are supplied with plant products eligible for phytosanitary certification. These records must be
30 maintained for a minimum of 2 years (Biosecurity New Zealand 2006).

31 ***Palau Export Regulations***

32 In Palau, an exporter may request an export inspection that will be conducted according to the
33 guidelines of the importing country. Inspectors may apply official seals to inspected packages, and issue
34 a phytosanitary certificate for plants produced in Palau (Palau BAMR 1999). Phytosanitary certificates

1 are modeled after the guidelines produced by the IPPC in ISPM 12 (FAO 2001). Any plant material
2 transiting through Palau must be clearly marked as intended for re-export. Inspectors will issue a re-
3 export phytosanitary certificate for such material provided there is a valid phytosanitary certificate from
4 the country of origin and the material is as described on the certificate (Palau BAMR 1999). The only
5 decontamination measure mentioned in Palau's Quarantine Manual is methyl bromide treatment
6 (Chambers and Englberger 1998).

7 ***Philippines Export Regulations***

8 Exporters wishing to export plant material from the Philippines must submit an application for
9 inspection to a Plant Quarantine Service Office at least 48 hours prior to shipment. However, if the
10 inspection is to be conducted on the exporter's premises, it must be submitted 3 to 7 days prior to
11 export. Inspectors require additional documentation at the time of the inspection, which includes an
12 import permit from the importing country if required, Convention on International Trade in Endangered
13 Species (CITES) permits if needed, and an application for a phytosanitary certificate. Inspectors perform
14 the inspection in accordance with the requirements of the importing country. A random sample
15 consisting of 10% of the total shipment is used for inspection. Both visual and laboratory inspections are
16 made of the random samples. If the material passes the inspection, a phytosanitary certificate will be
17 issued. Only the Bureau of Plant Inspection/Plant Quarantine Service is authorized to issue
18 phytosanitary certificates in the Philippines. The Bureau only issues re-export phytosanitary certificates
19 if they are required by the importing country. The Philippines has modeled its export certification and
20 phytosanitary certification systems on guidelines established by the IPPC (FAO 2001, 2006a).

21 If the shipment fails inspection, the exporter has the option of applying an internationally approved
22 treatment to rid the shipment of infestation. Treatment can be waived if it is not required by the
23 importing country. Treatment can be performed either at Plant Quarantine Service facilities or by a
24 private firm that is licensed to operate fumigation facilities. If performed by a private firm, the entire
25 operation must be supervised by a plant quarantine officer (Philippine PQS). Specific treatments are not
26 mentioned.

27 ***Puerto Rico Export Regulations***

28 No regulations pertaining to plant export requirements or treatment of plants and plant propagative
29 material could be accessed.

30 ***Singapore Export Regulations***

31 Exporters in Singapore are responsible for knowing the import requirements of the importing country.
32 The Singapore Agri-Food and Veterinary Authority will provide a phytosanitary certificate based on the
33 requirements of the importing country. An application for a phytosanitary certificate must be filled out
34 prior to inspection (Singapore SRS 2005). Exporters may become members of an Accredited Certification
35 Scheme that allows them to assume the inspection function for their own goods. To participate,
36 members must implement and document an Agri-Food and Veterinary Authority approved quality
37 assurance system to ensure the export product is free of pests. The Agri-Food and Veterinary Authority
38 conducts regular audits of members to ensure compliance. Under this arrangement, exporters are

1 issued phytosanitary certificates as long as they submit an application for a phytosanitary certificate and
2 provide documentation ensuring the material is pest free. Documentation can include an import permit,
3 regulations of importing countries, fumigation certificates, and test reports.

4 Pest control agencies in Singapore are required to obtain accreditation if they are performing
5 phytosanitary treatments. Registration under this accreditation scheme allows pest control operators to
6 perform phytosanitary treatments and issue certificates of treatment on behalf of the Singapore Agri-
7 Food and Veterinary Authority. Treatments mentioned in the official document covering pest control
8 agencies in Singapore are methyl bromide fumigation and heat treatment (Singapore SRS 2003). These
9 agencies must specify the types of treatments they intend to perform and for which plant materials.
10 They must describe in detail a quality assurance system that will ensure products have been properly
11 sanitized. The agencies are subject to audits by the Singapore Agri-Food and Veterinary Authority.

12 ***Taiwan Export Regulations***

13 No regulations pertaining to plant export requirements or treatment of plants and plant propagative
14 material could be accessed.

15 ***Thailand Export Regulations***

16 It is unclear from Thai regulations whether phytosanitary certificates for export are required unless
17 required by the importing country. However, to obtain a phytosanitary certificate, an inspection by a
18 plant quarantine official is required. Plants that are considered by the Minister of Agriculture as being
19 likely to export plant pests are considered controlled plants and must be accompanied by a
20 phytosanitary certificate. Exporters can request registration of their facilities with the Department of
21 Agriculture to have plant quarantine officials inspect their facilities and make recommendations
22 regarding pest control. The only information that could be obtained regarding treatment of plants in
23 Thailand referred to fumigation or treatment with chemicals by means of spraying without giving
24 specifics.

25 ***United States (California, Florida, and Hawai'i) Export Regulations***

26 Phytosanitary certificates and export certification are not required to export plants and plant
27 propagative material from the United States, but are issued if the importing country requires them.
28 Exporters requiring a phytosanitary certificate may request an export inspection. Only authorized
29 government officials and accredited agencies may perform export inspections. The exporter is
30 responsible for providing the import requirements of the destination country to inspectors if they are
31 different from what PPQ currently has (USDA-APHIS). These may be in the form of an official
32 communication or an EXCERPT. An EXCERPT is a publication containing phytosanitary requirements. The
33 entire shipment must be sampled in order for a phytosanitary certificate to be issued. Samples must be
34 of sufficient size and must be representative of the entire shipment. If a shipment is not considered high
35 risk (not defined), the sample size is 2% of the inspectional unit. An inspectional unit can be a box, bag,
36 tray, or similar unit. If inspection of 2% of the material is not practical, the sample size may be
37 determined from the hypergeometric table published in the export manual. Inspection of nursery stock
38 is to be 100%, or as close to 100% as practical. At a minimum, a visual inspection is performed. A

1 laboratory analysis may be required by the importing country. No specific information could be found
2 for screening procedures used for soil, fertilizer, or growing media. If treatment is required and
3 available, it must be applied prior to issuance of the phytosanitary certificate (USDA-APHIS-PPQ 2010b).

4 The APHIS-PPQ Treatment Manual describes the use of authorized fumigants, which are methyl
5 bromide, sulfuryl fluoride, and phosphine. Methyl bromide concentrations above 5 parts per million
6 require the use of a self-contained breathing apparatus by the operator; therefore, it can be assumed it
7 would be toxic to animals. Both sulfuryl fluoride and phosphine can be toxic to humans and animals. In
8 addition, the treatment manual describes the use of aerosols and micronized dusts. Non-chemical
9 treatments that are described are hot water immersion, steam, vapor heat, forced hot air, cold
10 treatment, and irradiation. Steam, dry heat, freezing, incorporation of granular pesticides, and methyl
11 bromide fumigation are all mentioned for treating soil (USDA-APHIS-PPQ 2008). It is unknown whether
12 these treatments are required for other plant propagative materials such as growing media or fertilizer.

13 ***California***

14 The California Department of Food and Agriculture currently inspects nurseries using county
15 commissioners as often as needed to ensure compliance with nursery stock regulations regarding pests.
16 Any entity that produces or sells nursery stock in California is required to comply with the cleanliness
17 standards outlined in the Nursery Inspection Procedure Manual. Cleanliness is defined in the manual as
18 follows: “Commercially clean shall mean that pests are under effective control, are present only to a
19 light degree, and that only a few of the plants in any lot or block of nursery stock or on the premises
20 show any infestation or infection, and of these none show more than a few individuals of any insect,
21 animal or weed pests, or more than a few individual infestations of any plant disease” (CA DFA
22 2001a, b).

23 ***Florida***

24 The Division of Plant Industry under the Florida Department of Agriculture and Consumer Services
25 requires nursery registration and currently inspects nurseries several times a year. Nurseries cannot
26 advertise in newspapers unless they can provide documentation that they are registered with the state
27 (FDACS, 2004; Florida Legislature 2009). Inspection tags are required on every container in a shipment
28 (Division of Plant Industry 2008).

29 ***Hawai'i***

30 The Hawai'i Department of Agriculture provides plant inspection, plant fumigation, and plant and
31 nursery certification services. Plants to be exported from Hawai'i are required to be brought to a plant
32 inspection station where an inspection is performed according to the regulations of the importing
33 country. Once plant material passes inspection, it is packed, sealed, and stamped at the plant inspection
34 station, and a phytosanitary certificate is issued. Nurseries can bypass the inspection at the plant
35 inspection station if they obtain certification. Nursery certification requires that plants are grown
36 according to a specific set of conditions agreed to by the nursery and the Hawai'i Department of
37 Agriculture. Compliance inspections are conducted once every 6 months. Each certified nursery receives

1 an official certification stamp with a unique identifying number (Hawai'i Department of Agriculture
2 1981).

3 ***Idaho***

4 The Idaho State Department of Agriculture licenses and inspects Christmas tree nurseries. Idaho state
5 regulations require a producer to be issued a permit prior to shipping trees. The producer must acquire
6 a phytosanitary certificate and have valid nursery license prior to exporting the trees (ID DoA 2010).

7 ***Oregon***

8 The Oregon Department of Agriculture Plant Division, Nursery and Christmas Tree Program performs
9 inspection of Christmas tree producers in Oregon. Christmas tree producers must be licensed by the
10 state and are required to obtain a phytosanitary certificate for trees to be exported to destinations that
11 require them. The requirements for each phytosanitary certificate depend on the destination market for
12 the trees. Fee-based inspection services are available for both production and harvest. Regulations
13 governing phytosanitary requirements are detailed in Oregon Regulations Chapter 571 (Oregon State
14 Legislature 2009).

15 ***Washington***

16 The Department of Agriculture of the State of Washington is required to license all commercial
17 Christmas tree producers that harvest more than 100 trees per year for sale to the public. All producers
18 are subject to phytosanitary inspection by state inspectors and failure to grant access may result in
19 revocation of the license (Chapter 15.13 RCW) (Washington State Legislature 2010). The Plant Services
20 Program provides phytosanitary inspection permits for trees on a fee basis for licensed producers. All
21 licensed producers are inspected for compliance with Washington State regulations.

22 ***Commonwealth of the Northern Mariana Islands Import Regulations***

23 No regulations pertaining to plant import requirements or treatment of plants and plant propagative
24 materials could be accessed.

25 ***Federated States of Micronesia Import Regulations***

26 No regulations pertaining to plant import requirements or treatment of plants and plant propagative
27 materials could be accessed.

28 ***Guam Import Regulations***

29 Guam requires a phytosanitary certificate for the importation of rooted plants and seedlings; cuttings
30 and grafts of woody plants, ornamental plants, horticultural plants; cut flowers; flower bulbs, corms,
31 tubers, rhizomes, and other vegetative plant propagating materials; and seeds meant for propagation
32 purposes. The phytosanitary certificate has to have been issued within 14 days of shipment and be in
33 English. If the material is not coming directly from the country of origin, it needs to be accompanied by a
34 certificate from the country of origin and a re-export certificate from the country of dispatch (GDOA
35 1997).

1 An import permit is required by anybody receiving plant materials in Guam. Immediately upon arrival in
2 Guam, GDOA must be notified in writing of the materials and given the following information:

- 3 • Way-bill number
- 4 • Container number
- 5 • Name and address of both the consignor and consignee
- 6 • Marks
- 7 • Number of packages
- 8 • Description of the contents of each package
- 9 • Port at which laden
- 10 • Any additional information necessary to locate and identify the shipment

11 The only approved ports of entry into Guam are air- and sea ports and the post office. Any package
12 coming in must be plainly and legibly marked in English with the name and address of the shipper and
13 receiver; name of country, state, or territory and locality therein where the product was grown; and a
14 description of the contents of the package (GDOA 2007a).

15 Guam requires a phytosanitary certificate for the importation of soil, but it is not known if this applies to
16 other types of plant propagative material (GDOA 1997). An import permit is also required for anybody
17 receiving soil. The definition of soil in Guam is as follows: "Soil means that part of the upper layer of
18 earth in which plants can grow; this material may or may not contain organic matter and includes such
19 planting media as deteriorated peat, except clean coral, sand, pottery and industrial clay, volcanic
20 cinders and other similar soil-free material." Soil itself may only be imported in limited quantities for
21 research, unless it is commercially manufactured and packaged potting soil (GDOA 2007a; Berringer
22 2010a). No specific information could be found for screening procedures for plant propagative material.

23 Guam requires that imported Christmas trees be mechanically shaken prior to netting for shipping
24 (Oregon Department of Agriculture 2010).

25 After inspection, the inspector places a tag, label, or stamp indicating the package has been inspected
26 and has passed inspection. Guam currently inspects 100% of all declared plant material entering the
27 country at its Plant Inspection Facility. All FedEx and United Parcel Service shipments are subject to
28 inspection without a search warrant because they are private companies. However, any packages
29 coming into Guam through the U.S. Mail that are not properly labeled as containing plants or plant
30 propagative material will not be inspected. United States Mail coming into Guam is considered domestic
31 and requires a search warrant to inspect (Shimizu 2010a).

32 The advent of e-commerce has made it much easier to buy plant parts online. Although this material is
33 required to be clearly marked so that it undergoes inspection upon entry into Guam, material may not
34 always be properly labeled either willfully, or through ignorance of the regulations. The person receiving

1 the shipment is also required to have an import permit (GDOA 1997). Plants shipped to Guam must be
2 free of soil. Persons buying plants online may be unaware of this regulation. This could potentially allow
3 plant material to bypass the inspection process, allowing entry of vertebrate invasives.

4 ***Palau Import Regulations***

5 Any person entering Palau with plant material or any entity importing plant material into Palau must
6 notify the proper officials of the arrival of the material. For individuals entering Palau, this would be the
7 Customs agent. For importers, Customs officials and the Chief of Agriculture must be notified. Import
8 permits are required for any material being imported. Permits must include the following information:

- 9 • Name and address of both the shipper and exporter
- 10 • Origin of the goods
- 11 • Quantity
- 12 • Common and scientific names
- 13 • Mode of transport
- 14 • Point-of-entry
- 15 • Approximate date of arrival

16 All imported plants are required to be free from soil, and only approved packing material (e.g., sterile
17 peat moss, sphagnum moss, perlite, vermiculite, sawdust, shredded paper, or inert material) can be
18 used around the roots of imported live plants. All plant material requires a phytosanitary certificate.
19 Imported material is inspected for the presence of soil and pests. A subsample of each shipment of cut
20 flowers that consists of four or more containers is taken for inspection, and every stem in the sample is
21 inspected. Shipments of three or fewer containers are all inspected. Quarantine officials are supposed to
22 inspect 100% of imported nursery stock (Chambers and Englberger 1998; Palau BAMR 1999). No specific
23 information could be found for screening procedures used for soil, fertilizer, or growing media. The only
24 treatment measures mentioned for imported material in Palau are spraying, methyl bromide
25 fumigation, immersion in glyphosate, or quarantine (Palau BAMR 1999).

26 **A4.1.3.8.2 *Summary of Findings***

27 The primary difference in risk rankings is related to the types of species transported and whether they
28 are associated with health, economic, or ecological impacts. These pathways are considered high risk
29 because they are likely to transport and introduce species such as mice that can negatively impact
30 human health, and amphibian species that will cause impact to the region's economy and ecology.
31 Material intentionally moved in these pathways that harbor hitchhikers unintentionally presents a
32 primary risk in that inspections of these commodities focus on insects and plant diseases, and terrestrial
33 vertebrate species are likely missed, particularly when hiding in places not normally inspected for
34 insects. Due to the large volume of material that may be shipped, inspections can only cover a small
35 portion of the total shipment, increasing the likelihood that a vertebrate invasive will be missed (Christy
36 et al. 2007c). Although some differences in inspection procedures do exist among the various countries

1 for which regulations could be obtained, the general procedure used is the same. Further, there is a high
2 risk for intentional transport of plants to bypass inspection processes. For example, packages coming
3 into Guam through the U.S. Mail that are not properly labeled as containing plants or plant propagative
4 material will not be inspected; U.S. Mail coming into Guam is considered domestic and requires a search
5 warrant to inspect. This is important because the Internet allows individuals to order plants and plant
6 propagative materials and have them shipped directly to themselves. If such material is not clearly
7 marked, it may not undergo inspection.

8 **A4.1.3.8.3** *Specific Risk Factors*

9 The specific risk factors we found to be associated with the plant pathways are as follows:

- 10 • Australia does not treat plants being exported unless they come from within 25 km (15.5
11 miles) of an area that is infested with the green snail or pests are detected during the export
12 inspection process. Current treatments target invertebrates rather than vertebrates.
- 13 • Some countries tailor their export inspections to the requirements of the importing country,
14 and therefore, may be likely to miss vertebrate invasives.
- 15 • Singapore relies on the exporter to supply inspection officials with the requirements of the
16 importing country before conducting export inspections.
- 17 • The United States relies on the exporter to supply inspection officials with the requirements
18 of the importing country if they are different from what PPQ currently has.
- 19 • Intentional transport of material entering Guam through the U.S. Mail that is not clearly
20 marked as containing plant material will not be inspected as this requires a search warrant
21 and poses a high risk of unintentionally transporting and introducing terrestrial vertebrate
22 pest species.
- 23 • The Internet allows individuals to order plants and plant propagative materials and have
24 them shipped directly to themselves. If such material is not clearly marked, it may not
25 undergo inspection.
- 26 • New Zealand uses authorized independent verification agencies to conduct export
27 inspections of plant material for Biosecurity New Zealand. These agencies are only audited
28 once per year by Biosecurity New Zealand to ensure compliance with accreditation
29 standards (Biosecurity New Zealand 2009b).
- 30 • Exporters in the Philippines have the option to waive treatment of plants if it is not required
31 by the importing country.
- 32 • Exporters in Singapore may become members of an accredited certification scheme that
33 allows them to assume the inspection function for their own goods. The Agri-Food and
34 Veterinary Authority conducts regular audits of members to ensure compliance.

- 1 • Exporters in Thailand are not required to have a phytosanitary certificate unless required by
2 the importing country or the plant is deemed by the Minister of Agriculture to be likely to
3 export plant pests.
- 4 • Currently, Hong Kong and Taiwan are not signatories to the IPPC.
- 5 • Export inspections generally look for insects and signs of plant disease, which may miss
6 vertebrate invasives.
- 7 • Due to the large volume of many shipments, generally only a sample of each shipment will
8 be inspected. Sampling schemes are designed to detect insects and plant disease, rather
9 than vertebrate invasives.
- 10 • Counterfeit phytosanitary certificates have been used. Phytosanitary certificates can be
11 purchased on eBay, with no way for the buyer to know whether they are authentic. Some of
12 these can be purchased in the absence of a plant purchase (eBay 2010).

13 **A4.1.3.9 Aquaculture**

14 Aquaculture is a well-known pathway for the introduction of anurans as shown by the list of species in
15 Table A4-17 (Christy et al. 2007c; Kraus 2009). Regulations regarding aquaculture and invasive species
16 pertain to the prevention of introducing exotic fish rather than anurans into an ecosystem. The
17 shipments of commodity fish that are of concern with respect to the introduction of anurans are
18 freshwater fish (Brown 2010b). In the Micronesia Region, this typically means tilapia and catfish.

19 **Table A4-17: Invasive Species Transported in the Aquaculture Pathway**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Fejervarya cancrivora</i>	Crab-eating frog	ECL
	<i>Fejervarya limnocharis</i>	Asian cricket frog	ECL
	<i>Microhyla pulchra</i>	Marbled pygmy frog	ECL
	<i>Polypedates megacephalus</i>	White-lipped tree frog	ECL
	<i>Rana catesbeiana</i>	American bullfrog	ECN, ECL
	<i>Rana guentheri</i>	Guenther's frog	H, ECL
	<i>Rana nigromaculata</i>	Dark-spotted frog	H
Birds	None likely	None likely	
Mammals	None likely	None likely	
Reptiles	None likely	None likely	

20 ^a H = health, ECN = economic, ECL = ecological.

22 **A4.1.3.9.1 Aquaculture Regulations**

23 The United Nations Food and Agriculture Organization developed a working definition of aquaculture,
24 which is as follows (Maryland DoA and NASAC 1995): "...the farming of aquatic organisms including fish,
25 mollusks, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing
26 process to enhance production, such as regular stocking, feeding, protection from predators, etc." Most
27 countries use regulations that would affect other industries to regulate aquaculture, such as regulations
28 pertaining to clean water and endangered species.

1 **China**

2 The Bureau of Fisheries under the Ministry of Agriculture regulates aquaculture in China (FAO and Spreij
3 2010a). The only regulation that could be found pertaining directly to aquaculture in China is the
4 Fisheries Law of the People’s Republic of China. This mainly formalizes the investment of the country in
5 the development of aquaculture (SCNPC 2004). This regulation does stipulate that aquaculture licenses
6 are granted, but these only give a person or entity the right to use water surfaces and tidal flats. Export
7 of fish is covered under plant and animal export regulations, but these do not mention inspections other
8 than to say that material must be free of quarantine pests (People's Republic of China 1991).
9 Presumably, these inspections look primarily for diseased fish.

10 **Indonesia**

11 The aquaculture industry in Indonesia is regulated by the Ministry of Marine Affairs and Fisheries
12 through the Directorate General of Aquaculture Development (FAO and Skonhoft 2010a). The
13 Indonesian Fisheries Act No. 31 2004 is similar to China’s Fisheries Law (Republic of Indonesia 2004; FAO
14 and Skonhoft 2010a). Fish that are to be exported are checked to ensure they are not infected with
15 quarantine pests or diseases, and that they are accompanied by the proper documents. Any fish to be
16 exported from Indonesia has to be accompanied by a health certificate if required by the importing
17 country (Wardoyo 1990). Unless prohibited by the importing country, carriers of fish quarantine pests
18 and diseases are not subject to quarantine actions. If a quarantine pest or disease is detected, the fish
19 are treated specifically for that pest or disease, but no particular treatments are mentioned. If no pests
20 or diseases are detected, a certificate of release is issued.

21 **Malaysia**

22 Regulation of aquaculture in Malaysia falls under the Ministry of Agriculture and Agro-based Industry
23 (FAO and Skonhoft 2010b). Export of live fish from Malaysia requires a permit from the Director General
24 of Fisheries (Malaysia CLR 2006). The Director General has the discretion to add provisions to the permit
25 to ensure communicable fish diseases are not spread and that non-indigenous species of fish are not
26 released. Nothing is stated regarding export inspections or what these might entail.

27 **Philippines**

28 Aquaculture regulation falls under the Department of Agriculture’s Bureau of Fisheries and Aquaculture
29 Resources in the Philippines (FAO and Spreij 2010b). The Philippines Fisheries Law governs leases for
30 aquaculture, and directs the Department of Agriculture to develop a code of aquaculture practice. It also
31 provides for aquaculture facilities to be covered by insurance, and prohibits the prevention of human or
32 fish movement because of aquaculture facilities. The law prevents the exportation of live fish unless
33 they were produced in accredited hatcheries and ponds, although nothing is mentioned regarding
34 accreditation requirements. A permit is required for export, but no specifics are given for permit
35 requirements. An export inspection for fish diseases and pests must be performed and fish must meet
36 quality standards if they are known carriers of pests or disease. No details are given on what the
37 standards entail, other than that they should be internationally accepted (Republic of the Philippines
38 1998). A health certificate will be issued if required by the importing country (Philippine Department of

1 Agriculture 2009). The code of practice stipulated in the Fisheries Law gives guidelines on site selection,
2 facility design and construction, water use and discharge, use of drugs, stocking practices, feed, and fish
3 health (Philippine Department of Agriculture 2001).

4 ***United States***

5 Aquaculture in the United States is mainly regulated by the Food and Drug Administration, the
6 Department of Health and Human Services, USDA, and the Environmental Protection Agency. Other
7 federal agencies involved in aquaculture regulation include the National Oceanic and Atmospheric
8 Administration, the Joint Subcommittee on Aquaculture, the Food and Drug Administration Center for
9 Veterinary Medicine, APHIS, and the USFWS. In addition, each State has its own regulations regarding
10 aquaculture. Exporters must keep records for a minimum of 3 years that fish meet the requirements of
11 the Federal Food, Drug, and Cosmetic Act and comply with the requirements of the importing country. If
12 a health certificate is required by the importing country, it will be issued by APHIS (FAO and King 2010).
13 The National Aquaculture Act of 1980 was designed to promote and develop aquaculture in the United
14 States by developing a national plan (United States Congress 2002). Hawai'i has regulations that cover
15 quality, use and discharge of water; areas where aquaculture can be developed; activities in coastal
16 zones; historic sites; and construction of facilities (Maryland DoA and NASAC).

17 ***Taiwan***

18 No information could be found on any requirements for the exportation of fish or regulation of
19 aquaculture in Taiwan.

20 ***Guam***

21 Guam requires an excavation permit, plan review and building permit, clearing and grading permit, well
22 permit, water quality certificate permit, wetland permit, and a U.S. Army Corps of Engineers permit. In
23 addition, Guam has regulations covering the construction of wastewater systems and the discharge of
24 storm water and dredged material. Fish coming into Guam are required to have an import permit if
25 coming from elsewhere in the United States, and a certificate of origin if coming from a foreign source.
26 In addition, a health certificate is required stating the fish are free from disease (Maryland DoA and
27 NASAC). The University of Guam aquaculture facility does not import much stock, but ships stock all over
28 the world. To minimize the risk of anurans being transported with stock, the facility ships in 34 parts per
29 trillion salinity deep well water and individually hand packs the animals (Brown 2010b).

30 ***Commonwealth of the Northern Mariana Islands***

31 Importation of fish into CNMI requires an import permit from the Division of Fish and Wildlife, an animal
32 quarantine entry permit from the Department of Agriculture, and an import license from the USFWS.
33 International sources for the purpose of permitting in CNMI include Palau, RMI, and FSM. In addition, a
34 USFWS-Designated Port Exception Permit is required. International shipments arriving in CNMI have to
35 be cleared by the USFWS at the port of first entry into the United States. USFWS only has nine ports in
36 the United States that are designated to approve fish and wildlife shipments, and these are in the
37 continental United States and Hawai'i. The Designated Port Exception Permit is required if Guam or

1 CNMI is the first port of entry for a fish shipment. Shipments may or may not be physically inspected,
2 and may require a federal wildlife inspector to come from Guam (CTSA 2003).

3 **A4.1.3.9.2 Summary of Findings**

4 Pathways were considered high risk when they were capable of transporting *Rana nigromaculata* or
5 *Rana guentheri*, both of which are capable of harming human health and safety. Pathways were
6 considered a moderate risk when they transported *Rana catesbeiana* which can cause economic damage
7 to aquaculture facilities by preying on fish fry. Information on treatments and screening procedures
8 related to ensuring that shipments of aquaculture stock are pure could not be found, other than
9 information from the University of Guam. One major risk in this pathway is the difficulty in
10 distinguishing tadpoles from fish fry (Brown 2010c). Another major risk of this pathway is that
11 jurisdiction for aquaculture is spread across several agencies, and regulations can vary at the State level
12 (United States Congress 2002). Very few, if any, permits exist that are specific to aquaculture transport.
13 Most permits apply to other industries such as agriculture or industries that impact the environment.
14 Permits generally cover water use, waste discharge, and endangered species (Maryland DoA and NASAC
15 1995; CTSA 2003).

16 **A4.1.3.9.3 Specific Risk Factors**

17 The specific risk factors we found to be associated with the aquaculture pathways are as follows:

- 18 • It is difficult to distinguish tadpoles from fish fry.
- 19 • Anurans may have access to areas where aquaculture stock is being raised.
- 20 • Packing procedures for most aquaculture facilities are unknown.
- 21 • Inspections of aquaculture stock are geared to look for signs of fish diseases and pests on
22 fish.
- 23 • Jurisdiction for aquaculture is often diluted across various agencies.
- 24 • Laws governing aquaculture are often not specific to aquaculture, but pertain to various
25 industries as a whole.
- 26 • *Fejervarya limnocharis* tadpoles can withstand salinity up to 13 parts per trillion, and may
27 survive fish fry shipments packaged in lower salinity water.

28 **A4.1.3.9.4 Plants and Plant Parts as Food**

29 The importation of produce has been identified as a potential pathway for the introduction of
30 amphibians into Guam (Vice et al. In preparation). In addition to amphibians, mammals and reptiles may
31 also be transported in produce (Table A4-18). The importation of vegetables and fruit into Guam is
32 heavily regulated; however, the emphasis is on preventing the importation of plants infested with
33 insects or diseases of agricultural significance (GDOA 1997). The Aquatic Nuisance Species Task Force
34 and National Invasive Species Council document used as a template for this risk assessment lists plants
35 used as food as a pathway of major concern (ANSTF and NISC 2007). The amount of produce imported

1 into Guam is expected to increase in association with the military relocation. An example of the types
 2 and amounts of produce imported into Guam is given elsewhere in this document. The only pathway
 3 analyzed was food being shipped from the continental United States to Guam.

4 **Table A4-18: Invasive Species Transported in Plants and Plant Parts Used as Food**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Eleutherodactylus coqui</i>	Coqui frog	ECN, ECL
	<i>Hyla cinerea</i>	Green tree frog	ECL
	<i>Pseudacris regilla</i>	Pacific tree frog	ECL
Birds	None likely	None likely	
Mammals	<i>Clethrionomys rutilus</i>	Northern red-backed vole	None found ^b
	<i>Microtus californicus</i>	California vole	H, ECN
	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
Reptiles	<i>Rattus rattus</i>	Black rat	H, ECN, ECL
	<i>Anolis cristatellus</i>	Common Puerto Rican anole	ECL
	<i>Calotes versicolor</i>	Eastern garden lizard	ECL
	<i>Chondrodactylus bibronii</i>	Bibron's thick-toed gecko	ECN

5 ^a H = health, ECN = economic, ECL = ecological.

6 ^b No impacts found in the literature, but undocumented impacts may exist.

7
 8 **A4.1.3.9.5 Inspection Procedures**

9 **Federal Inspection Regulations**

10 **Fruits and Vegetables Import Manual.** The APHIS-PPQ Fruits and Vegetables Import Manual contains
 11 guidance for PPQ and CBP inspectors regarding shipments of fresh fruits and vegetables (USDA-APHIS-
 12 PPQ 2010c). Inspectors first review the documentation accompanying a shipment of produce to
 13 determine whether the produce has restrictions placed on its entry. Next, a sample of the shipment is
 14 taken for inspection. In general, 2% of the shipment is taken as a sample for inspection. The size of the
 15 sample may be adjusted depending on the size of the shipment and past history with the shipper.
 16 Samples are to be representative of the whole shipment to avoid being misled by shippers placing the
 17 cleanest samples at the front of containerized shipments. If produce has been loaded in bulk, samples
 18 are to be taken at a minimum from the top 15.2 cm (6 in) of the shipment. Samples are inspected for
 19 plant pests such as insects, mites, mollusks, nematodes, noxious weeds, pathogens, plant debris, and
 20 soil. Depending on the type of commodity, there may be additional inspection procedures to be
 21 followed, and these are listed in the manual. The following paragraphs describe some general guidelines
 22 for broad categories of produce.

23 The entire surface of fleshy or pulpy fruits and vegetables is inspected for pests or signs of pest boring or
 24 feeding. Fruits and vegetables are to be sliced open to look for internal pests, such as larvae. The top
 25 and bottom of the fruit or vegetables are to be inspected closely as these are areas that are known to
 26 harbor insects. Signs of disease include discolored spots, lesions, and surface irregularities. Fruits and
 27 vegetables are also inspected for contaminants such as soil and plant parts, as these are not admissible.
 28 An example of a plant part contaminant is leaves still attached to an apple.

1 The surface of leafy herbs and vegetables is inspected for snails and slugs, or signs of their presence
2 such as slime trails. Leaf surfaces are to be examined for insect larvae or signs of their presence, such as
3 holes in the leaves, discolored paths under the leaf surface, and powdery insect excrement. If paths are
4 found under the leaf surface, the end of the path is pricked with a knife or probe to look for larvae. Leafy
5 vegetables that grow close to the ground are to be inspected for soil.

6 The pods and seeds of legumes are inspected for holes, as this may be a sign that insects or larvae are
7 present. In particular, legumes from Mexico, Central America, South America, and the West Indies may
8 contain significant pests. Legumes are also inspected for signs of disease such as discoloration, surface
9 irregularities, or malformed pods and seeds.

10 Root crops and bulbs are inspected for signs of insect boring. If holes are found, the root or bulb is cut to
11 look for insects. Both adults and larvae may be present in root crops, whereas bulbs most commonly
12 harbor larvae. Root crops and bulbs are also inspected for signs of nematodes such as surface
13 discoloration, surface blisters, depressions, or other irregularities. A cross section of the root is
14 examined under a hand lens or dissecting microscope for nematodes. Root crops and bulbs are also
15 inspected for soil that may be attached, or for loose soil present in the containers. Species found during
16 inspection are addressed using the following documentation as protocols and guidelines.

17 **Treatment Manual.** Chapter 5 of the APHIS-PPQ Treatment Manual contains the treatment schedule for
18 fruit, nuts, and vegetables (USDA-APHIS-PPQ 2008). The treatments listed in the schedule include
19 methyl bromide fumigation, water treatment, high temperature forced air, irradiation, vapor treatment,
20 cold treatment, and quick freeze. Treatments are listed either by commodity or by pest. Each particular
21 commodity has its own treatment schedule.

22 **Manual for Agricultural Clearance.** Cargo manifests are reviewed to determine whether it contains
23 items of agricultural interest such as fruits and vegetables (USDA-APHIS-PPQ 2013). Cargo of agricultural
24 interest is to be held until it can be cleared by CBP. Clearance of fruits and vegetables may be done by
25 an inspection of the paperwork, an inspection of the commodities, or both. Inspections may be random,
26 routine, or targeted. Guidance for inspections is provided in the APHIS-PPQ Fruits and Vegetables Import
27 Manual (USDA-APHIS-PPQ 2010c).

28 **Code of Federal Regulations.** Title 7 Part 319 of the CFR governs the importation of fruits and
29 vegetables. All fruits and vegetables are required to have an APHIS import permit. Fruits and vegetables
30 are subject to inspection upon arrival. Inspectors are to examine shipments for unauthorized plant
31 parts, plant pests, and noxious weeds. Disinfection is required if these are found in the shipment. If the
32 shipment is known to have been associated with another shipment that was infested, treatment may
33 also be required. A shipment may be refused entry if the commodity is prohibited, lacks the proper
34 documentation, or is infested in such a way that disinfection cannot be adequately accomplished. Part
35 319.56-7 contains a list of fruits and vegetables that can be imported into Guam without treatment
36 unless required in Part 319.56-3(d).

1 **Guam Regulations**

2 Title 8 (Division 2, Chapter 10) of the Guam Administrative Rules and Regulations governs the
3 importation of plants and plant products into Guam (GDOA 1997). Import permits and phytosanitary
4 certificates are required to ship regulated articles into Guam. The phytosanitary certificate must have
5 been issued from the country of origin. Shipments of plants are subject to inspection upon arrival.
6 Specific restrictions on certain commodities are given in this regulation. For example, commodities that
7 could be infested with the European corn borer are required to have been fumigated prior to shipment
8 and have documentation showing fumigation was conducted.

9 **A4.1.3.9.6 Summary of Findings**

10 This pathway was considered high risk because of its ability to transport rodents that may harm human
11 health. One of the primary risks for this pathway is that inspections tend to be focused on insects and
12 plant disease. Because of this, vertebrate invasives may get missed, particularly when hiding in places
13 not normally inspected for insects. Due to the large volume of material that may be shipped, inspections
14 can only cover a small portion of the total shipment, increasing the likelihood that a vertebrate invasive
15 will be missed (Vice et al. In preparation). This is particularly true for commodities shipped in bulk where
16 only the top layer may get inspected.

17 **A4.1.3.9.7 Specific Risk Factors**

18 The specific risk factors we found to be associated with the plants and plant parts as food pathways are
19 as follows:

- 20 • Import inspections generally look for insects and signs of plant disease, which may miss
21 vertebrate invasives.
- 22 • Insufficient agricultural inspection staff and other resources are available on Guam.
- 23 • Only the top portion of bulk shipments may get inspected.
- 24 • Inspectors may be misled by shippers if samples are not representative of the entire
25 shipment. For example, a shipper may place the lowest risk commodities at the front of a
26 container.

27 **A4.1.3.10 Ecosystem Disturbance**

28 Natural spread and ecosystem disturbance have the ability to move invasive species into locations they
29 previously did not inhabit (Table A4-19). In addition, ecosystem disturbance may poise invasive species
30 near locations where they can easily enter the transportation pathway, increasing the likelihood of their
31 introduction elsewhere (Engeman et al. 2002). The Aquatic Nuisance Species Task Force and National
32 Invasive Species Council document used as a template for this risk assessment lists natural spread and
33 ecosystem disturbance as major pathways of concern (ANSTF and NISC 2007). A formal risk analysis was
34 not conducted for the natural spread of populations because of the low likelihood this would move
35 invasive species off of Guam. However, the general risks are discussed below, particularly as they
36 pertain to the maintenance of the BTS population on Guam.

1 **Table A4-19: Invasive Species Moved in the Ecosystem Disturbance Pathway**

Class	Scientific name	Common name	Risk type ^a
Amphibians	<i>Eleutherodactylus planirostris</i>	Greenhouse frog	ECL
	<i>Litoria fallax</i>	Eastern dwarf tree frog	ECL
	<i>Polypedates megacephalus</i>	Hong Kong whipping frog	ECL
	<i>Rana guentheri</i>	Guenther's frog	H, ECL
	<i>Rhinella marina</i>	Cane toad	H, ECN, ECL
Birds	<i>Dicrurus macrocercus</i>	Drongo	ECL
	<i>Francolinus francolinus</i>	Black francolin	ECL
	<i>Lonchura malacca</i>	Black-headed mannikin	ECN
	<i>Streptopelia bitorquata dusimieri</i>	Philippine turtle dove	ECL
Mammals	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Polynesian rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL
	<i>Rattus rattus</i>	Black rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN, ECL
	<i>Suncus murinus</i>	Musk shrew	H, ECN, ECL
Reptiles	<i>Anolis carolinensis</i>	Green anole	ECL
	<i>Boiga irregularis</i>	Brown treesnake	H, ECN, ECL
	<i>Carlia ailanpalai</i>	Curious skink	ECL
	<i>Pelodiscus sinensis</i>	Chinese soft-shelled turtle	H, ECL
	<i>Trachemys scripta</i>	Red-eared slider	H, ECL

^a H = health, ECN = economic, ECL = ecological.

2
3

4 **A4.1.3.10.1 Natural Spread of Established Populations**

5 Natural dispersal of invasive species currently on Guam can occur due to increases in population size
6 forcing the dispersal of individuals. Species with high reproductive rates (r selected) tend to have an
7 advantage as an invasive species (Sax and Brown 2000). As a population increases and more dispersal
8 occurs, more populations will become established. This increase is of concern because of the potential
9 for several of the species listed to act as a prey base for BTS. These include *Eleutherodactylus*
10 *planirostris*, *Litoria fallax*, *Polypedates megacephalus*, and *Rana guentheri* (Christy et al. 2007a). An
11 increase in the prey base would allow the BTS population to persist, or perhaps even increase (Christy et
12 al. 2007a). Reducing the prey base has been suggested as a means of controlling BTS population on
13 Guam (Gragg et al. 2007).

14 In large part, the likelihood of migration off Guam to neighboring islands is negligible. The closest island
15 to Guam is Rota, which is approximately 80 km (50 miles) away. Of the bird species listed, only the
16 drongo (*Dicrurus macrocercus*) is documented to have migrated this distance, having migrated from
17 Rota to Guam sometime after 1935 (Lever 1987). The only other possible method of migration off the
18 island is the transport of animals on flotsam or swimming. None of the species listed are likely to swim
19 the distances required to reach neighboring islands, although it has been suggested that anoles may be
20 able to float for short periods of time (Schoener and Schoener 1984). *Anolis sagrei* was able to remain
21 afloat for at least 24 hours in the laboratory in a seawater wave tank, suggesting floatation may be
22 responsible in part for its success at long distance dispersal (Schoener and Schoener 1984). Anoles may

1 be able to survive in seawater longer than previously expected (Heatwole and Levins 1973, Schoener
2 and Schoener 1984). *Rhinella marina* may have reached Cayo Santiago from Puerto Rico on flotsam
3 (Heatwole et al. 1963; Heatwole and Levins 1972). Green iguanas (*Iguana iguana*) were able to reach
4 Anguilla on flotsam produced by a hurricane (Censky et al. 1998).

5 **A4.1.3.10.2 Man-made and Natural Disturbances**

6 The relocation of the Marines onto Guam will create man-made ecosystem disturbances in the form of
7 construction of facilities and utilities, roadway projects, land clearing, and landscaping (U.S. Navy
8 2009h). In addition to man-made ecosystem disturbance, Guam is prone to typhoons and earthquakes.
9 Although typhoons are more likely to be of a magnitude to cause widespread ecosystem disturbance,
10 the possibility of a large-magnitude earthquake cannot be ruled out. In addition, fire sometimes creates
11 ecosystem disturbance.

12 One of the characteristics of a successful invasive species is that it is often found in association with
13 disturbed or man-made habitats (Lozon and MacIsaac 1997; Sax and Brown 2000; Ineich 2010). Many of
14 these species are commensal with humans, such as the common mouse (*Mus musculus*) and rats (*Rattus*
15 species). Environments that are prone to invasion by invasive species are often disturbed naturally or
16 have a high amount of human activity (Lozon and MacIsaac 1997; Sax and Brown 2000). Although
17 unclear as to exactly why disturbance facilitates invasion, one hypothesis is that more opportunities
18 exist in disturbed habitats for human-mediated introductions (Simberloff 1989).

19 Typhoons play an important role in invasive species movement and establishment. Damage from
20 typhoons is due to several factors such as storm velocity, storm diameter, and storm severity (Tanner et al.
21 1991). During a typhoon, most of the methods of BTS detection are inoperable. Mice must be
22 removed from traps, and traps may be taken down altogether. The typhoon itself can damage traps, the
23 habitat the traps are placed in, and the barrier fences used to exclude BTS (Vice and Engeman 2000).
24 Because emergency equipment is being shipped from Guam to neighboring islands during this time, the
25 likelihood of transporting BTS increases dramatically. Defoliation of trees by typhoons or high winds can
26 cause long-term alterations to the microhabitat that include a reduction in humidity and higher
27 temperatures near the forest floor (Reagan 1991; Waide 1991; Greenberg 2001). These changes tend to
28 be detrimental to amphibians that require moisture, but beneficial to some reptiles reliant on warmer
29 temperatures for egg incubation and hatchling development (Reagan 1991, Waide 1991, Greenberg
30 2001). The sheer impact of the typhoon, and associated rain and moving objects, can cause mass
31 mortality of amphibians (Schriever et al. 2009), birds (Waide 1991), and reptiles (Woolbright 1991;
32 McCoid 1996; Spiller et al. 1998). Habitat specialist lizards were more prone to mortality than were
33 habitat generalist lizards in the Marianas (McCoid 1996).

34 Typhoons may facilitate overwater dispersal of lizards and lizard eggs (Censky et al. 1998; Schoener et al.
35 2001). Green iguanas (*Iguana iguana*) arrived on Anguilla in the Caribbean on a mat of logs and
36 uprooted trees a month after Hurricane Luis (Censky et al. 1998). Results of genetic examination of
37 Anolis lizards in the Caribbean suggest island colonization followed prevailing ocean currents, providing
38 evidence for overwater dispersal (Calsbeek and Smith 2003). Lizard eggs and lizards appear to be more

1 resilient to exposure to seawater than previously thought. Eggs that are hard-shelled remained viable
 2 for at least 11 days during exposure to salt water (Brown and Alcala 1957). *Anolis sagrei* eggs remained
 3 viable in saltwater for 3 to 6 hours, which was predicted to be the length of the storm surge during
 4 Hurricane Floyd (Losos et al. 2003).

5 Typhoons can readily facilitate the movement of pests within individual islands or between closely
 6 located neighboring islands. On Guam typhoons typically create mountains of debris and this debris
 7 ultimately may get moved around the island and may in fact transport pest species such as the little fire
 8 ant and the coconut rhinoceros beetle, potentially ultimately assisting in the spread of these and other
 9 pests. Protocols for dealing with these types of situations need to be established both for civilian and
 10 military authorities.

11 **A4.1.3.10.3 Specific Risk Factors**

12 The specific risk factors we found to be associated with the ecosystem disturbance pathways are as
 13 follows:

- 14 • Most BTS control measures are inoperable during a typhoon, leaving detector dogs the
 15 primary line of defense.
- 16 • Emergency equipment is shipped from Guam to neighboring islands during typhoons,
 17 increasing the likelihood of transporting BTS.
- 18 • Man-made disturbances may increase the risk of invasive species entering the
 19 transportation pathway.

20 **A4.1.3.11 Garbage**

21 Movement of invasive vertebrate species in garbage is a significant pathway, moving primarily rodents
 22 (Table A4-20). Although other species besides rodents can be moved in garbage, only rodents were
 23 analyzed because they are the primary species moved and are a significant health concern. The Aquatic
 24 Nuisance Species Task Force and National Invasive Species Council document used as a template for this
 25 risk assessment lists garbage as one of the major pathways of concern (ANSTF and NISC 2007). Ships and
 26 aircraft arriving on Guam and CNMI unload regulated garbage upon arriving. Additionally, with the
 27 relocation of the 3rd Marine Expeditionary Unit from Okinawa to Guam there is an anticipated increase
 28 in the amount of training that will occur on Tinian. Garbage generated during these training activities is
 29 to be shipped back to Guam for disposal (U.S. Navy 2009g). This analysis also includes garbage that is
 30 generated during transit for both aircraft and ships.

31 **Table A4-20: Invasive Species Moved in the Garbage Pathway**

Class	Scientific Name	Common Name	Risk Type ^a
Amphibians	None likely	None likely	
Birds	None likely	None likely	
Mammals	<i>Mus musculus</i>	Common mouse	H, ECN, ECL
	<i>Rattus exulans</i>	Pacific rat	H, ECN, ECL
	<i>Rattus norvegicus</i>	Norway rat	H, ECN, ECL

	<i>Rattus rattus</i>	Ship rat	H, ECN, ECL
	<i>Rattus tanezumi</i>	Asian house rat	H, ECN, ECL
Reptiles	None likely	None likely	

^a H = health, ECN = economic, ECL = ecological.

A4.1.3.11.1 Garbage Regulations

Garbage is defined in 7 CFR § 330.400 and 9 CFR § 94.5 as waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material (7 CFR § 330.400, 9 CFR § 94). Any other refuse that has been associated with such materials is also considered garbage. Incineration is defined as reducing garbage to ash by burning. Sterilization is the cooking of garbage at an internal temperature of 212°F (100°C) for 30 minutes. Garbage is considered regulated if the means of conveyance it is on has been outside the United States and Canada within the previous 2-year period. Garbage is also considered regulated if the means of conveyance the garbage is on has been moved within the last year between the continental United States, U.S. territory, U.S. possession, or Hawai'i. Non-regulated garbage that has been commingled with regulated garbage is also considered to be regulated. Regulated garbage is monitored to prevent the movement and dissemination of pests and diseases of plants and livestock. Tightly covered, leak-proof containers must be used to store regulated garbage. These containers must be kept inside the guard rail on a ship. Garbage may only be moved from a conveyance for disposal if it is stored in the proper container, and can only be moved under the direction of an inspector to an approved garbage handling facility.

The APHIS-PPQ Treatment Manual gives a choice of three treatments for destroying garbage that may be infested with insects pests or pathogens (USDA-APHIS-PPQ 2008). Garbage may be incinerated to ash, or ground up and discharged into an approved sewage system. An approved sewage system is one in which effluents are not discharged onto land or stationary waters, and prevents dissemination of plant pests and livestock diseases. Garbage may also be heated with steam or dry heat to an internal temperature of 212°F (100°C) for 30 minutes, followed by burial in a landfill.

The APHIS-PPQ Manual for Agricultural Clearance provides guidance on handling foreign regulated garbage (USDA-APHIS-PPQ 2013). The primary concern is preventing the spread of plant pests and animal diseases. Entities that handle garbage must be approved by USDA and either have a compliance agreement with, or be directly supervised by, CBP and/or APHIS personnel. The approved methods of disposing of garbage listed in the Manual for Agricultural Clearance are the same as those given in the APHIS-PPQ Treatment Manual (USDA-APHIS-PPQ 2008). Garbage may only be removed from a ship if USDA-approved garbage facilities exist at the port. Arrangements for disposal of the garbage must be made in advance with CBP. In this case, the only approved methods of garbage disposal are incineration or sterilization by heating to an internal temperature of 212°F (100°C).

The APHIS-PPQ Manual for Agricultural Clearance also instructs inspectors to monitor garbage handling on ships while they are in port (USDA-APHIS-PPQ 2013). This may involve monitoring visually from shore or boarding the vessel. Inspectors monitor garbage handling to ensure it is not disposed of in an unauthorized manner, garbage containers are not leaking and are covered, and garbage containers are not placed outside the ship's railing. Garbage chutes and containers built into the railings are sealed

1 while in U.S. territorial waters. All garbage is regulated when ships are traveling between the continental
2 United States and foreign countries. Garbage aboard military vessels is handled in the same manner as
3 garbage aboard private or commercial vessels.

4 Garbage from commercial and military craft can only be unloaded if the port or military base facility is
5 given the approval to handle garbage by APHIS-PPQ (USDA-APHIS-PPQ 2013). On Guam, Naval Facilities
6 Engineering Command (NAVFAC) Marianas at the Apra Harbor Naval Station and Pacific Environmental
7 Resources Incorporated at Andersen AFB are approved to handle garbage. Compliance enforcement
8 visits to ensure garbage is being handled and disposed of properly should be conducted quarterly at a
9 minimum.

10 The responsibility for monitoring the garbage handling activities of airports, caterers, cleaners, cruise
11 ships, fixed base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and
12 transfer stations falls to CBP (USDA-APHIS-PPQ 2013). APHIS-PPQ is responsible for monitoring the
13 activities of all non-military processing facilities that incinerate or sterilize regulated garbage. Garbage
14 handlers are responsible for ensuring that birds, rodents, and other vermin do not have access to
15 garbage.

16 The Quarantine Regulations of the Navy (OPNAVINST 6210.2) state that garbage must be placed in leak-
17 proof, covered containers. Garbage may only be disposed of following authorized port procedures under
18 the supervision of a PPQ representative. The only approved methods of disposal are incineration or
19 sterilization. Disposal of garbage from foreign flights in a landfill is not an approved method. The
20 Quarantine Regulations of the Armed Forces defines garbage as being derived in whole or in part from
21 fruits, vegetables, other plant products, animals, meat, meat products, or animal products (DoD 1992).
22 These regulations also state that garbage cannot be disposed of in a landfill unless it has first been
23 sterilized by heating to an internal temperature of 212°F (100°C). The Naval Supplemental Publication
24 486 contains similar guidance (NAVSUP 2004).

25 Both Guam and CNMI have their own customs and quarantine procedures with respective agencies for
26 enforcement. Customs officers on Guam focus ship inspections on compliance with regulated garbage
27 regulations (Merfalen 2010). Commercial transport companies handle the waste streams from
28 commercial vessels in the ports of Guam, Tinian, and at the airports on Guam and CNMI (Merfalen 2010,
29 Pangolinean 2010). Regulated garbage is incinerated on both Guam and CNMI.

30 **A4.1.3.11.2 Summary of Findings**

31 All pathways were considered high risk because they could harm human health due to their association
32 with the transport of rodents. Provided regulated garbage is handled properly, rodents should have
33 limited access to garbage or to other pathways from garbage containers. Garbage that is considered
34 non-regulated with respect to movement between Guam and CNMI does not contain plant or animal
35 parts. However, it could still harbor rodents because it contains items, such as cardboard, that provide
36 bedding material. Disposal of this type of garbage in a landfill is associated with the risk of introducing or
37 spreading non-native rodents.

1 **A4.1.3.11.3 *Specific Risk Factors***

2 The specific risk factors we found to be associated with the garbage pathways are as follows:

- 3 • Customs agencies focus on cleanliness and container integrity.
- 4 • Documentation is lacking with regard to interception of vertebrates in regulated trash.
- 5 • Processes for handling garbage generated during training exercises on Tinian may not
- 6 preclude the transport of a significant invasive vertebrate species.
- 7 • Non-regulated garbage may transport rodents that could be missed during inspections of
- 8 regulated garbage and during transport.

9 **A4.1.3.12 *Discussion and Conclusions***

10 The Aquatic Nuisance Species Task Force and National Invasive Species Council document used as a
11 template for this risk assessment was designed for risk analyses in the United States. It also contained
12 frames of reference more applicable to insects and aquatic species. As a result, portions of the process
13 needed to be modified to be more amenable to a risk analysis for vertebrate invasive species in a larger
14 region of the world. Although this assessment attempts to be as objective as possible in assigning risk
15 rankings, the process is inherently subjective. Despite these difficulties, the process allowed us to
16 identify pathways and gaps in security measures that could increase the likelihood of transporting
17 vertebrate invasive species.

18 We were not able to access all the information needed to accurately assess the risk of transporting
19 vertebrate invasive species associated with each pathway. For example, customs procedures for various
20 countries in Asia were often lacking or scant in nature. We did not have interception data for the
21 numbers and types of species transported in each specific pathway. For some pathways, such as WPM,
22 species lists were generated using reports of species that have been moved in cargo. Often reports
23 could be found of species being moved in cargo with no information on what type of cargo or where in
24 the cargo the species was found. Although some of the species are well known, others have little
25 biological information available. One of the key pieces of information that was lacking in this regard was
26 ability of a species to utilize various habitat types. Another critical piece of information concerned the
27 ability of a species to establish new populations in previously uninhabited areas through natural
28 dispersal. Therefore, this risk analysis should be re-evaluated as more information becomes available.

29 The pathways associated with the most risk of transporting invasive species were cargo and vehicles
30 used for military training exercises and military maritime and air transportation. This is due in part to the
31 fact that military ships and aircraft can be mobilized on a moment's notice for emergency missions that
32 preclude pre-departure inspections. There is a memo of understanding between PPQ and GCQA which
33 charges GCQA with the authority to inspect military ships and aircraft.

34 Commercial maritime and air traffic, as well as cargo containers, were also associated with a high degree
35 of risk for transporting invasive species. One of the primary factors is the current lack of adequate staff,
36 equipment, and funding in the Micronesia Region to conduct inspections. Volume will increase with the

1 military relocation in each of these pathways. Unless adequate resources become available, risk of
2 transporting vertebrate invasive species will also increase. Inspections are often limited to ships, aircraft,
3 and cargo arriving from a destination that harbors an agricultural pest or disease vector, or has had
4 previous violations. Additionally, inspections are focused on preventing the movement of agricultural
5 pests, and inspectors may not be looking for amphibians and reptiles. These limited inspections increase
6 the likelihood a vertebrate invasive species could be transported undetected.

7 Construction materials and equipment can be considered containerized cargo and bulk cargo, and are
8 associated with the same risks listed in the previous paragraph. Construction vehicles may undergo an
9 agricultural inspection for soil and plant parts to prevent the movement of plant pests and diseases.
10 APHIS-WS in Guam inspects construction vehicles for BTS, but the efficacy of these inspections may be
11 questionable due to the size and complexity of the vehicles themselves.

12 Although WPM is heavily regulated by international phytosanitary standards, inspections do little to
13 prevent the movement of vertebrate invasive species. Vertebrate invasive species are most likely to
14 enter WPM in the post-manufacturing phase when it is being used as packing material for cargo.
15 Although customs agencies do inspect WPM in cargo, they are limited by time and resources to inspect
16 only WPM present in the portion of the cargo selected for inspection. Due to the somewhat non-
17 random nature of the selection process as described above, vertebrate invasive species could go
18 undetected.

19 Plants are inspected for plant pests and diseases rather than vertebrate invasive species. Amphibians
20 may hide in areas inspectors might not be likely to inspect. Due to the large volume of plants and plant
21 materials arriving in any particular shipment, only a sample of the plants can be inspected. Inspectors
22 rely on phytosanitary certificates from the country of origin, and these can be counterfeited. As with
23 other types of cargo, the process of selecting a sample for inspection may not be entirely random,
24 leading to a greater likelihood that vertebrate invasive species might not be detected. In terms of
25 preventing the establishment of pests, much of the plant industry is self-regulating. For example,
26 nurseries can be certified to be free of certain pests.

27 Regulated garbage, when properly handled, presents a relatively low level of risk of transporting
28 vertebrate invasive species. Because regulated garbage is to be stored in leak-proof containers with
29 tightly fitting lids, animals should have very little access. Additionally, it cannot be disposed of without
30 first being incinerated or heated to 212°F (100°C) for 30 minutes, making species survival impossible.
31 The largest risk is associated with non-regulated garbage. Garbage that is considered non-regulated with
32 respect to movement between Guam and CNMI does not contain plant or animal parts. Because non-
33 regulated garbage does not contain plant or animal parts, it is not required to be stored in leak-proof
34 containers with tightly fitting lids. Such garbage may contain materials that can be used as bedding or
35 nesting material, and may attract rodents. Non-regulated garbage can be disposed of in a landfill
36 without undergoing any kind of treatment, making it more likely rodents could survive.

37 Household goods are packed indoors and are often individually handled. This decreases access for
38 vertebrate invasive species and makes detection highly likely. However, if household goods are packed

1 outside or left in an open container outside, animals could gain access. Personally owned vehicles are a
2 larger risk for the relocation pathway. Although vehicles owned personally by military personnel are
3 inspected closely for plant material, soil, and animals, vehicles in the private sector may not undergo the
4 same level of scrutiny. Additionally, used cars are shipped throughout the Micronesia Region. The short
5 transport time makes survival of hitchhiking vertebrate invasive species highly likely.

6 Natural dispersal was associated with a relatively low level of risk of moving invasive species because
7 there are few species likely to migrate from Guam to the nearest island. Although the Micronesia Region
8 is vulnerable to typhoons, it is unlikely typhoons will move species from one island to another because
9 of the distance between most of them. The risk associated with typhoons and man-made disturbance is
10 the increased potential for vertebrate invasive species to be moved into the transportation network.
11 This is because preventive measures, such as BTS traps, are inoperable during a typhoon. Increased
12 vigilance immediately following any type of disturbance should help mitigate any risks.

13 Aquaculture is known to transport anurans, and will likely increase with the increased population due to
14 the military relocation. The primary risk associated with this pathway is the difficulty in distinguishing
15 between fish fry and tadpoles primarily due to the way they are packed. Some of this risk can be
16 mitigated by changing packing and shipping practices. Individually handling and packing fish fry may
17 increase the resources needed, but will decrease the likelihood of packing undetected tadpoles. Where
18 possible, shipping in higher salinity water decreases the survival probability of anurans.

19 Finally, plants used as food were considered the least risky of the 12 pathways. This is because fruits and
20 vegetables are inspected very closely for small insects and larvae, making it unlikely a vertebrate
21 invasive species could go undetected during inspection. However, some risk still exists because time and
22 resources only allow for inspections of a representative sample of each shipment. If a shipper places the
23 cleanest material closest to the front or top, and samples are not representative of the entire shipment,
24 a vertebrate invasive species could be missed.

25 In general, the risk of transporting vertebrate invasive species throughout the Micronesia Region will
26 increase due to the military relocation. Preventing the movement of vertebrate invasive species will
27 require increasing awareness of the risks in both the public and private sectors. Inspectors at ports in
28 particular need to be given training to make them aware of and enable them to identify other species of
29 concern. Resources need to be identified and made available to allow for additional training, equipment,
30 and personnel to improve the inspection processes. Emphasis should be placed on preventing the
31 movement of vertebrate invasive species, rather than on eliminating them once they have become
32 established. Prevention is more effective and less costly than elimination. Finally, a high degree of
33 cooperation among agencies will be required to minimize the risk of transporting vertebrate invasive
34 species.

35 **A4.1.3.13** ***Recommendations***

36 This section will discuss some overall, general recommendations for mitigating the risk of transporting
37 vertebrate invasive species unintentionally. More specific recommendations are covered in other

1 sections. These general recommendations should not be considered as the only, or the most important,
2 recommendations. Rather, they should be viewed as a starting point for more formalized
3 recommendations. Five key issues are central to successful implementation of the recommendations
4 given here. These key issues are: funding, coordination and communication, education and training,
5 control methods development, and regulatory drivers and enforcement.

6 **A4.1.3.14** ***Funding***

7 Regardless of the biosecurity strategy developed, lack of sufficient and properly managed funds will be
8 the weak link in any effort implemented. Military presence in the region calls for long-term allocation
9 and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly
10 inadequate relative to the magnitude of the existing problems posed by invasive species, the emerging
11 problems and associated risks to other islands, and the scope and magnitude of military activity in the
12 region.

13 Short-term funding cycles hamper necessary methods development and interdiction activities and
14 restrict the forward momentum needed for effective control programs. For example, because BTS
15 efforts are currently underfunded, much higher costs are expected in the future to resolve expanding
16 threats not addressed now, such as eradicating the incipient population on Saipan. Cost-sharing among
17 agencies and the transportation industry has advanced greatly, with still more room for more
18 improvement. The Office of Insular Affairs is carrying much of the funding responsibility at present,
19 along with an incorrectly perceived primary ownership of the problem. Greater and sustainable
20 investment by the DoD is warranted as part of their doing business in high-risk areas for invasive species
21 dispersal and their overall stewardship of natural resources on their lands (USDA-APHIS WS 2008a).

22 **A4.1.3.15** ***Coordination and Communication***

23 The multiple human health and safety, economic, and ecological impacts of invasive species create
24 complex challenges in policy formation and governmental coordination (Williams et al. 2007). The
25 National Invasive Species Council was established by Executive Order 13112 to provide coordination and
26 planning, and facilitate cooperation among the diverse federal agencies and to take a more
27 comprehensive approach to invasive species. The National Invasive Species Council is co-chaired by the
28 Secretaries of Agriculture, Commerce and the Interior; and includes a total of 13 federal agencies and
29 departments that have a role in invasive species management (Williams et al. 2007). Communication
30 and coordination needs improved at all levels and in all directions. Micronesia and Hawai'i cover an
31 extensive area with numerous levels of authority for multiple sovereign nations as well as numerous
32 local, regional and international NGOs, all of which have roles to play in enhancing biosecurity and IAS
33 control and management for the region.

34 Federal agencies that must work in coordination to maintain a biosecurity plan include APHIS, the
35 USFWS, CBP, and the Departments of the Interior, Defense, Commerce, Energy, Homeland Security, and
36 Transportation, among others. Interagency coordination is effective to the implementation of planning,
37 and is sustained and enhanced by frequent and comprehensive communication. This communication
38 network still needs to be improved and more importantly expanded to insure that all levels including

1 non-U.S. nations are appropriately networked in order to facilitate a truly regional effort at improving
2 biosecurity and reducing the risk of IAS transport and establishment. The communication network that
3 occurs between government agencies results in information that can be compiled, consolidated, and
4 reproduced in a manner suitable and clear to the general public and private industry (e.g.,
5 transportation, construction). Local capacity-building is needed to support research, operations and
6 program management, and to improve local recruitment pools. Efforts could include cooperative
7 university and government programs, such that funding is utilized in a most resourceful manner (Colvin
8 et al. 2005). For example, the public outreach program on Saipan is a model, particularly the partnership
9 with private industry. This public outreach effort, fielded by the Office of Economic Adjustment and the
10 Military Integration Management Committee, conducts Community Outreach Dialogue sessions on
11 Saipan to hear concerns of citizens. This and other demonstration projects illustrate attempts at
12 achieving biological, social, and economic objectives through managing invasive species on islands
13 (Saunders et al. 2007).

14 **A4.1.3.16 Education and Training**

15 Gaps in invasive species management can be bridged by increased education and training, with an
16 emphasis placed on public outreach including both military and civilian populations. Public perception
17 and lack of support have affected efforts to manage or eradicate vertebrate species in the United States,
18 as elsewhere in the world (NISC 2001). Knowledge levels regarding invasive species and the harm they
19 can cause are relatively low amongst the general public (NISC 2001). For example, reports on invasive
20 species management in Hawai'i (TNC and NRDC 1992, OTA 1993) concluded an overall gap in public
21 awareness of invasive species. This resulted in the formation of the Coordinating Group on Alien Pest
22 Species (CGAPS), a voluntary government/non-government partnership, formed in 1995 to increase
23 public awareness of invasive species. Following the formation of the partnership, CGAPS launched phase
24 two of the campaign in 2006, with television and print media and a new toll-free hotline number
25 regarding the dangers of BTS. Encouragingly, follow-up surveys confirmed a rising awareness about BTS
26 (Martin 2007).

27 Furthermore, staff involved in the enforcement aspect of invasive species (e.g., inspection agents) need
28 to be educated on biological risks on which they act daily. Knowledge of the impacts of introduction is
29 bound to increase staff motivation and efficiency in the workplace. Training should include the
30 taxonomic identification of species, continued education on species status updates, changes to
31 regulations, and new pest species listings (e.g., White-List). In complement, multimedia educational
32 material, such as the Distance Diagnostic and Identification System (University of Florida 2010), can
33 further facilitate proper identification of species, with written descriptions, physical attributes, and
34 animal behavior, as well as immediate human health and safety concerns.

35 Rapid response programs are designed to implement immediate action upon the detection of invasive
36 species. They are comprehensive programs that require the melding of coordination, communication,
37 education, and training. Rapid response actions and sightings are documented in incident reports and
38 response times are substantially reduced by emphasizing training and public awareness, as shown in
39 CNMI in 2003 (Colvin et al. 2005). The BTS review by Colvin et al. (2005) found rapid response to be

1 most successful when the following aspects are incorporated into the program: extensive training,
2 public awareness and outreach, use of technological advances, centralized documentation (e.g., SOPs),
3 and networking that allows the program to operate on a regional level. These aspects are central to the
4 recommendations for rapid response programs outlined in the review. Currently, the most developed
5 rapid response programs exist in Guam, Saipan, and Hawai'i but training and organizational efforts in
6 other archipelagoes in the Pacific Basin is underway. For example, the U.S. Geological Survey Rapid
7 Response program has conducted training throughout the Micronesia Region, including CNMI, Palau,
8 Chuuk, Pohnpei, Kosrae, Kwajalein, Ebeye, and Majuro (Stanford and Rodda 2007) with the goal of
9 expanadding the capacity regional rapid response program for alien snakes.

10 **A4.1.3.17 Control Methods Development**

11 Methods development is also needed to facilitate prevention measures occurring at the pre-border
12 stage, but its largest application in mitigation at the post-border stage of introduction of invasive
13 species. Methods development is most productive when closely coordinated and integrated to maximize
14 efficient use of funds and execution in the field (Colvin et al. 2005).

15 While extensive progress has been made on many aspects of BTS biology and control measures,
16 additional ecological research is needed to facilitate control and interdiction, including topics such as
17 population dynamics, reproductive biology, bait and attractants, application of control agents and
18 logistics of control measures (Colvin et al. 2005). Unlike BTS, there remains a lack of methods
19 development for particular invasive species, such as the Asian beauty snake, gecko species, and house
20 shrew. Certain species require integrative solutions for effective control methods; characteristics
21 inherent in their biology and behavior may make some species more difficult to control. For example,
22 effective baited trapping of BTS is feasible due to their large movements, while bait and attractants are
23 not as effective on the more sedentary Habu snake (Hattori 1999). Successful methods development
24 relies heavily on sufficient funding to fuel the education, training, human resources, and facilities
25 required to pursue a comprehensive, integrative approach to control and management of invasive
26 species.

27 **A4.1.3.18 Regulatory Drivers and Enforcement**

28 Regulatory drivers are in place to prevent the transport of vertebrate species, but these regulations are
29 only realized under well-funded, comprehensive enforcement. For example, pertinent regulatory drivers
30 include the Brown Treesnake Control and Eradication Act of 2004 and the National Defense
31 Authorization Act, Public Law 110-181, Section 314, requiring implementation of control, eradication,
32 and reporting efforts, as well as actions prohibiting the transport and spread of BTS from Guam. The BTS
33 Control and Eradication Act of 2004 required formation of the Brown Treesnake Technical Working
34 Group under authority of the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990. The
35 Brown Treesnake Technical Working Group specifies 100% BTS interdiction on Guam, which requires
36 inspections of aircraft, vessels, and cargo departing Guam, as described in the Brown Treesnake Control
37 Plan of 2009. Enforcement of these regulatory drivers for BTS depends upon coordination and
38 communication of several agencies such as APHIS-PPQ, Military Customs Inspection, CBP, the USFWS,
39 and the Transportation Security Administration across water and air related pathways. One caveat of

1 regulations in application to biosecurity lies in the fact that enforcement of the regulation may differ by
2 sector. For example, biosecurity inspections of aircraft differ for military and commercial aircraft, with
3 military aircraft themselves being exempt from inspection, and only contents such as passengers and
4 cargo being subject to inspection (U.S. Navy 2009k). Also, in the United States, regulatory drivers have
5 the tendency to differ in enforcement by State. This is seen in the implementation of biocontrol where
6 policies can differ vastly in stringency by State leading to disjointed implementation of the regulation
7 (Messing and Wright 2006). Therefore, monitoring and surveillance of enforcement such as detailed
8 reports, summaries of prosecution of regulation breaches, and corresponding trends of introduction
9 incidences are all necessary checks and balances to evaluate the efficacy of the upholding of regulations
10 regarding invasive species through enforcement.

11 **A4.1.3.19** *General Recommendations*

12 **Address funding issues necessary for regional biosecurity.** Regardless of the biosecurity strategy
13 developed, lack of sufficient, consistent, and properly managed funds will be the weak link in any effort
14 implemented, allowing for biological invasions of terrestrial vertebrates to occur in the region.

15 **Military funding for biosecurity efforts in the region must be continued.** Military presence in the region
16 calls for long-term allocation and ongoing management of biosecurity funds, as many risks to biosecurity
17 are associated with the relocation.

18 **A centralized group should be responsible for creating avenues for funding within the Micronesia**
19 **Region.** Regional funding is necessary because many of the risks are interrelated and require efforts that
20 cross political boundaries and sustained efforts are required to effectively minimize risk.

21 **Mandate and enforce regulations for handling cargo,** including packing, transport, cargo-staging,
22 palletizing, and loading. Funding is required to adequately develop and enforce regulations for
23 movement of cargo by military and civilian sources.

24 **Centralize biosecurity efforts.** The National Invasive Species Council was established by Executive Order
25 13112 to provide coordination and planning, and facilitate cooperation among the diverse federal
26 agencies and to take a more comprehensive approach to invasive species. However, the multiple
27 economic, ecological, and human health impacts of invasive species create complex challenges in policy
28 formation and governmental coordination (Williams et al. 2007), such that efforts must be centralized in
29 order to operate cohesively and effectively. A central group acting as a liaison can bridge gaps between
30 formal and informal, and military and civilian communications. A central group would outline the
31 current network of the biosecurity communications in the Micronesia Region, identify communication
32 gaps, provide information in the appropriate format for public, private, and military sectors, and be a
33 representative for media and news releases concerning biosecurity.

34 **Develop a biosecurity surveillance system** for improved data collection, reporting, and information
35 sharing network. There is a paucity of available information to fully assess risks associated with the
36 unintentional and accidental movement of terrestrial vertebrate species, posing significant risks and
37 undermining biosecurity efforts in the Micronesia Region. Sustained surveillance of biosecurity risks to

1 lead an adaptive response will decrease the risk due to changing threats and changes in the way cargo
2 and people are moved in the future.

3 **Encourage and participate in action to preserve biodiversity.** Include actions taken by joint agency
4 collaborations, such as the Micronesia Challenge (Micronesia Challenge 2009).

5 **Create community funding sources for local programs.** Promote “environmental citizenship” (Barry and
6 Knab 2005) for local training, education, eradication efforts, etc.

7 **Expand and manage university research efforts and programs.** The universities of the region can serve
8 as local facilities for methods development, education, and training to enhance biosecurity measures.

9 **Comprehensive and continued education is needed.** Educate everyone that can help or positively
10 influence the campaign against invasive species. Elements can include disseminating reports and
11 newsletters to educators, journalists, lawmakers, and business and community leaders; establishing
12 local reporting systems for rapid response teams; developing curricula for the schools; and conducting a
13 pre-campaign poll of island residents to gauge levels of awareness regarding species
14 introductions/invasions and subsequent impacts (Holt 1997). Include military and military-civilian
15 personnel.

16 **Implement biosecurity measures for detecting myriad terrestrial vertebrate species.** Biosecurity
17 activities need to account for several species of terrestrial vertebrates in the Micronesia Region, but
18 hazards and regulations currently driving biosecurity efforts on Guam are aimed primarily at preventing
19 the transport and spread of BTS. Detection methods for various terrestrial vertebrate species would
20 involve an increase in awareness, adequate training, and proper equipment for dealing with inceptions
21 and the capabilities to report all incidences, including incidental sightings. Such an integrative approach
22 also permits assessment of the cumulative effects of terrestrial vertebrate species movement in the
23 region.

24 **Increase the number of USDA-APHIS-WS canine inspection teams** at Apra Harbor, at the Commercial
25 Port, and at Naval Base Guam. To adequately protect movement of snakes on military and commercial
26 boats, the number and capacity of USDA canine inspection teams should be increased in response to
27 adequately cover outgoing boats.

28 **Create regionally based canine inspection stations for USDA-APHIS-WS canine teams on Guam.** Make
29 the existing canine housing facility a central inspection headquarters that houses the majority of canine
30 teams. Build smaller housing units regionally around the island for one to three canine teams that are
31 rotated regularly and randomly; these smaller units would reduce inspection team travel time, save fuel
32 costs, and allow for more inspections to occur on island. These sub-stations could also serve as
33 community collection points for vertebrate terrestrial species information, and awareness/training
34 programs, and also where the public can report observations and bring specimens.

1 **Establish a role for USDA-APHIS-WS BTS canine inspection teams in CNMI.** USDA-APHIS-WS does not
2 have a presence in CNMI for BTS inspections of materials and vessels departing Saipan, Tinian, and Rota.
3 Establishing USDA-APHIS-WS canine teams in CNMI can enhance screening abilities performed by CNMI
4 Division of Fish and Wildlife canine teams by increasing the number of personnel and canine teams
5 available, increasing ability to conduct random inspections, and increasing the number of inspections
6 and amount of materials that can be inspected.

7 **Develop a labeling and tracking system for all cargo.** Cargo that originates in areas with high BTS
8 densities is considered high risk. Implement a barcode-based data collection system and incorporate it
9 into a centralized biosecurity system. A barcode-based system will typically be comprised of any or all of
10 the following components: barcode scanners, barcode-based mobile computers (including wireless
11 scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels
12 and ribbons, and barcode data collection software.

13 **Manage the grounds around ports to reduce populations of target invasive species.** Unintentional
14 transport of hitchhiking terrestrial vertebrate species may occur in a number of ways. Hitchhiking
15 species may be initially attracted to certain physical or chemical conditions, such as rats (*Rattus* spp.)
16 nesting in aircraft wheel wells (Vice 2010b), BTS sheltering inside shipping containers or packing material
17 (Fritts et al. 1999), and mice (*Mus* spp.) feeding on grain and garbage shipments transported overseas
18 (Baker 1994). Use vertebrate-proof staging areas, spot-lighting checks at night, etc.

19 **Expand capacity of control methods for BTS.** While progress has been made on many aspects of BTS
20 biology and control measures, additional or improvement of methods would facilitate control and
21 interdiction procedures, including bait and attractants, large area suppression, additional interdiction
22 techniques, and logistics of control measures (Colvin et al. 2005). Sustained funding to refine existing
23 strategies and develop new methods would decrease the long term costs of interdiction, improve
24 efficacy, and reduce risk.

25 **Improve detection methods for rodents on vessels and in cargo.** NAVMED P-5010-8 is the Naval
26 Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy
27 BMS 2004) and outlines preventive measures for rodent control on ships. This includes proper
28 sanitation, pierside inspections, rat guards, illumination and movement restrictions, glue boards, snap
29 traps, and limitations on access points to the vessel. The information available on rodent prevention
30 measures is more extensive than that of aircraft. Currently, control methods for rodents in cargo consist
31 of anti-coagulant bait, snap traps and sticky traps. Most efforts regarding rodent presence on vessels
32 and in cargo remain in the control realm, while methods on rodent detection are underdeveloped.

33 **Assign trained, uniformed USFWS personnel to law enforcement at commercial and military ports.**
34 USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated
35 animals, provide permits, provide education, assist in the handling and processing of terrestrial
36 vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of Rapid Response Plans
37 at the border.

1 **A4.2 INTENTIONAL PATHWAYS**

2 **A4.2.1 Summary**

3 There are 10 pathways by which terrestrial vertebrates may be intentionally introduced into the
4 Micronesia Region. These pathways are evaluated for their risks to the region by analyzing for each the
5 component risks of importation, establishment, and hazard (or impact). The pathways of greatest risk to
6 the Micronesia Region are the pet trade, release for aesthetic purposes, and release for food use. The
7 first two of these also present the greatest range of species associated with release, making it difficult to
8 mitigate risk via those pathways using a species-based approach such as reliance on banning a few
9 species. The four pathways of zoo releases, game-hunting, biocontrol, and scientific research present
10 moderate risks of introducing new invasive vertebrates. With the exception of the zoo pathway, each
11 presents only a narrow range of species liable for introduction, but several of these pose high risks of
12 impacts should they become established. The final pathways of fur-ranching, religious release, and
13 bioterrorism present only low probabilities of leading to new vertebrate invasions in the Micronesia
14 Region under current circumstances, although the second of these could increase in importance should
15 the proportion of Buddhists in the region increase in coming years. Several of these species also pose
16 high hazard, but risk will be directly related to propagule pressure (numbers released), which is currently
17 small.

18 Mitigation of these risks is feasible for many pathways because of the intentional nature of the
19 introductions. The most reliable mitigation actions involve expanding regulations of importation and
20 ensuring enforcement and public outreach regarding the regulations. Future methods development may
21 make it feasible to develop more specific screening models to determine comparative risks on a species-
22 by-species basis for a broad array of taxa, but that goal is not yet scientifically available. Until that goal is
23 met, banning certain well-known, high-risk invasives from importation into the region is a reasonable
24 measure for the avoidance of the potential spread of these invasive species. Supplementation of explicit
25 efforts to remove or highly restrict certain pathways (zoological gardens, game hunting, scientific
26 research, fur farming) would go some way toward providing the Micronesia Region greater biosecurity
27 for the near future.

28 **A4.2.2 Introduction**

29 Vertebrates have been among the most spectacularly destructive groups of alien species transported by
30 humans, with many species creating threats to human health and safety, the economy, and ecology in
31 the regions where they have been introduced (Greenway 1967; Honegger 1981; Morgan and Woods
32 1986; Ebenhard 1988; Case and Bolger 1991; Henderson 1992; Pimentel et al. 2000; Pimentel 2002;
33 Blackburn et al. 2004; Pimentel et al. 2005; Jenkins et al. 2007; Kroeger 2007). Progress has been made
34 in recent years toward reversing some of these impacts by removing certain alien vertebrates from
35 some invaded regions (Bell 2002; Burbridge and Morris 2002; Merton et al. 2002; Tershy et al. 2002;
36 Nogales et al. 2004; Campbell and Donlan 2005; Clout and Russell 2006; Howald et al. 2007). In most
37 instances, however, perpetual control of widespread or abundant alien vertebrates is required to
38 minimize damage to especially important areas or resources. But such eradication and control
39 operations are achieved at high cost and can only be successful in limited circumstances, making them

1 an unreliable foundation upon which to base a nation's biosecurity future. A much more efficient and
2 cost-effective means of managing alien species is to prevent their introduction (Naylor 2000; Touza et al.
3 2007). Consequently, prevention of future invasions should form the centerpiece of any region's alien-
4 species management program.

5 To date this has been rarely attempted. Australia and New Zealand have taken measures to develop
6 proactive systems to prohibit the introduction of new vertebrate species onto their shores unless they
7 are first evaluated and shown likely to be safe for importation. Most jurisdictions, however, if they
8 prohibit the importation of a species at all, only ban species famous for being pests elsewhere. This
9 approach is of some use for avoiding additional damages from known invasives having high impact, but
10 it is inherently reactive and can only be applied to species already creating damage elsewhere. It cannot
11 identify pests from the large pool of species not yet introduced anywhere or of those introduced
12 elsewhere but not yet having erupted into pest status.

13 In developing a meaningful prevention system for terrestrial vertebrates, assessment of risk must take
14 into account the means of introduction. This is important because different taxa are introduced for
15 different reasons and via different pathways (Kraus 2003). For example, the most important
16 introduction pathways for all terrestrial vertebrates are intentional pathways, with mammals being
17 introduced mostly for game hunting, food use, and fur farming; birds primarily for the pet trade and for
18 game hunting; and reptiles and amphibians mostly for the pet trade, for related aesthetic reasons, and
19 for food use (Kraus 2003; 2009). As well, some taxa are moved via more than one pathway. For example,
20 the invasive North American bullfrog (*Lithobates catesbeianus*) has been introduced via the pet trade,
21 for food use, and for aesthetic reasons, and the Chinese soft-shelled turtle (*Pelodiscus sinensis*) has been
22 introduced via the pet trade, for food use, and for religious purposes, with different pathways applying
23 in different locations (Kraus 2009). Pathway importance also varies temporally, with some pathways
24 increasing in importance through time (e.g., the pet trade since the 1960s) and others generally
25 decreasing in importance (e.g., biocontrol since the 1930s). As a result of the taxonomic, temporal, and
26 geographic variation among pathways, the proper means of assessing biosecurity risk will vary by
27 pathway, location, and time, as will the appropriate means of managing that risk (Kraus 2009).

28 Pathway definitions differ depending on which class of pathways is under consideration; intentional are
29 pathways based on the motive for importation. As a result, intentional pathway categories are diverse in
30 their introduction methods. For example, use of animals as pets may involve purchase via commercial
31 pet shops, purchase from websites, or direct smuggling of desired animals; their release may be
32 deliberate with the intent to establish new populations, deliberate to remove the burden of unwanted
33 animals, or accidental due to poor caging conditions.

34 In mitigating risk of intentional introductions, public education can prevent deliberate importation or
35 release of new invasive vertebrates and should be included in the arsenal of tools used for invasive-
36 species management. However, it is an insufficient tool in itself, so it is also desirable to prohibit the
37 intentional import and keeping of high-risk species (Reed 2005), and seek to remove the economic or
38 social incentives for some of the intentional pathways. Prevention of dangerous introductions via the

1 assorted intentional pathways can be most effectively achieved by means of adopting scientific
2 screening systems to evaluate proposed importations for likelihood of invasiveness. This would enable
3 quarantine authorities to permit the import of low-risk species, while identifying and excluding high-risk
4 species (Kolar and Lodge 2002; Bomford 2003). Yet how these risks can be reliably assessed is still a
5 matter for debate, and it is likely that simple generalizations across all taxonomic groups are not feasible
6 (Williamson 1999b; Kolar and Lodge 2001; Heger and Trepl 2003; Cassey et al. 2004). But risk
7 assessment across a particular taxonomic group (e.g., birds) may be feasible. So, ecologists continue to
8 suggest and test a large number of attributes for these different vertebrate groups in search of a set that
9 is consistently predictive of establishment success for each group, and risk analysts continue to
10 recommend their use in risk-management schemes (Kolar and Lodge 2002; Stohlgren and Schnase 2006;
11 Hayes and Barry 2008).

12 To that end, a number of studies have sought to identify such attributes for birds (Moulton and Pimm
13 1986; Brooke et al. 1995; Duncan 1997; Sol and Lefebvre 2000; Blackburn and Duncan 2001; Cassey
14 2001; Duncan et al. 2001; Cassey 2002; Cassey et al. 2004; Allen 2007a; Blackburn and Cassey 2007;
15 Blackburn et al. 2009), mammals (Forsyth et al. 2004; Bomford et al. 2006), and reptiles and amphibians
16 (Bomford et al. 2009). Different attributes have been found to be important in these various studies,
17 depending in large part on the taxon and region investigated. Hayes and Barry (2008) examined 24 of
18 these studies, and they found that only three parameters (climate match between native and host
19 ranges, successful prior establishment elsewhere, and propagule pressure) consistently predicted
20 establishment success across all taxa, although other factors were sometimes important for a particular
21 taxon, such as birds. The results of these assorted studies have been used by Bomford (Bomford 2003;
22 Bomford et al. 2005; 2006; Bomford 2008; Bomford et al. 2009) to construct simple models for assessing
23 the likely invasiveness of vertebrates proposed for introduction to Australia and New Zealand. Some of
24 the relevant variables (e.g., prior history of invasion, propagule pressure) are uniform across regions
25 because they are taxon specific, but the climate-matching variables need to be adjusted for each
26 separate jurisdiction under consideration because climate varies so widely among regions.

27 Even with proper application of an effective screening system for intentional introductions, smuggling of
28 pest species by uninformed or malicious individuals will continue to be attempted. So, effective
29 enforcement of biosecurity laws prohibiting pest importations is also a requisite part of any meaningful
30 preventive system for intentionally introduced vertebrates. Developing a screening system without
31 some form of enforcement capability is a sterile exercise and will compromise biosecurity.

32 In considering the risk of introduction of alien vertebrates into the Micronesia Region via intentional
33 pathways, the most sensible approach at present is to identify all relevant motives, consider the most
34 hazardous types of animals that are likely to arrive by that motive, and assess the degree of threat
35 posed. For some pathways, only a few taxa are able to be transported; for other pathways, many taxa
36 may be moved (e.g., zoological garden stocking). This threat will be the product of likelihood of
37 introduction, likelihood of establishment, and the hazard posed by the taxa arriving by that pathway.
38 Likelihood of introduction will be a function of the volume of material arriving by the pathway, degree to
39 which the pathway is inspected or regulated, and degree to which compliance with regulations occurs.

1 Likelihood of establishment can be dependent on many things, but factors scientifically assessed and
2 proven useful for birds and mammals include degree of climate match, whether the species is already
3 established somewhere else outside its native range, overseas range size, taxonomic order, diet, ability
4 to inhabit disturbed habitats, and non-migratory behavior (Bomford 2008). Factors proven useful for
5 reptiles and amphibians include degree of climate match, whether the species is already established
6 somewhere else outside its native range, and taxonomic family (Bomford and Kraus 2008; Bomford et al.
7 2009). For all terrestrial vertebrate taxa, climate match is best ascertained by using a formal climate-
8 matching algorithm, such as CLIMATE (Bomford 2008; Bomford et al. 2009). However, such comparisons
9 rely on quantitative matching between meteorological stations within a species' total range and those in
10 the jurisdiction of concern. These comparisons are not easily made for oceanic islands because the
11 sampling of meteorological stations in such regions is often too sparse to sample the full range of
12 climatic variation, especially that variation due to ascending elevation. So, for this risk assessment,
13 climatic suitability of the Micronesia Region for a species was assessed by determining whether that
14 species occurred in similar climatic zones or ecoregions elsewhere in the world. A caveat to the
15 application of climatic suitability is that it does not account for other parameters or pressures that may
16 make the given region unsuitable for reasons other than climate.

17 Hazard (or pest status, or invasiveness) posed by a species has been moderately well assessed for birds
18 and mammals (Bomford 2008) but has been poorly evaluated for reptiles and amphibians. For both
19 birds and mammals, hazard is a function of taxonomic group as well as other factors. Factors that also
20 heighten risk of establishment for both taxa (overseas range size, whether it is a pest elsewhere, and
21 climate match) also predict invasiveness, as do whether a species is harmful to humans, their property,
22 or their domesticated animals, either by direct action or by transmitting disease or parasites. Mammal
23 orders that have a demonstrated history of detrimental effects on prey abundance or habitat quality
24 (Artiodactyla, Carnivora, Lagomorpha, Marsupialia, Perissodactyla, and Rodentia) and mammal families
25 that are prone to causing agricultural damage (Bovidae, Canidae, Cervidae, Leporidae, Muridae, and
26 Mustelidae) are of higher hazard, as are those that are strict carnivores, or strict browsers/grazers. Bird
27 taxa that cause high agricultural damage (Anatidae, Corvidae, Fringillidae, Ploceidae, Sturnidae, and
28 Psittaciformes) or which frequently hybridize with native species (e.g., Anatidae, Cacatuidae,
29 Phasianidae) are of higher hazard. Species in both Aves and Mammalia can also be social hazards
30 because they invade buildings, have communal nests that create large amounts of waste, or generate
31 large amounts of noise. Hazard for reptiles and amphibians is more tentatively assigned, but factors that
32 clearly impinge on hazard include risk to human health via envenomation or constriction, noise
33 production, whether the species has been a pest elsewhere, or whether it is congeneric with isolated
34 native species and thereby increases the risk of hybridization (Kraus 2009). The first of these hazard
35 categories for herpetofauna is unambiguously determined, but the last three have received little
36 attention, although some species clearly fall into each category.

37 Because risk assessment for alien vertebrates is still in the process of development, probabilities of
38 introduction, establishment, and hazard are often only qualitatively ranked by category at present. In
39 the United States, categories used by USDA and the Environmental Protection Agency are "high",
40 "medium", and "low" (Simberloff 2005). In this approach, the total risk is taken to be the lowest-ranked

1 probability across the three categories, an approach that is in accord with a juridical tradition of
2 presuming innocence until proven otherwise, but which seems inadequate to stopping additional
3 invasions (Simberloff 2005). Thus, e.g., a species having a low probability of introduction, a medium
4 probability of establishment, but a high probability of hazard would be assigned a total risk score of
5 “low”. The Australian government provides a slightly more expanded set of risk ranks, including “low”,
6 “moderate”, “high”, and “extreme”, and addresses contrasting risks across the categories of
7 introduction, establishment, and hazard in a more quantitative and directly comparable fashion. In this
8 system, values for each variable contributing to risk, whether for introduction, establishment, or hazard,
9 are given numerical values, with assigned values depending on how much the attribute contributes to
10 the particular risk. These numerical scores are then summed across all pertinent variables among the
11 three stages of invasiveness and the final risk is determined by the overall score, with high scores
12 meriting assessments of “extreme” risk, while low totals merit a “low” overall ranking (Bomford 2003;
13 Bomford et al. 2006; Bomford 2008). As noted above, as attributes predictive of risk become better
14 identified, these quantitative models may be expanded to provide a finer degree of risk assessment than
15 can currently be achieved.

16 **A4.2.3 Risk Assessment**

17 Ten pathways potentially contribute to the risk of intentional introduction of vertebrate pests into the
18 Micronesia Region, with the first nine being well-documented pathways from around the globe, and the
19 last being hypothetical. Different sets of taxa characterize each pathway. Most pathways have a
20 relatively small set of taxa of primary concern, but the pet trade and aesthetic pathways move a large
21 and open-ended set of species, making assessing specific risks from those pathways more challenging.
22 For consideration of risk to the Micronesia Region, a set of representative taxa of greatest likely risk is
23 here identified for each pathway, basing this on species known to be involved in these pathways and of
24 ecological, economic, or social hazard elsewhere. This allows for quick comparison of relative risk among
25 the pathways, points out the potential risks that invasive terrestrial vertebrates can pose to the
26 Micronesia Region, and highlights biological and transport issues relevant to developing appropriate
27 biosecurity mitigation measures.

28 As stated earlier, each pathway can typically involve several different routes of ingress. Specimens may
29 be either purchased or carried personally into the jurisdiction in question. Purchases may be through
30 commercial local businesses (such as pet shops) or via the Internet (Derraik and Phillips 2010), in which
31 case, transportation may be via commercial freight carrier or the mail. Personally carried items may be
32 legally brought into the jurisdiction of interest or may be smuggled. In the Pacific islands, smuggling is
33 generally very easy because of poor inspection of arriving passengers and baggage for contraband
34 animals (see for example Kraus and Cravalho 2001 for Hawai’i). Although there are no data to indicate
35 that it is happening, smuggling would be very easy for personnel arriving on military craft. When
36 developing biosecurity programs for intentional pathways of introduction it will be important to ensure
37 that the public and military are educated about prohibited items, that rigorous inspection of each
38 potential route of arrival is provided, and that enforcement of laws is politically and financially
39 supported. Otherwise, merely identifying source pathways and noting their hazards are of little benefit.

1 For this risk assessment for the Micronesia Region, insufficient information is available to meet the
2 detailed, quantitative standards followed by the Australian system (Bomford 2003; Bomford et al. 2006;
3 Bomford 2008). However, the USDA approach, which chooses an overall risk score by automatically
4 defaulting to the lowest of the three constituent risk scores, is of dubious justification or utility in
5 stopping invasions (Simberloff 2005). For the purposes of this risk assessment, the best that can be done
6 at present is to assign a risk of “low,” “moderate,” or “high” to each component of introduction risk
7 (importation, establishment, and hazard), similar to the approach adopted by USDA. But then a score is
8 assigned to each of these risk levels (low=1, moderate=2, high=3), and the scores summed across the
9 three components of risk to achieve a final score, with the overall risk of introduction being “low” if the
10 sum score is 3-5, “moderate” if 6-7, and “high” if 8-9. This provides a more balanced means of
11 adjudicating overall risk among the three constituent components of introduction risk.

12 Historically, the Pacific region, and especially the oceanic islands, have been heavily impacted by
13 introductions of alien terrestrial vertebrates. Virtually no island in the region has been immune to them.
14 More than 40% of bird introductions around the world have been to Pacific islands (Long 1981; Kraus
15 2003), as have large numbers of mammals (Lever 1985; Long 2003) and reptiles and amphibians (Kraus
16 2009). Many of these have been deliberate introductions. As a result of this heavy introduction history,
17 some of the most heavily impacted jurisdictions (especially New Zealand and Hawai’i) have served as
18 cautionary tales for much of the remainder of the Pacific islands and have been at the vanguard of
19 research into the impacts and invasion processes on these species. This research, as well as that from
20 lower-elevation islands (e.g., Guam, Ogasawara Islands, see Fritts and Rodda, 1998; Kawakami and
21 Okochi, 2010), has made clear how susceptible oceanic islands are to introduced alien species generally
22 (Fritts and Rodda 1998; Kawakami and Okochi 2010). Thus, even though many areas of the Micronesia
23 Region currently lack most of the invasive terrestrial vertebrates that plague other regions, without
24 thoughtful assessment of the risks of acquiring these species, protection of those islands from these
25 pests is compromised.

26 One important component of risk is whether eradication of a species is feasible should it become
27 established. It is politically easy to think that prevention of additional invasions can be neglected
28 because too many species are involved, and that instead management can be focused on removing the
29 worst invasive species that do become established. Invasive species are difficult to eradicate once
30 established, and the same holds equally for most vertebrate species. It is true that several species of
31 mammals were successfully eradicated from islands with new techniques developed in the past 20 years
32 (Nogales et al. 2004; Campbell and Donlan 2005; Howald et al. 2007). However, only a very few species,
33 primarily rats, cats, and ungulates, have widely benefited from this attention. There are very few
34 instances of successful eradication efforts for amphibians, and none for reptiles (Kraus 2009) or birds,
35 although ongoing efforts in Britain against ruddy ducks (*Oxyura jamaicensis*) seem successful (Genovesi
36 2005; Henderson 2010). One important reason for these failures is that detection of these species is
37 usually sufficiently difficult that not all members of the targeted population are liable to control, a
38 precondition for successful eradication operations (Bomford and O'Brien 1995). Another reason is that
39 control methods have not been developed for many species beyond those few mammals mentioned
40 above (Kraus 2009). Even for the few species that are sometimes feasibly eradicated, costs are almost

1 always high (Martins et al. 2006; Donlan and Wilcox 2007; Howald et al. 2007), restricting such actions
2 to only the most damaging invasions. The importance of this is that the impossibility or difficulty of
3 eradication increases the hazard of virtually all species considered below because damage usually
4 continues in perpetuity.

5 **A4.2.3.1** *Pet Trade*

6 This pathway includes all acquisitions of animals for use as pets, whether purchased from commercial
7 pet stores, purchased from Internet dealers, or directly captured and imported by interested individuals.
8 It also involves the deliberate release of animals to establish populations that will then be harvested to
9 sell to the pet trade. Globally, the pet trade is the largest source of introductions for reptiles and
10 amphibians and is one of the two largest pathways for birds, with introductions of those taxa increasing
11 exponentially (Kraus 2003, 2009). But the pathway is a relatively insignificant source for mammal
12 introductions, with a few notable exceptions. For reptiles, amphibians, and birds this pathway has
13 exploded in importance since the 1960s and shows no sign of abating in the near future (Kraus 2003,
14 2009). Furthermore, although the pathway has been of greatest importance in the wealthier countries,
15 there is virtually no part of the world untouched by it (Kraus 2009). The diversity of bird, reptile, and
16 amphibian species spread via this pathway numbers in the hundreds (Jenkins et al. 2007), and the
17 numbers of individuals moved is in the millions (e.g., Beissinger 2001; Franke and Telecky 2001). The
18 most commonly spread mammals via this pathway are cats, dogs, rabbits, and an assortment of rodents,
19 again moved worldwide by the millions.

20 Importation risk via this pathway is high and growing. A large and diverse array of species is available
21 through the pet trade, and there are few restrictions in the Micronesia Region on what is available for
22 importation. Pet stores occur in at least Guam, CNMI, and FSM, and even where pet stores are lacking,
23 travelling citizens will often bring animals of interest back with them from overseas trips (e.g., Buden et
24 al. 2001). Occasionally, visitors arriving on private boats or on foreign fishing vessels also bring in pets
25 that escape captivity. Even when import restrictions on some pets do apply, smuggling and release or
26 escape of banned species is sufficiently common that risk remains high. An example of this is from
27 Guam, where ball pythons have recently been confiscated or turned over to officials even though the
28 possession of snakes in the territory is banned (Vice 2010a). Smuggling is probably more frequent than
29 that single example suggests, judging from the experience in culturally similar Hawai'i (Kraus and
30 Cravalho 2001). The magnitude of the pet-trade problem will generally co-vary with population size,
31 meaning that smaller jurisdictions will have fewer problems, but these will not disappear entirely. This is
32 well illustrated by the appearance of turtles brought into Pohnpei for use as pets and maintained there,
33 in at least one instance, by government officials (Buden et al. 2001). The CNMI has three or four active
34 pet stores. IAS which are typical of the pet trade and which are known to have feral populations in the
35 CNMI include the red-eared sliders (*Trachemys scripta*), orange-cheeked waxbills (*Estrilda melpoda*),
36 rock doves (*Columba livia*), and quails (Williams 2010). Importation risk via this pathway will entail the
37 risk of species legally allowed for import for commercial sale or ownership as well as the risk of
38 smuggling, done either by direct personal transport of an animal or by Internet purchase and shipment
39 via postal service or private carrier service (Derraik and Phillips 2010). Experience in Hawai'i has shown

1 that smuggling of banned animals is generally easy because of lax inspection standards (Kraus and
2 Cravalho 2001). The same will be true for much of the Micronesia Region.

3 Establishment risk via the pet trade is high overall, although there is tremendous variation among
4 species. Quantification of establishment success for reptile and amphibian introductions indicates this
5 pathway to be one with the lowest probability of successful establishment per release. However,
6 because the total number of releases via this pathway is so vast, overall establishment risk is high, and
7 the pathway has contributed the greatest number of herpetofaunal introductions worldwide (Kraus
8 2009). A similar pattern holds for birds (Kraus 2003). Although not explicitly tested, the same pattern
9 may be expected for mammals, although mammals seem to establish more easily than do the other two
10 groups. Many species of birds, reptiles, and amphibians introduced through the pet trade have become
11 established in numerous countries around the globe, including tropical Pacific islands (Long 1981; Kraus
12 2009). Other taxa frequently kept in the pet trade are predicted to pose high establishment risks even
13 though populations have not yet established (Bomford et al. 2005; Reed 2005; Carrete and Tella 2008;
14 Bomford et al. 2009). At least among birds, wild-caught animals appear at greater risk of establishment
15 than do species that have been bred in captivity for many generations, which seem to have lost much of
16 their ability to live in the wild (Carrete and Tella 2008). It is doubtful whether the wild-caught vs.
17 captive-bred distinction in establishment success will hold for reptiles and amphibians because their
18 behavior is probably less environmentally dependent, so few species have been genetically modified in
19 captivity, and, even when they have, there is evidence that mutant forms can survive when released into
20 novel environments (e.g., Pether and Mateo 2007). However, at least one exception exists: wild-caught
21 pythons are at greater risk of release and present a greater risk of impact because behavioral irascibility
22 promotes release by owners and parasite loads present an added risk to native wildlife when released
23 (Reed 2005). The most widely kept mammals (cats, dogs, rabbits, mice, rats) have well-established
24 histories of successful establishment around the globe in a broad diversity of environments, including
25 tropical islands (Lever 1985; Long 2003), and there is no doubt that they can easily establish populations
26 if released in new islands in the Micronesia Region.

27 Hazard for species transported via this pathway is just as variable as is establishment risk, and for the
28 same reason: the large pool of species travelling via this pathway are diverse in biological attributes,
29 providing some species that are highly hazardous invaders and others that are of little concern.
30 Especially hazardous among mammals are predatory cats (Lever 1985; Pimentel et al. 2000; Nogales et
31 al. 2004; Vázquez-Domínguez et al. 2004; Pimentel et al. 2005; Denny and Dickman 2010; GISD 2010),
32 dogs (Lever 1985; van't Woudt 1990; Pimentel et al. 2000; Bergman et al. 2002; Pimentel et al. 2005),
33 and grazing rabbits (Lever 1994; Courchamp et al. 2003; Long 2003). Rats and mice are also highly
34 invasive across the globe (Atkinson 1978, 1985; Towns et al. 2006; Hilton and Cuthbert 2010), but it is
35 uncertain whether domesticated pet varieties survive well upon release. Among the most destructive
36 birds imported for pets are mynahs, bulbuls, pigeons, and a wide variety of parrots and finches, which
37 damage agriculture, disperse seeds of invasive plants, harass native birds, compete with native birds for
38 food and nest sites, and serve as reservoirs or vectors for diseases (Long 1981; van Riper and van Riper
39 III 1985; van Riper III et al. 1986; Lever 1987; Meyer and Florence 1996; Pell and Tidemann 1997;
40 Pimentel et al. 2000; Loope et al. 2001; Bergman et al. 2002; Bomford and Sinclair 2002; Thibault et al.

1 2002; Blanvillain et al. 2003; Eguchi and Amano 2004; Pimentel et al. 2005; Koopman and Pitt 2007;
2 Bomford 2008; Atkinson and LaPointe 2009; Linnebjerg et al. 2009; Feare 2010; Linnebjerg et al. 2010).
3 Some of these species are known to be actively sold as pets in the Micronesia Region. Hazard from
4 reptiles and amphibians moved via the pet trade is less clear, but is likely to be large in some cases,
5 especially on oceanic islands. In particular, snakes of many species are likely to be of high risk to native
6 wildlife via predation (Kraus and Cravalho 2001; Loope et al. 2001), and venomous snakes and large
7 constrictors, which pose obvious threats to human welfare and have become established on several
8 tropical islands (Martínez-Morales and Cuarón 1999; Ota 1999, 2000; Nishimura 2005; Quick et al. 2005)
9 as well as in the sub-tropical United States (Greene et al. 2007; Snow et al. 2007) are of considerable risk
10 (Fritts et al. 1990; Fritts et al. 1994; Rodda et al. 1997; Nishimura 2005; Reed 2005). But snakes are not
11 the only herpetofaunal threat. Predatory lizards are a potential problem, including monitor lizards
12 (Varanidae) and chameleons (Chameleontidae) (Loope et al. 2001; Campbell 2003; Enge et al. 2004;
13 Holland et al. 2009), due to predation on native wildlife, although large monitors can be a danger to
14 humans as well. North American bullfrogs (*Rana catesbeiana*) have been introduced into some countries
15 via the pet trade, and these frogs pose a large number of risks to native wildlife, including from
16 predation, competition, and disease vectoring (summarized in Kraus 2009). Perhaps the most frequent
17 impact from established populations of invasive reptiles and amphibians will be from changes in food-
18 web dynamics occasioned by the high densities formed by novel predators in tropical island ecosystems.
19 This can serve to either keep populations of other invasive pests unnaturally high by serving as a large
20 food resource, or such species may act as energy sinks, making nutrients unavailable to native species
21 (Fritts and Rodda 1998; Kraus et al. 1999; Moore et al. 2004; Greenlees et al. 2006; Kraus 2009). Many
22 species of small frogs (e.g., Hylidae, Ranidae) and lizards (e.g., Gekkonidae, Scincidae) kept in the pet
23 trade have the potential to induce such effects if released and established in the right environments. A
24 final risk of considerable importance for all taxa is the risk of transmitting disease to humans or native
25 species. Mammals, of course, pose a higher risk of transmitting diseases to humans because of their
26 closer phylogenetic affinity (e.g., Daszak et al. 2000; Karesh and Cook 2005), but birds and reptiles also
27 serve as vectors or reservoirs for human diseases (e.g., Haddock et al. 1990; Haddock and Nocon 1993;
28 Mermin et al. 1997; Reed et al. 2003; Mermin et al. 2004). Spread of diseases to native wildlife is of even
29 higher probability and threatens to reduce global biodiversity, with several spectacular examples
30 emerging in recent years (Daszak et al. 2000, 2001; Fisher and Garner 2007).

31 Total risk via the pet-trade pathway is high in the Micronesia Region. Importation risk for many species
32 is virtually assured by moderate to high public interest, lack of government regulation of the industry,
33 and poor inspection and enforcement capabilities. Also, establishment risk and hazard are high for many
34 of the most popular pet species. This is clearly the riskiest intentional pathway for terrestrial vertebrates
35 in the Micronesia Region and in many other parts of the world. Given the relatively modest scope of the
36 commercial pet trade in the Micronesia Region, the largest risk at present is probably the transport of
37 cats and dogs to islands on which they currently lack feral populations, but a wide diversity of species,
38 both mammalian and non-mammalian, pose a significant risk to the region.

- 39 • Risk of importation 3
- 40 • Risk of establishment 3

- 1 • Hazard 3
- 2 • Total risk 9 **HIGH**

3 **A4.2.3.2 Aesthetic Releases**

4 This pathway is very closely related to the pet-trade pathway and involves intentional release of animals
5 to establish populations because the species is considered in some sense desirable by the releaser (this
6 is the "intentional" pathway of Kraus 2009). Examples of this include birds (largely songbirds and some
7 parrots), frogs, or lizards released around a home because they remind the owner of a place they lived
8 previously or because they like the appearance of the species or the calls made by it (e.g., Long 1981;
9 Kraus and Campbell III 2002). Historically, this has been an important, but uncommon, introduction
10 pathway for birds, but a more important pathway for mammals, reptiles, and amphibians (Kraus 2003,
11 2009). Animals introduced via this pathway may be obtained directly from the pet trade for release, but
12 often those introducing the animals collect the species directly from the wild and release them in an
13 extralimital location. One variant of this pathway of particular concern is the desire by some resort
14 hotels to release colorful birds such as ducks and parrots on their grounds to amuse tourists and
15 increase the appearance of these resorts as "exotic." Among other problems created by this practice is
16 the release of mallard ducks (*Anas platyrhynchos*) in Hawai'i, which hybridize with and threaten the
17 native koloa ducks (*Anas wyvilliana*) (Browne et al. 1993; Engilis Jr. and Pratt 1993; Fowler et al. 2009).

18 Importation risk for this pathway will be largely the same as that for the pet trade, with animals
19 available in the pet trade or available for personal legal importation typically being those chosen for
20 release. However, this pathway also includes animals smuggled into a jurisdiction that bans their
21 ownership, as has repeatedly been demonstrated in Hawai'i (Kraus 2002). Given the overlap with the
22 pet trade for legal importations (see above) and the additional risk of importation posed by smugglers of
23 banned wildlife, importation risk via this pathway is just as high as for the pet-trade pathway.

24 Risk of establishment via this pathway is a function of three variables: the number of individuals within a
25 population desiring to establish a new species, the availability of animals for release, and the number of
26 animals released (propagule pressure). For smaller jurisdictions, the first number will generally be low
27 because relatively few people want new species in their environment that they will go through the
28 trouble (sometimes including smuggling) to attempt establishing new populations. Availability of
29 animals in the Micronesia Region varies depending on size of the local commercial pet trade and
30 frequency with which citizens travel overseas and, therefore, have the opportunity to return with
31 animals. Both of these are likely highest for Guam and CNMI because their large military presence leads
32 to high passenger volume and frequent turnover of personnel. Lastly, propagule pressure via this
33 pathway is usually high once a decision has been made to try to establish a species because everyone
34 knows that multiple animals will increase the probability of founding a population. For most countries in
35 the Micronesia Region, it is probably safe to assume that interest in establishing novel species is low.
36 Across the region, availability of animals varies, but may be summed as moderate in Guam and CNMI
37 and low in the other countries. But propagule pressure will generally be high. In sum, these three
38 variables make establishment risk via this pathway moderate.

1 For the same reasons described above for the pet-trade pathway, hazard of animals released via this
2 pathway will be of wide variability, but should generally be considered high because of the large number
3 of clearly hazardous species transported. Hence, as for the aesthetic release pathway, overall risk is
4 high. Opportunity for release is high, establishment risk is moderate, and impact risks are high. The only
5 uncertainty is the will to release animals for this purpose, and experience around the globe shows that a
6 significant (but small) percentage of most human populations are willing to engage in this behavior (see
7 data in Long 1981, 2003; Lever 1985, 1987; Kraus 2009). Once that decision is made, animals are
8 generally sufficiently available that a determined individual can acquire the needed material.

- 9 • Risk of importation 3
- 10 • Risk of establishment 2
- 11 • Hazard 3
- 12 • Total risk 8 **HIGH**

13 **A4.2.3.3** *Animals for Entertainment*

14 Releases by zoological gardens are also closely related to the previous two categories inasmuch as the
15 species displayed (and sometimes released) are chosen for their aesthetic interest. However, species
16 available via this pathway present an even wider array of taxa than those available in the pet-trade or
17 aesthetic pathways. Zoos range from large publicly funded, well-secured institutions to small, private,
18 poorly secured tourist facilities. Most records of release come from the latter end of the spectrum;
19 however, there have clearly been several instances of intentional releases of animals by personnel at
20 larger, public zoos too (Shaw 1946; Long 1981). Releases include those done deliberately as well as
21 escapees from poor caging conditions. Releases via this pathway have not been as well documented as
22 for other pathways, but those involving reptiles and amphibians have recently been summarized (Kraus
23 2009), and some records of bird and mammal releases have also been noted (Long 1981; Washitani
24 2004; Holzapfel et al. 2006; Jansson et al. 2008). But most mammals retained in zoos are larger and
25 dangerous enough to attract immediate recapture efforts, so few records exist of mammals becoming
26 established via this pathway (but see Washitani 2004).

27 There are relatively few zoos in the Micronesia Region, with one (previously two) on Guam, one on Rota,
28 and one on Saipan (Stanford 2010). A recently captured skunk on Guam likely arrived via this pathway,
29 suggesting that, although few zoos exist in the Micronesia Region, the pathway cannot be ignored. Low
30 volume of activity via this pathway makes risk of importation rather low, but the rather poor
31 maintenance standards evinced by many private zoos make risk of release into the wild rather high. So
32 overall, risk of importation and release/escape is moderate.

33 Risk of establishment is probably lower than for the pet-trade pathway because most species retained in
34 zoos are kept only in small numbers. However, when large colonies of a species are kept, risk of
35 establishment will increase. Information on what stocks are currently held in zoos in the Micronesia
36 Region is not easily available, so establishment risk is currently uncertain for most jurisdictions.
37 However, the zoo on Saipan has multiple individuals of some species (Calindas 2006), including some

1 that are invasive elsewhere, so establishment risk will be higher for those. Given this uncertainty,
2 establishment risk is here scored as “moderate.” Assuming that governments have the interest to
3 mandate that zoos retain only one or two individuals of each species, however, establishment risk can
4 be kept low.

5 Hazard via this pathway is high. Current regulations on Guam and possible elsewhere are likely not
6 adequate to deal with this pathway effectively (as was demonstrated when the animal facility on Guam
7 closed a few years ago where it appears that the ultimate repository of some of the captive animals
8 from that facility were never ascertained (Pers Comm. Bassler). This high hazard results from all the
9 same reasons given above under discussion of the pet-trade pathway as well as the fact that zoos
10 frequently exhibit a number of species dangerous to humans. As well, some of the species exhibited at
11 the Saipan Zoo (and obtained from a prior zoo on Guam) are known invasives elsewhere. These include
12 parrots, cockatoos, and green iguanas (Calindas 2006).

- 13 • Risk of importation 2
- 14 • Risk of establishment 2
- 15 • Hazard 3
- 16 • Total risk 7 **MODERATE**

17 **A4.2.3.4 Food Use**

18 Transport of animals for use as food sources has historically been one of the largest pathways for
19 mammal introductions but has been an important source of bird, reptile, and amphibian introductions
20 as well (Kraus 2003, 2009). Introductions of domesticated mammals and birds via this pathway were a
21 fundamental characteristic of European colonization efforts around the world (Crosby 1986), but most
22 of these introductions tapered off by the start of the 20th century because virtually worldwide spread of
23 their domesticated mammals had been completed. Prior to that, Polynesians and Micronesians had
24 spread pigs and red jungle fowl widely across the Pacific, and Polynesians also moved iguanas
25 (*Brachylophus* spp.) regionally (Gibbons 1981). However, there still remain many Pacific islands that lack
26 feral populations of these Eurasian domesticated animals. Introductions of reptiles and amphibians for
27 food use intensified during the 20th century and still continue around the world, with the most well-
28 known example being the continued farming and spread of the North American bullfrog (*Lithobates*
29 *catesbeianus*) for frog legs. Several of the most notoriously invasive mammals (pigs, goats, sheep, cattle,
30 rabbits), reptiles (Chinese soft-shelled turtles, *Pelodiscus sinensis*), and amphibians (North American
31 bullfrogs) have been spread via this pathway. Most of the alien vertebrates currently used for food in
32 Micronesia include the usual assortment of ungulates (pigs, cattle, goats, caribou, sheep) and birds
33 (chickens, quail, geese, ducks). Some members of the Asian communities in this region also eat dogs.

34 Risk of continued importation via this pathway is high. Most humans view their domesticated mammals
35 and chickens as a natural part of their environment and do not think of them as invasive. As a
36 consequence, transport and release of domesticated food species onto islands lacking them is typically
37 viewed as simply exercising one’s right to feed oneself, and the practice continues around the globe.

1 Many of these introductions will involve transport between islands within nations, although others
2 involve importation across national boundaries. Other food introductions are for more directly
3 commercial purposes. North American bullfrogs and other large frog species continue to be touted as an
4 easy way to raise protein in one's backyard either for direct consumption or, more often, for commercial
5 sale. This despite the fact that frog farming is logistically difficult and most farms fail, with leftover
6 animals released or escaping into nearby habitats. Despite decades of evidence that this is a difficult
7 way of making money, agricultural extension agents around the world still promote the practice. As a
8 result, regions naive to the experience of trying to farm frog legs are susceptible to the claims of easy
9 profits and, therefore, to future invasions by these animals. None of the Micronesian Region countries
10 has suffered commercial attempts to farm frogs before and, hence, each may be liable to persuasion
11 that it is worthwhile. This inexperience makes risk of introduction of these species high for the region. In
12 addition, new food species often attend the immigration of new ethnic groups into countries as they
13 bring in preferred food resources from their home regions. For example, birds and turtles were
14 introduced into Hawai'i by Chinese immigrants in the late 1800s/early 1900s for this purpose (Brock
15 1947; McKeown and Webb 1982). CNMI, Guam, and Palau all have significant populations from East
16 Asian countries (56.3%, 32.6%, and 22.6%, respectively) (CIA 2010) and would be most liable to these
17 sorts of introductions, although risk would increase should other countries also allow increased
18 immigration or tourism from these regions.

19 Risk of establishment via the food pathway is high. Bird, reptile, and amphibian establishment rates
20 have all been quantitatively shown to be very high for this pathway (Kraus 2003, 2009), and the same is
21 certainly true for mammals, judging from the widespread distributions of the most popular food species
22 (Lever 1985; Long 2003). High establishment rates reflect the persistent, deliberate attempts by humans
23 to establish such species, which has led to frequent and widespread releases of large numbers of
24 animals, and, consequently, provided the high propagule pressure needed for successful establishment
25 (Forsyth et al. 2004; Lockwood et al. 2005; Hayes and Barry 2008). Given this continued motivation,
26 there is no reason for establishment risk to decline through time.

27 Hazard of species released via this pathway is also very high. The assorted feral ungulates are among the
28 most widely distributed and most destructive invasive species globally (Coblentz 1978; Cuddihy 1984;
29 Ebenhard 1988; Atkinson 1989; Tunison et al. 1995; Pimentel et al. 2000; Donlan et al. 2002; Pimentel et
30 al. 2005; GISD 2010), as is the bullfrog (Kraus 2009). Many other species known to be introduced as food
31 sources (e.g., rabbits [*Oryctolagus cuniculus*], banteng [*Bos javanicus*], water buffalo [*Bubalus bubalis*],
32 Polynesian rat [*Rattus exulans*], spotted turtledove [*Streptopelia chinensis*], and water frogs [*Rana*
33 *ridibunda*]) are also highly invasive in one or more countries (Crook 1973; Atkinson 1978; Long 1981,
34 2003; Lever 1994; Arano et al. 1995; Pagano and Schmeller 1999; Athens et al. 2002; Courchamp et al.
35 2003; Pagano et al. 2003; Vorburger and Reyer 2003; Towns et al. 2006; Hunt 2007). Less frequently
36 released species have not been well studied, but, on average, this pathway has generated a tremendous
37 amount of ecological and economic damage worldwide. The fact that relatively few vertebrate species
38 are moved via this pathway, and that a large percentage of those have figured among the most
39 destructive invasive species in the world gives this pathway a very high risk of continued hazard.

1 Overall risk via this pathway is high for the Micronesia Region. Component risks of importation,
2 establishment, and hazard are all high; social constraints on moving food animals are minimal and,
3 hence, regulation and enforcement against such movements are likely to remain low in the Micronesia
4 Region, as elsewhere.

- 5 • Risk of importation 3
- 6 • Risk of establishment 3
- 7 • Hazard 3
- 8 • Total risk 9 **HIGH**

9 **A4.2.3.5 Game Hunting**

10 This pathway is not entirely separate from the previous one inasmuch as game hunting is engaged in
11 both to provide food as well as for recreation, and animals are not actively farmed. However, the
12 species pools in each category are largely non-overlapping because the domesticated animals
13 transported for food use are generally not transported for use as game animals, although feral
14 populations may be secondarily utilized as a game resource. Further, the motivations behind the
15 pathways are not entirely the same, so separate consideration of them is warranted. Game
16 introductions include only mammals and birds; reptiles and amphibians are not transported for this
17 purpose (Kraus 2003, 2009). Globally, this has been the most important pathway for mammals,
18 accounting for 25% of total introductions; it has been the second most important pathway for bird
19 introductions, accounting for 35% of the total (Kraus 2003). For both groups, introduction rates have
20 exploded since the mid-1900s and continue to be high (Kraus 2003).

21 Importation risk for mammals in the Micronesia Region would appear to be moderate via this pathway.
22 The only mammals currently hunted in the region were introduced centuries ago, although some of
23 them continue to be moved to new islands within countries (Long 2003; Vogt and Williams 2004). The
24 only birds introduced into the region for this purpose appear to be the black francolin (*Francolinus*
25 *francolinus*) and bluebreasted quail (*Coturnix chinensis*) (Long 1981; Fritts and Rodda 1998; Vogt and
26 Williams 2004), introduced in the 1960s. However, large numbers of game birds have been introduced
27 elsewhere in the Pacific (Long 1981; Wodzicki and Wright 1984; Moulton et al. 2001), and interest in
28 additional releases of game animals has recently been expressed in at least CNMI (Williams 2010), so the
29 Micronesia Region may not be immune to this pathway. In recent decades most introductions via this
30 pathway have occurred under government auspices, so proper education of authorities about the risks
31 of game animals may serve to keep future risk low via this pathway.

32 Establishment risk via the game pathway is moderate. Globally, this pathway has had a rather low
33 probability of success for birds (35%, Kraus 2003). Although information was insufficient for assessing
34 establishment probability for mammals via this pathway, it is probably somewhat higher because many
35 of the widely used game mammals are less susceptible to extinction via predation than are the game
36 birds. Against this rather low establishment rate must be counted the frequently persistent attempts at
37 establishment via this pathway, which have often resulted in ultimate success. This combination of

1 persistence with a low establishment probability per attempt results in an overall moderate risk of
2 establishment. As for probability of importation, risk of establishment largely depends on what local
3 governments will tolerate in this regard because so many of these efforts have involved either direct
4 government sponsorship or at least governmental acquiescence in importation and release of large
5 numbers of animals.

6 Hazard from this pathway is very high for mammals and moderate to high for birds. Many of the
7 ungulates introduced for game purposes (primarily involving a variety of deer [*Cervus*, *Odocoileus*], tahr
8 [*Hemitragus jemlahicus*], and mouflon [*Ovis ammon*]) have proven very destructive of native ecosystems
9 on Pacific islands and elsewhere (Stone 1985; Conry 1988b; Wardle et al. 2001; Wiles 2005; Hughey and
10 Hickling 2006; GISD 2010). This is both because of direct herbivory on native vegetation as well as
11 trampling of the substrate (e.g., Duncan and Holdaway 1989), both of which lead to loss of vegetation
12 and increased erosion. Galliform game birds may benefit local ecosystems by dispersing seeds of native
13 plants previously dispersed by extinct avifauna (Cole et al. 1995), but they may also threaten native
14 ecosystems by dispersing invasive plant seeds, preying on rare native invertebrates, or serving as
15 reservoirs for parasites or diseases that threaten native species (Lewin and Mahrt 1983; Lewin and
16 Lewin 1984; van Riper and van Riper III 1985; Cole et al. 1995). Mallard ducks are notorious for having
17 hybridized with many other native duck species in North America, Asia, and Australia (Rhymer and
18 Simberloff 1996), and introduced populations have threatened native ducks with introgressive
19 hybridization in Hawai'i (Browne et al. 1993; Engilis Jr. and Pratt 1993; Fowler et al. 2009) and New
20 Zealand (Gillespie 1985; Rhymer et al. 1994). Similar problems would be expected to attend
21 establishment of mallards in Palau or Chuuk, FSM, where the native Pacific Black Duck (*Anas*
22 *supercilliosa*) occurs.

23 Overall introduction risk to the Micronesia Region via this pathway is moderate. Recent importation risk
24 has been low, and governmental control over this pathway is rather easily established, so with proper
25 attention by government authorities, risk of importation can readily be kept low. Similarly,
26 establishment risk can be kept low by proper government regulation of the practice, but without this,
27 releases for game purposes have often involved large numbers of animals, so establishment risk must be
28 considered moderate without explicit governmental policy discouraging this practice. Absent
29 governmental attention, risk would increase because of the tendency for some people to move animals
30 regardless of broader societal risks. Hazard from many of the most frequently distributed species is high,
31 and some of these have already colonized parts of the Micronesia Region.

32 Proper education of authorities regarding the risk associated with game animals would undoubtedly
33 assist with keeping future risks low to moderate. The hunters should also be educated about the
34 impacts of the animals they hunt and how hunting can help the environment and sustainability of
35 natural resources.

- 36 • Risk of importation 2
- 37 • Risk of establishment 2
- 38 • Hazard 3

- 1 • Total risk 7 **MODERATE**

2 **A4.2.3.6 Fur Ranching**

3 The majority of alien mammals introduced for fur ranching have involved the three species mink
4 (*Mustela vison*), muskrat (*Ondatra zibethicus*), and nutria or coypu (*Myocastor coypus*), although a few
5 introductions have involved raccoon (*Procyon lotor*), raccoon dog (*Nyctereutes procyonoides*), and
6 brush-tailed possum (*Trichosurus vulpecula*) (Lever 1985; Long 2003). Virtually all of these introductions
7 have been to temperate areas; none has been to an oceanic island (Lever 1985; Long 2003).

8 Risk of importation of species for this purpose in the Micronesia Region is very low. There is no record of
9 historical interest in the fur trade in that region, and it is doubtful that the industry could establish in
10 that climate with any of the species historically released through the trade.

11 Risk of establishment is low for the same reason: it is unlikely that any of the species historically
12 released through the trade would survive the climate and habitat, although raccoons might be an
13 exception, given their wide habitat tolerance and adaptability.

14 Hazard from the species involved in the fur trade is high. Mink depredate native vertebrates in Europe
15 and may interfere with metapopulation dynamics, thereby increasing chances of population extinction;
16 they also cause some economic damage from their depredations (Telfer et al. 2001; Banks et al. 2004;
17 Bonesi and Palazon 2007). Coypu and muskrats depredate crops; undermine human structures; and
18 graze vegetation, thereby depressing native plants, altering community structures of plants and
19 invertebrates, and sometimes resulting in complete loss of marsh habitat (Danell 1996; Carter and
20 Leonard 2002; Nummi et al. 2006; DAISIE 2008; GISD 2010). Raccoons depredate and compete with
21 native animals, depredate crops, damage buildings, and potentially spread serious human diseases
22 (Ikeda et al. 2004; Hayama et al. 2006). Raccoon dogs depredate and compete with native animals and
23 serve as an important vector of rabies and other diseases in Europe (DAISIE 2008). Brush-tailed possums
24 browse on native plants, leading to forest dieback, shifts in community structure, and endangerment of
25 native flora; they also serve as disease reservoirs for humans and livestock (Veblen and Stewart 1982;
26 Norton 1991; Rose et al. 1992; Crump et al. 2001). All of these species are invasive and should not be
27 imported to the Micronesia Region.

28 Overall risk to Micronesia from the fur trade is low. Although hazard from the species involved is high,
29 probabilities of importation and survival of these species are low in that region.

- 30 • Risk of importation 1
- 31 • Risk of establishment 1
- 32 • Hazard 3
- 33 • Total risk 5 **LOW**

1 **A4.2.3.7 Biocontrol**

2 Biocontrol introductions are those made for the purpose of providing predatory control of another pest
3 species. Most of these releases have failed to control the pests they were intended to destroy; rather,
4 the biocontrol species have become pests themselves. The classic examples involving vertebrates
5 released for this purpose are cats (*Felis catus*) and weasels (*Mustela erminea*, *M. nivalis*, *M. putorius*, *M.*
6 *sibirica*), widely released around the world for controlling rodents and rabbits damaging to agriculture
7 (Lever 1985; Parkes and Murphy 2003; Denny and Dickman 2010); mongoose (*Herpestes edwardsi*, *H.*
8 *ichneumon*, and *H. javanicus*), widely released around the world for controlling rats and vipers (Lever
9 1985; Long 2003); and cane toads (*Rhinella marina*), widely released across the tropics for controlling
10 insect pests of sugarcane (Easteal 1981; Lever 2001). Although these are the classic species typically
11 associated with biocontrol releases, a wide array of bird, frog, lizard, snake, and turtle species has been
12 introduced for these purposes too. For example, at least 19 species of birds and 32 species of reptiles
13 and amphibians have been introduced for biocontrol (Long 1981; Kraus 2009). Early releases of
14 vertebrates for biocontrol often involved official government sponsorship (Thomson 1922; Easteal 1981;
15 Long 1981; 2003), although private action was also common. Nowadays, government release of
16 vertebrates is rare because the damage caused by prior releases is widely known, and, consequently,
17 these actions have lost official favor. However, education about this subject among the general public is
18 less advanced, and private individuals still frequently retain the simplistic notion, largely lacking in
19 factual merit, that animal pests can be controlled simply by introducing a predator. Even so, if a target
20 group with specific behavior changes is identified, this is where effort should begin. As a result, more
21 recent vertebrate introductions for “biocontrol” purposes have tended to be private actions, often done
22 for the purpose of providing local control (sometimes restricted to a single building) of pest insects such
23 as cockroaches.

24 Because of negative fallout from prior vertebrate introductions and government eschewal of those
25 releases, the global risk of introduction via this pathway has declined dramatically since the 1960s (Long
26 1981; Kraus 2009). Such private actions that still occur often involve either translocation of species easily
27 obtained from nearby source areas or from the pet trade. Hence, importation risk for the biocontrol
28 pathway will be correlated to these two factors. In the Micronesia Region, ready access to foreign
29 faunas for private importation is generally limited, although individuals may be able to translocate
30 invasives already established on nearby islands. The species of greatest concern for movement that way
31 would be cats and some lizards, which are present as pests on some islands in the Micronesia Region but
32 not on all. Control of the pet trade via proper regulation (see above) could limit access to hazardous
33 species via the biocontrol pathway as well. The long flight times to the Micronesia Region from most
34 parts of the world also make obtaining live animals via internet purchase of doubtful reliability. Hence,
35 risk of importation for biocontrol purposes is probably generally low at present (except for animals
36 available in the pet trade) and likely to stay that way for the foreseeable future. One exception to this
37 rule is the ease with which U.S. servicemen can import pet animals from overseas stations by hand-
38 carrying them on military aircraft. This route of importation is worsened by the fact that the USFWS and
39 national quarantine services do not typically have inspectors stationed at military bases in the region, so
40 the probability of interception of such imports is remote. This route has led to numerous illegal
41 importations of banned reptiles into Hawai’i (Hawai’i DoA 2010), and some of these species include

1 those released elsewhere for control of house pests. Similar activities likely occur on military bases in
2 the Micronesia Region and would likely increase with the relocation of military personnel to Guam and
3 in CNMI, making this the likeliest source of importations via the biocontrol pathway.

4 Vertebrate biocontrol releases have tended to have high probabilities of successful establishment (Kraus
5 2003; Long 2003; Kraus 2009). This is because these releases were often the result of well-funded
6 programs supported by scientific or agency personnel and often resulted in the coordinated release of
7 many individual animals (Kraus 2009), which is highly correlated with successful establishment across a
8 wide variety of taxa (Lockwood et al. 2005; Hayes and Barry 2008; Bomford et al. 2009). Even when
9 releases were not the result of scientific effort, the widespread release of a preferred species by
10 numerous interested parties often created sufficient numbers of propagules that successful
11 establishment was ensured (Long 2003). As well, even releases by single parties often involve multiple
12 animals because the intent of release is to establish viable populations of the vertebrates, and everyone
13 recognizes that multiple individuals are needed for this purpose. Thus, because propagule pressure is
14 typically high, this pathway presents a very high risk of successful establishment, whether done under
15 the auspices of an official governmental or scientific program or enacted solely by private parties. This
16 would hold true in the Micronesia Region as elsewhere.

17 Hazard of the species involved in this pathway can be high. Indeed, biocontrol using vertebrates was
18 largely discontinued for precisely this reason, with wide recognition of the ecological and economic
19 impacts from cats (Lever 1985; Pimentel et al. 2000; Nogales et al. 2004; Vázquez-Domínguez et al.
20 2004; Pimentel et al. 2005; Denny and Dickman 2010; GISD 2010), mongooses (Honegger 1981; Case
21 and Bolger 1991; Pimentel et al. 2000; Roy et al. 2002; Yamada and Sugimura 2004; Pimentel et al. 2005;
22 Hays and Conant 2007; GISD 2010), weasels (Thomson 1922; McLennan et al. 1996; Basse et al. 1999;
23 Dowding and Murphy 2001; GISD 2010), and cane toads (Freeland 1994; Williamson 1999a; Crossland
24 2000; Lever 2001; van Dam et al. 2002; Phillips et al. 2003; Boland 2004b, a; Doody et al. 2006a; Doody
25 et al. 2006b; Greenlees et al. 2006; Smith and Phillips 2006; Griffiths and McKay 2007). What are less
26 well studied are the impacts attending the dozens of other species introduced for purported biocontrol
27 purposes. Mynahs (*Acridotheres tristis*) are well-known pests on tropical islands (Long 1981; Pell and
28 Tidemann 1997; Bergman et al. 2002; Feare 2010), as are several other birds (Long 1981), but most
29 other released biocontrol species remain unstudied. Cats are still widely spread by humans, so islands in
30 the Micronesia Region that currently lack them are susceptible to receiving this pest. The other
31 notorious invaders via the biocontrol pathway are no longer moved intentionally, except perhaps rarely
32 by ignorant private parties. Biocontrol introductions made by private individuals now rely largely on
33 animals available in the pet trade, because most insectivorous vertebrates will easily be viewed as
34 meaningful biocontrol agents by the general public, and because availability within the pet trade
35 fluctuates based on fads and perceived novelty, the pool of vertebrates potentially available for
36 “biocontrol” use is potentially unlimited. This makes precise estimation of hazard for species other than
37 those discussed above impossible at this time. However, given the large pool of species potentially
38 available, it is reasonable to assume that they range in hazard risk from low to high. Hence, hazard for
39 future biocontrol introductions can perhaps be best viewed as an average across this gamut and
40 summarized as “moderate.”

1 As a safeguard measure any proposed biocontrol releases should follow a standard SOP including
2 conducting a risk assessment, environmental impact studies and host specificity testing prior to any
3 releases.

4 In sum, risk for the Micronesia Region from the biocontrol pathway is low for probability of importation,
5 high for probability of establishment, and moderate for probability of impact, providing an overall risk
6 via this pathway of “moderate.”

- 7 • Risk of importation 1
- 8 • Risk of establishment 3
- 9 • Hazard 2
- 10 • Total risk 6 **MODERATE**

11 **A4.2.3.8 Scientific Research**

12 Vertebrates have frequently been released in association with scientific research enterprises. Releases
13 have been of two main types: 1) intentional or unintentional releases from medical research facilities,
14 and 2) intentional releases to study the ecology or behavior of the released species. The most
15 destructive consequences have arisen from the first of these, which have involved the release primarily
16 of monkeys and frogs. A variety of monkey species has been introduced into tropical and subtropical
17 locations around the globe from medical and/or behavioral research labs (Long 2003). Release of these
18 animals has sometimes been deliberate and sometimes resulted from poor caging. Most releases date
19 from the 1930s through the 1960s (Long 2003), but some are still occurring (Kyes 1993). Monkeys are
20 notoriously difficult to control once wild populations are established, with even decades-long control
21 efforts failing (Evans 1989; Boulton et al. 1996; Breckon 2000). This is a consequence of their
22 intelligence, which makes them elusive, and their ability to utilize a wide variety of food resources,
23 which allows them to attain high population densities in a diversity of environments.

24 Frog releases stemming from medical research have largely involved formerly widespread use of
25 *Xenopus laevis* (African clawed frogs) in pregnancy tests, a practice that is now obsolete. However,
26 releases of this species from medical research facilities have continued through the 1990s, making it still
27 a relevant concern. This species too has proven invasive in many areas of release, spreading quickly and
28 widely and creating some ecological damage in at least Chile (Lobos et al. 1999; Lobos and Measey 2002;
29 Lobos and Jaksic 2005), France (Grosselet et al. 2005; Eggert and Fouquet 2006), and California (Lafferty
30 and Page 1997). Populations of this frog have not generally proven amenable to control although three
31 small populations in the eastern United States were eradicated with the assistance of cold weather
32 (Tinsley and McCoid 1996).

33 Several species of frogs, salamanders, and lizards have been released in the United States, Caribbean
34 islands, and Europe with a view of determining what ecological results attended their establishment in
35 novel circumstances (Kraus 2009). Most releases for ecological research occurred prior to the 1970s, and

1 the practice is largely condemned now. But a few rogue researchers have continued such releases into
2 more recent times (Kraus 2009).

3 Risk of importation to the Micronesia Region from this pathway appears relatively low. There is only one
4 medical school in the area (Pacific Basin University Medical School in FSM). Inasmuch as that institution
5 appears to provide only the basics of a medical education, it is unlikely to be involved in research
6 involving hazardous vertebrates. Ecological research in the region involving movement of hazardous
7 vertebrates also appears non-existent to the present time. Given the growing expansion of awareness of
8 the risks posed in the Pacific region by invasive alien species, this seems unlikely to change.
9 Furthermore, at least some countries in the region (e.g., Palau) explicitly prohibit the introduction of
10 monkeys, which are the species of greatest hazard moving via this pathway.

11 Risk of establishment from this pathway is high. Monkeys could easily establish in the Micronesia
12 Region, as they have elsewhere in the tropics (Lever 1985; Long 2003), but it is less certain whether the
13 African clawed frog could do so. Populations have established on tropical Ascension Island in the Atlantic
14 (Tinsley and McCoid 1996), and this frog inhabits tropical regions of Africa, so it is feasible that it is
15 capable of colonizing tropical Pacific islands too.

16 The hazard of these species ranges from moderate to high. Impacts from monkeys can be severe, with
17 them proving especially damaging to birds and plants in island ecosystems (Meier et al. 1989; Breckon
18 2000; Cheke and Hume 2008), but also depredating agriculture and serving as potentially serious vectors
19 of human diseases (Boulton et al. 1996; Jensen et al. 2004; Engeman et al. 2010). Damage from *Xenopus*
20 has also been observed, with the species resulting in displacement of native amphibians (Lobos et al.
21 1999; Lobos and Measey 2002; Grosselet et al. 2005; Lobos and Jaksic 2005; Eggert and Fouquet 2006).
22 The Micronesia Region, however, lacks native amphibians, so hazard from this species would be
23 correspondingly less; however, broader impacts on freshwater ecosystems from this species remain
24 uninvestigated.

25 In sum, risk from this pathway appears moderate for the Micronesia Region under current regulatory
26 regimes. Such risk could be lowered if importation of monkeys and *Xenopus laevis* were banned and
27 such bans enforced.

- 28 • Risk of importation 1
- 29 • Risk of establishment 3
- 30 • Hazard 3
- 31 • Total risk 7 **MODERATE**

32 **A4.2.3.9 Religious Ceremonies**

33 There have been two sources of vertebrate releases for religious purposes. The larger of the two is the
34 common Buddhist and Taoist practice of releasing captive animals as an expression of compassion to
35 improve one's karma (Shiu and Stokes 2008). Typically, these releases occur during religious services

1 once or twice per year, but some traditions involve monthly releases (Shiu and Stokes 2008), and a large
2 percentage of releases may be conducted individually, not in organized groups (Severinghaus and Chi
3 1999). Birds and turtles are the most common terrestrial vertebrates used for release (Severinghaus and
4 Chi 1999; Kraus 2009), but mammals, frogs, and snakes are targeted as well (Agoramoorthy and Hsu
5 2005; 2007; Corlett 2010). Many of these released animals are purchased from pet stores, with one
6 study finding one-quarter of all birds stocked in Taipei pet stores slated for this purpose (Severinghaus
7 and Chi 1999). Releases of terrestrial vertebrates via this pathway have been primarily documented
8 from countries or regions with practicing Buddhists comprising a significant portion of the population,
9 such as Cambodia, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, Thailand, and Vietnam
10 (Severinghaus and Chi 1999; Kraus 2009; Corlett 2010), but they have occurred in Western countries too
11 (Sherwood 2001; Shiu and Stokes 2008; Gochfeld 2010). Numbers released can be huge, with 0.5-1
12 million birds imported annually into Hong Kong for release (Shiu and Stokes 2008) and 200 million
13 animals being released annually in Taiwan alone (Agoramoorthy and Hsu 2005; 2007), although most of
14 these latter involve native species. In locations where ritual Buddhist release of animals occurs, risk of
15 establishment is high because of the large volume of animals released and the high frequency of release,
16 both of which lead to high propagule pressure. Hazard can also be high, first due to direct competition
17 or hybridization with native species (Severinghaus and Chi 1999), and second via vectoring of diseases to
18 native wildlife or to humans. The latter has been an especial concern with the avian flu virus (Shiu and
19 Stokes 2008).

20 The second documented source of religious release has been by members of Christian snake-handling
21 cults, who have released alien venomous snakes on occasion (Wilson and Porras 1983). This particular
22 form of religious practice is largely limited to small numbers of individuals in the southern United States,
23 and, to date, the release of only two alien cobras has been documented in the literature.

24 Risk of importation to the Micronesia Region for this purpose appears rather low at this time. The
25 Micronesia Region presently contains few Buddhists (NationMaster 2010), although at least one
26 Buddhist temple is present in Guam and at least one is present in the CNMI, suggesting the presence of
27 a large community there (Williams 2010) that is not captured in the NationMaster database. The
28 varieties of Christianity present in the region do not include snake-handling cults. Consequently,
29 introduction volume along the religious pathway is likely to remain low through much of this region
30 (CNMI may be an exception), and, correspondingly, risk will also remain low. However, risk will not be
31 non-existent given that even small numbers of Buddhists can release significant numbers of animals in
32 private ceremonies. Should immigration patterns change such that more Buddhists migrate to the
33 region, this could become a pathway of greater importance. In that event, alien birds, frogs, and turtles
34 of east or southeast Asian origin would be the taxa most liable to introduction and establishment
35 because that would be the likely source of immigrating Buddhists and, hence, the easiest source from
36 which to obtain animals. Many of those species have already proven successful in colonizing Pacific
37 islands (Long 1981; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009).

38 Risk of establishment is probably low for most species so long as propagule pressure is low. This will be a
39 reflection of release effort, which will, in turn, reflect the size of the Buddhist population in the region,

1 which currently is low. However, should release effort focus on one or a few species readily available in
2 the pet trade, establishment risk would increase because of the greater propagule pressure per species.

3 Hazard for released species probably ranges from low to moderate. Most species bought for release are
4 probably relatively inexpensive, which rules out rampant release of some species (like many parrots)
5 that create much damage but are of greater monetary value. Some released birds (e.g., finches, bulbuls)
6 may have higher hazard because of their depredations on agriculture, ability to spread weed seeds, and
7 ability to transmit disease (Long 1981; van Riper and van Riper III 1985; van Riper III et al. 1986; Lever
8 1987; Pell and Tidemann 1997; Pimentel et al. 2000; Loope et al. 2001; Bergman et al. 2002; Bomford
9 and Sinclair 2002; Thibault et al. 2002; Blanvillain et al. 2003; Eguchi and Amano 2004; Pimentel et al.
10 2005; Koopman and Pitt 2007; Bomford 2008; Atkinson and LaPointe 2009; Linnebjerg et al. 2009;
11 Linnebjerg et al. 2010). Most reptiles and amphibians associated so far with this pathway have relatively
12 limited impacts, or their impacts have not been investigated (Kraus 2009).

13 In summary, risk from this pathway is low for the Micronesia Region at present, although this could
14 change if larger numbers of Buddhists were to immigrate to the region.

- 15 • Risk of importation 1
- 16 • Risk of establishment 1
- 17 • Hazard 2
- 18 • Total risk 4 **LOW**

19 **A4.2.3.10 Bioterrorism**

20 Most vertebrates that are directly dangerous to humans are generally large and often rare. The use of
21 vertebrate species for bioterrorism would be unlikely because of the number of animals required to
22 produce the desired response. One possible exception would be that a large number of a common
23 venomous snake could potentially be introduced for such a purpose, but the numbers required for
24 importation for the task (hundreds to thousands would have to be released for the public to notice them
25 in anything approximating real time) could likely not easily be overlooked by even a modestly
26 functioning border-security system. Hence, volume of animals introduced for such purposes appears
27 low, and degree of inspection and corresponding regulations are likely sufficient to deter massive
28 importation of such animals. Establishment risk could be moderate to high for some venomous snake
29 species, and risk to humans would be high by definition. In sum, because of low probability of
30 importation and low probability of establishment, the risk of vertebrates being introduced for this
31 purpose seems low.

- 32 • Risk of importation 1
- 33 • Risk of establishment 1
- 34 • Hazard 3
- 35 • Total risk 5 **LOW**

1 **A4.2.3.11** *Discussion and Conclusions*

2 A large diversity of terrestrial vertebrates potentially threatens the human health and safety, economy,
3 and ecology of the five Micronesian Region jurisdictions under consideration in this risk assessment.
4 Risks come from 10 potential intentional pathways, with 3 (pet-trade, aesthetic, and food pathways)
5 posing a high overall risk of introduction, 4 (zoos, game-hunting, biocontrol, and scientific research
6 pathways) posing a moderate overall risk, and 3 (fur-ranching, religious, and bioterrorism pathways)
7 posing a low overall risk. In each case, overall risk is a compound of risk of importation and release, risk
8 of establishment, and risk of impact or hazard.

9 Risk at this time is rather broadly painted by pathway in order to allow government leaders in the region
10 to decide how best to direct resources in protecting their islands from further invasions of terrestrial
11 vertebrates. Except for species that have proven damaging elsewhere in tropical regions, it is difficult at
12 this time to predict exact risk for each species on a case-by-case basis without a far more detailed
13 examination of each species of concern. This is feasible for some taxa (Bomford 2003; Bomford et al.
14 2005; 2006; Bomford 2008; Bomford et al. 2009), with many mammal species and some bird species
15 most amenable to this more detailed approach (Bomford 2008). But there are few comparable variables
16 yet available for determining risk of reptiles and amphibians (Bomford and Kraus 2008; Bomford et al.
17 2009), and for many species in all taxa there are limitations in available biological knowledge that will
18 hinder or prevent detailed species-by-species assessments. Lastly, not all of the world's tens of
19 thousands of species amenable to human movement can feasibly be evaluated in politically meaningful
20 time-frames. Hence, at this time, analysis of the important pathways of ingress provides the best guide
21 for determining risk of additional introductions of terrestrial vertebrates to Micronesia.

22 Risks of introducing additional invasive vertebrates will expand with increasing population and
23 increasing transport activities in the region, most notably with the relocation of additional military
24 forces on Guam and in the CNMI. This is for the simple fact that numbers of alien introductions track
25 both increase in population density and growth in trade (Levine and D'Antonio 2003; Costello et al.
26 2007; Westphal et al. 2008; Pyšek et al. 2010). So, with more people living in the Micronesia Region and
27 transiting in and out of the area, intentional movement of desirable animals can be expected to
28 increase. This increased risk may well be significant, at least for the pathways involving pets, aesthetic
29 release, and the zoo trade, which will serve to better entertain the larger population.

30 Species invasions are not an ineluctable force of nature but simply reflect values and actions of humans.
31 Hence, there is much that can be done to mitigate a predicted rise in risk of future introductions. For
32 intentional pathways of introduction, such as those considered here, governmental efforts to restrict
33 the availability of the most serious invaders can considerably mitigate such risk. That already occurs to
34 some extent in the Micronesia Region. For example, Palau, CNMI, and Guam prohibit the importation
35 and ownership of several highly invasive vertebrates, such as snakes, parrots, mink, mongoose, and
36 bulbuls. Such limited lists are a good beginning to preventing some future invasions, but they are
37 inherently reactive (to known invasives) and, hence, limited in preventing further disasters. For
38 pathways moving only a few hazardous species (e.g., fur ranching, medical research), banning trade in
39 those species could provide an effective degree of protection from the risk attendant upon those

1 pathways. For pathways that move a greater diversity of species (e.g., pet trade and the other pathways
2 largely dependent on it), simply banning a few species will provide insufficient protection, and broader
3 regulation of the pathways themselves will be required. A more useful approach would be to allow for
4 importation of only species known to be non-hazardous in the region, a so-called White List approach
5 that has been adopted elsewhere in the Pacific Region. But application of this approach to a wide variety
6 of vertebrates is currently hindered by insufficient biological information for most species that make
7 prediction of invasiveness reliable. Hence, the former (so-called Black List) approach is a feasible
8 beginning while better predictive models of vertebrate invasiveness are developed (Pyšek et al. 2010).
9 But additional measures may be taken to better protect the Micronesia Region from these invasions as
10 well. These are enumerated in the following section.

11 **A4.3 ACKNOWLEDGMENTS**

12 We gratefully acknowledge the individuals listed below for their assistance during this project.

13 Daniel Vice and Kathy Fagerstone, USDA-APHIS-WS

14 Earl Campbell, George Phocas, and Domingo Cravalho, U.S. Fish and Wildlife Service

15

1 **A5 WILDLIFE DISEASES⁷**

2 **SUMMARY**

3 The importation of animals and/or animal products involves an element of disease risk to the country
4 that is importing the animal or their parts (OIE 2009d). For obvious reasons, this is the case whether
5 animals are intentionally or unintentionally imported into the country in question. For example,
6 monkeypox virus was unintentionally brought into the United States in 2003 from wild African mammals
7 through the legal pet trade (Guarner et al. 2004). In addition, a shipment including 101 Silver-eared
8 Mesia (*Leiothrix argenteauris*) from Taiwan arrived at London's Heathrow Airport; subsequent laboratory
9 analyses found Asian-strain H5N1 AIV in 13.5% of specimens tested. From these few examples, it is
10 obvious that a wildlife disease introduction could occur almost anywhere in the world. Therefore, the
11 objective of this document is to assess, given the data available, the risk of introduction of select
12 wildlife-associated pathogens (where the pathogen has been found in wildlife in some region of the
13 world), their hosts, and vectors during the DoD build-up in the Micronesia Region.

14 This document outlines potential disease threats in the Micronesia Region from wildlife-associated
15 pathogens (Table A5-1). Ten primary pathogens associated with expected trade partners in the Pacific
16 Rim were assessed using a qualitative risk assessment tool developed by Morgan et al. (2009) for
17 emerging public health diseases in the United Kingdom. The tool was adapted to consider disease
18 threats to humans, livestock, and endemic wildlife in the Micronesia Region. The 10 pathogens
19 considered were hantaviruses, rabies virus, WNV, JEV, highly pathogenic AIVs, Plasmodium species
20 (avian malaria), henipaviruses (Hendra virus and Nipah virus), NDV, Yersinia pestis (plague), and TBEV.
21 The risk tool was divided into two parts such that we separately assigned a risk category (minimal, low,
22 moderate, high) to the probability that a pathogen would be introduced into the Micronesia Region
23 (Probability of Infection) and a risk category (minimal, low, moderate, high, very high) to the likely
24 impact of a pathogen if it were introduced (Impact of Infection). Risk assignments ranged from minimal
25 to very high for the various pathogens, depending whether probability or impact of infection was
26 examined.

27 This document is not intended to provide data on all potential pathogens that could be imported into
28 the Micronesia Region. Rather, it is intended to be a tool that focuses on select potentially important
29 pathogens as assessed by the authors at the time of writing. Many aspects of the pathogen(s) in
30 question, as well as the ecology of the wildlife associated with these pathogens, were evaluated for
31 inclusion in this list. However, this document should be revised as more data become available, when
32 new pathogens emerge in strategic locations, and when major changes in the Micronesia Region might

⁷ This section was prepared by APHIS-WS, National Wildlife Research Center, Ecology of Emerging Viral & Bacterial Diseases in Wildlife Project, 4101 Laporte Avenue, Fort Collins, Colorado 80521-2154. Suggested citation for this section: Wildlife Services, National Wildlife Research Center, Ecology of Emerging Viral & Bacterial Diseases in Wildlife Project. 2010. Wildlife diseases. In Terrestrial plant and animal health risks associated with the U.S. military relocation in the Micronesia Region. United States Department of Agriculture, Animal and Plant Health Inspection Service. Washington, D.C.

1 affect the underlying assumptions of this risk assessment. As such, adaptive management is key to
2 reduce this risk associated with the introduction of wildlife-associated pathogens to this region.

3 **A5.1 INTRODUCTION**

4 **A5.1.1 Threat of Wildlife-Associated Diseases**

5 Of the 1,415 infectious organisms (pathogens) known to cause disease in humans, the majority (61%)
6 are zoonotic, i.e., transmissible between humans and animals (Taylor et al. 2001; Jones et al. 2008), and
7 zoonotic pathogens are twice as likely to be associated with diseases that have recently emerged in

8
9
10 *Box A5-1 – Near introduction of avian
11 influenza Asian-strain H5N1 virus into
12 England.*

13 Although Asian-strain H5N1 already
14 occurred in England at the time of this
15 story, it serves as an example of how a
16 disease of consequence can be
17 introduced through the legitimate
18 wildlife trade, much less the illegal
19 trade.

20 On 27 September 2005, a shipment
21 including 101 Silver-eared Mesia
22 (*Leiothrix argenteauris*; pictured below)
23 from Taiwan arrived at London's
24 Heathrow Airport and were
25 subsequently transferred about 80
26 miles to the quarantine facilities in
27 Essex, England where they were held
28 (NEEG 2005). Four of the birds were
29 dead on arrival and 10 more died
30 shortly thereafter but none were tested
31 for pathogens. Between 7 and 14
32 October 38 more died and were placed
33 in cold storage. Subsequent laboratory
34 analyses of 37 of these specimens
35 found highly pathogenic Asian-strain
36 H5N1 avian influenza virus in five
37 (13.5%) of them. This strain of A/H5N1
38 was most closely genetically related to
one found in wild ducks in China.



8 humans (Taylor et al. 2001). In addition, the incidence of
9 emerging infectious diseases has increased dramatically since
10 1940, and most of this increase has occurred in tropical regions
11 (Jones et al. 2008). These recent incidents of emerging
12 infectious diseases have been caused by 1) newly evolved
13 strains of pathogens, such as drug-resistant strains of bacteria
14 and the Asian-strain H5N1 AIV, 2) pathogens that have recently
15 entered populations for the first time, such as a coronavirus
16 causing SARS in humans and Nipah virus in domestic swine,
17 and 3) pathogens that have been present historically but have
18 recently increased in incidence, such as *Borrelia burgdorferi*
19 causing Lyme disease in humans (Wolfe et al. 2007; Jones et al.
20 2008).

21 Wildlife plays a critical role in both the emergence of new
22 pathogens in livestock and humans and the increased
23 incidence of emerging diseases. Here, we define wildlife as
24 non-domestic vertebrate species that can be either invasive
25 (e.g., Norway rat, house mouse, etc.) or native and we focus on
26 key pathogens that are associated with wildlife and have the
27 potential to cause disease in humans, domestic animals, or
28 native wildlife. Of the recent increases in incidence of
29 emerging infectious diseases in humans, 71.8% were caused by
30 pathogens originating in wildlife (Jones et al. 2008). In addition,
31 there is an inextricable linkage among pathogens affecting
32 wildlife, domestic animals, and humans, with these pathogens
33 often originating in wildlife and subsequently moving to
34 domestic animal hosts and then to humans (Wolfe et al. 2007).
35 For example, Nipah virus recently moved from its wildlife host
36 (fruit bats) to domestic swine where it caused disease and
37 mortality in both swine and local agricultural workers (Epstein
38 et al. 2006).

1 In this assessment, we examined the risk of wildlife-associated diseases relative to three primary
2 categories of concern for pathogens transmitted from wildlife either directly or indirectly (i.e., through
3 intermediate hosts):

- 4 • Human health—a public health threat because they cause morbidity and mortality in humans.
- 5 • Agricultural health—causing morbidity and mortality in livestock (including poultry)
- 6 • Wildlife conservation—threaten population viability of native wildlife species, especially those
7 that are currently considered threatened and endangered.

8 In developing this assessment, we considered human disease only from a wildlife perspective (i.e., only
9 those zoonotic diseases affecting humans that were associated with wildlife). There are a number of
10 transmission routes by which wildlife-associated pathogens can be introduced into the Micronesia
11 Region, including infected stowaway hosts (e.g., rodents, bats, etc.) on ships and aircraft, intentional and
12 unintentional introductions of infected host and reservoir species, natural invasions by infected wildlife,
13 and infected human travelers. These mechanisms and their pathways are described in more detail
14 elsewhere in this document. In general, the role of wildlife and domestic animal movement in pathogen
15 transmission has been well understood, with controls and legislation implemented to prevent such
16 spread (Fèvre et al. 2006). Despite preventive and mitigation measures, disease outbreaks regularly
17 occur because of legal and illegal movement of infected animals (Fèvre et al. 2006). International trade
18 in both wildlife and livestock contribute to this problem; trade in livestock is discussed in more detail in
19 Section A6, *Livestock and Poultry Diseases*. The global trade in wildlife involves billions of dollars and
20 hundreds of millions of animals (Rosen and Smith 2010), with much of this trade being illegal. One
21 example of how wildlife-associated pathogens can enter a country or region is described in Box A5-1.
22 However, there are a number of requisite conditions before a novel or re-emerging pathogen can
23 become established in an area and affect one or more of the categories of concern (human health,
24 agricultural health, and wildlife conservation) (Wobeser 2006):

- 25 • Pathogen longevity and survival—how long the pathogen can remain infectious in the host and
26 outside of the host under different environmental conditions.
- 27 • Environmental conditions—the optimal conditions outside of hosts under which the pathogen
28 can persist and remain infectious.
- 29 • Pathogen infectivity—how infectious the pathogen is and at what doses.
- 30 • Host presence—whether the natural host species is present.
- 31 • Vector presence—for vector-borne diseases, whether a competent vector is present.
- 32 • Host density—whether the host is of sufficient density to spread and maintain long-term
33 pathogen persistence.
- 34 • Contact rates—how often hosts and/or vectors contact each other to spread and maintain the
35 pathogen and whether pathogens are transmitted between hosts by direct, air-borne and/or
36 vector-borne transmission.

1 Because of these requisite conditions, it is often very difficult for most pathogens to become established
2 in a new environment. In most cases, there needs to be a “perfect storm” of events where all the
3 requisite conditions fall into place. For example, for WNV to become established on Guam from an
4 infected human arriving there, the human needs to be viremic at a minimum threshold, the requisite
5 mosquito vectors need to be present, the human individual needs to be bitten by an appropriate
6 mosquito vector, and the mosquito needs to feed upon and pass on the virus to a suitable host, which in
7 turn needs to be fed upon by a mosquito while the host is infectious and the virus passed on to another
8 suitable host. While seemingly implausible, this is one hypothesis as to how WNV was first introduced
9 into North America in 1999.

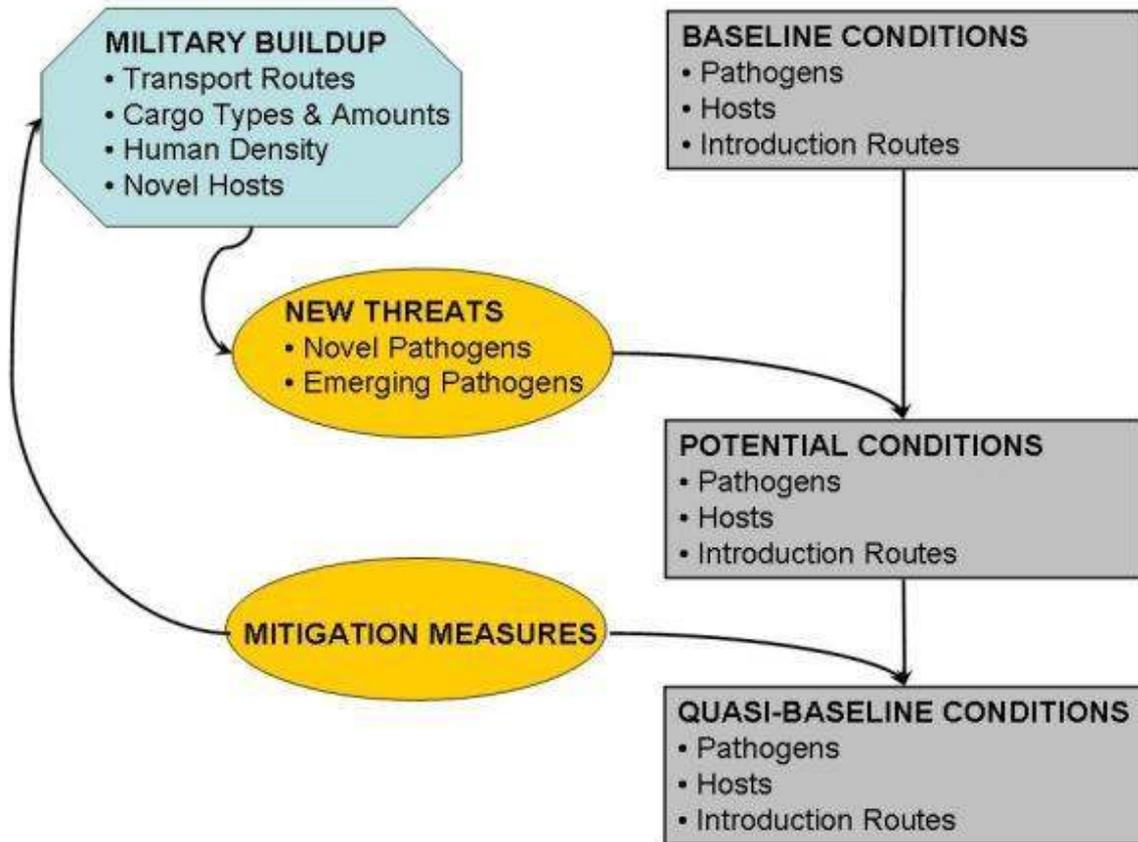
10 Not only are currently recognized diseases moving into new environments and regions around the
11 globe, but novel diseases have emerged in the past two decades that include interactions among
12 wildlife, domestic animals, and humans (Daszak et al. 2000; Cleaveland et al. 2001; Dobson and
13 Foutopoulos 2001; Jones et al. 2008). In particular, the number of emerging infectious disease events for
14 humans has increased significantly since the 1940s. These events have increasingly been zoonotic with
15 wildlife as the primary origin, and the increases in emerging infectious disease events stemming from
16 wildlife have been significantly associated with human population density and wildlife host richness
17 (Jones et al. 2008), although in recent years more surveillance efforts and improved technology may
18 have also contributed to increased detection of emerging infectious diseases.

19 Here, our primary objective was to identify and qualitatively evaluate risk of introduction or re-
20 introduction of wildlife-related pathogens causing disease in humans, livestock, and native terrestrial
21 vertebrate fauna to the Micronesia Region as a result of the proposed U.S. military relocation in that
22 region. Specifically, given the available data, we attempted to:

- 23 • Identify the risk of introduction of wildlife-associated pathogens causing disease in humans,
24 agriculture, and native wildlife from wild and feral animals to the Micronesia Region as a result
25 of the military relocation.
- 26 • Assess occurrence of pathogen and host introduction (given the probability of species
27 introduction) through field sampling in the Micronesia Region.
- 28 • Assess pathogen introduction from a variety of potential pathways using risk assessment.
- 29 • Recommend mitigation measures based on risk assessment modeling.
- 30 • In order to accomplish these objectives, we used the following general strategy (Figure A5-1):
 - 31 • Identified the baseline conditions in the Micronesia Region with respect to existing pathogens,
32 hosts, and routes of introduction using existing information,
 - 33 • Identified how the military build-up may add and/or modify those baseline conditions,
 - 34 • Identified how the changes from the military build-up could provide opportunities for new
35 threats from historically occurring pathogens that have not yet been introduced into the Region,
36 recently emerged pathogens that are not yet found in the Region, or re-emerging pathogens

- 1 (pathogens that have been found in the Region, but have been eradicated, yet have the
 2 potential to be re-introduced) and how this will affect baseline conditions, and
- 3 • Developed mitigation measures targeted at eliminating and/or minimizing threats, such that
 4 baseline conditions are closely maintained.

5 **Figure A5-1: General Strategy Used For Identifying and Mitigating Threats of Introduction of**
 6 **Wildlife-Associated Pathogens to the Micronesia Region**



7

8

9 We collected data pertaining to relevant disease agents and pathways associated with wildlife. A focus
 10 was made on wildlife-associated diseases not currently found in the Micronesia Region that either are of
 11 high consequence or have a reasonable probability of introduction. Literature reviews were conducted
 12 for relevant pathogens using multiple databases. Data sources included published literature,
 13 government reports, and, in some instances, articles in the popular media (e.g., if they were the only
 14 source available). In addition, multiple interviews and/or site visits were conducted in Guam, Saipan,
 15 Tinian, and Palau to obtain additional information pertaining to wildlife and wildlife diseases. The
 16 interviews were conducted with government officials, nongovernmental organizations, and/or citizens
 17 of the islands.

1 The purpose of this risk analysis was to assess the increased risk of introduction of wildlife-associated
2 diseases that the proposed military relocation could introduce into Guam and the rest of the Micronesia
3 Region. The objective was to identify likely pathways of introduction of relevant wildlife-associated
4 diseases directly and indirectly associated with the military relocation on Guam, assess the potential
5 impacts of these pathogens if they are introduced, and recommend procedures for risk reduction. In
6 developing this risk assessment, we focused on wildlife-associated diseases in the Pacific Rim (Asia,
7 Australia, and North America), and wildlife-associated diseases and their potential hosts that could have
8 significant morbidity and mortality in humans, livestock, and native wildlife. We did not consider
9 wildlife-associated diseases already widespread throughout the Micronesia Region.

10 In addition, the scope of this risk assessment is limited to relevant pathogens of terrestrial vertebrate
11 wildlife species (primarily birds and mammals) that could be associated with the military relocation in
12 Guam (e.g., increased building materials and other commodities, temporary construction workers,
13 military activity, etc.). Because the bulk of the DoD relocation is associated with Guam, it is our primary
14 focus. However, several other islands in the Micronesia Region were considered in the risk assessment,
15 with an additional emphasis on CNMI and Palau.

16 It is beyond the scope of this risk assessment to determine an overall risk on Guam for the introduction
17 of all wildlife-associated disease agents. As such, a focus was made on potentially high-consequence
18 pathogens not known from the Micronesia Region that could be introduced during multiple phases of
19 the military relocation. In addition, wildlife-associated diseases from regions from which trade is likely to
20 the Micronesia Region (e.g., Asia and the United States) are a focus of this risk assessment. Overall, we
21 focused on wildlife-associated pathogens which could affect the health of humans, livestock, or native
22 wildlife.

23 **A5.1.2 Current Situation**

24 **A5.1.2.1 Pathways of Introduction and Spread**

25 **A5.1.2.1.1 People**

26 Humans can become infected with zoonotic pathogens and act as direct introduction pathways by
27 moving disease agents to novel locations. People also contribute to the spread of zoonotic pathogens by
28 1) acting as amplifying hosts for some pathogens, 2) interacting with livestock (increasing the probability
29 of transmission to livestock from infected humans or transmission to humans from infected livestock),
30 or 3) interacting with wildlife (increasing the probability of transmission to wildlife from infected
31 humans or transmission to humans from infected wildlife).

32 **A5.1.2.1.2 Shipping**

33 **Military**

34 Maritime vessels can harbor rodent populations that are host competent for a variety of wildlife
35 pathogens. The DoD has many established procedures to conduct rodent control on ships (U.S. Army et
36 al. 1992).

1 Recently, a DoD memorandum directed Navy medical personnel with authority to inspect and issue ship
2 sanitation certificates (ship sanitation control exemption certificate and ship sanitation control
3 certificate) for Navy, Army, Military Sealift Command, Coast Guard, and National Oceanic and
4 Atmospheric Administration vessels (U.S. Navy 2010b). The certificate, issued in accordance with Article
5 39 of the International Health Regulations 2005, has a section for observed rodent infestations and is
6 valid for 6 months (U.S. Navy 2010c). Data pertaining to military seaports is included in Section A2.2.3.

7 **Commercial**

8 Commercial maritime vessels can harbor rodent populations that may be infected with zoonotic disease
9 agents and can therefore cause the introduction of wildlife pathogens to novel areas or spread
10 pathogens between mooring locations. Data pertaining to commercial shipping is summarized in Section
11 A2.2.

12 Maritime vessel route durations are discussed in Section A2.2.1. Route times are important factors
13 determining the likelihood of pathogen movement via ships because short-lived pathogens can “burn
14 out” prior to a ship arriving at its next destination. Thus, pathogens associated with long-term
15 persistence are more likely to move via ships. On the other hand, if a large host or vector population is
16 on a vessel, shorter-lived pathogen infections can be maintained until a ship arrives at its next
17 destination.

18 Maritime vessels are important contributors to the introduction and spread of wildlife pathogens and
19 their vectors. Historic outbreaks of plague, cholera, and yellow fever have resulted from unintentional
20 movement of pathogens via hosts or their vectors on ships (Tatem et al. 2006a; Tatem et al. 2006b).
21 More than 100 disease outbreaks since 1970 have been associated with ships (WHO 2002) and rats on
22 ships are considered to be responsible for the current global distribution of plague (Gubler 1998).

23 Rodent importation through international transport can cause serious problems. For example, an
24 inspection in China found 266 rats arriving in a single ship, while a survey of ships arriving from 1990 to
25 1998 indicated that 270 of 1,093 ships arrived with rodents aboard (Song et al. 2003). In addition,
26 aircraft, trains, and cargo containers arriving in China have been found to have rodent problems (Song et
27 al. 2003). Very low percentages of international vessels inspected entering New Zealand and Australia
28 had rats or rat sign during the 2006-2007 financial year (Russell et al. 2007). During 1981 to 1986, a
29 study was conducted to assess the prevalence of antibodies reactive with Hantaan virus among *Rattus*
30 *norvegicus* and *Rattus rattus* sera collected in the harbor area and anchored vessels of Port Shimizu,
31 Japan (Suzuki et al. 1988). Seropositive rates were 12.8% (49/384) and 4.7% (3/64) of sera collected in
32 the harbor area and 20% (1/5) and 4.8% (2/42) of sera collected from anchored ships from *R. norvegicus*
33 and *R. rattus*, respectively (Suzuki et al. 1988).

34 **Methods**

35 Maritime cargo shipping containers may harbor rodent species or bat species infected with wildlife
36 pathogens either inside the container or on the outside of the container. Infected vectors such as

1 mosquitoes and ticks may also be present in shipping containers. In general, standard 20- and 40 foot
2 metal containers are used in association with maritime vessels.

3 **A5.1.2.1.3 Air**

4 **Military**

5 Aircraft can harbor infected rodent species, bat species, or arthropod vectors such as ticks and
6 mosquitoes infected with wildlife pathogens. Host species may be found in cargo areas or on the outside
7 of aircraft such as in wheel wells. Air Force joint instruction 48–104, the Quarantine Regulations of the
8 Armed Forces (DoD 1992), incorporate regulations to mitigate the risk for introduction and
9 dissemination of arthropod vectors by movement of vessels, aircraft, and other transport of the Armed
10 Forces arriving at or leaving installations in the United States and foreign countries, ports, or other
11 facilities where arthropod vector-borne diseases are known to exist. The information on the materials
12 and procedures for disinsection can be found in the Military Entomology Operational Handbook
13 (NAVFAC M0-310; Army TM 5-632; Air Force AFM 91-16) (U.S. Navy 1972; USAPHC 2010). The DoD
14 outlines recommendations in their DoD customs and border clearance policies and procedures (DoD
15 2001).

16 **Commercial**

17 Commercial aircraft can harbor infected avian, mammalian, or arthropod species in cargo areas or on
18 the outside of the aircraft. In particular, mosquitoes and their larvae are commonly transported via
19 aircraft. In 1961, the U.S. Public Health Service published a comprehensive survey of insects found in
20 aircraft over a thirteen year period. Among the more than 20,000 insects were 92 species of mosquito,
21 51 of which were not known to be present in the continental United States, Hawai'i, or Puerto Rico.
22 Since then several similar reports have corroborated these findings (Gratz et al. 2000). Mosquito species
23 commonly intercepted from flights of Asiatic origin include *Culex pipiens*, *Culex quinquefasciatus*, *Culex*
24 *tritaeniorhynchus*, *Ochleratus japonicus*, *Aedes albopictus*, *Aedes aegypti*, and *Anopheles subpictus*
25 *indefinitus* (Joyce 1961; Takahashi 1984; Goh et al. 1985).

26 Mosquitoes can survive air traffic under a variety of conditions (Laird 1947). The longest survival period
27 recorded aboard aircraft was 6.5 days. Furthermore, adult and newly hatched mosquitoes can survive
28 and go on to breed and lay eggs in other locations. Mosquitoes tend to remain aboard an airliner despite
29 multiple stopovers. Flights from major Asian countries to Guam are on average less than 5 hours away
30 such that high survival is likely.

31 **Methods**

32 Air cargo shipping containers may harbor rodent species or bat species infected with wildlife-associated
33 pathogens. Infected arthropod vectors may also be present inside or outside of shipping containers. Air
34 cargo shipping containers are generally smaller than maritime containers, but larger aircraft can
35 transport standard 20- and 40 foot containers. Commercial air cargo may harbor rodent (Baker 1994) or
36 bat species (Wiles and Hill 1986; Constantine 2003) that may be infected with zoonotic disease agents

1 and can therefore cause the introduction of wildlife pathogens to novel areas or spread pathogens
2 between landing locations.

3 **A5.1.2.1.4 Natural**

4 ***Wind and Natural Movements***

5 Bird migration and dispersal can lead to the introduction and spread of wildlife pathogens. All islands in
6 the Micronesia Region provide winter grounds for a large number of migrating birds which come from a
7 myriad of locations within the Pacific Rim where a number of wildlife pathogens are endemic, but are
8 not distributed in the Micronesia Region.

9 There is some evidence that Mariana fruit bats travel between Guam and Rota (Wiles and Jonhson
10 2004). In addition, the black drongo (*Dicrurus macrocercus*), introduced to Rota during the 1930s, is
11 thought to have naturally moved to Guam and established a population during the late 1950s and is now
12 found throughout the island (Guam DAWR 2010).

13 ***Rafting***

14 Various animal species have the potential to raft (e.g., float on a piece of vegetation or other object)
15 from island to island. If rafting species are infected with a wildlife disease agent or an infected vector is
16 parasitizing them there is the opportunity for pathogen introduction or spread.

17 It has been suggested that reptiles may be more capable of rafting than mammals (Murphy and Wilcox
18 1986). In addition, various species may have different abilities. For example, at an island study site in
19 Washington it was suggested that *Microtus* (voles) can easily swim distances up to 1 km (0.6 mile) while
20 *Peromyscus* (mice) apparently must rely on rafting across water bodies at this site (note: neither of
21 these rodent species occur in the Micronesia Region) (Aubry and West 1987).

22 ***Smuggling***

23 Smuggling of wildlife species or products harboring wildlife species and/or disease vectors provides
24 introduction pathways for the movement of wildlife-associated disease agents into novel regions as well
25 as opportunities for the spread of pathogens. Large quantities of smuggled goods (e.g., agriculture and
26 wildlife) are most likely to be moved by international shipping routes (Ferrier 2009). For wildlife and
27 wildlife products, the average shipment refusal rate was approximately 2.5% annually during 2000
28 through 2004, although personal shipments were refused more frequently than commercial shipments
29 (Ferrier 2009).

30 **A5.1.2.1.5 Foreign Trade Partners**

31 Commodities from multiple countries currently are imported into Guam. In addition, several countries in
32 the Micronesia Region host tourists from several regions of the world. These data are discussed in
33 Section A2. Multiple shipping lanes currently serve Guam. Waterways to the east/northeast connect
34 with Hawai'i and the continental United States, while the waterways running north and west connect to
35 CNMI and ports in Asia. In 2002, Guam imported agricultural commodities primarily from Australia, Asia
36 (China, Korea, Hong Kong, Japan, Malaysia, the Philippines, Singapore, Taiwan, and Thailand), the rest of

1 the Micronesia Region (Chuuk, CNMI, Palau, Pohnpei, and Yap), New Zealand, and the United States.
2 Tourism is also a large industry in the Micronesia Region. In 2008 in Guam, most visitors (excluding
3 transit arrivals and crew) arriving by air were from Japan or Korea (see Table A5-2). The bulk of arrivals
4 to CNMI yielded a similar trend during 2002 (data from Table A5-5) and for Palau during 2007 (data from
5 Table A5-8). The bulk of visitors arriving by air to FSM were from the United States, followed by Japan,
6 and Europe (see Table A5-6). The bulk of visitors to Majuro were from the Americas, Japan, and other
7 Pacific islands (see Table A5-10). In terms of the risk of introducing diseases associated with wildlife,
8 movement of people and products from Asia poses the greatest risk, especially with respect to emerging
9 zoonotic diseases (Mackenzie et al. 2001). Of particular concern is introduction of wildlife-associated
10 diseases from China, Korea, Hong Kong, and Thailand (e.g., highly pathogenic AIVs), and Malaysia and
11 the Philippines (e.g., henipaviruses).

12 **A5.1.2.1.6 Wildlife-associated Diseases in the Micronesia Region**

13 Several wildlife-associated diseases are known to occur in the Micronesia Region. Important wildlife-
14 associated diseases presently found in the Micronesia Region are summarized in Table A5-1. Some of
15 these include Aujeszky's disease, avian chlamydiosis, avian infectious laryngotracheitis, avian leukosis,
16 avian mycoplasmosis, avian tuberculosis, botulism, brucellosis, canine distemper, clostridial infections,
17 fowl pox, infectious bursal disease, leptospirosis, Old World screwworm, Q fever, salmonellosis, scrub
18 typhus, and toxoplasmosis (see citations in Table A5-1). Other disease-causing pathogens likely exist in
19 the Micronesia Region, but have not yet been detected. Overall, much of the Micronesia Region appears
20 to be presently free of many of the high-consequence pathogens that affect many other regions of the
21 world, including many high-consequence pathogens from Asia.

Table A5-1: Wildlife-Associated Diseases and Their Pathogens That Have Been Found on one or More Islands in the Micronesia Region on at Least One Occasion

Disease ^a	Type ^b	Pathogen	Wildlife host(s)	Impact			Transmission	Distribution ^c	References ^d
				Humans	Agriculture	Wildlife			
Aujeszky's disease*	V	Pseudorabies virus	Feral swine		X	X	Contact, body fluids	Palau, FSM	1, 29
Avian chlamydiosis*	B	<i>Chlamydia psittaci</i>	Doves, gulls, Anseriformes	X	X	X	Contact, fecal/oral	FSM	2
Avian infectious laryngotracheitis*	V	Herpesvirus	Pheasants, partridge, peafowl		X	X	Oral/nasal discharge	Guam	3, 29
Avian leukosis	V	Leukosis/sarcoma group viruses	Gamebirds, pigeons		X	X	Contact, vertical	Guam	2
Avian mycoplasmosis*	B	<i>Mycoplasma gallisepticum</i>	Finches		X	X	Contact, aerosol	Guam, CNMI	4, 5
Avian tuberculosis*	B	<i>Mycobacterium avium</i>	All birds, many mammals		X	X	Fecal/oral	Guam	4, 6
Botulism	B	<i>Clostridium botulinum</i>	Ruminants, birds	X	X	X	Food borne, wound infection	Guam, Palau	7
Brucellosis*	B	<i>Brucella</i> spp.	Cervids, swine, buffalo, rodents	X	X	X	Contact with birth tissue/fluids	Guam, FSM, CNMI	4, 5, 29
Canine distemper	V	Canine distemper virus	Canids, mustelids			X	Aerosol	Guam	8
Clostridial infections	B	<i>Clostridium perfringens</i>	Birds, mammals	X	X	X	Food borne, wound infection	Guam	9, 10
Fasciolosis	P	<i>Fasciola hepatica</i> , <i>F. gigantica</i>	Herbivores	X	X	X	Food contamination	Guam	13, 14
Fowl pox	V	Avipoxvirus	Passerines, Galliformes		X	X	Mosquito vector	Guam, Palau	6, 29
Infectious bursal disease	V	Infectious bursal disease virus	Ducks, gulls		X	X	Mealworm vector, fomites	Micronesia Region	4, 15, 29
Leptospirosis	B	<i>Leptospira</i> spp.	Vertebrates	X	X	X	Body fluid, bites	Micronesia Region	16, 17, 18, 19

Disease ^a	Type ^b	Pathogen	Wildlife host(s)	Impact			Transmission	Distribution ^c	References ^d
				Humans	Agriculture	Wildlife			
Old world screw-worm*	P	<i>Chrysomya bezziana</i> larvae	Mammals	X	X	X	Wound infection	Guam	5
Q fever*	B	<i>Coxiella burnetii</i>	Rodents, feral swine	X	X	X	Tick vector, body fluid, fomites	Guam, CNMI	20, 29
Salmonellosis	B	<i>Salmonella</i> spp.	Many species	X	X	X	Fecal/oral	Guam	6
Scrub typhus	B	<i>Orientia tsutsugamushi</i>	Rodents	X		X	Mite vector	Palau	21,22, 23
Toxoplasmosis	P	<i>Toxoplasma gondii</i>	Rodents, felines	X	X	X	Food contamination	Guam, Palau	7, 24, 29

^a Diseases of importance to international trade based on World Organization for Animal Health (OIE) list (see Table A5-2) are marked with an asterisk (*).

^b B = bacterial, P = parasitic, V= viral.

^c FSM = Federated States of Micronesia, CNMI = Commonwealth of the Northern Mariana Islands.

^d Reference codes: 1 = (CFSPH 2006b); 2 = (Thomas et al. 2007); 3 = (OIE 2008a); 4 = (Duguies et al. 2000); 5 = (CFSPH 2007b); 6 = (Friend and Franson 1999); 7 = (CFSPH 2005a); 8 = (Lobetti 2009); 9 = (Asaoka et al. 2004); 10 = (CFSPH 2004a); 11 = (WHO 2010g); 12 = (CDC 2010d); 13 = (Mas-Coma et al. 1999); 14 = (Stanford University 2001); 15 = (Intervet 2010); 16 = (Berlioz-Arthaud et al. 2007); 17 = (Haddock et al. 2002); 18 = (Pineda 2001); 19 = (WHO 2009d); 20 = (USACHPPM 2008); 21 = (Demma et al. 2006); 22 = (USACHPPM 2006); 23 = (WHO 2009a); 24 = (Wallace 1976); 25 = (Duffy et al. 2009); 26 = (Hayes 2009); 27 = (Lanciotti et al. 2008); 28 = (CDC 2007a); 29 = (Saville 1999).

1 **Table A5-2: Some OIE-listed Diseases and Other Diseases Important to Animal Trade that**
 2 **could have a Wildlife Component**

Species	Disease
Multiple species	Anthrax
	Aujeszky's disease
	Bluetongue
	Brucellosis
	Crimean Congo haemorrhagic fever
	Echinococcosis/hydatidosis
	Epizootic haemorrhagic disease
	Equine encephalomyelitis (Eastern)
	Foot and mouth disease
	Heartwater
	Japanese encephalitis
	Leptospirosis
	New world screwworm (<i>Cochliomyia hominivorax</i>)
	Old world screwworm (<i>Chrysomya bezziana</i>)
	Paratuberculosis
	Rabies
	Rift Valley fever
	Rinderpest
	Surra (<i>Trypanosoma evansi</i>)
	Trichinellosis (<i>Trichinella spiralis</i>)
	Tularemia
	Vesicular stomatitis
	West Nile fever
Birds	Avian chlamydiosis
	Avian infectious bronchitis
	Avian infectious laryngotracheitis (<i>rare in wildlife</i>)
	Avian influenza (high- and low pathogenic in poultry)
	Avian mycoplasmosis (<i>Mycoplasma gallisepticum</i> and <i>M. synoviae</i>)
	Avian tuberculosis
	Duck virus enteritis
	Duck virus hepatitis
	Fowl cholera
	Fowl typhoid and pullorum disease
	Infectious bursal disease (Gumboro disease)
	Marek's disease (<i>primarily galliformes</i>)
	Newcastle disease
Lagomorphs ^a	Myxomatosis
	Rabbit haemorrhagic disease
Suidae ^b	African swine fever
	Classical swine fever
	Nipah virus encephalitis
	Porcine cysticercosis
	Porcine reproductive and respiratory syndrome
	Swine vesicular disease
	Teschovirus encephalomyelitis
	Transmissible gastroenteritis

Source: Modified from OIE 2010e
^a For example, pet rabbits released.
^b For example, feral swine.

There is little information pertaining to the status of wildlife diseases in the Micronesia Region. The few and dated animal disease surveys that have been conducted were typically conducted on livestock. With the exception of wild bird surveillance for AIV, few systematic surveys have been conducted for wildlife diseases in the Micronesia Region. Because of this, several assumptions were made in this risk assessment. If, e.g., a pathogen is known to have occurred in the Micronesia Region in livestock and the pathogen in question has been detected in wildlife in some other region at some point in time, the pathogen is considered to be a wildlife pathogen in the Micronesia Region. In addition, due to the limited data on this subject in this region, published data were supplemented with personal communications, interviews, and other resources.

In March 2010, we conducted a brief survey of rodents, bats, feral swine, and wild birds on Guam and Saipan. We sampled 230 birds (30 on Guam, 119 on Saipan, and 81 on Palau; Table A5-3) and 297 mammals (21 on Guam, 48 on Saipan, 80 on Palau, and 148 interdicted), which were from *Rattus* spp., *Suncus murinus*, *Mus* sp., feral swine (*Sus scrofa*), and fruit bats (*Pteropus* spp.) (Table A5-4). Select results of this survey are included for some pathogens of concern elsewhere in this document.

Table A5-3: Avian Species and Numbers Sampled for Pathogens in 2010 on Guam, Saipan, and Palau

Common name	Scientific name	Individuals
	Guam	
Blue-breasted Quail	<i>Coturnix chinensis</i>	11
Eurasian Tree Sparrow	<i>Passer montanus</i>	12
Pacific Golden-Plover	<i>Pluvialis fulva</i>	2
Philippine Turtle Dove	<i>Streptopelia bitorquata</i>	3
Yellow Bittern	<i>Ixobrychus sinensis</i>	2
	Saipan	
Bridled White-eye	<i>Zosterops conspicillatu</i>	62
Collared Kingfisher	<i>Halcyon chloris</i>	3
Golden White-eye	<i>Cleptornis marchei</i>	17
Mariana Fruit-Dove	<i>Ptiliopus roseicapilla</i>	2
Orange-cheeked Waxbill	<i>Estrilda melpoda</i>	2
Rufous Fantail	<i>Rhipidura rufifrons</i>	32
White-throated Ground Dove	<i>Gallicolumba xanthonura</i>	1
Various	Palau	81

1 **Table A5-4: Samples Collected from Mammals in the Micronesia Region**

Species	Source	N	Tests pending
<i>Rattus</i> spp.	Guam	13	Antibody and viral RNA
	Saipan	46	Antibody and viral RNA
<i>Suncus murinus</i>	Guam	6	Antibody and viral RNA
	Saipan	1	
<i>Mus</i> sp.	Saipan	1	Antibody and viral RNA
<i>Sus scrofa</i>	Guam	2	Antibody and viral RNA
<i>Pteropus</i> spp.	Palau	80	Population genetics
	Micronesia Region (interdicted specimens)	148	Population genetics

2
3 Samples will be tested for various pathogens associated with human, livestock, or wildlife disease or
4 population genetic analyses will be conducted on them. Results are pending.

5 **A5.1.2.1.7 Hosts for Wildlife-associated Diseases in the Micronesia Region**

6 There are a variety of species, mostly introduced, present on Guam and elsewhere in the Micronesia
7 Region that could serve as potential hosts for introduced pathogens (Table A5-5, Table A5-6).

8 **Table A5-5: Exotic Terrestrial Mammalian Vertebrate Species Known or**
9 **Thought to Occur on Guam**

Species	Species source	Potential pathogens ^a	Reference
<i>Rattus exulans</i>	GISIN ^b	An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
<i>Rattus rattus</i>	GISIN	Seoul-like virus	Cambodia (Reynes et al. 2003)
		Various <i>Leptospira</i> serotypes	New Zealand (Carter and Cordes 1980)
		Hepatitis E virus	Nepal (He et al. 2002)
		<i>Bartonella</i> spp.	Multiple (Ellis et al. 1999)
		<i>Francisella tularensis</i>	Europe (Gundi et al. 2004) Bulgaria (Christova and Gladnishka 2005)
		<i>Borrelia burgdorferi</i>	Bulgaria (Christova and Gladnishka 2005)
		<i>Anaplasma phagocytophilum</i>	Bulgaria (Christova and Gladnishka 2005)
		An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
<i>Rattus norvegicus</i>	GISIN	Unknown hantavirus	Thailand (Tantivanich et al. 1992)
		Seoul virus or Seoul-like virus	Indonesia (Plyusnina et al. 2004) United States (Easterbrook et al. 2007)
		Various <i>Leptospira</i> serotypes	Cambodia (Reynes et al. 2003) New Zealand (Carter and Cordes 1980)
		<i>Leptospira interrogans</i>	United States (Easterbrook et al. 2007)
		<i>Bartonella</i> spp.	Multiple (Ellis et al. 1999)
		Hepatitis E virus	United States (Easterbrook et al. 2007)
		<i>Rickettsia typhi</i>	United States (Easterbrook et al. 2007)
		<i>Cryptosporidium parvum</i>	United Kingdom (Webster and Macdonald 1995)
		<i>Salmonella</i> spp.	Canada (Harvey and MacNeill 1984)
		An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
<i>Suncus murinus</i>	GISIN	Hepatitis E virus	Nepal (He et al. 2002)
<i>Mus musculus</i>	GISIN	<i>Francisella tularensis</i>	Bulgaria (Christova and Gladnishka 2005)
		<i>Borrelia burgdorferi</i>	Bulgaria (Christova and Gladnishka 2005)

1 The potentially important pathogens of these species to human or livestock health are listed, but their listing does
 2 not suggest that these pathogens are necessarily located on Guam.
 3 ^a Indicates that evidence of the pathogen (e.g., the pathogen, a genetic signature, or antibodies to the pathogen
 4 of interest) has been detected in this species and the pathogen has the potential of being introduced into
 5 Guam.
 6 ^b Global Invasive Species Information Network.
 7

8 **Table A5-6: Other Exotic Terrestrial Mammalian Vertebrate Species Known or Thought to**
 9 **Occur on Guam in Reasonable Numbers**

Species	Species source	Potential pathogens	Reference
Feral house cat	GISIN	Feline leukemia virus	Longcore et al. 2009
		Influenza virus	Longcore et al. 2009
		<i>Toxoplasma gondii</i>	Longcore et al. 2009
		Rabies virus	Longcore et al. 2009
		Feline immunodeficiency virus	Longcore et al. 2009
Philippine deer	Guam DAWR ^a	Unknown but chronic wasting disease, bovine tuberculosis, epizootic hemorrhagic disease, and other ungulate diseases could affect this species	
Feral swine	Guam DAWR	Pseudorabies virus	United States (Campbell et al. 2008, Corn et al. 2009)
		<i>Brucella suis</i>	United States (Campbell et al. 2008, Corn et al. 2009)
		Porcine circovirus	United States (Campbell et al. 2008, Corn et al. 2009)
		Influenza A virus	United States (Hall et al. 2008)
		<i>Giardia</i> <i>Cryptosporidium</i> <i>Balantidium</i> <i>Entamoeba</i>	Australia (Hampton et al. 2006)
		Multiple pathogens (viral and bacterial)	Spain (Vicente et al. 2002)
		At least 30 viral and bacterial pathogens	Multiple (Witmer et al. 2003)
		Foot and mouth disease virus	(Pinto 2004)
Asiatic water buffalo	Guam DAWR		

10 Potentially important pathogens of these species are listed, but their listing does not suggest that these pathogens
 11 are necessarily located on Guam.
 12 ^a GDOA, Division of Aquatic and Wildlife Resources.
 13

14 **A5.1.2.1.8 Small Mammals**

15 The terrestrial small mammal fauna of Guam and CNMI typically comprises approximately five species
 16 (Wiewel et al. 2009) (see Table A5-5). The major species typically include *Rattus exulans*, *Rattus*
 17 *norvegicus*, *Mus musculus*, *Suncus murinus*, and a third *Rattus* species of uncertain taxonomic identity
 18 (i.e., *R. rattus*, *R. tanezumi*, or *R. diardii*) (Wiewel et al. 2009). Some species have been thought to occur

1 in this region for great periods of time (e.g., *Rattus exulans*) (Steadman 1999), while other introductions
2 are thought to have been more recent (e.g., *Suncus murinus*) (Peterson Jr. 1956). Rats of the genus
3 *Rattus* are common on many islands of the Micronesia Region and can be found in most regions of the
4 world. In a wildlife trade risk assessment for the United States, rats of this genus were listed as one of
5 the top mammalian species for having the capacity to harbor a large number of zoonotic pathogens for
6 risk of importation into the United States (Pavlin et al. 2009). Indeed, a large variety of pathogens can be
7 harbored by a great diversity of rodent species. Because of this, many islands within the Micronesia
8 Region, often with very abundant rat (i.e., host) populations, appear to have the elements needed to
9 sustain select pathogens if they were to be introduced by related species. In addition, *Suncus murinus*, a
10 shrew species known to occur on some islands within the Micronesia Region, is known to host
11 Thottapalayam virus (a hantavirus not known to be a human pathogen) (Calisher et al. 2003). Overall, it
12 is obvious that certain small mammal species are well established on many islands within this region. As
13 such, their potential to perpetuate an introduction of many pathogens is of great concern. A good
14 example of this scenario can be found in Seoul virus (an Old World hantavirus hosted by the genus
15 *Rattus*). This virus, which has its origins in the Old World, can now be found in many port cities (e.g.,
16 Baltimore, Maryland, United States), likely originating from rats transported on cargo ships. In addition,
17 the initial introduction of *Suncus murinus* onto Guam has been hypothesized to have occurred through
18 cargo materials from ports in the Philippines (Peterson Jr. 1956).

19 **A5.1.2.1.9 Birds**

20 Most native land birds have been extirpated on Guam due to the invasive BTS. Currently native birds are
21 restricted to the critically endangered Mariana crows (*Corvus kubaryi*), Mariana swiftlets (*Aerodramus*
22 *vanikovens*), and the endangered Micronesian starling (*Alphonis opaca guami*). Guam rails (*Rallus*
23 *owstoni*), and Guam Micronesian kingfisher (*Halcyon cinnamomina cinnamomina*) are extinct in the wild,
24 although some individuals are presently held in captivity. Each of these species is threatened by the
25 potential introduction of avian disease agents. In particular, crows have been shown to be very
26 susceptible to WNV such that its introduction to Guam has the potential to drive the Mariana Crow to
27 extinction if an outbreak occurs. Some HPAIVs have been shown to be lethal to a number of wild bird
28 species and therefore endangered poses a serious threat to native bird species. Five species of introduced
29 land birds are currently common on Guam—black drongo (*Dicurus macrocercus*), black francolin
30 (*Francolinus francolinus*), Philippine turtle dove (*Streptopelia bitroquata*), rock dove (*Columba livia*), and
31 Eurasian tree sparrow (*Passer montanus*). The presence of these species provides a pool of avian species
32 that have the potential to maintain and spread introduced avian diseases to native birds. The yellow
33 bittern (*Ixobrychus sinensis*) is the only common native aquatic bird on Guam although more than 150
34 migratory species have been known to visit Guam. The most common migratory species is the Pacific
35 Golden-Plover (*Pluvialis fulva*). Migratory species on Guam visit many countries along the Pacific Rim
36 and have the potential to carry a number of avian disease agents such as AIV and WNV.

37 The landbird fauna of the Northern Mariana Islands is more intact than that of Guam, but a number of
38 species are endangered or critically endangered, including the Mariana crow, Mariana swiftlet,
39 nightingale reed warbler (*Acrocephalus luscinia*), and the Micronesian megapode (*Megapodius*
40 *laperouse laperouse*).

1 A serological survey of poultry on Guam indicated serological evidence of infectious bronchitis (multiple
 2 types), infectious laryngotracheitis, infectious bursal disease, Marek’s disease, *Mycoplasma*
 3 *gallisepticum*, *Mycoplasma synoviae*, eggdrop syndrome, avian encephalomyelitis, and *Mycobacterium*
 4 sp. (Duguies et al. 2000). However, no evidence of antibodies to the etiologic agents associated with
 5 avian influenza and Newcastle disease were found during this survey (Duguies et al. 2000).

6 Savidge et al. (1992) tested 762 avian biological samples from Guam and conducted 112 necropsies on
 7 wild birds but did not find any significant pathogens. The authors tested for evidence of hematozoans
 8 (blood parasites of the Haemosporidia family), AIV, and NDV, but did not detect any evidence of the
 9 pathogens causing these diseases. More recently, U.S. surveillance efforts by the U.S. Department of
 10 Interior and USDA for HPAIV in wild birds from 2006 to 2010 have not detected the presence of highly
 11 pathogenic H5N1 AIV out of 5,827 samples tested that were collected in Guam, CNMI, Palau, and RMI
 12 and have detected only three cases of low pathogenic AIV (NBII 2010) (Table A5-7).

13 **Table A5-7: AIV Surveillance Results for U.S. Department of Interior and USDA Testing for**
 14 **the Detection of HPAIV, 2006-Present**

Location	Samples tested	H5N1 positives	LPAIV positives	Percent LPAIV positives
Guam	4,201	0	1	0.02
CNMI	611	0	1	0.16
Palau	824	0	1	0.12
RMI	191	0	0	0.00
TOTAL	5,827	0	3	0.05

15

16 **A5.1.2.1.10 Feral Swine**

17 Feral swine (*Sus scrofa*) are an invasive and destructive species found in many regions of the world.
 18 Foraging activities by feral swine can result in damage to crops and natural ecosystems (USDA-APHIS-WS
 19 2008b). Although destructive, feral swine are often valued as a natural resource for hunting. Aside from
 20 their destructive tendencies, this species can also harbor a significant number of pathogens of
 21 agricultural and public health significance (Witmer et al. 2003) (see Table A5-6). Feral swine are known
 22 to occur on some islands within the Micronesia Region. It appears unlikely that feral swine will be
 23 smuggled or accidentally introduced onto islands in the present day. Therefore, there is a low likelihood
 24 of new feral swine associated pathogens being introduced into the Micronesia Region via this route.
 25 However, feral swine have been well documented to interact with domestic swine. This interface could
 26 be of key concern if a virulent swine pathogen were to be accidentally imported into Guam. Notably, the
 27 swine industry, although relatively small, is the largest livestock industry on Guam (Duguies et al. 2000).
 28 A serological survey of Guam swine during 1999 indicated evidence of only one pathogen, a parvovirus,
 29 among the swine tested (Duguies et al. 2000).

30 **A5.1.2.1.11 Philippine Deer**

31 As of 1999, Philippine deer (*Cervus mariannus*) were known to occur on four islands in the Micronesia
 32 Region: Guam, Rota, Saipan, and Pohnpei, with populations thought to be expanding on Guam and
 33 stable or declining on the other islands at that time (Wiles et al. 1999). The size of these animals makes

1 them and similar sized animals unlikely to be accidentally introduced into most islands in the Micronesia
2 Region. In addition, no significant diseases were found during literature reviews of this species.
3 However, there are several wildlife diseases known to negatively affect various deer species, such as
4 chronic wasting disease and others (see Table A5-6).

5 **A5.1.2.1.12 Asiatic Water Buffalo**

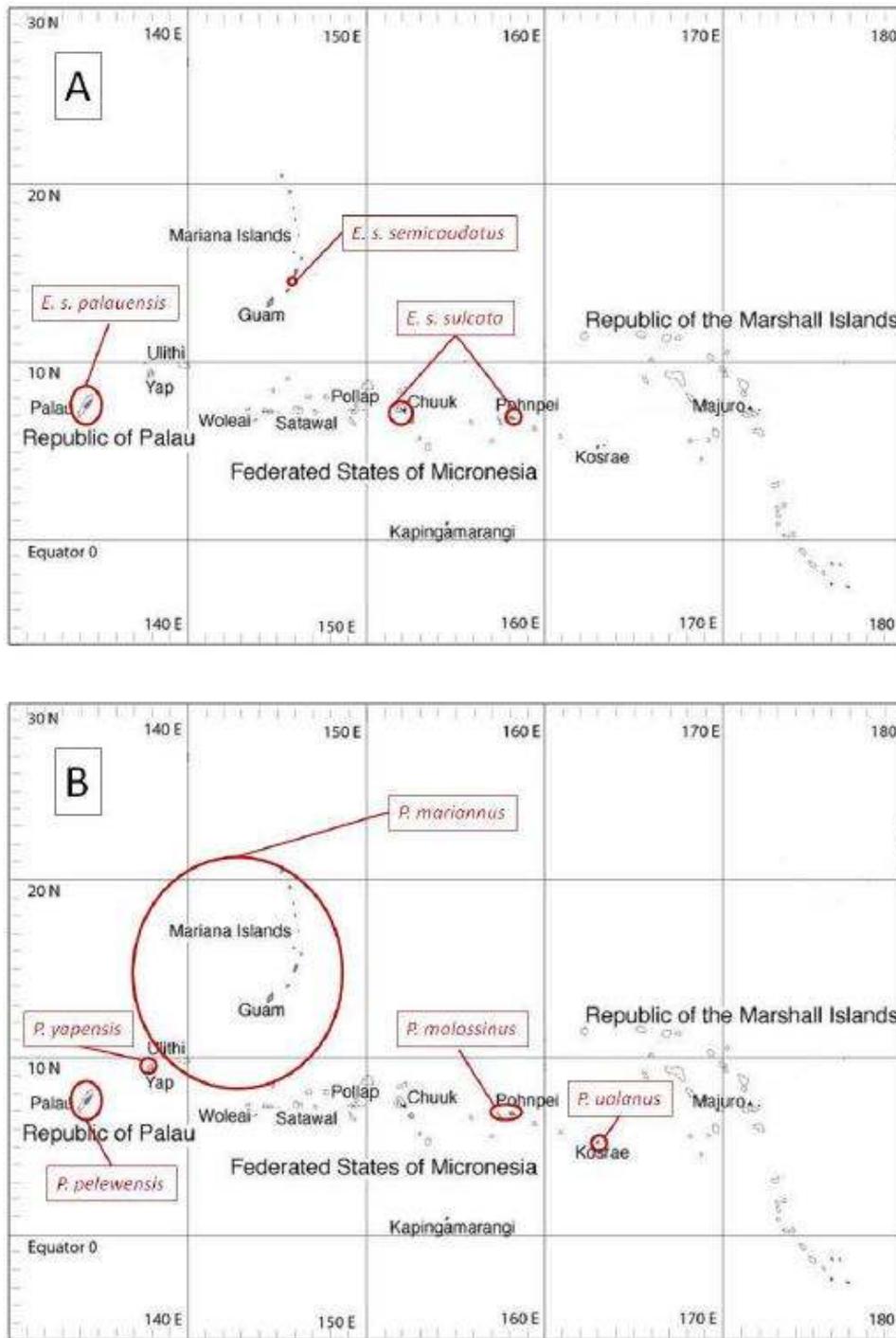
6 Likely originally introduced for farm use from the Philippines, a large feral herd of Asiatic water buffalo
7 existed on Guam as of 1988 (Conry 1988b). Efforts to control this species on naval lands have been
8 conducted since 1996 and the population is thought to have been reduced (personal communication
9 cited in USFWS 2009b). It is highly unlikely that an animal of this size could be accidentally introduced
10 into Guam or elsewhere in the Micronesia Region. No accounts of serious disease associated with this
11 species on Guam were discovered. In a serosurvey of a small number of animals, only one animal tested
12 positive for a single disease agent (*Anaplasma* sp.) of nine tested (Duguies et al. 2000). However, this
13 species could be afflicted by bovine diseases of cattle. For example, workers have indicated that Indian
14 water buffalo (*Bubalus bubalis*) are susceptible to infection with foot and mouse disease virus (Pinto
15 2004).

16 **A5.1.2.1.13 Bats**

17 There are one species of insectivorous bat and five extant species of frugivorous bats (flying foxes or
18 fruit bats) in the Micronesia Region (Simmons 2005); two other species of frugivorous bats once
19 occurred in the Micronesia Region but are now extinct. In the Micronesia Region, the single species of
20 insectivorous bat (Pacific sheath-tailed bat, *Emballonura semicaudata*) is currently found as *E. s.*
21 *palauensis* on Palau (Koror, Peleliu, Babeldaob, and Anguar), *E. s. sulcata* on Chuuk and Pohnpei, and *E.*
22 *semicaudata rotensis* only on Aguiguan (Goat) Island in the Mariana archipelago, although this
23 subspecies was historically found on Guam, Rota, Tinian, and Saipan (Lemke 1986; Simmons 2005;
24 Bonaccorso and Allison 2008) (Figure A5-2). Outside of the Micronesia Region, this species is also found
25 in Tonga and Fiji (Bonaccorso and Allison 2008). Historically, it was also found on American Samoa
26 (Bonaccorso and Allison 2008), but it has not been detected there in recent surveys (Fraser et al. 2009).
27 Pacific sheath-tailed bats are insectivorous and nocturnal and roost colonially in caves. They forage
28 primarily in mature forest on Aguiguan (Esselstyn et al. 2004; Gorresen et al. 2009), although they have
29 been observed in urban areas on Palau and Chuuk (Bruner and Pratt 1979; Wiles et al. 1997). Thus, in
30 some areas in the Micronesia Region, such as Palau, Chuuk, and Pohnpei, this species may come into
31 contact with humans. We found no evidence of pathogen surveys for Pacific sheath-tailed bats.

1
2

Figure A5-2: Distribution of Pacific Sheath-Tailed Bat (A) and Flying Foxes (B) in the Micronesia Region



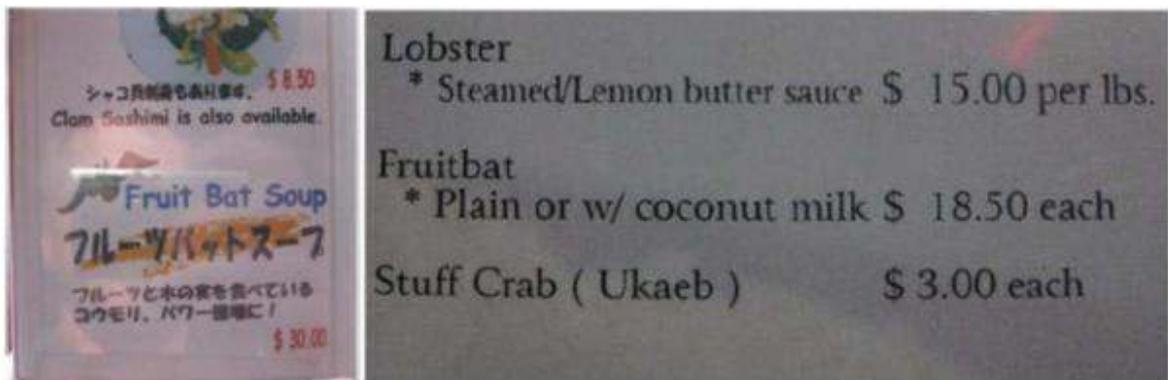
3
4
5

Source: Lemke 1986; Allison et al. 2008; Bonaccorso and Allison 2008; Bonaccorso et al. 2008a; Bonaccorso et al. 2008b; Buden et al. 2008; Wiles 2008; Wiles et al. 2008b, a

1 Historically, there were seven species of flying foxes (or fruit bats) in the Micronesia Region, all in the
2 genus *Pteropus* (Simmons 2005). Two of these species are now extinct: the Guam flying fox (*P. tokudae*),
3 which was endemic to Guam (Bonaccorso et al. 2008b) and the Large Pelew flying fox (*P. pilosus*), which
4 was endemic to Palau (Bonaccorso et al. 2008a). The remaining extant five species (Simmons 2005) are
5 the Mariana flying fox (*P. mariannus*) on Guam, the northern Mariana Islands, and Ulithi (Allison et al.
6 2008); the Caroline flying fox (*P. molossinus*) on Pohnpei and nearby atolls (Buden et al. 2008); the
7 Pelew flying fox (*P. pelewensis*) on Palau (Wiles 2008); the Kosrae flying fox (*P. ualanus*) on Kosrae (Wiles
8 et al. 2008a); and the Yap flying fox (*P. yapensis*) on the four main islands of Yap (Wiles et al. 2008b).
9 Flying foxes (herein referred to generically as fruit bats) are phytophagous, feeding on plant flowers,
10 leaves, and fruits (Marshall 1985).

11 In the Micronesia Region, fruit bats are a culturally significant food resource (Sheeline 1991). Fruit bats
12 are considered a delicacy for many of the native population of the Micronesia Region and are still legally
13 hunted and served in restaurants in Palau (Figure A5-3). Historically, there was considerable trade in
14 fruit bats among the islands of the Micronesia Region. Prior to federal listing as endangered in 1984 and
15 subsequent reclassification as threatened in Guam and CNMI (USFWS 2005), the Mariana flying fox was
16 commonly hunted for food. Overharvesting of these fruit bats severely depleted numbers on Guam and
17 fruit bats from other islands and countries were imported to supply demand (Wiles and Payne 1986;
18 Wiles 1992).

19 **Figure A5-3: Fruit Bat Offered on Restaurant Menus and Fruit Bat Soup in Restaurant In**
20 **Palau, Where Fruit Bats are Served Whole, Including Entrails and Fur**



21
22 Photos by Alan B. Franklin 2010
23

24 As of 1989, the trade in fruit bats had expanded from the Marianas to other islands in the Micronesia
25 Region, the South Pacific, and Asia (Wiles and Payne 1986; Wiles 1992). While the trade from within the
26 Marianas declined because of increased legal restrictions on hunting and declining fruit bat populations
27 (USFWS 2005), commercial imports from outside the Micronesia Region increased (Wiles and Payne
28 1986). From 1975 through 1989, at least 220,437 fruit bats were imported into Guam (an average of
29 11,550 bats per year) with 21.5% of these imports coming from outside the Micronesia Region (Table
30 A5-8). These were all legal imports and imported fruit bats were often sold commercially in stores,

1 fetching prices from \$17 to \$30 per bat (Wiles and Payne 1986). After 1990, legal imports of bats to
 2 Guam were curtailed considerably with the implementation of regulations under CITES and the addition
 3 of USFWS inspectors on Guam (Wiles 1990; Mickleburgh et al. 2002).

4 **Table A5-8: Imports of Fruit Bats (*Pteropus* Spp.) into Guam Before and After 1989**

Exporter	1975 through 1989		After 1989			
	Total bats	Annual \bar{X}	Total bats	Annual \bar{X}	Period	No. years
<i>Within the Micronesia Region</i>						
CNMI						
Rota	7,145	476				
Saipan	7,813	521				
Tinian	1,366	91				
Pagan	190	13				
FSM						
Chuuk	5,795	386				
Kosrae	69	5				
Pohnpei	15,223	1,015				
Ulithi	50	3				
Yap	23,410	1,561				
Palau	112,184	7,479	38,936	7,787	1990-1994	5
Total	172,975	11,550				
<i>Outside the Micronesia Region</i>						
South Pacific islands						
Western Samoa	33,341	2,223				
American Samoa	4,155	277				
Fiji	6	<1				
Tonga	5,060	337				
Vanuatu	12	<1				
Indonesia	7	<1				
Papua New Guinea	1,789	119				
Philippines	3,092	206				
Total	47,462	3,165				

5 Source: Wiles and Hill 1986; Wiles 1992; Wiles et al. 1997

6

7 As of 1993, demand for fruit bats continued and they were still sold commercially (Wiles and Payne
 8 1986) for up to \$40 to \$50 per bat at markets and in roadside stands (Hamm 1994). Culturally, 53% of
 9 Chamorro residents of Guam surveyed indicated that they enjoyed eating fruit bats and significantly
 10 more older Chamorros ate fruit bat than younger Chamorros, suggesting an eventual decrease in
 11 demand (Sheeline 1991). However, many Chamorros further interviewed during this survey indicated
 12 that their children and grandchildren ate fruit bat, which suggested that some level of demand would
 13 continue into the future. At this time, imports of fruit bats from Palau were still legal because Palau was
 14 still part of the United States and, therefore, not regulated by CITES. However, implementation of the
 15 U.S. Lacey Act finally curtailed these exports (Wiles 1990).

1 Because of current legal restrictions across the Micronesia Region, fruit bats can now only be legally
2 hunted and sold within the Republic of Palau (USFWS 2005), where they are still hunted and sold in
3 markets and restaurants (see Table A5-8). Legal exports from Palau to other parts of the Micronesia
4 Region were discontinued under CITES when Palau became the Republic of Palau and no longer under
5 U.S. jurisdiction (Wiles 1990). However, illegal shipments continued through smuggling, based on
6 information on interdictions. For example, more than 200 fruit bats from 9 interdicted shipments were
7 collected at the GDOA that had been confiscated by Guam and Saipan Customs during 1990 through
8 1994; these shipments were coming from Palau, Yap, Rota, Chuuk, and Pohnpei. It is unknown to what
9 degree the demand for fruit bat continues today in the Micronesia Region, but the trade in fruit bats has
10 likely shifted from the legal commercial trade in the past to illegal smuggling today. How this demand
11 will shift in response to the military relocation on Guam depends largely on the nationality of the
12 workers employed to assist in the relocation and whether their customs include the consumption of
13 fruit bats. For example, fruit bats are widely used as a food resource in Indonesia, Malaysia, and the
14 Philippines, and some species of fruit bats (e.g., *Pteropus vampyrus*) have been smuggled into Guam
15 from the Philippines (Kunz and Jones 2000). In Malaysia and Indonesia, most of the trade in fruit bat
16 meat is with Chinese and Manadonese customers, who believe bat meat can be used to treat asthma,
17 kidney disease and malaise (Fujita 1988; Fujita and Tuttle 1991; Struebig et al. 2007). Bat hunting is legal
18 in Malaysia, and as of 2001, bat hunters could obtain licenses to take up to 50 individuals (Mohd-Azlan
19 et al. 2001). The estimated reported legal harvest from 1990 to 1996 on the Malaysian peninsula was
20 56,273 individuals; however, this was likely an underestimate of the total kill because of lack of
21 enforcement of quotas (Mohd-Azlan et al. 2001). In Indonesia, up to 4,500 fruit bats per month have
22 been harvested from a single location (Struebig et al. 2007). Hunted areas have become more remote as
23 fruit bat populations dwindle but the epicenters of trade, even from remote areas, are still large cities
24 and urban areas (Riley 2002). In the Philippines, fruit bats are also hunted heavily for food (Heaney and
25 Heideman 1987), especially by people with lower incomes (Shively 1997). In addition, market vendors in
26 Malaysia and Indonesia prefer live bats, which are then killed and prepared in front of the customer
27 when sold (Fujita and Tuttle 1991; Struebig et al. 2007). The illegal smuggling of live bats from these
28 countries (rather than dead, bats are now frozen) into the Micronesia Region could be disastrous in
29 terms of pathogen introduction.

30 As far as we know, there are no known pathogens carried by either the insectivorous or fruit bats in the
31 Micronesia Region that seriously affect human or agricultural health. The Chamorro people do suffer
32 from a neurodegenerative disease similar to Alzheimer's and Parkinson's disease (Amyotrophic Lateral
33 Sclerosis-Parkinsonism Dementia Complex), but this has been linked to consumption of fruit bats that
34 have fed on and bioaccumulated neurotoxins from cycad seeds (Cox and Sacks 2002; Monson et al.
35 2003), rather than a pathogen. Globally, both insectivorous and frugivorous bats are of considerable
36 concern because of the wide variety of pathogens they can carry, many of which can seriously affect
37 both human and agricultural health. For example, fruit bats have been implicated as reservoirs for Zaire
38 Ebola and Lake Victoria Marburg viruses (Leroy et al. 2005; Leroy et al. 2009; Kuzmin et al. 2010), SARS
39 (Calisher et al. 2008), and Henipaviruses, such as Hendra and Nipah viruses (Mackenzie et al. 2003;
40 Epstein et al. 2006). In addition, all species of bats in the Micronesia Region, including fruit bats, may
41 have the ability to carry rabies and/or other lyssavirus (Constantine 2009). While insectivorous bats are

1 often associated with rabies, fruit bats also serve as reservoirs for rabies-related lyssaviruses
2 (Constantine 2009), which has been transmitted to humans with fatal consequences (Samaratunga et al.
3 1998). These pathogens are discussed in more detail elsewhere in this document.

4 **A5.1.2.1.14 Interdiction Procedures**

5 GDOA provides technical assistance to USDA-APHIS-PPQ, has assisted in identifying confiscated wildlife
6 and wildlife products, placing wildlife in quarantine, and has assisted in multi-faceted efforts to prevent
7 illegal wildlife imports from entering Guam (Beck 2000). In general, anyone engaging in the business as
8 an importer or exporter of wildlife (living, dead, parts, or products) in the United States or its territories
9 must obtain a license from the USFWS (USFWS OLE 2006). Information on pet importation into Guam is
10 presented elsewhere in this document.

11 **A5.1.2.1.15 Wildlife Products**

12 During 2006 to 2008, USFWS inspected wildlife-derived products arriving in Guam from the following
13 countries or undefined regions: Argentina, Australia, Bolivia, Cameroon, Canada, Chad, China, Columbia,
14 Denmark, Fiji, Finland, French Polynesia, French Southern and Antarctic land, Germany, Greece, Hong
15 Kong, India, Indonesia, Japan, South Korea, Macau, Madagascar, Malawi, Malaysia, Mali, FSM,
16 Mozambique, Namibia, New Zealand, Norway, Palau, Papua New Guinea, Philippines, Russia, South
17 Africa, Switzerland, Taiwan, Thailand, United States, Unspecified, Venezuela, Vietnam, Zimbabwe.
18 During 1998 to 2003, there were 4,053 imported shipments and 696 exported shipments associated
19 with wildlife trade in Agana, Guam (USFWS OLE 2004). During 2003, 5,752,168 amphibians, 1,594,515
20 reptiles, 449, 294 birds, and 63,716 mammals were imported into the United States from foreign
21 countries (USFWS OLE 2004). From 1997 to 2003, the top 10 suppliers of wildlife shipments to the
22 United States included Canada (102,227), Hong Kong (48,936) Philippines (40,294), Italy (38,404),
23 Thailand (22,629), Indonesia (19,267), South Africa (18,844), Switzerland (14, 643), Mexico (13,701), and
24 China (12,896) (USFWS OLE 2004). Although much of the trade in wildlife is legal, it is difficult to assess
25 the risk from currently tabulated data if it is associated with illegally traded wildlife (Ferrier 2009). In
26 terms of the risk of introducing diseases associated with wildlife into the Micronesia Region, movement
27 of wildlife products from Asia, Africa, and South America pose the greatest risk, especially with respect
28 to emerging zoonotic diseases (Mackenzie et al. 2001; Karesh and Cook 2005; Karesh et al. 2005; Karesh
29 et al. 2007). Of particular concern to the Micronesia Region are the introduction of wildlife-associated
30 diseases from China, Korea, Hong Kong, Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

31 **A5.1.3 Areas of Concern**

32 **A5.1.3.1 Wildlife-associated Diseases Outside the Micronesia Region**

33 There are a large number of wildlife pathogens of potential concern for introduction into the Micronesia
34 Region (Table A5-9). The World Organization for Animal Health (OIE) lists many animal diseases of
35 importance to international trade, many of which are applicable to this section, such as those that can
36 be found in wild or feral animals (see Table A5-2). For the sake of brevity, this section focuses on some
37 pathogens of major concern (as determined by the authors) primarily associated with Asia and the
38 United States, which will likely be two major regions for increased trade following the DoD relocation on

1 Guam. The biological and economic consequences of the introduction of a wildlife-associated disease
2 could vary widely. For example, if a pathogen is introduced but no competent host is available the
3 pathogen will likely go undetected and pose no biological or economic consequence to the region. This
4 may occur regularly in many regions of the world. However, an alternative scenario in which a pathogen
5 becomes established with significant host species could have enormous biological and economic
6 consequences.

1 **Table A5-9: Important Wildlife-Associated Diseases, Listed with their Pathogens, Hosts, and Distribution, that Could Be**
 2 **Introduced into the Micronesia Region**

Disease ^a	Type ^b	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact			Transmission	Distribution in the Pacific Rim	References ^c
				Humans	Agriculture	Wildlife			
Anthrax*	B	<i>Bacillus anthracis</i>	Most warm-blooded species (primarily grazing animals)	X	X	X	Ingestion, skin contact, or inhalation of spores, insect bites	Asia, Australia, N. America	1, 4
H5N1 A/HPAI*	V	Influenza virus A/H5N1	Birds (particularly waterfowl)	X	X	X	Close contact with secretions from infected animals, aerosol	Asia	2, 24
Low pathogenic avian influenza *	V	Influenza virus A	Feral swine, birds (particularly waterfowl and shore birds)	X	X	X	Close contact with secretions from infected animal, aerosol, environmental	Worldwide	2
Avian malaria	P	<i>Plasmodium spp.</i>	Birds		X	X	Mosquitoes	Worldwide	3
Bovine tuberculosis*	B	<i>Mycobacterium bovis</i>	Most mammals (particularly introduced water buffalo and deer)	X	X	X	Contact, aerosol, ingestion	N. America, Asia	5, 7
Chikungunya fever	V	Chikungunya virus	Rodents, birds	X		X	Mosquitoes	Asia	6, 30
Classical swine fever*	V	Classical swine fever virus	Feral swine		X	X	Contact between swine, ingestion of contaminated garbage, aerosol	Asia	7
Crimean Congo hemorrhagic fever	V	Crimean Congo hemorrhagic fever virus	Rodents, feral swine, bats	X			Ixodid ticks	Asia	26
Duck viral enteritis	V	Duck herpesvirus 1	Waterfowl			X	Contact between infected birds,	N. America, Asia	8

Disease ^a	Type ^b	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact			Transmission	Distribution in the Pacific Rim	References ^c
				Humans	Agriculture	Wildlife			
							aerosol, vertical transmission		
Duck viral hepatitis*	V	Duck hepatitis A virus 1, Duck astrovirus I, Duck astrovirus II	Waterfowl		X	X	Contact with contaminated feces	Asia, N. America	9
Echinococcosis*	P	<i>Echinococcus</i> spp.	Intermediate hosts–wild herbivores. Definitive hosts–wild carnivores	X	X	X	Ingestion of eggs, or cyst-containing tissues	Worldwide	7, 10
Encephalomyocarditis	V	Encephalomyocarditis virus	Rodents, feral swine	X	X	X	Ingestion of contaminated fomites, close contact between swine	Australia, N. America	23
Equine encephalomyelitis*	V	Equine encephalomyelitis virus	Birds, rodents	X	X	X	Mosquitoes	N. America	12, 29
Erysipelothrix infections	B	<i>Erysipelothrix rhusiopathiae</i>	Feral swine, birds	X	X	X	Food contamination, wound infection	Worldwide	13, 25
Fowl cholera*	B	<i>Pasteurella multocida</i>	Birds		X	X	Contact with contaminated fomites or other infected birds	Worldwide	8
Fowl typhoid and pullorum disease*	B	<i>Salmonella enterica</i>	Birds		X	X	Respiratory, oral, contaminated environmental, vertical	Asia	7
Haemorrhagic septicaemia*	B	<i>Pasteurella multocida</i>	Introduced water buffalo, feral swine		X	X	Ingestion of contaminated feed, aerosol	Asia	11, 27

Disease ^a	Type ^b	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact			Transmission	Distribution in the Pacific Rim	References ^c
				Humans	Agriculture	Wildlife			
Hemorrhagic fever with renal syndrome and hantavirus pulmonary syndrome	V	Hantaviruses	Rodents, shrews	X			Aerosols from rodent excretions, bite of infected animal	N. America, Asia	12
Intestinal capillariasis	P	<i>Capilaria philippinensis</i>	Fish; Fish-eating birds	X		X	Consumption of raw freshwater fish	Philippines, Asia	14, 28
Japanese encephalitis*	V	JEV	Feral swine, birds	X	X	X	Mosquitoes	Asia, Pacific islands	15
Leishmaniasis	P	<i>Leishmania</i> spp.	Rodents	X		X	Sandflies	Asia, N. America	7, 31
Lyme disease/Borreliosis	B	<i>Borrelia</i> spp.	Rodents	X		X	Ixodid ticks	Worldwide	32
Lymphocytic choriomeningitis	V	Lymphocytic choriomeningitis virus	House mice	X		X	Exposure to mouse excretions	Worldwide	33
Melioidosis	B	<i>Burkholderia pseudomallei</i>	Various birds, reptiles, fish, and mammals	X	X	X	Ingestion, inhalation, direct contact with contaminated soil or water	Asia, Australia	4, 34
Menangle*	V	Menangle virus	Fruit bats, feral swine	X	X	X	Suspected fecal-oral	Australia	18, 35
Murine typhus	B	<i>Rickettsia typhi</i>	Rodents	X		X	Fleas	Worldwide	16
Murray Valley encephalitis	V	Murray Valley encephalitis virus	Birds	X		X	Mosquitoes	Australia	37
Newcastle disease*	V	NDV	Birds	X	X	X	Contact with contaminated secretions	Worldwide	17
Nipah virus encephalitis	V	Nipah virus	Fruit bats, feral swine	X	X	X	Contaminated swine products,	Asia	7, 36

Disease ^a	Type ^b	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact			Transmission	Distribution in the Pacific Rim	References ^c
				Humans	Agriculture	Wildlife			
							contaminated fruit, close contact with infected humans		
Paratuberculosis*	B	<i>Mycobacterium avium</i>	Ruminants, other mammals, birds		X	X	Contact with contaminated secretions or fomites	Worldwide	7
Plague	B	<i>Yersinia pestis</i>	Rodents	X		X	Fleas, aerosols	N. America, Asia	38, 39
Porcine brucellosis*	B	<i>Brucella suis</i>	Feral swine	X	X	X	Ingestion of contaminated feed or tissues, copulation	N. America, Asia, Australia	11
Psittacosis/avian chlamydiosis	B	<i>Chlamydothila psittaci</i>	Birds	X		X	Inhalation of infectious dust, biting insects, mites, lice	Worldwide	40
Queensland tick typhus	B	<i>Rickettsia australis</i>	Rodents	X		X	Ixodid ticks	Australia	41
Rabies and rabies related infections–Lyssaencephalitis*	V	Rabies virus, Duvenhage virus, Mokola virus, Ibadan shrew virus, Obodhiang virus	Wild and feral carnivores, bats	X	X	X	Bites from infected animals	N. America, Asia	7, 42
Rat bite fever	B	<i>Streptobacillus moniliformis</i> , <i>Spirillum minus</i>	Rats	X		X	Rat bites and scratches, exposure to contaminated urine or feces	Asia, N. America	18
Ross River fever	V	Ross River virus	Small mammals,	X			Mosquitoes	Australia,	43, 44

Disease ^a	Type ^b	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact			Transmission	Distribution in the Pacific Rim	References ^c
				Humans	Agriculture	Wildlife			
			Rodents					South Pacific Is.	
Sarcocytosis	P	<i>Sarcocystis</i> spp.	Feral swine, rodents, carnivores, birds	X	X	X	Ingestion of raw pork, ingestion of contaminated feces	Australia, N. America	19, 20
Sindbis virus diseases	V	Sindbis virus	Birds	X		X	Mosquitoes	Australia, Asia	45
Tick-borne relapsing fever	B	<i>Borrelia</i> spp.	Rodents	X		X	Ticks	Asia, N. America	46
Trichinellosis*	P	<i>Trichinella spiralis</i>	Carnivores, feral swine	X	X	X	Ingestion of meat containing cysts	Worldwide	21
Tularemia	B	<i>Francisella tularensis</i>	Rodents, rabbits	X		X	Insect bites, inhalation, handling infected carcasses	N. America, Asia, Australia	7
Vesicular stomatitis*	V	Vesicular stomatitis virus	Feral swine	X	X	X	Insects (especially flies), contaminated fomites	N. America	12
West Nile fever/West Nile neuroinvasive disease*	V	WNV	Birds, some reptiles and mammals	X	X	X	Mosquitoes, ingestion of infected carcass	N. America	15
Yersiniosis	B	<i>Yersinia</i> spp.	Rodents, feral swine	X	X	X	Ingestion of infected pork products, contact with contaminated feces	N. America	22

1 Note: This table is not intended to be an inclusive list of all potential pathogens that could be introduced into the Micronesia Region.

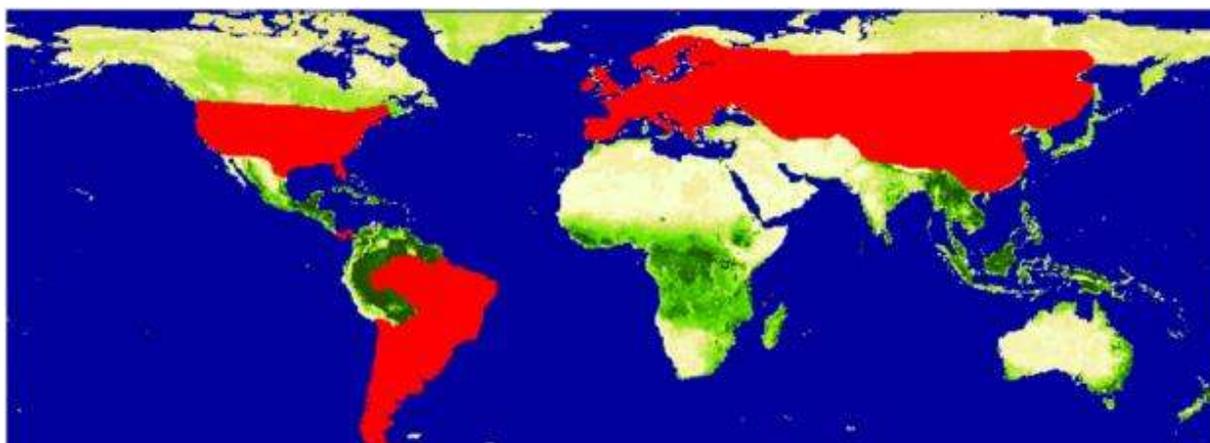
1 ^a Diseases of importance to international trade based on OIE list (see Table A5-2) are marked with an asterisk (*).
2 ⁿ B = bacterial, P = parasitic, V= viral.
3 ^c Reference Codes: 1 = (Dragon and Rennie 1995); 2 = (Stallknecht et al. 2007); 3 = (Atkinson 2008); 4 = (CFSPH 2007a); 5 = (State of Michigan 2007); 6 =
4 (CDC 2008b); 7 = (CFSPH 2009c); 8 = (Friend and Franson 1999); 9 = (OIE 2008d); 10 = (Bennett Undated); 11 = (OIE 2008m); 12 = (CFSPH 2008a); 13 =
5 (Wolcott 2007); 14 = (Cross 1992); 15 = (McLean and Ubico 2007); 16 = (Texas Department of State Health Services 2010); 17 = (Leighton and Heckert
6 2007); 18 = (CFSPH 2006c); 19 = (CFSPH 2005c); 20 = (Friend and Franson 1999); 21 = (Despommier and Chen 2007); 22 = (Mair 1973); 23 = (Kahn and Line
7 2008); 24 = (CFSPH 2010b); 25 = (Wood and Steele 1994); 26 = (Ergönül 2007); 27 = (De Alwis 1999); 28 = (Cross 1992); 29 = (Mackenzie et al. 2004); 30 =
8 (Pardigon 2009); 31 = (Desjeux 2004); 32 = (CDC 2007b); 33 = (CFSPH 2010c); 34 = (White 2003); 35 = (USDA-APHIS-VS CEAH CEI 1998); 36 = (Epstein et al.
9 2006); 37 = (Cordova et al. 2000); 38 = (CDC 2010f); 39 = (Gage and Kosoy 2005); 40 = (CFSPH 2004b); 41 = (McBride et al. 2007); 42 = (CDC 2010g); 43 =
10 (Boyd and Kay 2002); 44 = (Carver et al. 2008); 45 = (Kurkela et al. 2008); 46 = (Hall et al. 2008).

1 **A5.1.3.1.1 *Hantaviruses***

2 Hantaviruses are members of the genus *Hantavirus* and the viral family Bunyaviridae. They are etiologic
3 agents of human diseases called hantavirus pulmonary syndrome in the New World and hemorrhagic
4 fever with renal syndrome (HFRS) in the Old World and these diseases range from mild to severe. Even
5 in mild cases, these diseases should not be taken lightly. HFRS, e.g., has been thought to cause a large
6 number of human illnesses in Asia and Europe (e.g., as many as 50,000 to 100,000 per year) (Johnson
7 1999) (Figure A5-4). In addition, in China alone, 1,557,622 cases of HFRS were reported between 1950
8 and 2007, resulting in 46,427 deaths (Zhang et al. 2010). Even following the recent implementation of
9 preventive measures, the numbers of HFRS cases and deaths caused by this disease in China remain
10 amongst the highest reported in the world (Zhang et al. 2010). The viruses causing these diseases are
11 thought to be frequently transmitted to humans through the inhalation of rodent excreta (e.g., via
12 aerosolized virus (Padula et al. 2004). These viruses are hosted primarily by rodent hosts, but some
13 insectivore (e.g., shrew) associations with these viruses have been documented as well. Hantaviruses
14 are thought to cause persistent (i.e., the virus is not rapidly cleared from the host) infections in rodents,
15 which is often initiated by a short acute phase (high infectious virus levels) followed by a chronic stage
16 (typically lower virus levels) (Padula et al. 2004). Hantaviruses are generally thought to be transmitted
17 among rodents through interspecific interactions among animals. Although some of these viruses could
18 pose a great threat to human health, they appear to pose little threat to wildlife and livestock health.
19 The primary means of introduction of these viruses into the Micronesia Region are through rodent hosts
20 in cargo on ships and airplanes. Because one *Rattus* spp. could potentially transmit a hantavirus to naïve
21 individuals within this genus, and many islands within the Micronesia Region have large rat populations,
22 select viruses (e.g., Seoul virus) within this genus could become established following their introduction.
23 Because hantaviruses can be found in many different environmental conditions, the climate in much of
24 the Micronesia Region is likely suitable for their introduction. Hantaviruses are examples of wildlife-
25 associated diseases that could have both biological and economic consequences. Although these viruses
26 are unlikely to negatively affect native wildlife or livestock, they could cause human disease such as
27 hemorrhagic fever with renal syndrome. Thus, the economic consequences of this group of viruses could
28 entail increased hospitalizations, decreased work and productivity, increased need for laboratory
29 networks, and increased surveillance.

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Figure A5-4: Global Distribution of Hantaviruses



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Source: CHAART 1999

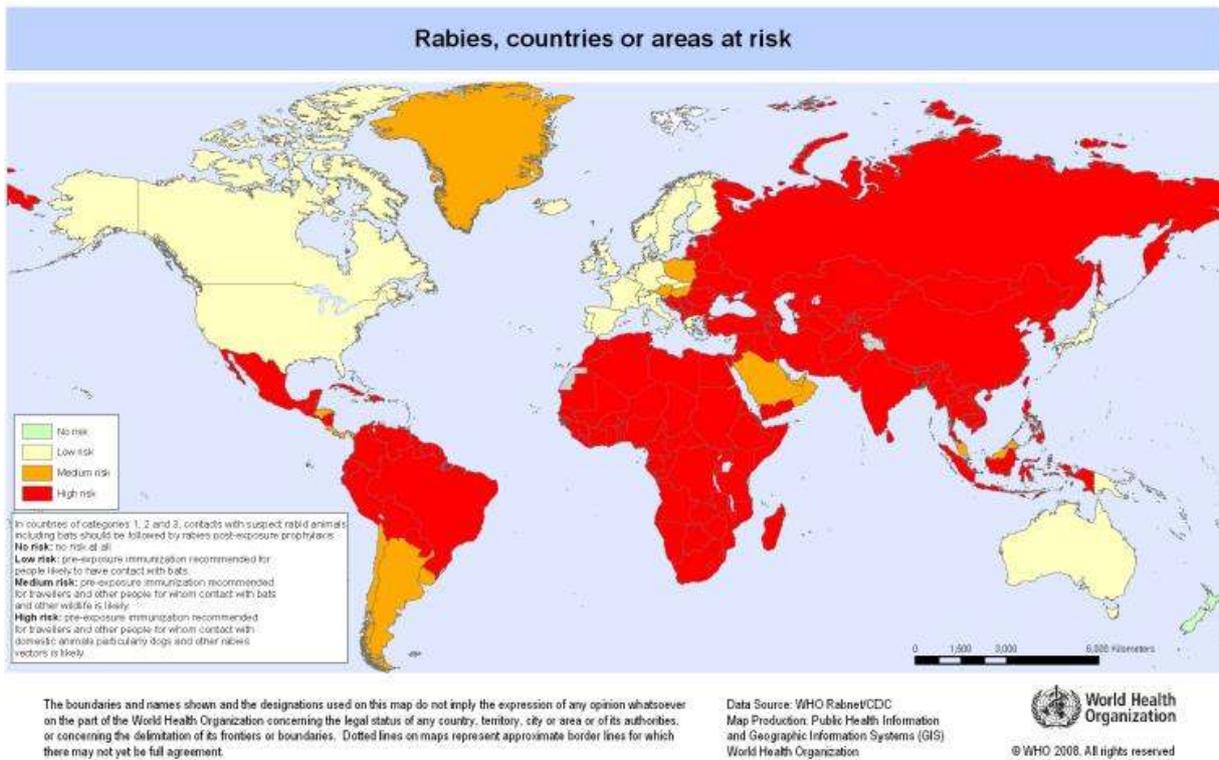
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A5.1.3.1.2 Rabies Virus

6 Rabies virus is a member of the viral family Rhabdoviridae and the genus *Lyssavirus*. It can cause severe
7 human disease (typically resulting death) and is known to cause thousands of deaths each year,
8 especially in developing countries (Figure A5-5). The natural hosts of rabies virus are mammals, primarily
9 carnivores and bats. Rabies is primarily transmitted among susceptible individuals through bite wounds.
10 Guam is known to be free of rabies, as is Hawai'i. Wildlife poses a potential threat to the introduction of
11 rabies to Guam through the importation of wildlife (deliberate or not), especially through bats and
12 carnivores. Further, this virus poses a serious threat to human, agricultural, and wildlife health. Of
13 interest, in a recent risk assessment of wildlife importation into the United States, rabies viruses,
14 including zoonotic lyssaviruses, were listed as being able to potentially affect 155 of 190 genera
15 analyzed (Pavlin et al. 2009). Due to the lack of carnivores in much of the Micronesia Region, the
16 primary wildlife threat of rabies virus spread would appear to be associated with bat and feral
17 carnivores on these islands. However, the small Indian mongoose, *Herpestes javanicus*, is well-
18 established in parts of Hawai'i (Baldwin et al. 1952); although Hawai'i is rabies free, this species is known
19 to be a major reservoir and vector of rabies on other islands such as Puerto Rico (Everard and Everard
20 1988).

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Figure A5-5: Global Distribution of Rabies, Based on Risk to Travelers



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Source: WHO 2010b

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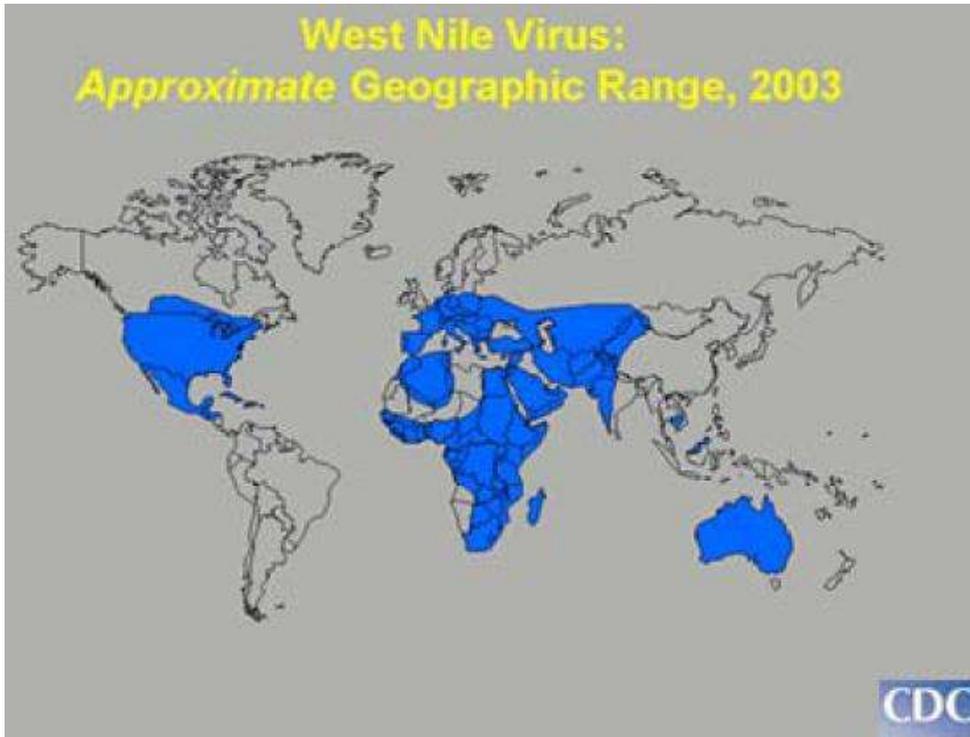
A5.1.3.1.3 West Nile Virus

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WNV is an arthropod-borne virus (i.e., an arbovirus) of the viral family Flaviviridae that is now common in many regions of the world (Figures A5-6 and A5-7). The normal transmission of WNV is thought to be associated with transmission of the virus from mosquito vectors to certain bird species (McLean et al. 2002). The virus is known to be able to cause severe disease in humans, some bird species, and some mammals. The mosquito *Aedes albopictus*, which is known to have occurred on Guam since 1944 (Rozeboom and Bridges 1972), is thought to be an efficient vector of WNV in a laboratory setting (Turell et al. 2005) (see Table A5-10). Although Guam does not have a rich avian fauna, some islands in the Micronesia Region still possess many avian species. Thus, this virus could pose a threat for some of these species if it were to be introduced into an area with competent vectors through the introduction of mosquitoes or viremic birds. For example, workers have estimated that a small number of WNV infected mosquitoes could reach Hawai'i by airplane each year following the expansion of this virus to the western United States and that U.S. exemptions of quarantine regulations (at the time of publication or earlier) could lead to the inadvertent importation of a small number of viremic birds each year (Kilpatrick et al. 2004). If introduced, WNV could have a severe biological impact on some bird populations in the Micronesia Region, such as the limited native bird populations on Guam which have already had severe population declines and extinctions due to the introduction of invasive species. In addition, a severe biological consequence exists in terms of human health and safety from this virus if the appropriate mosquito vectors are present on the island in question. Testing of 108 avian serum

1 samples and 2 pig serum samples collected in early 2010 by our group on Guam and Saipan were all
2 negative for generic flaviviruses (Franklin et al. unpublished data), which suggested that WNV was not
3 present in the samples we tested.

4 **Figure A5-6: Global Distributions of WNV**



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6 Source: CDC 2010a
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Figure A5-7: Global Distributions of JEV



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3 Source: CDC 2010a

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Table A5-10: Native and Introduced Mosquito Species in Guam and CNMI

Species	Distribution	Potential disease through pathogen transmission	Global distribution	References ^b
ENDEMIC				
<i>Aedes oakleyi</i>	Anatahan Island Saipan and Guam	None found	Belongs to a group found throughout Australian, Papuan, Oriental, Indomalayan, South and West Pacific regions	1,3,4
<i>Aedes pandani</i>	Guam, CNMI	None found	Micronesia Region	1,4
<i>Aedes rotanus</i>	Guam, CNMI	None found	Micronesia Region	1,4
<i>Aedes saipanensis</i>	Guam, CNMI	None found	Micronesia Region	1,3,4
<i>Aedes guamensis</i>	Guam, Rota, Saipan, and Tinian	None found	Guam, Rota, Saipan, Tinian	1,4
<i>Culex litoralis</i>	Guam, CNMI	None found	Guam, CNMI	1,4
<i>Culex annulirostris marianae</i>	Guam, CNMI	Japanese encephalitis	<i>C. annulirostris</i> has a broad distribution in Pacific	1,3,4
COSMOTROPICAL INTRODUCTIONS				
<i>Aedes vexans</i>	Guam, Saipan	Japanese encephalitis, Dirofilariasis	Cosmotropical	1,2,3,4
<i>Culex quinquefasciatus</i>	Guam, Saipan	St. Louis encephalitis, Japanese encephalitis, Chikungunya fever, Avian malaria	Cosmotropical	1,2,3,4
ORIENTAL INTRODUCTIONS				
<i>Anopheles indefinitus</i>	Guam, Saipan	Malaria	Species extends from Malaya and Java to Taiwan and Philippines	1,3,4
<i>Culex fuscocephalus</i>	Guam	Japanese encephalitis	Widespread in Asia and found to be naturally infected with two strains of JEV in Thailand	1,2,4
<i>Anopheles barbirostris</i>	Guam	Japanese encephalitis	Widespread in Asia	1,2,4
<i>Anopheles litoralis</i>	Guam	Malaria vector in Philippines	Philippines	1,4
MICRONESIA INTRODUCTIONS				
<i>Aedes neopandani</i>	Guam, Rota, Saipan and Tinian	None found	Endemic to Saipan and Tinian. Introduced onto Guam and Rota	1,3,4
GLOBAL INTRODUCTIONS				

Species	Distribution	Potential disease through pathogen transmission	Global distribution	References ^b
<i>Aedes albopictus</i> ^a	Guam, Saipan	Dengue fever, Chikungunya fever, select hemorrhagic fevers, Japanese encephalitis, yellow fever, West Nile fever, western equine encephalitis	Abundant on many Pacific islands and responsible for Dengue epidemics on Guam	1,2,3,4
<i>Culex sitiens</i>	Guam, Saipan	Japanese encephalitis	Wide distribution through S. Pacific islands, Oriental, Papuan, Australian, Afrotropical and Palearctic areas	1,2,3,4
<i>Aedeomyia catastica</i>	Guam	None found	Distributed from India and Philippines to Fiji and North Australia	1,4
<i>Culex tritaeniorhynchus</i>	Guam, Saipan	Japanese encephalitis, Chikungunya fever, Sindbis fever	Widely distributed in Oriental, Afrotropical and Asian areas. Most important vector of Japanese encephalitis in Oriental region. Potentially involved in Japanese encephalitis outbreak in Saipan in 1990	1,2,3,4
<i>Mansonia uniformis</i>	Guam	Chikungunya fever	Old World tropics	1,2,4
<i>Armigeres subalbatus</i>	Guam	None found	Widely distributed through Oriental region	1,4
<i>Culex fuscans</i>	Guam, Saipan	Japanese encephalitis	Records of occurrence on Saipan/Rota. Widely distributed through Oriental region, Asian Palearctic, and Pacific islands	1,3,4
<i>Anopheles vagus</i>	Guam	Malaria	India, China, Indonesia, Borneo, and Philippines	1,2,4
<i>Anopheles subpictus</i>	Guam	Malaria	Middle East to India, Indonesia, New Guinea, Philippines	1,2,4

1 ^a Since the eradication of *Aedes aegypti* in 1945, *A. albopictus* has filled the *A. aegypti* niche and could be responsible for future Dengue outbreaks on
2 Guam.

3 ^b Reference codes: 1 = (Ward 1984); 2 = (Knechtges 1989); 3 = (Mitchell et al. 1993); 4 = (Nowell 1977).

1 **A5.1.3.1.4 *Highly Pathogenic Avian Influenza***

2 Avian influenza is a highly contagious disease of birds caused by influenza viruses from the family
3 Orthomyxoviridae, genus *Influenzavirus A*. AIVs are found worldwide and are closely related to human
4 and swine influenza viruses. While there are three influenza types—influenza A, influenza B, and
5 influenza C—all avian influenzas are type A. AIVs are a threat to humans, poultry, and wild birds. Humans
6 can be directly infected with AIVs and these viruses have the potential to recombine with mammalian
7 influenza virus strains to form novel strains that readily transmit between humans and have pandemic
8 potential. Poultry may experience reduced productivity or mass die-offs in response to different AIV
9 strains. Moreover, wild birds can suffer severe disease from some AIV strains.

10 The primary reservoirs for AIVs are wild birds, especially waterfowl, seabirds, and shorebird species.
11 AIVs have been isolated from more than 90 species and 13 orders of birds (CIDRAP 2010). Wild birds
12 have been associated with all known subtypes of Influenza A viruses. While wild birds are the natural
13 hosts for Influenza A viruses, many mammals such as humans, cats, dogs, pigs, horses, marine mammals,
14 mice, and rats are spillover species that can become infected with the low pathogenic strains of the
15 virus.

16 AIVs generally cause little or no disease in wild birds, but may cause significant disease in poultry. The
17 pathogenicity of an AIV is based on its ability to cause severe morbidity or mortality to poultry. Low
18 pathogenic AIVs (LPAIV) cause mild disease in poultry whereas AIVs (HPAIV) cause significant disease
19 and/or death in poultry. HPAIV that cause significant disease in poultry species may cause little or no
20 disease in wild birds which can be asymptomatic spreaders of the virus. Alternatively, HPAIV may cause
21 severe illness and death in wild species.

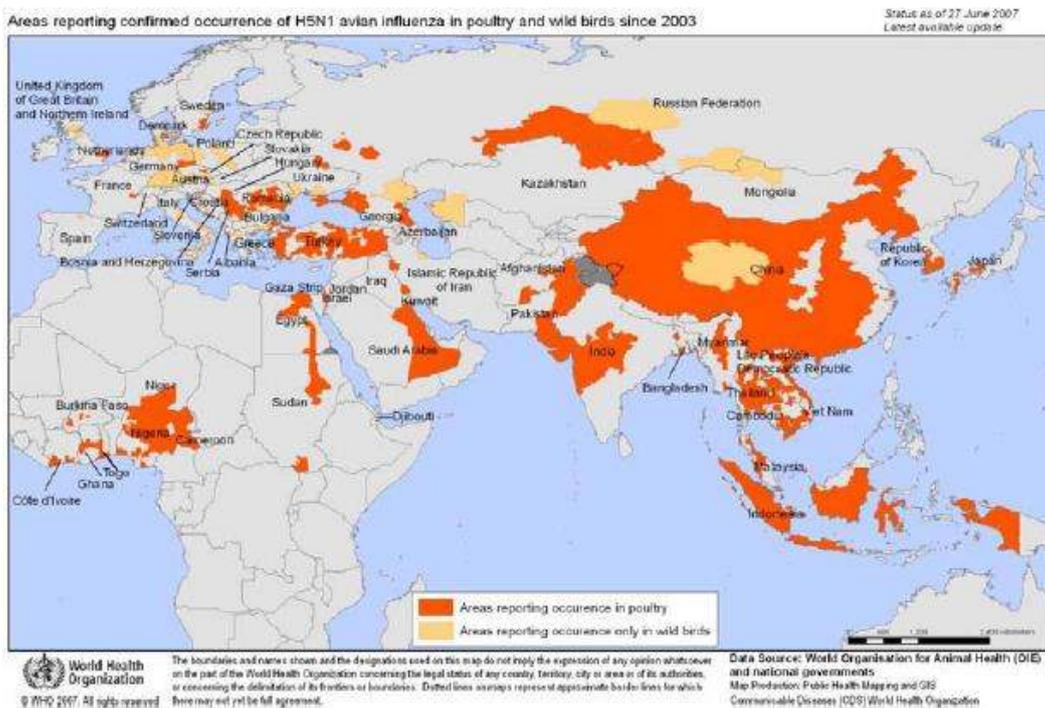
22 Influenza viruses are very dynamic and have a high capacity to evolve. Viral evolution generally occurs
23 via small genetic changes over time or via abrupt changes in response to novel environments. HPAIV are
24 thought to develop when poultry species are exposed to LPAIV from wild birds and the virus undergoes
25 a major change in response to a different host species. Alternatively, novel influenza viruses can also
26 evolve via genetic reassortment which occurs when a host species is infected with more than one strain
27 of influenza virus and the two viruses recombine into a new strain. Although wild birds may become
28 infected and transmit HPAIV, they are not associated with the development of HPAIV strains. To date, all
29 HPAIV have been subtypes including an H5 or H7 hemagglutinin surface protein.

30 While AIVs are closely related to human influenza A viruses, human and avian virus strains exhibit
31 significant genetic differences. Currently only subtypes H1N1, H1N2, and H3N2 are readily transmitted
32 between humans. Nonetheless, some AIVs, including H5N1, H7N2, H7N3, H7N7, H9N2, and H10N7, have
33 been known to cause human infections. Serological testing has shown human exposures to H3, H4, and
34 H6 subtypes. HPAIV do not readily transmit to humans, but humans can become infected with these
35 viruses. HPAIV infections in humans can cause disease symptoms that range from mild to severe.
36 Similarly, LPAIV do not generally infect humans and the infections that do occur are usually limited to
37 people that have extended and direct contact with birds. Most humans infected with LPAIV are
38 asymptomatic or develop conjunctivitis. However, in some cases, LPAIV infections have been known to

1 cause influenza-like symptoms. An influenza pandemic occurs when a novel subtype is introduced into
2 the human population, the novel virus causes serious illness, and the virus spreads easily from person to
3 person.

4 While a novel influenza virus can evolve at any time, currently the major avian influenza threat is from
5 highly pathogenic Asian-strain H5N1. This virus was originally detected in Hong Kong in 1997 and re-
6 emerged as an outbreak that began in poultry in Southeast Asia in 2003. The virus has spread to
7 domesticated and wild birds in Asia, Europe, the Pacific, the Middle East, and Africa and is now
8 considered endemic in Southeast Asia (Figure A5-8 and A5-9). To date, highly pathogenic Asian-strain
9 H5N1 has been associated with the death or depopulation of tens of millions of poultry, severe disease
10 in some wild birds, and more than 500 human cases (including nearly 300 deaths). As of July 2010,
11 human cases have occurred in Indonesia (166), Vietnam (119), Egypt (109), China (39), Thailand (25),
12 Turkey (12), Cambodia (10), Azerbaijan (8), Iraq (3), Pakistan (3), Bangladesh (1), Djibouti (1), Myanmar
13 (1), and Nigeria (1) (WHO 2010a). For obvious reasons, the introduction of this virus into the Micronesia
14 Region could have devastating economic effects due to loss of tourism revenue.

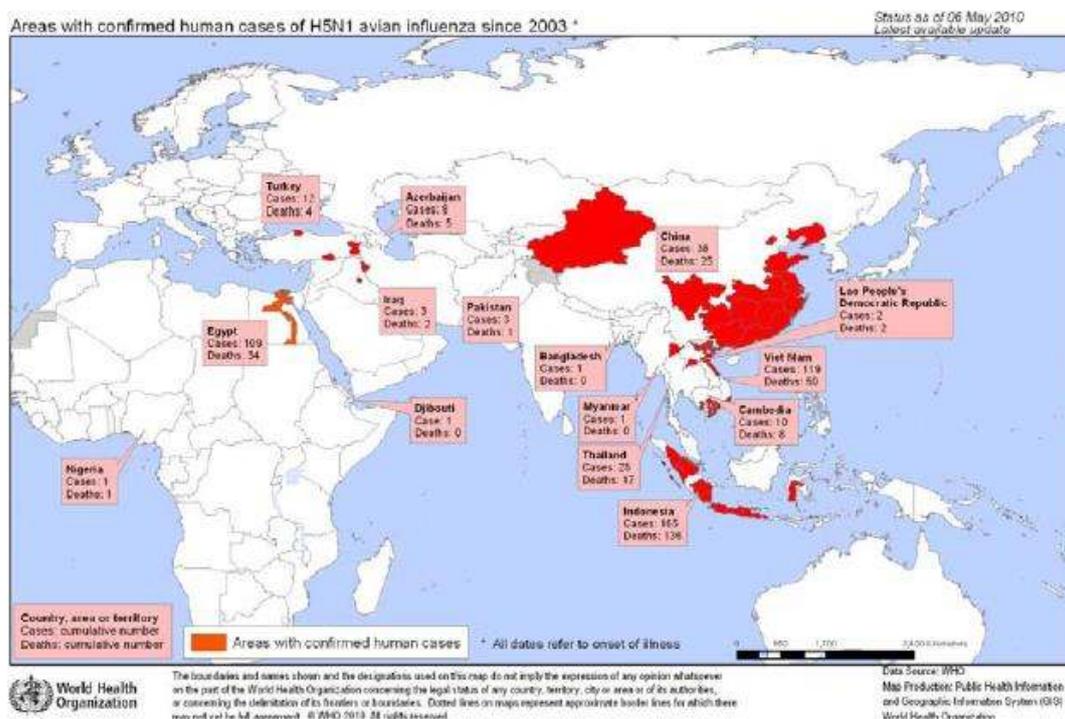
15 **Figure A5-8: Global Distribution of Asian-Strain H5N1 AIV Detected In Poultry and Wild**
16 **Birds, Including Fatalities**



17
18
19

Source: WHO 2006

1 **Figure A5-9: Global Distribution of Asian-Strain H5N1 AIV Detected In Human Cases,**
 2 **Including Fatalities**



3
 4 Source: WHO 2006
 5

6 The primary shedding pathway in wild birds is fecal excretion of the virus accompanied by some
 7 respiratory shedding. Shedding in feces versus respiratory tissues can vary by strain. For example, the
 8 highly pathogenic Asian-strain H5N1 virus has been found to exhibit higher shedding rates in
 9 oropharyngeal swabs compared to cloacal swabs. Feces deposited in water (ponds, lakes, reservoirs, and
 10 streams) by wild birds are most hazardous when the virus does not become diluted due to large water
 11 volume and/or movement. The virus can be transmitted to suitable hosts by ingestion of contaminated
 12 water, eye contact with contaminated water, or possibly by inhalation of aerosols.

13 Avian influenza infection occurs by direct contact with infected individuals via their feces or respiratory
 14 secretions or contact with contaminated materials (vehicles, clothing, shoes, food, water, crates, and
 15 cages). Transmission can also occur from contact with tissues from an infected animal. Virus can be
 16 moved by wild bird movement or transportation of infected birds, or it can be transported on humans
 17 and their machines. Aerosol transmission is unlikely, but may occur in enclosed, high density poultry
 18 operations. Vertical transmission is unlikely because virus causes egg death such that exposed eggs do
 19 not hatch. However, transmission can occur if chicks are exposed to broken infected eggs. Currently it is
 20 unknown whether HPAIV can become endemic in wild birds or if infections are a result of spillover from
 21 infected poultry.

1 Cool temperatures and the presence of organic material favor long term AIV survival in the
 2 environment. Different subtypes and conditions lead to differential virus survival. Virus can persist for
 3 long periods in water. Webster et al. (1978) were able to detect virus for up to 32 days at 4° C and for 4
 4 days at 22° C. More recently, Stallknecht et al. (1990) found that AIV could persist for 207 days in
 5 distilled water at 17°C and 102 days at 28°C. Brown et al. (2009) found that pH, temperature, and
 6 salinity affect the survival of AIVs. Virus is viable in liquid feces for 30 to 35 days at 4° C and for 7 days at
 7 20° C (Webster et al. 1978). LPAIV H7N2 persists for up to 2 weeks in feces and on cages, and
 8 composting kills most strains of AIV within 10 days (OIE 2009m).

9 Capua and Alexander (2004) summarized global avian influenza outbreaks and showed that the number
 10 of outbreaks has been increasing over the last decade (Table A5-11).

11 **Table A5-11: Major HPAI Outbreaks in Poultry**

Year	Subtype	Location	Impact	Comments
1983	H5	United States	17 million birds depopulated	Similar LPAIV had been detected in the previous 6 months (Swayne 2008)
1994-2003	H5N2	Mexico	Nearly 1 billion birds sick or culled	
1995-2003	H7N3	Pakistan	3.2 million birds died in 1995	Outbreak controlled via vaccination
1997	H5N1	Hong Kong	1.5 million birds depopulated/died in 3 days	18 human cases with 6 deaths; first human case of H5N1 infection
2002	H7N3	Chile	618,00 birds depopulated on one farm	First report of HPAIV in South America
2003	H7N7	Netherlands	30 million birds depopulated/died; 255 infected flocks	Spread to Belgium; outbreak rapidly controlled
2003-2010	H5N1	Asia, Europe, Africa	Panzootic; Nearly 300 million birds depopulated/died	Now considered endemic in Southeast Asia, more than 500 human cases and nearly 300 deaths
2004	H5N2	United States		
2004	H7N3	British Columbia	More than 19 million birds depopulated/died	Two human cases (conjunctivitis)
2005	H7	North Korea	Approximately 200,000 birds depopulated/died	

12 Source: Capua and Alexander 2004
 13

14 **A5.1.3.1.5 Japanese Encephalitis**

15 Japanese encephalitis is a disease caused by the arthropod-borne Japanese encephalitis virus (JEV)
 16 which is a member of the genus *Flavivirus* in the family Flaviviridae. Japanese encephalitis is a significant
 17 public health concern in Asia. While the majority of infections cause subclinical disease, acute
 18 encephalitis may occur and can result in permanent neurologic damage and mortality rates up to 60%
 19 (CDC 2010a). JEV is widespread in eastern, southeastern and southern Asia with 30,000 to 50,000 cases

1 reported annually (Umenai et al. 1985). Major epidemics have occurred in China, Korea, Japan, Taiwan,
2 and Thailand and minor epidemics have occurred in Vietnam, Cambodia, Myanmar, India, Nepal, and
3 Malaysia (see Figure A5-9). Epidemics are typically controlled by vaccination which can result in
4 significant economic impacts due to the high cost of the vaccine. JEV has been spreading both eastward
5 and westward (Mackenzie 2007). Currently Japanese encephalitis has spread to Indonesia, New Guinea,
6 and Northern Australia. While not currently established in the Micronesia Region, an outbreak occurred
7 in Guam in 1947/1948 (Hammon et al. 1958) and in Saipan in 1990 (Mitchell et al. 1993; Paul et al.
8 1993).

9 Wild birds, especially members of the family Ardeidae (herons and egrets) are the primary enzootic host
10 species for JEV and mosquitoes are the primary vector. Wild birds do not generally exhibit clinical
11 disease associated with JEV infection, but infected birds develop high viremias. Pigs are considered to be
12 a primary amplifying host for the virus and an important host species associated with Japanese
13 encephalitis outbreaks in humans.

14 In endemic areas in the tropics JEV is continuously transmitted between birds, pigs, and mosquitoes.
15 Humans become infected as a result of being bitten by an infected mosquito. One of the main mosquito
16 vectors is *Culex tritaeniorhynchus*, which is currently established in Guam and Saipan (Nowell 1977;
17 Ward 1984; Knechtges 1989; Mitchell et al. 1993). The virus is maintained by mosquitoes becoming
18 infected by taking a blood meal from wild birds and pigs infected with JEV. Infected mosquitoes can then
19 transmit the virus to susceptible wild birds and pigs where the virus replicates.

20 Definitive introduction pathways for the previous Japanese encephalitis outbreaks in Guam and Saipan
21 were not determined. Possible routes (Paul et al. 1993) are viremic mammals or birds, introduction of
22 infected mosquitoes or their eggs, or the movement of a viremic human. Some workers (Paul et al.
23 1993) also note that CNMI hosts several migratory bird species that migrate from Japanese encephalitis-
24 endemic countries to CNMI, such as the black-crowned night heron, the plumed egret, and the cattle
25 egret—all of which have the potential to develop adequate viremias for infecting mosquitoes (Buescher
26 et al. 1959). Likely routes of JEV introduction or re-introduction include migratory birds (Van Den Hurk et
27 al. 2009), migratory bats (Nga et al. 2004), especially fruit bats (Sulkin and Allen 1974), windblown
28 mosquitoes (Ming 1993; Ritchie and Rochester 2001), and incidental transport of infected mosquitoes
29 on aircraft (Haseyama et al. 2007).

30 **A5.1.3.1.6 Avian Malaria**

31 Avian malaria is a parasitic disease caused by protozoans in the genus *Plasmodium* that can infect birds.
32 *Plasmodium* parasites belong to the Haemosporidia family. The parasites reproduce in avian red blood
33 cells and if parasite loads becomes high enough red blood cells are lost and anemia may occur. The
34 parasites are not transmitted directly between birds, but are moved between hosts by mosquito vectors
35 (see Table A5-10), such as *Culex quiquefasciatus*. More than 40 *Plasmodium* species have been
36 described, but the primary species of concern in the Micronesia Region is *P. relictum*, which was
37 introduced into the Hawai'ian Islands and has been associated with significant population declines in
38 endemic Hawai'ian birds. While *Plasmodium* species are common in many continental areas, the

1 mosquitoes that transmit the parasite were traditionally absent in most island archipelagos such that
2 many endemic island bird species evolved in the absence of the parasites and are currently assumed to
3 be highly susceptible to morbidity and mortality associated with avian malaria infection.

4 The distribution of *P. relictum* on the Pacific islands has not been well characterized. Jarvi et al. (2003)
5 found a high prevalence of *P. relictum* in American Samoa along with stable bird populations. Due to the
6 presence of endemic mosquito vectors, the authors suggest *Plasmodium* is endemic in American Samoa.
7 Steadman et al. (1990) did not detect *Plasmodium* species in the Cook Islands and Savidge (1984) did not
8 find *Plasmodium* on Guam. Tompkins and Gleeson (2006) recently showed that *P. relictum* is common in
9 New Zealand, but additional study is needed to determine whether it is endemic or introduced.

10 The pathogen (*Plasmodium relictum*) causing avian malaria is considered one of the 100 worst invasive
11 species on the globe (Lowe et al. 2000). While many birds are susceptible to *Plasmodium* infection,
12 perching birds (Passeriformes) are primarily affected. *Plasmodium* may be a serious threat to endemic
13 Micronesian birds if those species have not evolved in the presence of this parasite.

14 Haemoproteus is another protozoan avian blood parasite genus in the Haemosporidia family. These
15 parasites are represented by more than 140 species, many of which are host specific. Haemoproteus
16 species are transmitted primarily by mosquitoes, but also by some midges and louses. Haemoproteus
17 infections are generally associated with subclinical infections and are considered less of a threat than
18 *Plasmodium* species. Nonetheless, Haemoproteus infections may cause significant disease in some
19 species and have been known to cause significant declines in poultry productivity and in some cases
20 mortality rates can be as high as 20%. Infections with Haemoproteus are sometimes referred to as
21 pseudomalaria.

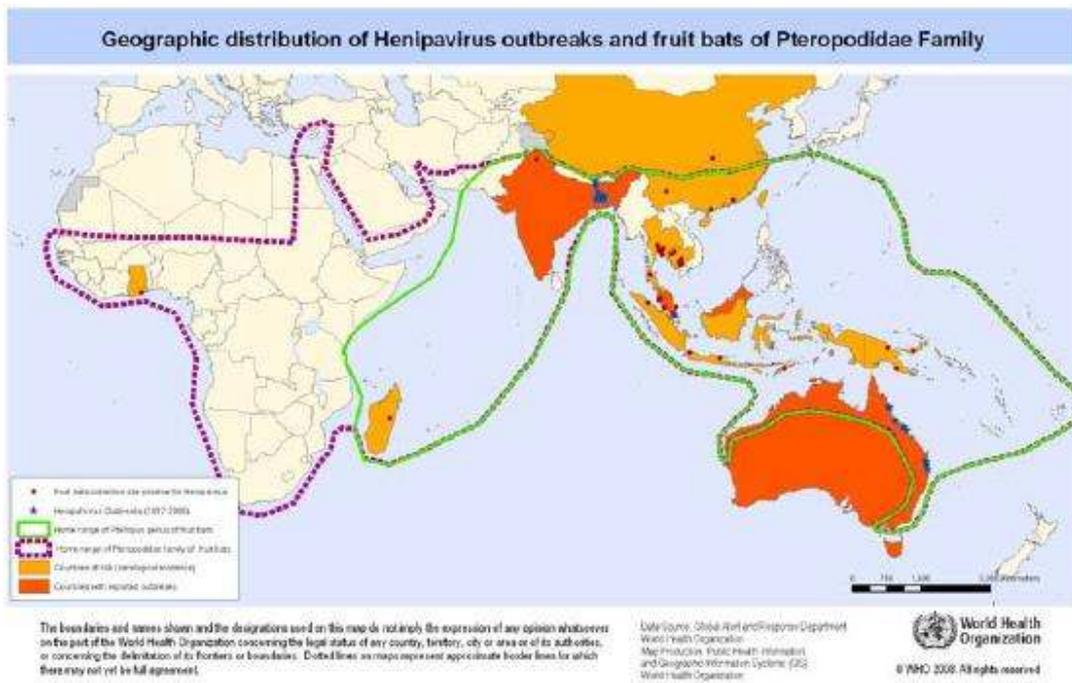
22 Preliminary screening of more than 100 avian serum samples collected by our group in early 2010 on
23 Guam and Saipan is currently ongoing for avian blood parasites (Franklin et al. unpublished data). The
24 blood samples (n=138) were screened for infection based on the presence of blood parasite DNA. The
25 proportion of samples provisionally positive in this initial screen was between 46.4% and 85.5%.
26 Suspected positives from Guam include several introduced species including the Philippine turtle-dove,
27 Eurasian tree sparrow, and bobwhite quail. Two yellow bittern, a common species on Guam, were also
28 suspected blood parasite positives. Subsequent testing on 30 samples from Saipan confirmed 53.3% to
29 be infected with *Plasmodium* species. These confirmed samples include several bridled white-eyes
30 which are endemic and currently listed as endangered. Confirmatory results for all samples are still
31 pending.

32 **A5.1.3.1.7 Henipaviruses**

33 Henipaviruses are zoonotic paramyxoviruses (family Paramyxoviridae) of the genus *Henipavirus* (Halpin
34 et al. 2000; Harcourt et al. 2000). The genus *Henipavirus* was first described based on the emergence of
35 two new viruses, Hendra virus, which first emerged in Australia in 1994, and Nipah virus, which first
36 emerged in Malaysia in 1998/1999. Although Hendra virus has remained confined to northeast
37 Australia, Nipah virus was subsequently detected in other Asian countries, including India and

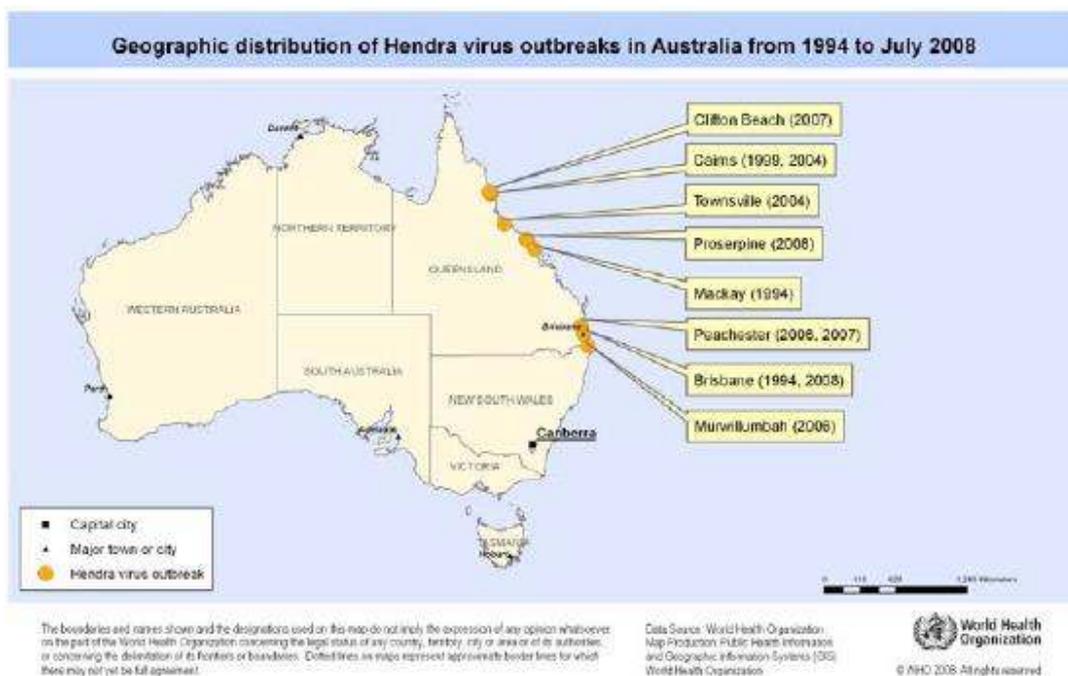
1 Bangladesh (Figures A5-10 and A5-11). The two viruses are similar in that they first emerged in domestic
2 animals (which served as amplifier hosts), were subsequently transmitted to humans, and have fruit
3 bats of the genus *Pteropus* as natural reservoirs (Epstein et al. 2006).

4 **Figure A5-10: Known Distribution of Henipavirus Outbreaks, Mostly Nipah Virus and Hendra**
5 **Virus**



6
7 Source: WHO 2010f
8

1 **Figure A5-11: Geographic Distribution of Hendravirus Outbreaks Currently Confined to**
 2 **Northeast Australia**



3
 4 Source: WHO 2010d

5
 6 Both Hendra and Nipah viruses appear to be relatively stable in the environment. These viruses can
 7 survive for days in fruit bat urine and contaminated fruit juice, have a wide pH tolerance (4.0 to 10.0),
 8 and are inactivated only at high temperatures for relatively long periods (60°C for 60 minutes) (OIE
 9 2010f). Fruit bats are the natural reservoirs for both Hendra and Nipah viruses and generally show no
 10 signs of infection (i.e., are asymptomatic) from either virus.

11 Hendra virus was first discovered in 1994 when it caused an outbreak of severe, acute respiratory
 12 disease in domestic horses on two farms in Queensland, Australia (Murray et al. 1995, Mackenzie et al.
 13 2003). During these initial outbreaks, three humans in contact with the horses contracted the disease
 14 and two died from it (Field et al. 2007). Since then, eight more outbreaks have occurred in horses, all in
 15 northeast Australia (see Figure A5-11; Field et al. (2007)). Three of these outbreaks involved six human
 16 cases, with a case fatality rate of 50% (WHO 2009c). Thus far, horses have been the only domestic
 17 animals that have been naturally infected, with a case fatality rate of about 75% (WHO 2009c). The
 18 incubation period is 8 to 16 days for horses and 5 to 14 days for humans; there are no drugs or vaccines
 19 available to treat Hendra virus infection in either horses or humans (WHO 2009c).

20 Nipah virus was first discovered in pigs in Ipoh, Malaysia in 1998/1999 and was subsequently
 21 transmitted to humans. It was first identified as a swine respiratory and neurological disease, which
 22 spread throughout the Malaysian peninsula (Epstein et al. 2006). In the initial outbreak, 1.1 million pigs
 23 were destroyed and 105 (39.6%) of the 265 humans infected with this virus died (mostly adult male

1 Chinese farmers in contact with pigs) (Mackenzie et al. 2001; Field et al. 2007). Another outbreak
2 occurred during 1999 among slaughterhouse workers in Singapore, where 80% of the pigs slaughtered
3 came from Malaysia (Ling 1999; Chan et al. 2002). Nipah virus has since been detected in five outbreaks
4 in Bangladesh and one outbreak in India between 2001 and 2005 (Wang et al. 2008b). These outbreaks
5 involved 168 human cases with a case fatality rate of 67 to 92% (Wang et al. 2008b). Infections during
6 these outbreaks were also reported in domestic dogs, cats, horses, and goats (OIE 2010f). Average
7 incubation period in humans is 4 to 20 days (WHO 2009e).

8 Fruit bats of the genus *Pteropus* have been implicated as the likely reservoir in the outbreaks of Nipah
9 virus in both pigs and humans. The virus has been detected in urine collected under fruit bat roosts and
10 in fruits partially eaten by free-ranging fruit bats, suggesting two modes of transmission to pigs and
11 humans (Tee et al. 2009). Nipah virus and antibodies have been detected in fruit bats from Thailand,
12 Cambodia, Indonesia, Malaysia, Bangladesh, and India, suggesting widespread dissemination of the virus
13 in fruit bat populations (especially *Pteropus*) in Southeast and South Asia (Reynes et al. 2005; Field et al.
14 2007; Tee et al. 2009). Nipah virus has been classified as a potential agent of bioterrorism because it is
15 an extremely pathogenic organism, with no vaccines or drugs to treat infections (Lam 2003).

16 Hendra and Nipah virus infections can result in extremely high mortality rates in both domestic livestock
17 and humans but generally do not cause clinical signs in fruit bats of the genus *Pteropus*, which appear to
18 be the natural reservoirs for these viruses. The linkage of these viruses with fruit bats is cause for
19 concern when viewed in terms of the Micronesian fruit bat trade.

20 **A5.1.3.1.8 Newcastle Disease Virus**

21 Newcastle disease is caused by viruses in the genus *Avulavirus* in the family Paramyxoviridae. This is a
22 complex of viruses with nine serotypes and five pathotypes (Alexander 2009). Generically, the virus
23 causing Newcastle disease is referred to as NDV (used here) or avian paramyxovirus. Natural or
24 experimental infection of NDV has been demonstrated in 241 avian species from 27 (54%) of the 50
25 taxonomic orders of birds.

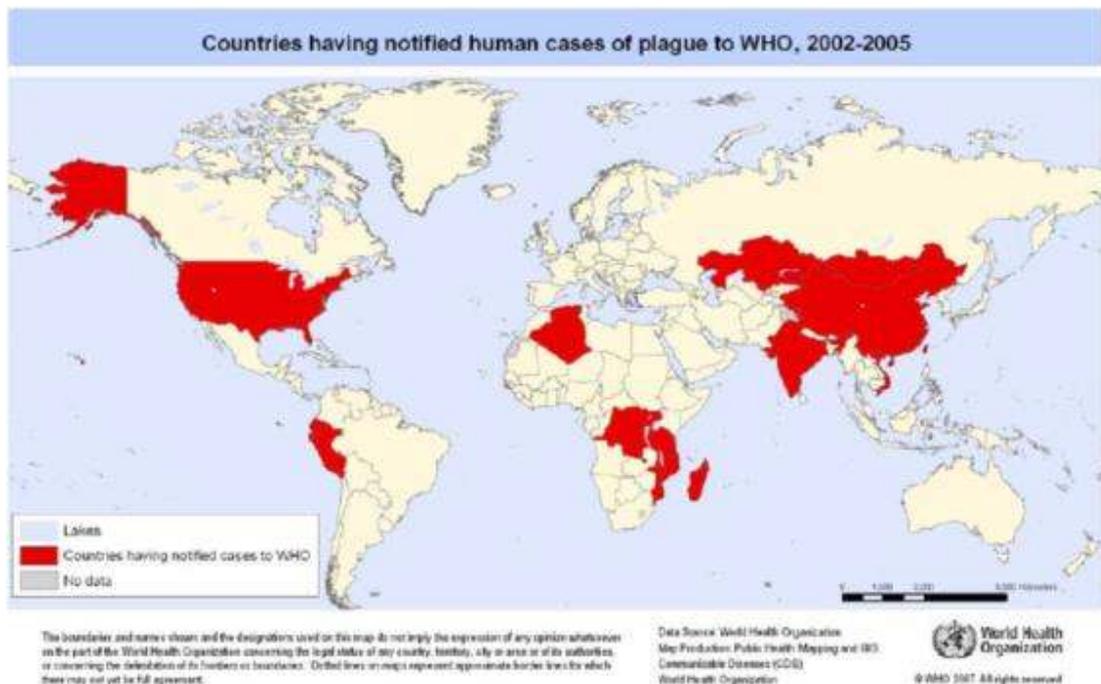
26 Domestic poultry and wild birds are infected by NDV, with the effects of infection dependent on the
27 serotype and pathotype. Although a wide variety of wild birds can remain asymptomatic when infected
28 (Alexander 2009; Coffee et al. 2010), poultry and some wild birds, such as certain passerine species,
29 Galliformes, crows and ravens, pigeons, and parrots, may exhibit severe mortality, depending on the
30 NDV strain (OIE 2010f). Humans are rarely infected and, when infected, show mild symptoms. Thus, NDV
31 is primarily of concern in the Micronesia Region because of effects on poultry and native wild birds,
32 especially pigeons (order Columbiformes).

33 Transmission occurs via direct contact with the secretions of infected birds which can be ingested (most
34 likely) or inhaled; transmission may also occur by way of fomites from feed, water, or equipment. Virus
35 survival is enhanced by the presence of feces (Alexander 2009).

1 **A5.1.3.1.9 *Plague***

2 The effect of plague on humanity has had a long history. It has been estimated that this disease may
3 have caused more than 200 million deaths (WHO 2005a). Significant plague foci are currently recognized
4 in Africa, Asia, North America, and South America (WHO 2005a; Meerburg et al. 2009) (Figure A5-12).
5 Notably, the observation of human cases of plague following decades of inactivity does not always mean
6 that plague foci are re-emerging, as *Yersinia pestis* bacteria have been thought to be naturally
7 maintained and circulated at low levels with no obvious indication of disease in the rodent populations
8 (Duplantier et al. 2005).

9 **Figure A5-12: Global Distribution of Human Cases of Plague, 2002–2005**



10
11
12 Source: WHO 2006
13

14 Plague is a rodent-associated, flea-borne infectious disease caused by the bacterium *Yersinia pestis* (CDC
15 2010f). Overall, this organism is found in rodents and their fleas in many regions of the world (WHO
16 2005a). Human plague infections are typically associated with being bitten by a rodent flea infected with
17 *Yersinia pestis* or by handling an infected rodent or other animal (WHO 2005a; CDC 2010f). Over 200
18 species of mammals (typically rodents and lagomorphs) are known to have been naturally infected with
19 *Yersinia pestis* (Gage and Kosoy 2005; WHO 2005a), although only a small number of these species that
20 have been exposed to the bacterium are considered significant hosts (Gage and Kosoy 2005). Untreated
21 plague has high case fatality rates (WHO 2005a). Globally, there are typically 1,000 to 3,000 human
22 cases of plague reported annually (CDC 2010f).

1 **A5.1.3.1.10 *Tick-borne Encephalitis***

2 Tick-borne encephalitis is a zoonotic disease caused by the tick-borne encephalitis virus (TBEV). TBEV is a
3 member of the genus *Flavivirus*, family Flaviviridae and is endemic throughout much of Europe and far-
4 eastern Asia. Three main subtypes of TBEV have been identified: European, Siberian, and far-eastern
5 (reviewed by Gritsun et al. 2003). While a majority of infections are asymptomatic, the reported case
6 mortality rates for tick-borne encephalitis are approximately 1 to 2% for European subtype infections, 2
7 to 3% following Siberian subtype infections, and as high as 20 to 40% in far-eastern subtype infections
8 (Gritsun et al. 2003; Mandl 2005). In terms of morbidity, TBEV is second only to JEV among neurotropic
9 flavivirus infections (reviewed by Lindquist and Vapalahti 2008). Safe and effective TBEV vaccines are
10 available but, with the exception of Austria, vaccination campaigns have had limited success due to cost
11 and necessary booster vaccinations (Gritsun et al. 2003).

12 TBEV is transmitted primarily through the bite of an ixodid tick. *Ixodes ricinus* is responsible for most
13 TBEV transmission in western Europe, while *I. persulcatus* is the primary vector in Siberia and the far-
14 east (Lindquist and Vapalahti 2008). The maintenance cycle for TBEV primarily involves ixodid ticks
15 feeding on small rodents. Rodents appear to act as both an amplifying host and a reservoir host for the
16 virus because they can maintain chronic infections throughout the year (Süss 2003; Bakhvalova et al.
17 2006). Humans, large mammals, and birds are also hosts for these same ticks, but are not primary
18 contributors to the TBEV maintenance cycle.

19 Tick-borne encephalitis may be considered an emerging disease as the geographic distribution of TBEV
20 and list of competent *Ixodes* vectors seem to be expanding (Kim et al. 2008; Lu et al. 2008). Generally
21 TBEV is isolated from areas with temperature ranges from 6°C to 25°C, humidity >85%, and a high
22 density of rodent hosts. However, even within areas where *Ixodes* vectors and rodent hosts are
23 abundant, TBEV is found only in small foci indicating that other environmental factors may be key in
24 predicting the risk of TBEV in an area (Lindquist and Vapalahti 2008). It is hypothesized that climate
25 change, social, political, ecological, economic, and demographic factors including changes in land use are
26 also factors that may contribute to increased incidence and risk of TBEV infection (reviewed by
27 Mansfield et al. 2009). Thus far *Ixodes* species have not been isolated from Guam, but *I. mindanensis* has
28 been reported on the island of Palau (Kohls 1957) suggesting that these vectors could thrive in the
29 Micronesia Region if introduced. The presence of rodent hosts, tick vectors, and suitable climate could
30 present a risk of TBEV introduction into Guam.

31 **A5.1.3.2 *Novel Hosts***

32 Some of the vertebrate species in the Micronesia Region are found only on certain islands at this point
33 in time. The musk shrew, *Suncus murinus*, provides a good example. The initial introduction of *Suncus*
34 *murinus* into Guam has been hypothesized to have occurred through cargo materials from ports in the
35 Philippines (Peterson Jr. 1956). Considering its relatively recent introduction into Guam, this species may
36 be of considerable risk for introduction into additional islands in the Micronesia Region, although it does
37 occur on more islands than Guam at present. Further, this species is known to play a role in plague
38 cycles in select locations (Duplantier et al. 2005) and is known to host a hantavirus (Calisher et al. 2003).

1 As of 1999, Philippine deer (*Cervus mariannus*) were known to occur on four islands in the Micronesia
2 Region: Guam, Rota, Saipan, and Pohnpei, with populations thought to be increasing on Guam and
3 stable or declining on the other islands at that time (Wiles et al. 1999). The introduction of pathogens
4 affecting this species is unlikely through wildlife-related means. However, this species could potentially
5 be a host of various pathogens affecting deer and related species in other regions of the world,
6 dependent on the introduction of the pathogen and, in some cases, the appropriate vector. Some
7 examples include chronic wasting disease, epizootic hemorrhagic disease, and bovine tuberculosis.

8 There are many avian species on some islands in the Micronesia Region. Some of these are endemic to
9 certain islands. As such, many of the avian species on some these islands have never been exposed to
10 some of the pathogens that have affected birds in other regions of the world (i.e., highly pathogenic
11 H5N1 AIV and WNV).

12 **A5.1.3.3 Potential Trade Partners**

13 During the past decade, Guam imported commodities from several countries, many of which were from
14 Asia. Tourism is a large industry in the Micronesia Region, with the majority of tourists originating from
15 Asian countries for several islands. In terms of the risk of introducing diseases associated with wildlife
16 into the Micronesia Region, movements between Asia and the Micronesia Region are of particular
17 concern because of the number and rate of emerging zoonotic diseases originating from wildlife species
18 in that region (Mackenzie et al. 2001; Jones et al. 2008). It is anticipated that trade and tourism will
19 continue with many of the countries that Guam currently trades with during and after the DoD
20 relocation. In addition, the relatively close proximity of many Asian countries to several islands in the
21 Micronesia Region may facilitate future trade among these countries.

22 The anticipated military relocation on Guam will likely increase construction on this island via increased
23 residences and support facilities. It is anticipated that this may result in a large influx of temporary
24 workers, possibly from Asian countries. Along with these foreign workers, wildlife products may be
25 imported (legally and illegally), which are culturally significant to some of these temporary workers.

26 **A5.2 RISK ASSESSMENT**

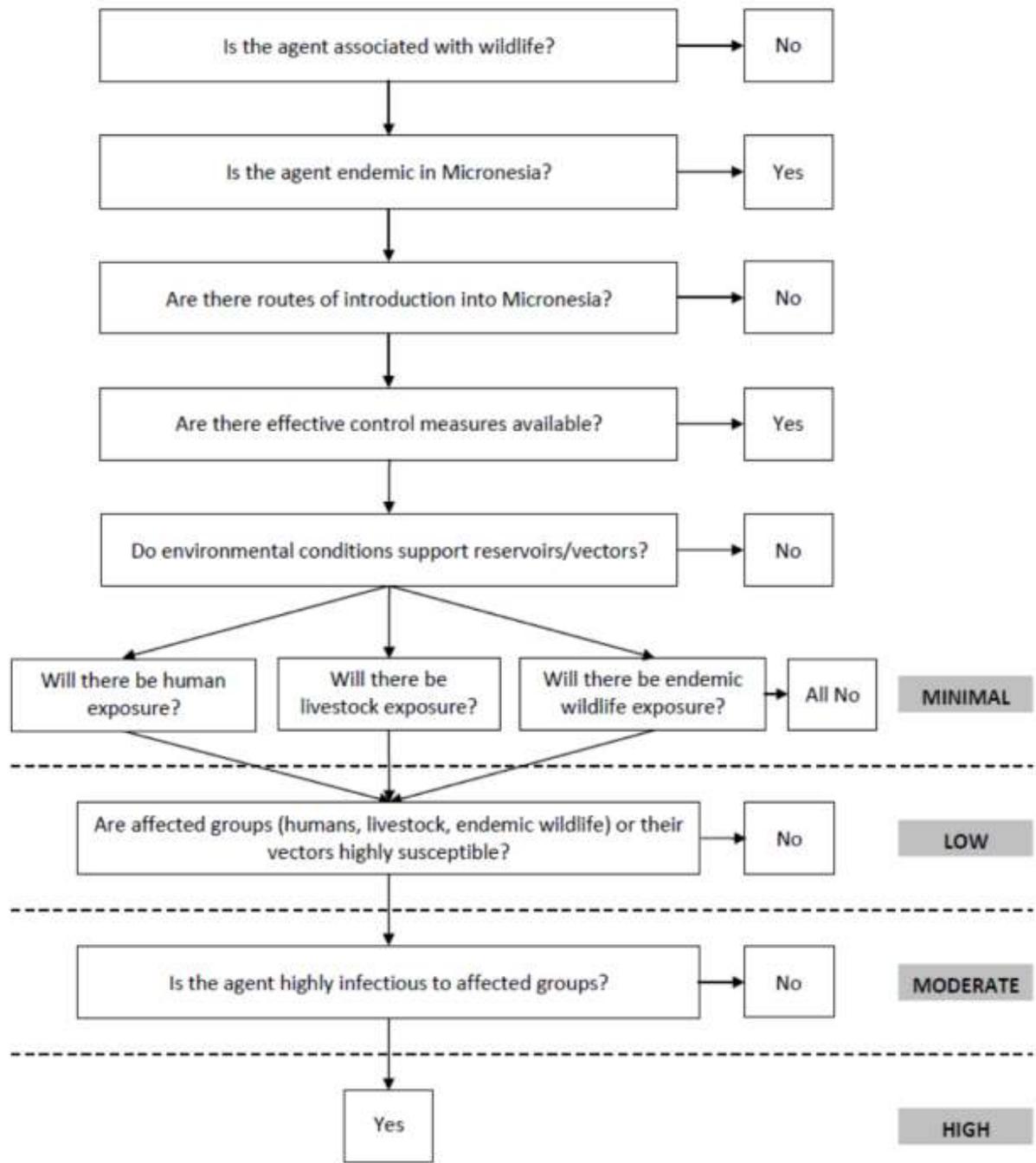
27 **A5.2.1 General Approach**

28 The risk associated with the 10 wildlife-associated pathogens outlined in Section A5.1.3 was assessed
29 following the general procedures outlined by Morgan et al. (2009) for estimating risk for emerging
30 infectious diseases. We focused on these 10 pathogens as they are all associated with Pacific Rim
31 countries that are the most likely trade partners with the Micronesia Region. These pathogens do not
32 represent a comprehensive list of possible pathogens that may enter the Micronesia Region as a result
33 of the military relocation. Rather, they represent the pathogens that we identified as representing
34 potential threats based on the properties of the pathogen in question and the ecology of its host(s).
35 Other potential pathogens are described in Table A5-9. Moreover, emerging pathogens that may
36 become important in the future are not addressed in the following analyses.

1 We adapted the Morgan et al. (2009) approach from a focus on human disease potential to disease
2 potential in humans, livestock, and endemic wildlife species from wildlife-associated diseases. In
3 general, Morgan et al. define risk as the product of the probability that a new infection occurs in the
4 area of interest and the potential impact of the infection. The method uses a series of decision questions
5 in a flow chart format to determine a qualitative estimate of risk for 1) the probability that an agent will
6 cause an infection in the area of interest and 2) the potential impact of the agent.

7 The risk assessment tool comprises two flow charts (Figure A5-13 and Figure A5-14) that characterize
8 the pathogen of interest and assign a level of risk (minimal, low, moderate, high, or very high) based on
9 the answers to the series of questions associated with each chart. The first flow chart addresses the
10 Probability of Infection as a function of a series of eight questions aimed at assessing the likelihood that
11 a pathogen will be introduced and the probability that the agent could be maintained based on
12 environmental conditions, host availability, and host infectiousness. In this risk assessment, the
13 probability of infection refers to the probability of an infectious agent causing infection in the
14 Micronesia Region in human populations, livestock populations, or endemic wildlife populations. The
15 specific questions in the Probability of Infection flow chart aimed at assessing risk are as follows (Figure
16 A5-13):

1 **Figure A5-13: General Procedure Used for Assessing the Probability of Infection from an**
 2 **Infectious Pathogen Associated with Wildlife into the Micronesia Region**



3
 4 Note: See text for explanation.
 5

6 The second flow chart assesses the potential Impact of Infection, or the level of potential harm that
 7 could be caused by the wildlife-associated pathogen in terms of morbidity and mortality. Impact is a
 8 function of the mode of transmission, infectiousness, severity of illness, and whether or not effective

1 interventions are available. The specific questions in the Impact of Infection flow chart are as follows
2 (Figure A5-14):

3 1. Is there spread to affected populations (humans, livestock, or endemic wildlife) or their vectors?
4 Spread should be considered as the potential for both spatial and temporal movement of the
5 pathogen. Factors that affect spread are the infective dose, the virulence of the pathogen,
6 whether or not routes of spread are available, and the susceptibility of affected populations.

7 2. Are wildlife hosts and/or vector populations present in the Micronesia Region?

8 3. Are affected populations susceptible?

9 4. Does the agent cause severe disease in affected populations? Severity refers to the level of
10 harm that can be inflicted on affected populations with respect to morbidity and mortality.

11 5. Is the agent highly infectious to affected populations?

12 6. Are effective interventions available? Factors to consider for assessing interventions are
13 whether or not it is feasible to change the potential impact of the introduction and spread of the
14 pathogen by containing or eliminating the pathogen via treatment or prophylaxis.

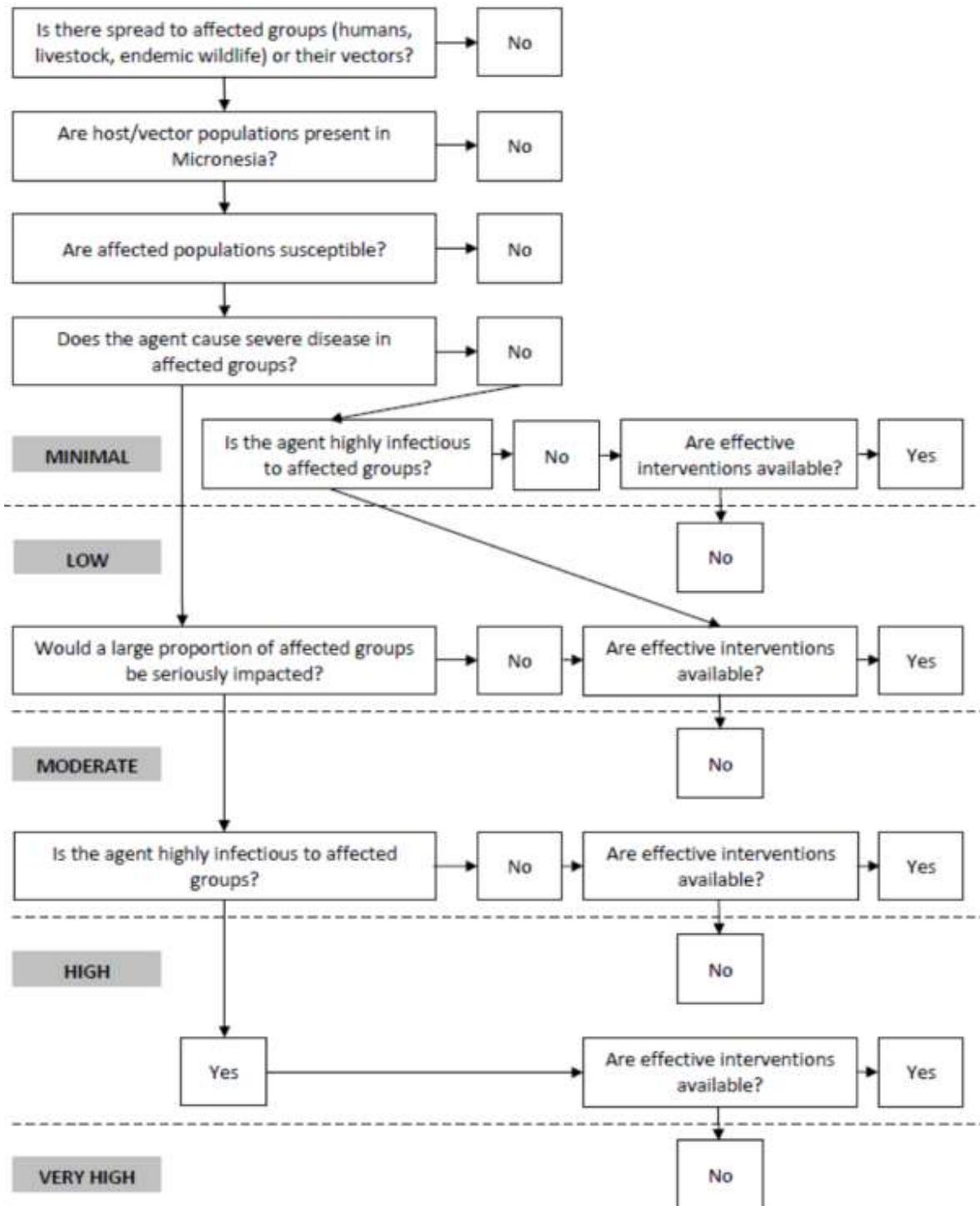
15 7. Would a large proportion of affected populations be seriously impacted?

16 8. Is the agent highly infectious to affected populations?

17 The risk assessment for each agent is based on current knowledge and should be updated and revised as
18 additional information becomes available.

1
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Figure A5-14: General Procedure Used for Assessing the Impact of Infection from an Infectious Pathogen Associated with Wildlife into the Micronesia Region



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1 **A5.2.2 Assumptions**

2 This risk assessment assumes that:

- 3 1. Current knowledge of pathogen, host, and vector distributions and characteristics is
4 relatively accurate. Knowledge gaps create uncertainty in the analyses and are generally
5 represented by alternative risk assignments to account for unknown information.
6
- 7 2. Major trade partners for the Micronesia Region are Pacific Rim countries: the United States
8 (especially Hawai'i), Russia, China, Singapore, Hong Kong, Taiwan, Japan, Indonesia, the
9 Philippines, Korea, Vietnam, Australia, and New Zealand.

10 **A5.2.3 Pathways of Introduction and Spread Associated With the Military Relocation**

11 **A5.2.3.1 People**

12 **A5.2.3.1.1 Military**

13 It is anticipated that the proposed DoD relocation on Guam will bring more than 30,000 people to Guam
14 through permanent military personnel, dependents, transient military personnel, and the DoD civilian
15 workforce (U.S. Navy 2009h) by 2014.⁸ Individual military members and their family members are
16 required to follow rules and laws of the host country in question and the laws and regulations
17 associated with imports to the United States (DoD 2001).

18 **A5.2.3.1.2 Civilian**

19 In addition to the increase in population associated directly with the proposed military relocation, the
20 DoD currently estimates that thousands (up to 18,373) of off-island temporary workers will be needed
21 for construction projects during certain years (U.S. Navy 2009h). There is an insufficient labor force for
22 the construction work associated with this upcoming relocation (U.S. Navy 2009h). During past
23 construction projects, much of the labor force came from China and the Philippines, but some skilled
24 labor came from other locations of the United States (U.S. Navy 2009h). It is anticipated that most off-
25 island construction workers will originate from the Philippines (U.S. Navy 2009h).

26 **A5.2.3.1.3 Methods**

27 Increases in human populations, both military and civilian, are expected to significantly increase the
28 likelihood of wildlife pathogen introductions and spread via humans.

29 **A5.2.3.2 Shipping**

30 **A5.2.3.2.1 Military**

31 The military relocation is expected to significantly increase maritime vessel traffic to accommodate
32 increased commodities to support military personnel and their dependents. Increased maritime traffic
33 will increase the likelihood of pathogen introduction.

⁸ Ibid.

1 It is anticipated that the relocation of the 3rd Marine Expeditionary Unit from Okinawa to Guam will
2 increase the amount of containerized cargo shipped into Guam to support the relocation and the
3 provisioning of increased military personnel stationed there.

4 Naval ships can carry up to 5,000 crewmen, of which up to 43% have been shown to be infected with
5 bacterial and viral pathogens (WHO 2002). Military transportation was the second highest reason for
6 insect invasion behind importation of plant material in Japan (Kiritani and Yamamura 2003).

7 **A5.2.3.2.2 Commercial**

8 Maritime vessel traffic to Guam is expected to increase through more container and break-bulk vessels
9 per year (U.S. Navy 2009f; PAG 2010b). These estimated increases in maritime traffic are expected to
10 significantly increase the likelihood of pathogen introduction.

11 **A5.2.3.3 Air**

12 **A5.2.3.3.1 Military**

13 The military relocation is expected to significantly increase military aircraft traffic to accommodate
14 increased commodities to support military personnel and their dependents. Increased military air traffic
15 will increase the likelihood of pathogen introduction.

16 **A5.2.3.3.2 Commercial**

17 The military relocation is expected to significantly increase commercial aircraft traffic due to expected
18 increases in commodities to support the population increase on the island and increased movement of
19 humans. Increased commercial air traffic will increase the likelihood of pathogen introduction.

20 **A5.2.3.4 Natural Movements**

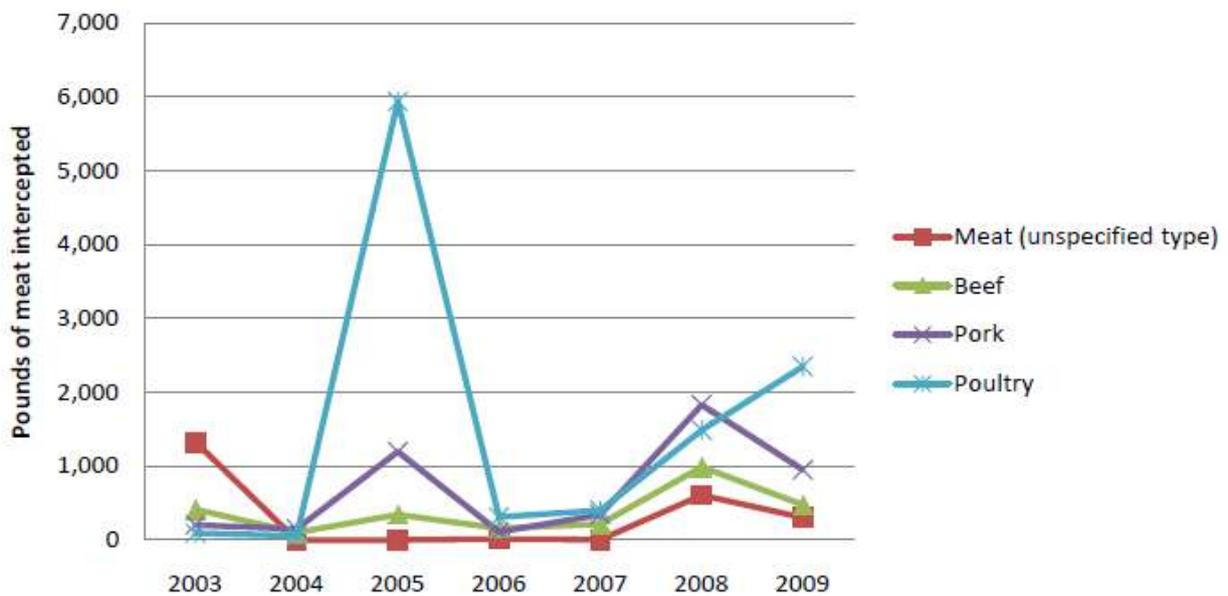
21 The military relocation is not expected to have a significant impact on the introduction of wildlife
22 pathogens via wind, rafting, and natural movements. However, the military relocation may be
23 associated with increased probabilities of establishment and spread of pathogens that are introduced
24 naturally. For example, a zoonotic disease agent is more likely to become established if increased human
25 population densities enhance the likelihood that the pathogen will move into a human host. Similarly,
26 increased human population densities may enhance the likelihood of zoonotic pathogen spread due to
27 higher numbers of susceptible individuals to act as hosts, so long as humans are not dead-end hosts for
28 the pathogen in question.

29 **A5.2.3.5 Smuggling and Legal Wildlife Trade**

30 The military relocation is expected to significantly increase the probability of introduction and spread of
31 wildlife pathogens due to increased demand for illegal and legal wildlife goods associated with the
32 anticipated increase in human population density. Up to 2,722 kg (6,000 pounds) of meat are
33 intercepted annually from travelers and shipments into Guam and Saipan (Figure A5-15 and A5-16), as
34 much as 15% which is from undetermined species. With an increase of foreign workers, there is concern
35 that illegal importation of bushmeat (the meat of wild animals) will increase, depending on the origin of

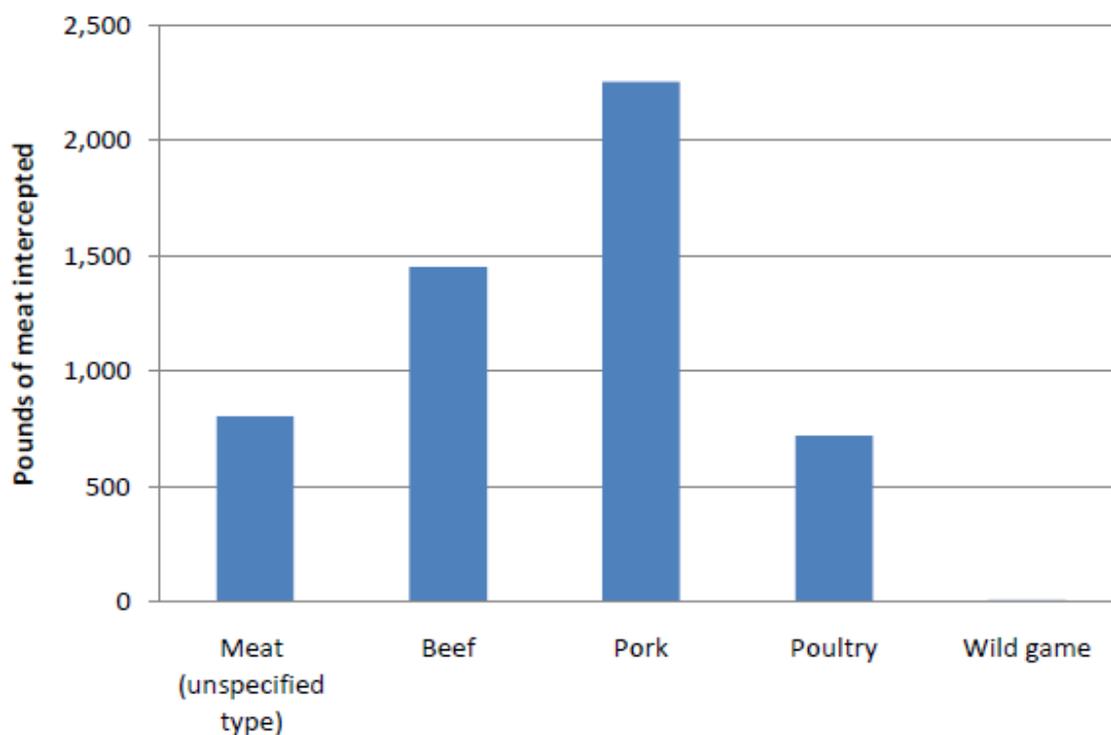
1 workers. Bushmeat is an important component of diet and culture in many parts of the world, especially
 2 Asia and Africa (Milner-Gulland et al. 2003; Chaber et al. 2010). The illegal importation of bushmeat has
 3 become a global problem related to immigration of different cultures. For example, more than 4,990
 4 metric tons (11 million pounds) of bushmeat and wildlife parts were smuggled into the United States
 5 between 2000 and 2004 from 14 species of monkeys, rodents, bats, and apes seized in mail and luggage
 6 (Viegas 2010). Projections indicate that 247,661 kg (273 tons) of bushmeat enter Paris annually via
 7 airline flights from Africa (Chaber et al. 2010) and 4,536 kg (5 tons) annually through Heathrow Airport
 8 in London (Milmo and Garman 2006).

9 **Figure A5-15: Meat Intercepted during Customs Inspections on Saipan from 2003 to 2009**



10

1 **Figure A5-16: Meat Intercepted during Customs Inspections on Guam in 2009**



2
3
4 Of particular concern in the Micronesia Region is the potential importation of fruit bats, which are
5 culturally important in the Micronesia Region and are regularly eaten in Asia (Cambodia, China, India,
6 Indonesia, Lao, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam) and other Pacific islands
7 (American Samoa, Fiji, and New Caledonia) (Mickleburgh et al. 2002). Fruit bats illegally smuggled into
8 the Micronesia Region have the potential of introducing a wide variety of diseases, some of which cause
9 considerable morbidity and mortality in livestock and humans.

10 **A5.2.4 Risk Assessment Steps**

11 **A5.2.4.1 Release**

12 The biological pathways needed for an importation event to release (i.e., introduce) a pathogen are
13 complex with regard to many factors (OIE 2009d). We suggest that small mammals may be key species
14 of risk. In Guam, e.g., unlike domestic carnivores (e.g., cats and dogs, which are required to remain in
15 quarantine and arrive pre-vaccinated against some pathogenic agents; small mammals could arrive
16 undetected via various modes of transportation. Further, these small mammals could arrive from
17 various ports around the world. Although previous deratting procedures and modern recommended
18 ship sanitation procedures have likely led to a less frequent incidence of small mammal stowaways, it
19 likely still happens on occasion.

20 In addition to small mammals, bird species represent a risk pathway for the importation of wildlife-
21 associated disease agents. Infected birds could arrive via natural migration, excessive wind events,

1 smuggling, or intentional importation. Bats are another taxon of concern as they can host a number of
2 important pathogens such as rabies virus, other lyssaviruses, and henipaviruses. While importation of
3 bats is currently illegal outside of Palau, smuggling of bats is considered to occur such that the
4 introduction of a bat-hosted infectious agent into Palau is likely to be disseminated throughout the
5 Micronesia Region via smuggling.

6 **A5.2.4.2 Exposure**

7 **A5.2.4.2.1 Pathogen Properties**

8 The properties of a pathogen certainly influence the probability of it being introduced into a new
9 environment. An important characteristic that can affect the probability that a pathogen is introduced
10 into a novel region is the length of the typical infectious period. Many viruses infect a host but are
11 subsequently cleared by the host through immunological processes. On the other hand, some
12 pathogens cause persistent infections within hosts. In many instances, pathogens causing persistent
13 infections will have a higher probability of introduction when compared to pathogens which are cleared
14 from the host in a short amount of time.

15 Infectivity is another important pathogen attribute in terms of probability of introduction. For example,
16 some viruses are only efficiently transmitted through vector-competent arthropods, while others are
17 easily transmitted from host to host. The latter scenario suggests that multiple hosts may be needed on
18 a long-term movement (e.g., shipping containers) to maintain pathogen viability for pathogens that are
19 quickly cleared by susceptible hosts. Infectivity is also affected by the infectious dose required for an
20 active infection to develop for a particular pathogen. Exposure to agents with a low infectious dose is
21 more likely to result in an infection.

22 **A5.2.4.2.2 Vector and Host Presence**

23 A large number of mosquito species are known to occur on Guam (see Table A5-10). Some are endemic
24 and others have been introduced. Some of these species are known vectors of pathogens in many
25 regions of the world. For example, *Culex quinquefasciatus* is associated with a number of potential
26 diseases (e.g., St. Louis encephalitis, Japanese encephalitis, Chikungunya fever, and avian malaria) and
27 filarial infections (e.g., Bancroftian filariasis and Dirofilariasis). In addition, *Aedes albopictus*, which was
28 first recognized in Guam in 1944 (see Table A5-10) and is abundant on many Pacific islands, is associated
29 with many vector-borne diseases (e.g., Dengue fever, Chikungunya fever, Japanese encephalitis,
30 Dirofilariasis, yellow fever, and West Nile fever) some of which could pose a threat through the
31 introduction of their pathogens into the Micronesia Region. The large-scale global expansion of this
32 mosquito species during the last three decades has increased public health concerns because it is a
33 potential vector of a number of medically important arthropod-borne viruses (Lambrechts et al. 2010).

34 **A5.2.4.2.3 Human and Host Populations**

35 As of 2009, the population of the Micronesia Region was relatively small, estimated to be less than
36 500,000 individuals. The proportions of visitors to Guam are expected to change, with visitors from
37 Japan declining from 80 to 68% of total visitors, visitors from Korea increasing from 10 to 19% of total

1 visitors, visitors from the continental United States and Hawai'i increasing from 4to 5% of total visitors,
2 and visitors from East Asia increasing from 4to 6% of total visitors (PB International 2008).

3 Wildlife host populations are limited in much of the Micronesia Region. In some instances, this may be
4 primarily due to past introductions of invasive species (i.e., BTS). Guam, e.g., has low population levels
5 of most bird species and many of the mammal species (e.g., small mammals) that are found there.
6 When compared to the three major islands of CNMI, the densities of several small mammal species
7 were often notably lower on Guam (Wiewel et al. 2009). Overall, several small mammal species
8 (especially *Rattus* spp.) can be found on many islands in the Micronesia Region. Very few mammals are
9 endemic to these islands. However, many mammalian introductions have occurred in this region, often
10 leading to viable populations. For example, feral swine and Philippine deer are known to occur on
11 multiple islands in the Micronesia Region. In many instances, densities of potential wildlife host
12 populations are limited or non-existent.

13 **A5.2.4.2.4 Human Culture**

14 Human culture in the Micronesia Region directly affects the probability of exposure to wildlife-
15 associated pathogens. Historically many wildlife species, including fruit bats and most avian species,
16 were eaten and hunted by native humans. This legacy increases the probability of close interaction
17 between humans and wildlife and increases the likelihood of human exposure in the event of pathogen
18 importation. In addition, relatively high population densities on Guam increase the likelihood of human-
19 wildlife interactions and consequently the likelihood of pathogen exposure. Increased population
20 densities associated with the military relocation will only exacerbate human-wildlife interactions in the
21 region.

22 **A5.2.4.2.5 Environment**

23 Micronesian countries have tropical climates that offer excellent environmental conditions for a wide
24 variety of wildlife-associated pathogens, wildlife hosts, and vectors. Human environmental exposure to
25 wildlife-associated pathogens is likely to result from contact with vectors (e.g., mosquitoes) while
26 outdoors (for recreation, work, cooling off) as well as disease agents that are able to survive in the
27 environment (e.g., AIVs).

28 **A5.2.4.2.6 Trade**

29 Legal and illegal wildlife trade provides a pathway for exposure/introduction of wildlife pathogens.
30 While few animal hosts are imported legally, disease exposure/introduction may occur from animals
31 with subclinical disease. In addition, illegal importation of wildlife is more likely to cause wildlife-
32 associated pathogen exposure as animals are not checked for signs of disease.

33 **A5.2.4.2.7 Consequences**

34 The consequences of exotic pathogen introductions can be enormous. WNV provides a good example.
35 There is little doubt that the introduction of this virus caused tens of millions of dollars in costs
36 associated with animal infections, disease, and/or human health. For example, an outbreak of WNV in
37 Louisiana during 2002 was estimated to cost more than \$20 million to treat illnesses and for public

1 health responses (e.g., mosquito control) (The Associated Press 2004). During 2002, this virus was
2 thought to cost the equine industry hundreds of thousands of dollars in Colorado and Nebraska (USDA-
3 APHIS-VS 2003b). During 2005, a WNV outbreak in Sacramento County, California was estimated to have
4 cost nearly \$3 dollars (Barber et al. 2010).

5 Emerging infectious diseases of wildlife pose a substantial threat not only to human health but also to
6 wildlife conservation (Daszak et al. 2000). For example, the introduction of WNV has affected wildlife
7 conservation issues, as has been the case with sage grouse (Naugle et al. 2004). Further, several
8 extinctions and near extinctions of local animal populations that have been thought to have been
9 directly caused by disease have been noted (Woodroffe 1999).

10 **A5.2.4.2.8 Estimation**

11 Because information is often lacking for specific pathogens, alternative answers to the risk assessment
12 questions listed elsewhere in this document were considered in cases where a definitive answer could
13 not be confidently drawn. In such cases the most likely qualitative risk level is assigned, but the
14 alternative outcome is also reported. In order to visualize the assignments of risk and potential
15 alternatives, for each wildlife-associated pathogen considered, the flow charts for Probability of
16 Infection and Impact of Infection are filled in to represent the answers to the series of questions. The
17 more likely path is filled in as gray and if an alternative path and risk assignment is considered, it is
18 represented with cross-hatching in the flow chart (Figure A5-17 through Figure A5-36). As noted
19 previously, in addition to considering multiple risk categories for pathogens lacking complete
20 information, risk assessments should be updated in response to new information or developments. The
21 following section describes our estimates of risk of introduction for specific wildlife-associated
22 pathogens. The categorization of risk for each of these pathogens is summarized in Table A5-12.

23 **HANTAVIRUSES** (described in Section A5.1.3.1)

24 **PROBABILITY OF INFECTION** (Figure A5-17)

25 **Is the agent associated with wildlife?** Yes, the reservoir hosts are small mammals (rodents, most often
26 mice and rats, also insectivores, such as shrews).

27 **Is the agent endemic in the Micronesia Region?** No, but host species are known to occur. No detections
28 have been reported, but Seoul virus (an old world hantavirus) is known to have been imported into
29 ports in the New World.

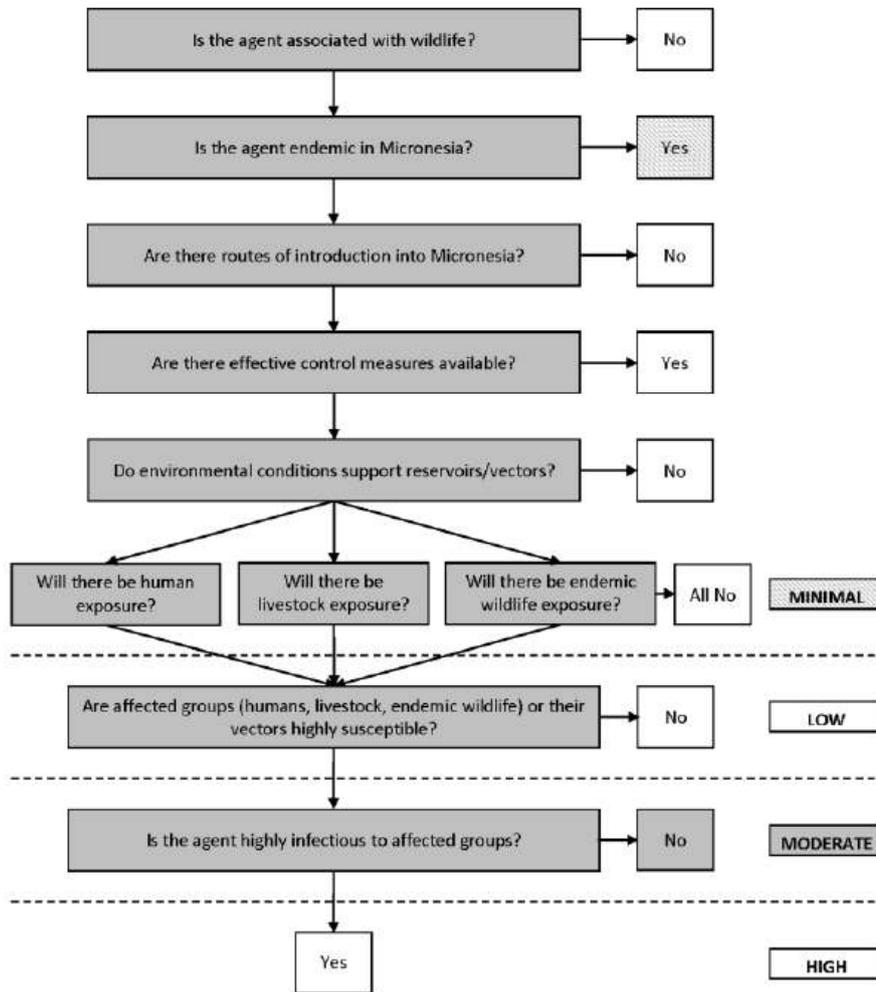
30 **Alternative answer:** Yes. No screening has been conducted in the Micronesia Region so it is possible that
31 the agent is present, but has not been detected.

32 **Are there routes of introduction into the Micronesia Region?** Yes, infected mammals may be
33 introduced via shipping and cargo planes. The agent often causes persistent infections in rodents.
34 Therefore, rodents introduced via shipping cargo can easily be infectious upon arrival in the Micronesia
35 Region.

- 1 **Are there effective control measures available?** No.
- 2 **Do environmental conditions support reservoirs/vectors?** Yes.
- 3 **Will there be human, livestock, or endemic wildlife exposure?** Yes, human exposure is possible for high
4 risk populations living in close association with commensal rodents.
- 5 **Are affected populations highly susceptible?** Yes, for humans that have a high rate of exposure to
6 commensal rodents or their excreta, especially in enclosed environments.
- 7 **Is the agent highly infectious to affected populations via hosts or vectors?** No, humans are considered
8 dead-end hosts for most hantaviruses. However, hantaviruses are readily transmissible between select
9 non-endemic wildlife species (introduced small mammals).
- 10 **Risk category:** Moderate
- 11 **Alternative risk category:** Minimal
- 12 **IMPACT OF INFECTION** (Figure A5- 18)
- 13 **Is there spread to affected populations?** Yes.
- 14 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, rodent densities
15 are very high on some islands, especially in CNMI.
- 16 **Are affected populations susceptible?** Yes.
- 17 **Does the agent cause severe disease in affected populations?** Yes, humans can develop severe disease
18 with high rates of mortality. On the other hand, rodent populations infected with the virus do not
19 exhibit severe disease.
- 20 **Is the agent highly infectious to affected populations?** No; the agent is primarily infectious to humans
21 that come in frequent contact with commensal rodents in enclosed spaces where urine and feces may
22 become aerosolized due to disturbance.
- 23 **Are effective interventions available?** No.
- 24 **Risk category:** Low

1

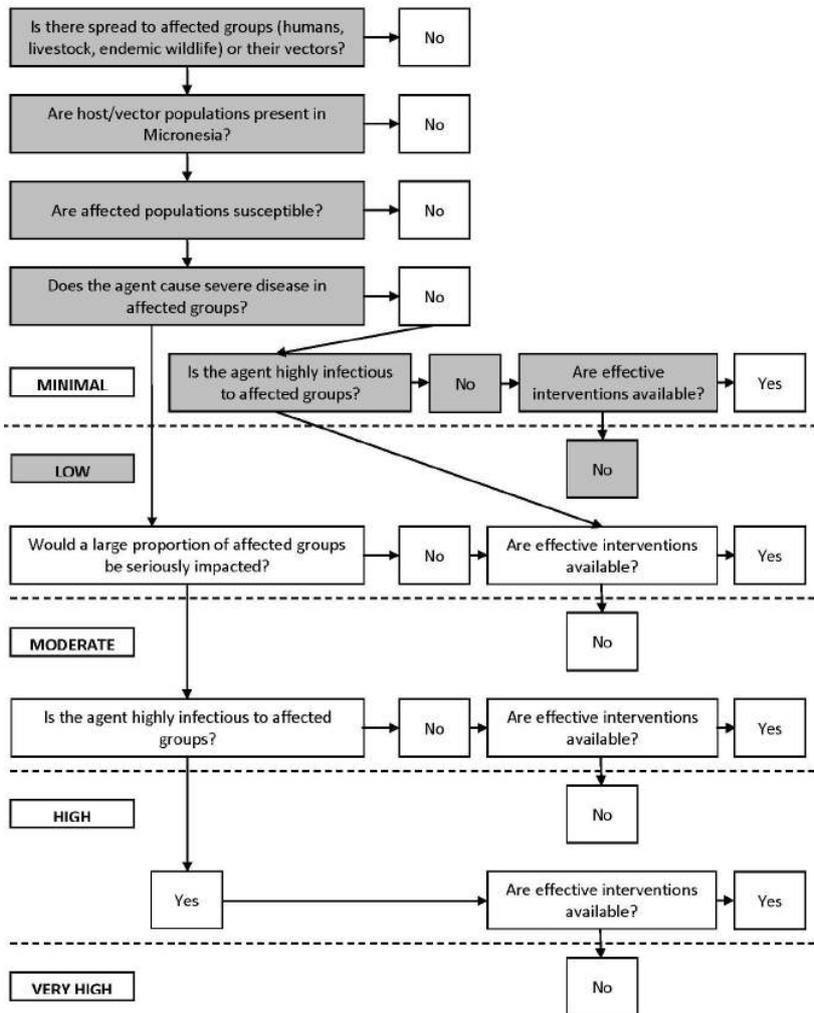
Figure A5-17: Probability of Infection with Hantaviruses



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1 **Figure A5-18: Impact of Infection with Hantaviruses in the Micronesia Region**



2
 3 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
 4 assignment is considered, it is represented as light gray in the flow chart.

5 **RABIES VIRUS** (described in Section A5.2.3.1)

6 **PROBABILITY OF INFECTION** (Figure A5-19)

7 **Is the agent associated with wildlife?** Yes, the reservoir hosts are typically carnivores and bats.

8 **Is the agent endemic in the Micronesia Region?** No, Guam is considered to be free of rabies. Little
 9 testing has been conducted outside of Guam. However, despite limited testing it is unlikely that the
 10 agent is present elsewhere, but has not been identified since the symptoms of the disease are well
 11 known.

- 1 **Are there routes of introduction into the Micronesia Region?** No, Guam has strict quarantine
- 2 procedures to prevent the introduction of rabies from cats, dogs, and other carnivores. However,
- 3 illegally smuggled live bats may be a potential route of introduction.

- 4 **Are there effective control measures available?** Yes, vaccination programs would likely limit the spread
- 5 of rabies among feral carnivores.

- 6 **Risk category:** Minimal

- 7 **IMPACT OF INFECTION** (Figure A5-20)

- 8 **Is there spread to affected populations?** Yes, if the agent was introduced via wildlife, it would likely
- 9 spread to pets and then to humans.

- 10 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes.

- 11 **Are affected populations susceptible?** Yes.

- 12 **Does the agent cause severe disease in affected populations?** Yes.

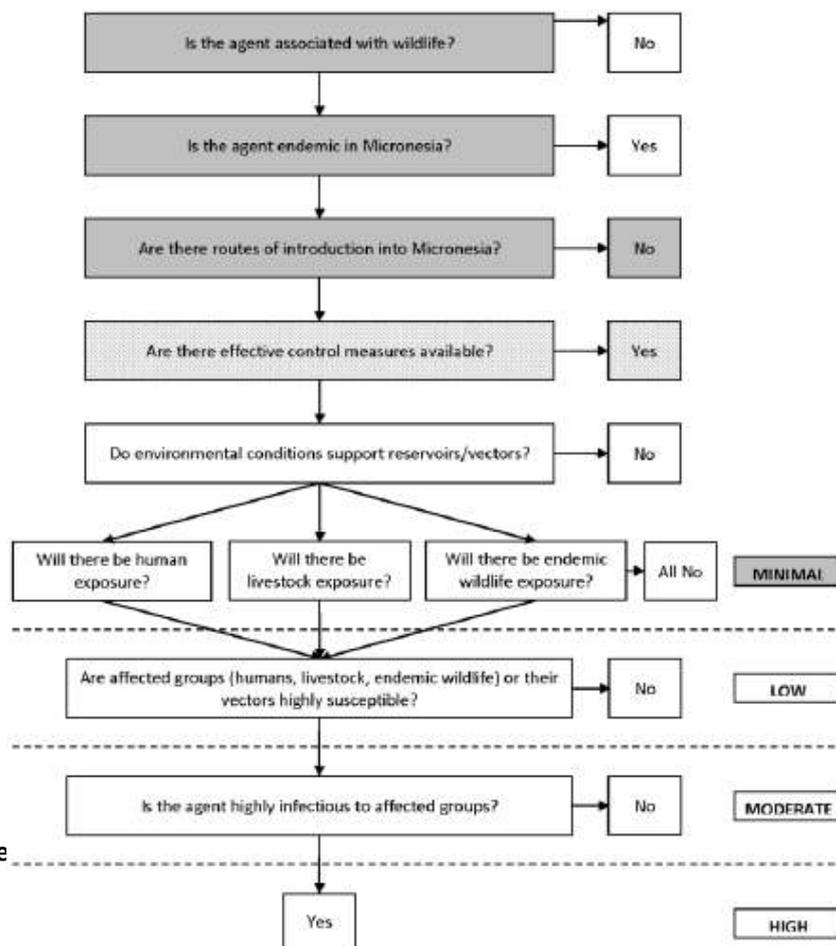
- 13 **Is the agent highly infectious to affected populations?** Yes.

- 14 **Would a large proportion of affected groups be seriously impacted?** No.

- 15 **Are effective interventions available?** Yes.

- 16 **Risk category:** Low

**Figure A5-19:
Probability
Infection with
Rabies Virus**



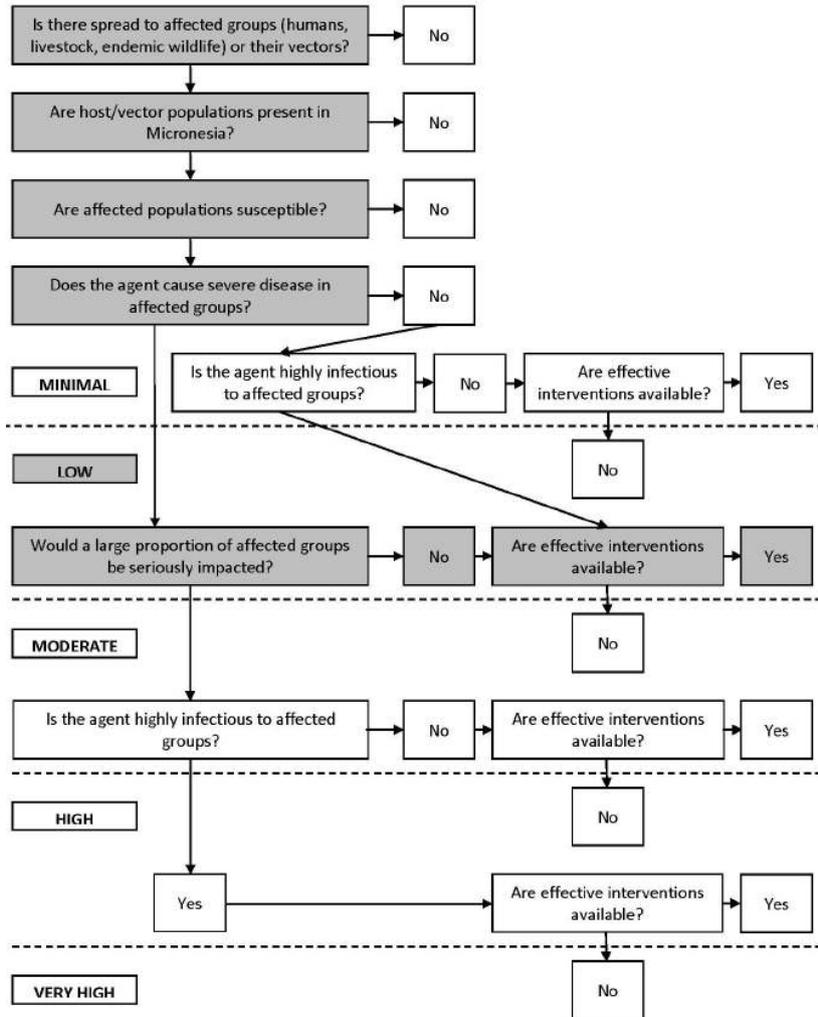
of

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Figure A5-20: Impact of Infection with Rabies Virus in the Micronesia Region



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5

6 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
7 assignment is considered, it is represented as light gray in the flow chart.

8 **WNV** (described in Section A5.2.3.1)

9 **PROBABILITY OF INFECTION** (Figure A5-21)

10

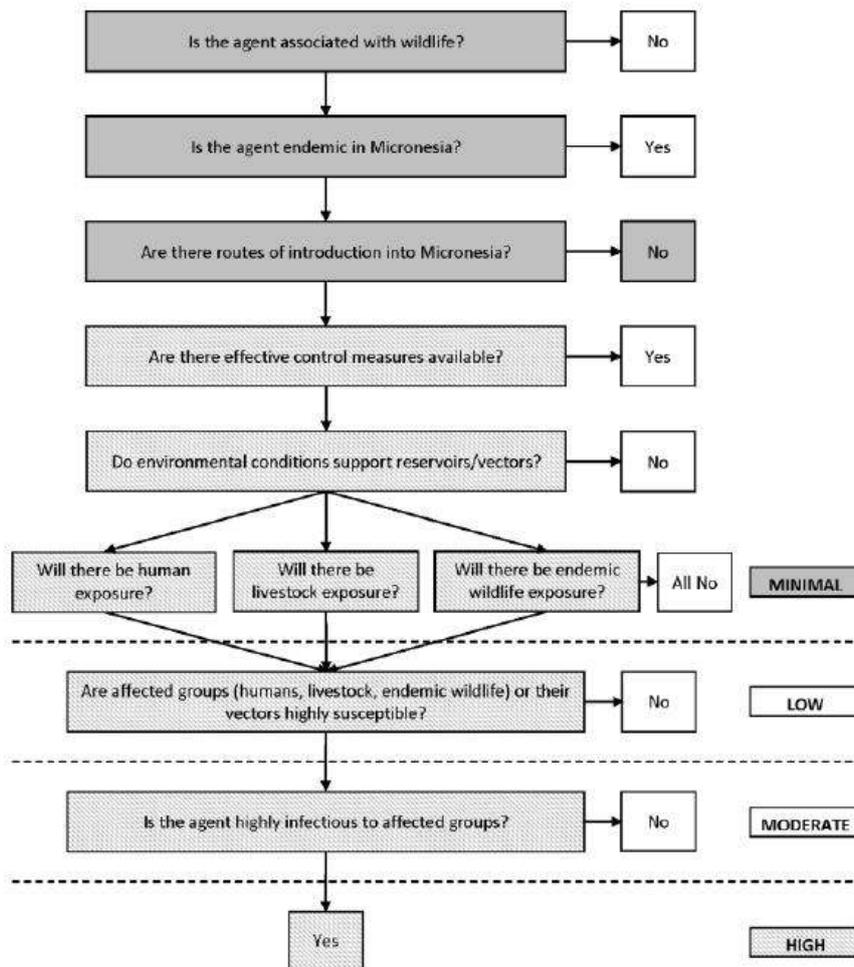
11

- 1 **Is the agent associated with wildlife?** Yes, wild birds are reservoir competent. Most mammals are not
2 involved in natural WNV cycles; however, some mammal species have recently been shown to develop
3 viremias sufficient for infecting some mosquito species.
- 4 **Is the agent endemic in the Micronesia Region?** No.
- 5 **Are there routes of introduction into the Micronesia Region?** No, the likelihood of introduction is low.
- 6 **Alternative answer:** Yes, if WNV becomes established in Hawai'i or Alaska in which case WNV would
7 have the potential to enter Micronesian countries via infected mosquitoes or migratory birds arriving
8 from Alaska or Hawai'i. Introduction via the import of poultry and fighting cocks is negligible. A lesser
9 probability of introduction via an infected mammal (including humans) is possible.
- 10 **Are there effective control measures available?** No.
- 11 **Do environmental conditions support reservoirs/vectors?** Yes.
- 12 **Will there be human, livestock, or endemic wildlife exposure?** Yes, human, livestock, and endemic
13 wildlife exposures are possible.
- 14 **Are affected populations highly susceptible?** Yes.
- 15 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes.
- 16 **Risk category:** Minimal
- 17 **Alternative risk category:** High (if WNV becomes established in Hawai'i or Alaska)
- 18 **IMPACT OF INFECTION** (Figure A5-22)
- 19 **Is there spread to affected populations?** Yes.
- 20 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, both host and
21 vector species are present in the Micronesia Region.
- 22 **Are affected populations susceptible?** Yes.
- 23 **Does the agent cause severe disease in affected populations?** Yes, WNV can cause serious disease in
24 wild bird populations, especially corvids. In addition, a small proportion of humans can suffer severe
25 morbidity and mortality.
- 26 **Is the agent highly infectious to affected populations?** Yes, WNV is highly infectious to wild birds.
- 27 **Would a large proportion of affected populations be seriously impacted?** Yes.
- 28 **Is the agent highly infectious to affected populations?** Yes.

1 **Are effective interventions available?** Yes, mosquito control and education can reduce vector
2 populations.

3 **Risk category:** High

4 **Figure A5-21: Probability of Infection with WNV**

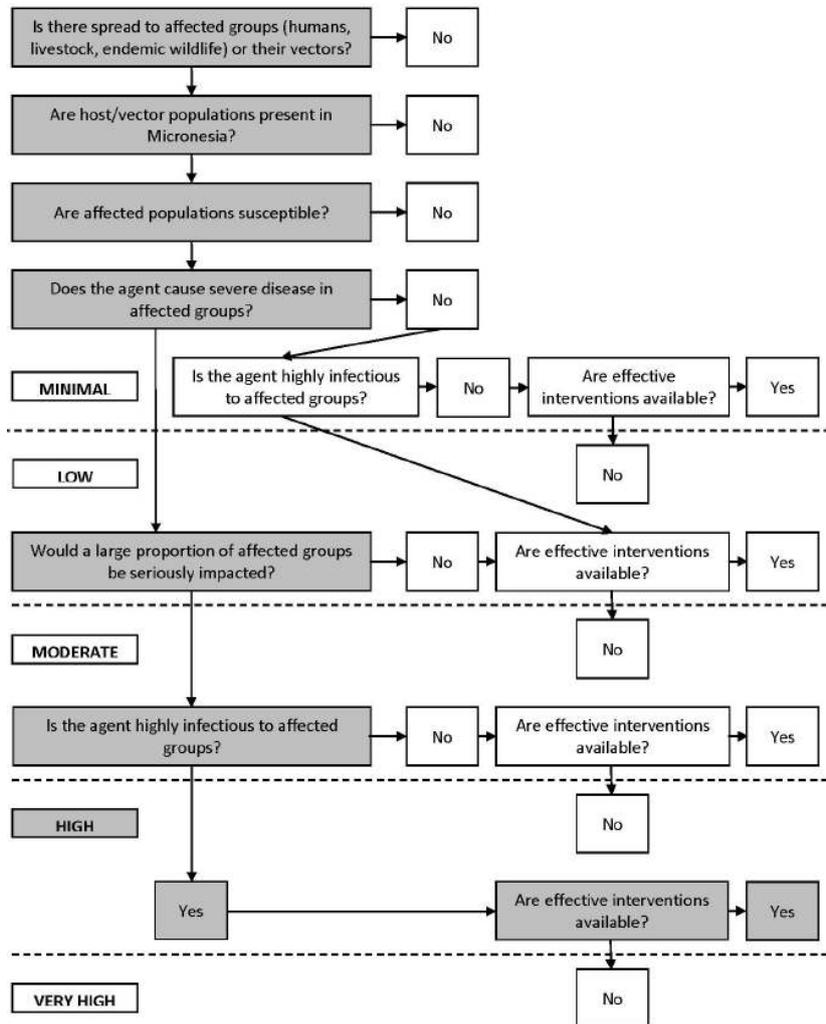


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Figure A5-22: Impact of Infection with WNV



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3 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
4 assignment is considered, it is represented as light gray in the flow chart.

5 **HIGHLY PATHOGENIC AVIAN INFLUENZA VIRUS** (described in Section A5.2.3.1)

6 **PROBABILITY OF INFECTION** (Figure A5-23)

7 **Is the agent associated with wildlife?** Yes, the reservoir host is wild birds, particularly waterfowl,
8 shorebirds, and seabirds. In addition, select wild mammals have been infected.

9 **Is the agent endemic in the Micronesia Region?** No, but low pathogenic AIVs have been detected in 3
10 wild birds (out of more than 5,000 sampled).

11 **Are there routes of introduction into the Micronesia Region?** Yes, AIVs have the potential to enter
12 Micronesian countries via infected migratory birds. Introduction via the import of poultry and fighting

1 cocks is negligible. AIVs may also enter Micronesian countries via spillover into mammals. However,
2 because the course of infection is approximately a week, this type of release is likely to be limited to air
3 cargo because infections would be expected to resolve prior to shipping for sea cargo.

4 **Are there effective control measures available?** No, control measures (depopulation and quarantine)
5 are generally effective if implemented quickly, but the high densities of feral chickens on Guam and
6 Saipan render effective control unlikely.

7 **Do environmental conditions support reservoirs/vectors?** Yes.

8 **Will there be human, livestock, or endemic wildlife exposure?** Yes.

9 **Are affected populations highly susceptible?** Yes (for livestock and endemic wildlife).

10 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes.

11 **Risk category:** High

12 **IMPACT OF INFECTION** (Figure A5-24)

13 **Is there spread to affected populations?** Yes.

14 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes.

15 **Are affected populations susceptible?** Yes.

16 **Does the agent cause severe disease in affected populations?** No, highly pathogenic subtypes do not
17 generally cause severe morbidity and mortality in wild birds.

18 **Alternative answer:** Yes, while uncommon, some strains of HPAIV have been associated with severe
19 disease and mortality in wild birds.

20 **Is the agent highly infectious to affected populations?** Yes, especially in wild birds; moreover, humans
21 in close contact with infected birds can also become infected.

22 **Are effective interventions available?** No, vaccines are available for domestic birds, but control of the
23 virus in wild populations is not feasible.

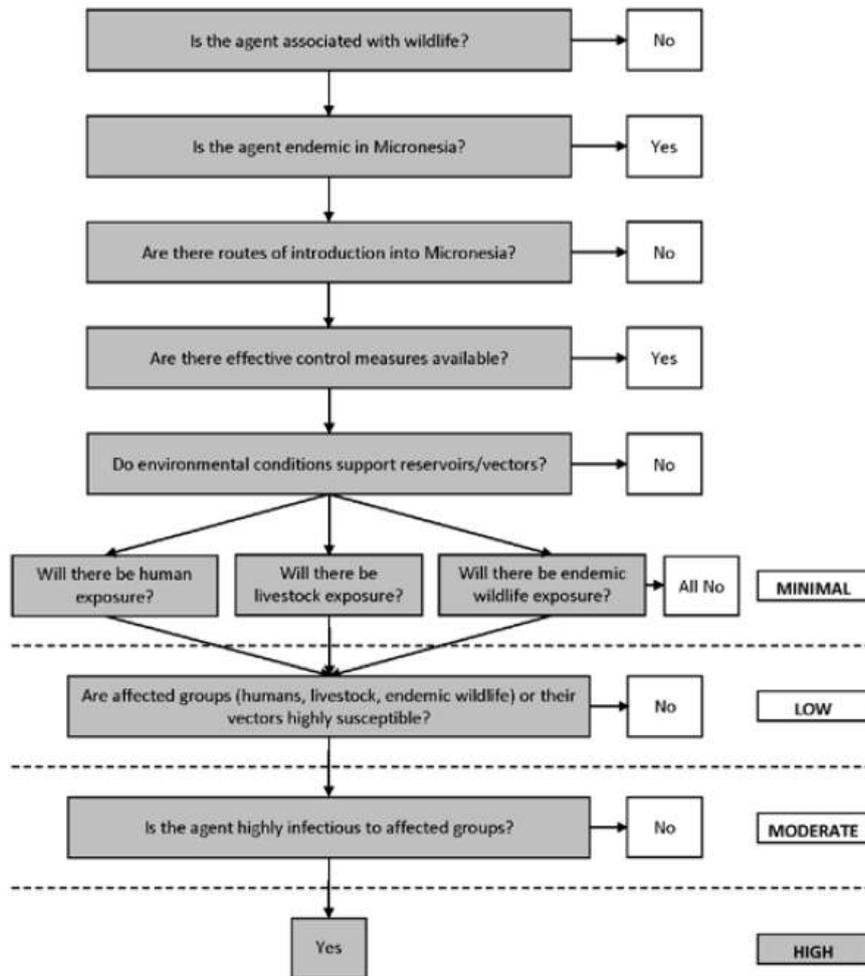
24 **Would a large proportion of affected groups be seriously impacted?** No, most wild bird populations do
25 not exhibit severe morbidity or mortality.

26 **Risk category:** Moderate

27 **Alternative risk category:** Moderate

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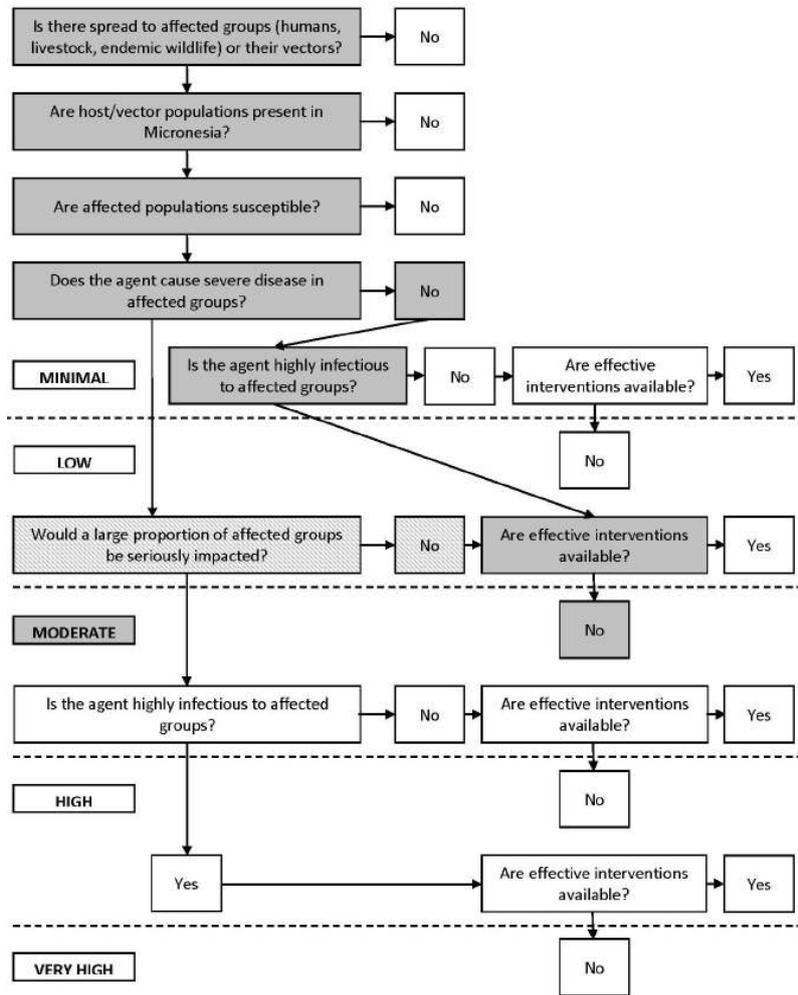
Figure A5-23: Probability of Infection with Highly Pathogenic Avian Influenza Virus in the Micronesia Region



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Figure A5-24: Impact of Infection with HPAIV in the Micronesia Region



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
5 assignment is considered, it is represented as light gray in the flow chart.

6 **JAPANESE ENCEPHALITIS VIRUS** (described in Section A5.2.3.1)

7 **PROBABILITY OF INFECTION** (Figure A5-25)

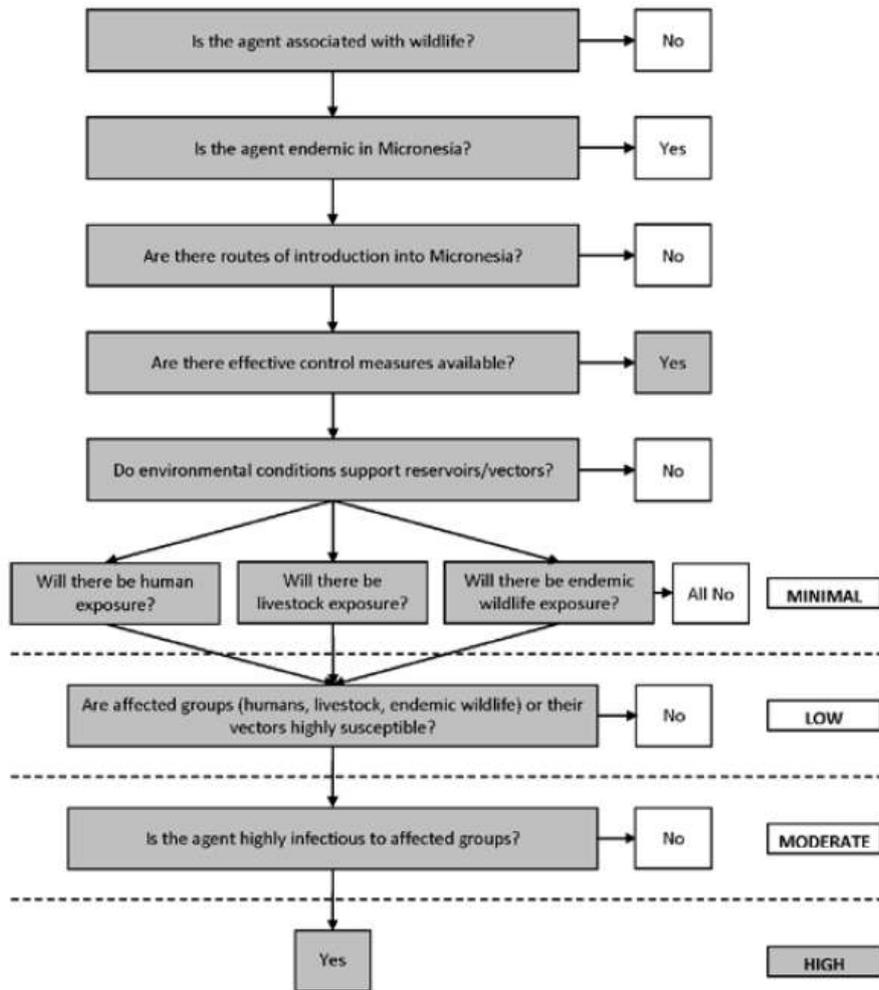
8 **Is the agent associated with wildlife?** Yes, wild birds are reservoir competent and pigs can act as
9 amplifying hosts.

10 **Is the agent endemic in the Micronesia Region?** No, but an outbreak occurred in Guam in 1947 and in
11 Saipan in 1990.

- 1 **Are there routes of introduction into the Micronesia Region?** Yes, infected mosquitoes, migratory
2 birds, or humans could move the virus into the Micronesia Region
- 3 **Are there effective control measures available?** Yes for mitigation of human and swine infections, but if
4 the virus becomes established in wild birds, control is unlikely. However, JEV does not cause clinical
5 illness in wild birds.
- 6 **Do environmental conditions support reservoirs/vectors?** Yes.
- 7 **Will there be human, livestock, or endemic wildlife exposure?** Yes, human, livestock, and endemic
8 wildlife exposures are possible.
- 9 **Are affected populations highly susceptible?** Yes.
- 10 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes, wild birds as well as
11 humans and livestock are readily infected.
- 12 **Risk category:** High
- 13 **IMPACT OF INFECTION** (Figure A5-26)
- 14 **Is there spread to affected populations?** Yes, JEV is easily spread among wild birds which represent the
15 primary natural reservoir. Humans and livestock can act as spillover hosts.
- 16 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, both host (birds
17 and mammals) and vector populations are currently present.
- 18 **Are affected populations susceptible?** Yes, wild birds, livestock, and humans are susceptible.
- 19 **Does the agent cause severe disease in affected populations?** No, JEV does not cause severe disease in
20 wild bird populations.
- 21 **Alternative answer:** Yes, JEV may cause severe disease in a small proportion of humans that may
22 become infected.
- 23 **Is the agent highly infectious to affected populations?** No; while JEV is highly infectious to wild birds, it
24 is less infectious to humans which are most likely to be impacted.
- 25 **Are effective interventions available?** Yes, vaccinations are available for humans.
- 26 **Would a large proportion of affected populations be seriously impacted?** No.
- 27 **Risk category:** Minimal
- 28 **Alternative risk category:** Low

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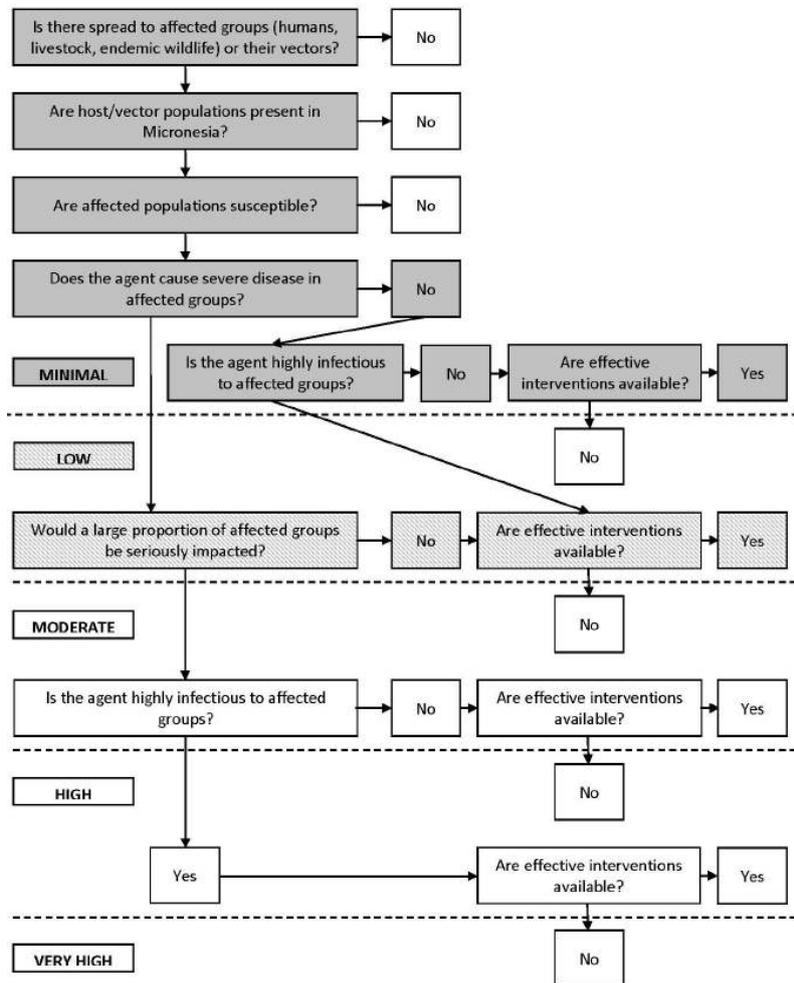
Figure A5-25: Probability of Infection with Japanese Encephalitis Virus in the Micronesia Region



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Figure A5-26: Impact of Infection with JEV in the Micronesia Region



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
5 assignment is considered, it is represented as light gray in the flow chart.

6 **AVIAN MALARIA PARASITES** (*Plasmodium* spp.) (described in Section A5.2.3.1)

7 **PROBABILITY OF INFECTION** (Figure A5-27)

8 **Is the agent associated with wildlife?** Yes, wild birds are reservoir competent.

9 **Is the agent endemic in the Micronesia Region?** No (not likely), screening for blood parasites in Guam
10 has not yet identified any *Plasmodium* spp.

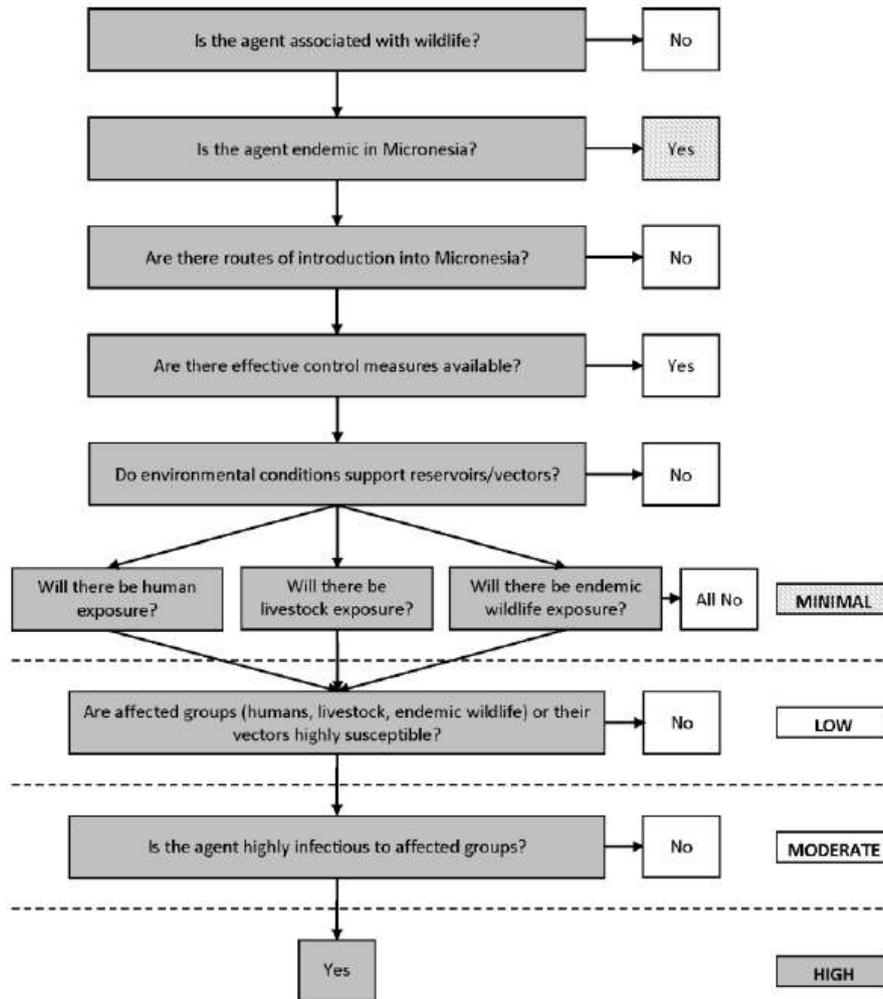
11 **Alternative answer:** Yes, testing in Saipan more than 50 years ago revealed the possible presence of
12 *Plasmodium* sp. in birds; however, modern detection methods were not available.

- 1 **Are there routes of introduction into the Micronesia Region?** Yes, infected mosquitoes or migratory
2 birds could move the virus into the Micronesia Region. Movement of infected mosquitoes or their larvae
3 from Hawai'i is possible via air cargo.
- 4 **Are there effective control measures available?** No.
- 5 **Do environmental conditions support reservoirs/vectors?** Yes.
- 6 **Will there be human, livestock, or endemic wildlife exposure?** Yes, endemic wild bird exposures are
7 possible.
- 8 **Are affected populations highly susceptible?** Yes, wild birds are highly susceptible.
- 9 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes, *Plasmodium* spp. are
10 highly infectious to wild birds.
- 11 **Risk category:** High
- 12 **Alternative risk category:** Minimal
- 13 **IMPACT OF INFECTION** (Figure A5-28)
- 14 **Is there spread to affected populations?** Yes, *Plasmodium* spp. would spread easily between wild bird
15 hosts via mosquito vectors.
- 16 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, both wild bird
17 hosts and mosquito vectors are present.
- 18 **Are affected populations susceptible?** Yes, wild bird populations are highly susceptible to *Plasmodium*
19 spp.
- 20 **Does the agent cause severe disease in affected populations?** No, *Plasmodium* spp. do not cause
21 severe disease in most bird species.
- 22 **Alternative answer:** Yes, *Plasmodium* spp. are associated with severe disease in some Hawai'ian bird
23 species that did not evolve with the agent. If bird species in the Micronesia Region did not evolve in the
24 presence of *Plasmodium* spp. it is possible that severe population impacts may be felt in some wild bird
25 species as has happened in Hawai'i.
- 26 **Is the agent highly infectious to affected populations?** Yes.
- 27 **Are effective interventions available?** No.
- 28 **Would a large proportion of affected populations be seriously impacted?** No, not all wild bird species
29 would be likely to suffer serious impacts.

1 Risk category: Moderate

2 Alternative risk category: Moderate

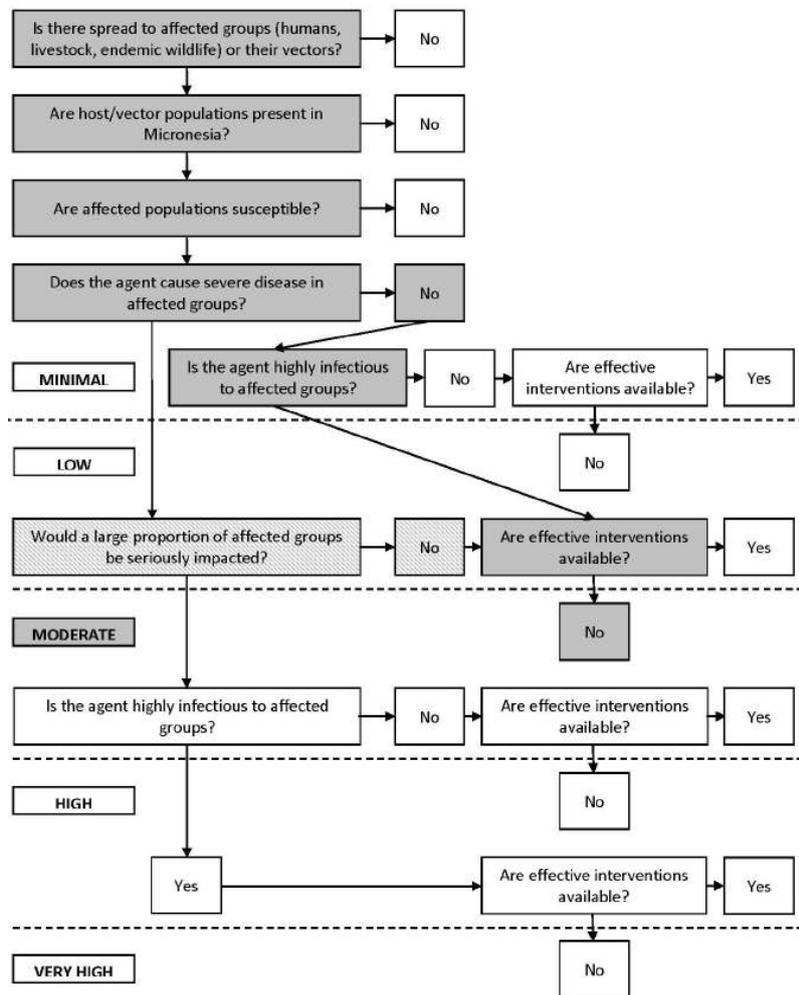
3 Figure A5-27: Probability of Infection with Avian malaria Parasites in the Micronesia Region



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1 **Figure A5-28: Impact of Infection with Avian Malaria Parasites in the Micronesia Region**



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3 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk

4 assignment is considered, it is represented as light gray in the flow chart.

5 **HENIPAVIRUSES** (described in Section A5.2.3.1)

6 **PROBABILITY OF INFECTION** (Figure A5-29)

7 **Is the agent associated with wildlife?** Yes, bats are considered the reservoir species and livestock can

8 act as amplifying hosts.

9 **Is the agent endemic in the Micronesia Region?** No.

10 **Are there routes of introduction into the Micronesia Region?** No, the likelihood of introduction is low.

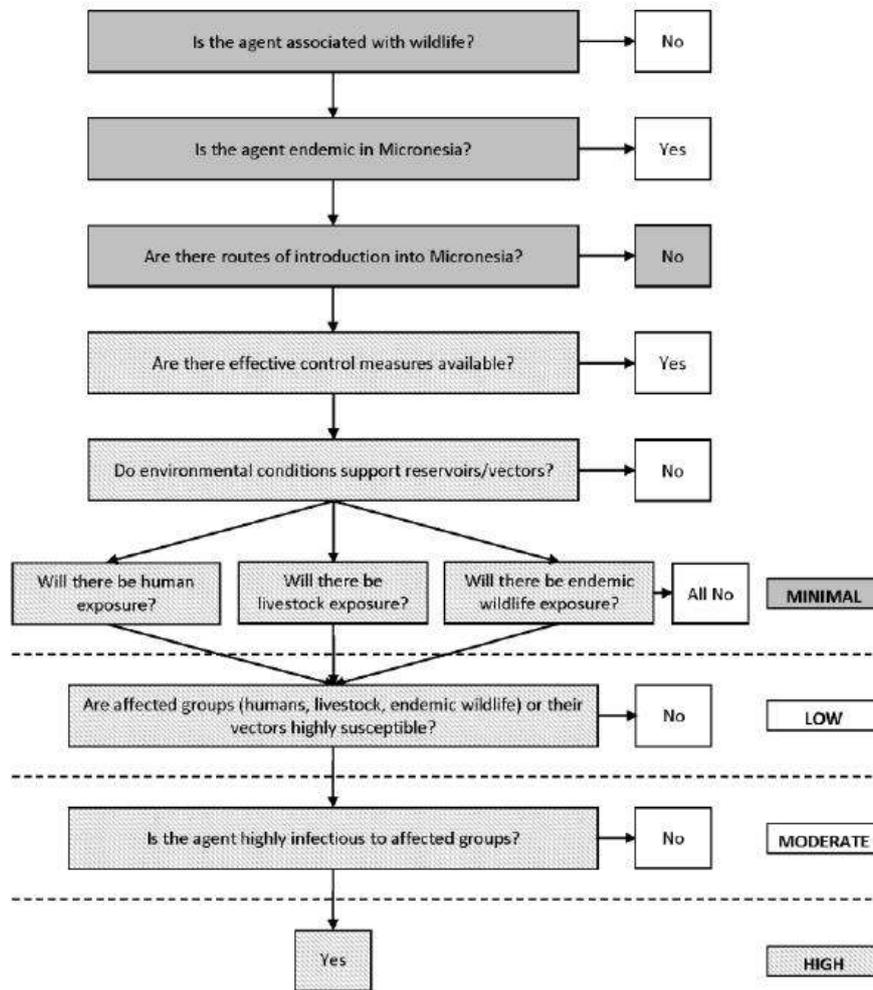
11 **Alternative answer:** Yes, henipaviruses could move into the Micronesia Region via smuggling of infected

12 bats or introduction via shipping or air cargo.

- 1 **Are there effective control measures available?** No.
- 2 **Do environmental conditions support reservoirs/vectors?** Yes.
- 3 **Will there be human, livestock, or endemic wildlife exposure?** Yes, if introduced, human, livestock, and
4 endemic wildlife exposures are possible.
- 5 **Are affected populations highly susceptible?** Yes.
- 6 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes.
- 7 **Risk category:** Minimal
- 8 **Alternative risk category:** High
- 9 **IMPACT OF INFECTION** (Figure A5-30)
- 10 **Is there spread to affected populations?** Yes, the virus spreads easily between bats and spillover hosts
11 such as pigs and humans.
- 12 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, in parts of the
13 Micronesia Region (e.g., Palau), bat populations are still relatively large.
- 14 **Are affected populations susceptible?** Yes, bats, humans, and pigs are susceptible.
- 15 **Does the agent cause severe disease in affected populations?** No, henipaviruses do not cause severe
16 illness in reservoir bat populations.
- 17 **Alternative answer:** Yes, henipaviruses can cause severe disease in pigs and humans.
- 18 **Is the agent highly infectious to affected populations?** Yes.
- 19 **Are effective interventions available?** No.
- 20 **Would a large proportion of affected populations be seriously impacted?** No; while the agent can
21 cause severe morbidity and mortality in humans and pigs, only individuals in close contact with bats are
22 likely to be impacted.
- 23 **Risk category:** Moderate
- 24 **Alternative risk category:** Moderate

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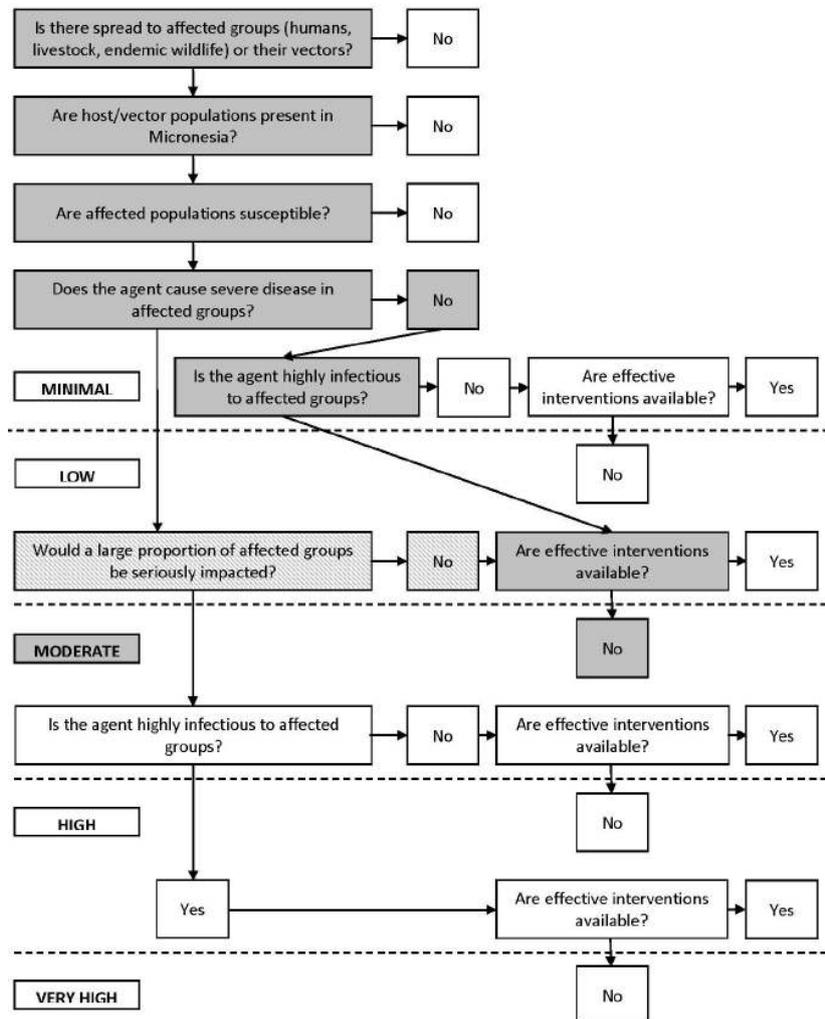
Figure A5-29: Probability of Infection with Henipaviruses in the Micronesia Region



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1 **Figure A5-30: Impact of Infection with Henipaviruses in the Micronesia Region**



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk

5 assignment is considered, it is represented as light gray in the flow chart.

6 **NEWCASTLE DISEASE VIRUS** (described in Section A5.2.3.1)

7 **PROBABILITY OF INFECTION** (Figure A5-31)

8 **Is the agent associated with wildlife?** Yes, more than 240 wild bird and poultry species are known to

9 become infected.

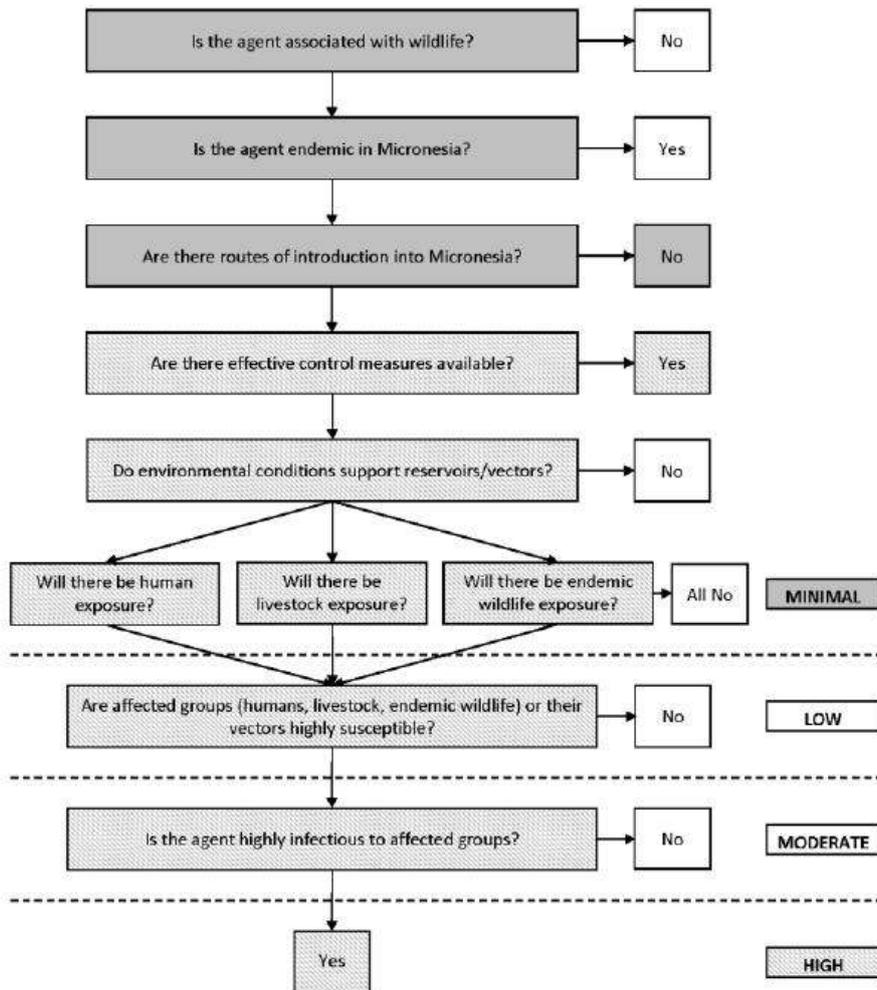
10 **Is the agent endemic in the Micronesia Region?** No.

- 1 **Are there routes of introduction into the Micronesia Region?** No, NDV has been endemic throughout
2 Southeast Asia for a long period of time without any known introductions into the Micronesia Region.
- 3 **Alternative answer:** Yes, infected migratory birds from Southeast Asia are a potential route of
4 introduction. Introduction via the import of poultry or fighting cocks is negligible.
- 5 **Are there effective control measures available?** Yes, vaccination and quarantine are effective for
6 poultry species, but are not a viable option for wild birds.
- 7 **Do environmental conditions support reservoirs/vectors?** Yes.
- 8 **Will there be human, livestock, or endemic wildlife exposure?** Yes, livestock and endemic wildlife
9 exposures are possible. NDV can be particularly harmful to columbid species and therefore pose a risk to
10 the endangered fruit doves.
- 11 **Are affected populations highly susceptible?** Yes.
- 12 **Is the agent highly infectious to affected populations via hosts or vectors?** Yes, wild bird populations
13 are highly susceptible to NDV.
- 14 **Risk category:** Minimal
- 15 **Alternative risk category:** High
- 16 **IMPACT OF INFECTION** (Figure A5-32)
- 17 **Is there spread to affected populations?** Yes, NDV spreads readily among wild birds.
- 18 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, wild bird species
19 expected to be susceptible to the agent are present.
- 20 **Are affected populations susceptible?** Yes.
- 21 **Does the agent cause severe disease in affected populations?** No, many bird species remain
22 asymptomatic.
- 23 **Alternative answer:** Yes, certain pathotypes of the agent are capable of causing severe morbidity and
24 high mortality certain of wild bird species (e.g., columbids).
- 25 **Is the agent highly infectious to affected populations?** Yes.
- 26 **Are effective interventions available?** No, there are no feasible interventions for wild bird populations.
- 27 **Would a large proportion of affected populations be seriously impacted?** No, only select species are
28 expected to be seriously impacted.

1 Risk category: Moderate

2 Alternative risk category: Moderate

3 Figure A5-31: Probability of Infection with Newcastle Disease Virus in the Micronesia Region

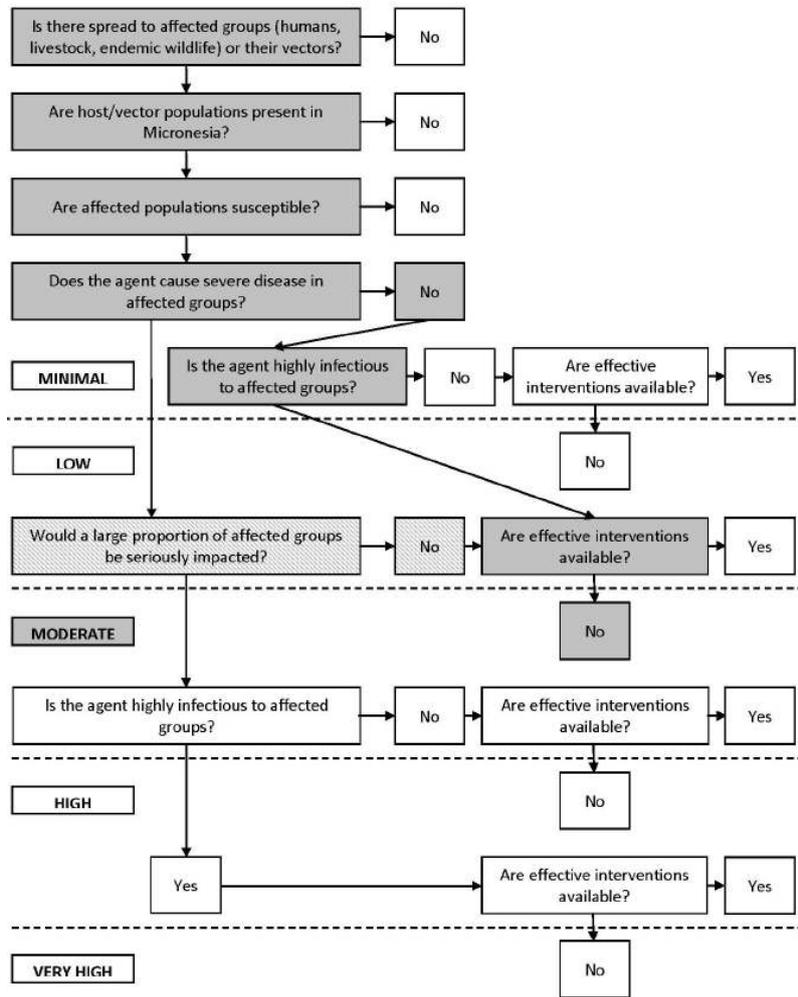


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Figure A5-32: Impact of Infection with NDV in the Micronesia Region



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
5 assignment is considered, it is represented as light gray in the flow chart.

6 **YERSINIA PESTIS (PLAGUE)** (described in Section A5.2.3.1)

7 **PROBABILITY OF INFECTION** (Figure A5-33)

8 **Is the agent associated with wildlife?** Yes, rodents and their associated fleas.

9 **Is the agent endemic in the Micronesia Region?** No.

10 **Are there routes of introduction into the Micronesia Region?** Yes, introduction of infected rodents and
11 their fleas is possible via shipping and air cargo originating from Southeast Asia or the West Coast of
12 North America.

- 1 **Are there effective control measures available?** Yes, environmental management (e.g. use of
- 2 appropriate insecticides in response to plague outbreaks), public health education, and preventive drug
- 3 therapy are effective control measures for reducing the impact of plague on humans.

- 4 **Risk category:** Minimal

- 5 **IMPACT OF INFECTION** (Figure A5-34)

- 6 **Is there spread to affected populations?** Yes, if introduced, *Yersinia pestis* would likely spread to
- 7 reservoir rodent species and could subsequently spread to humans as a spillover species.

- 8 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes.

- 9 **Are affected populations susceptible?** Yes.

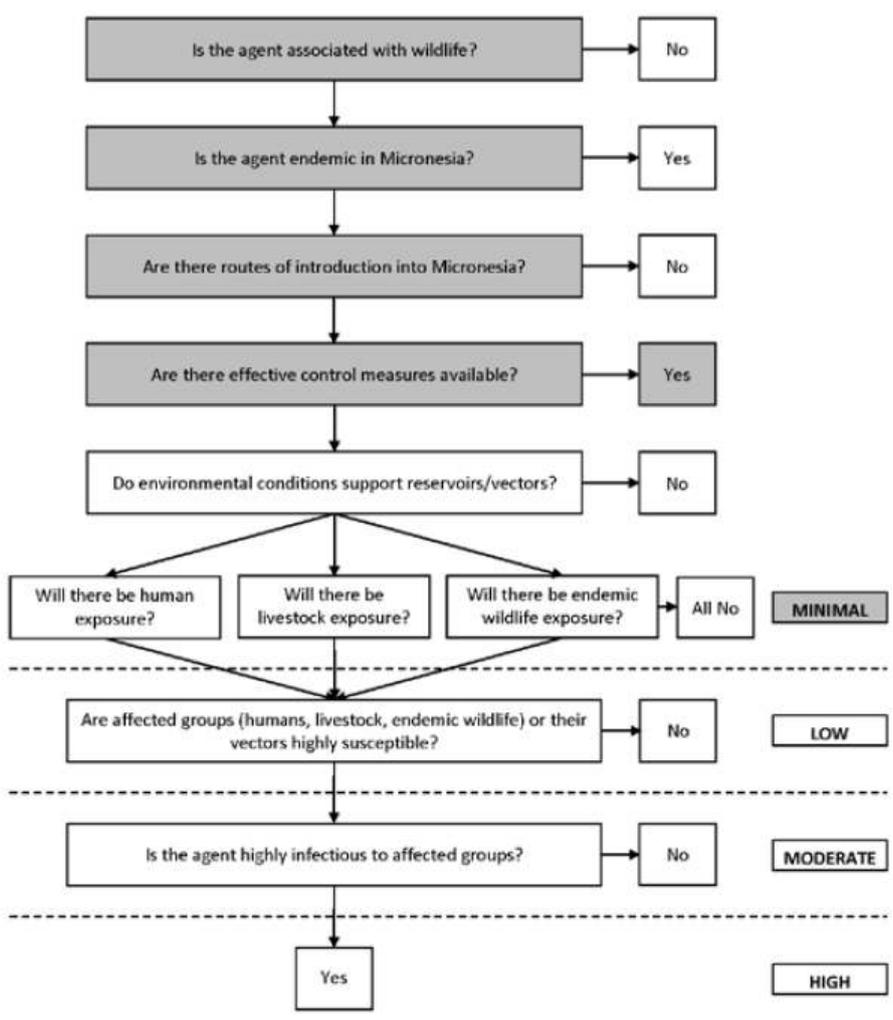
- 10 **Does the agent cause severe disease in affected populations?** Yes, plague has the potential to cause
- 11 severe disease in humans.

- 12 **Would a large proportion of affected populations be seriously impacted?** No, only humans in close
- 13 contact with infected rodents would be impacted.

- 14 **Are effective interventions available?** Yes.

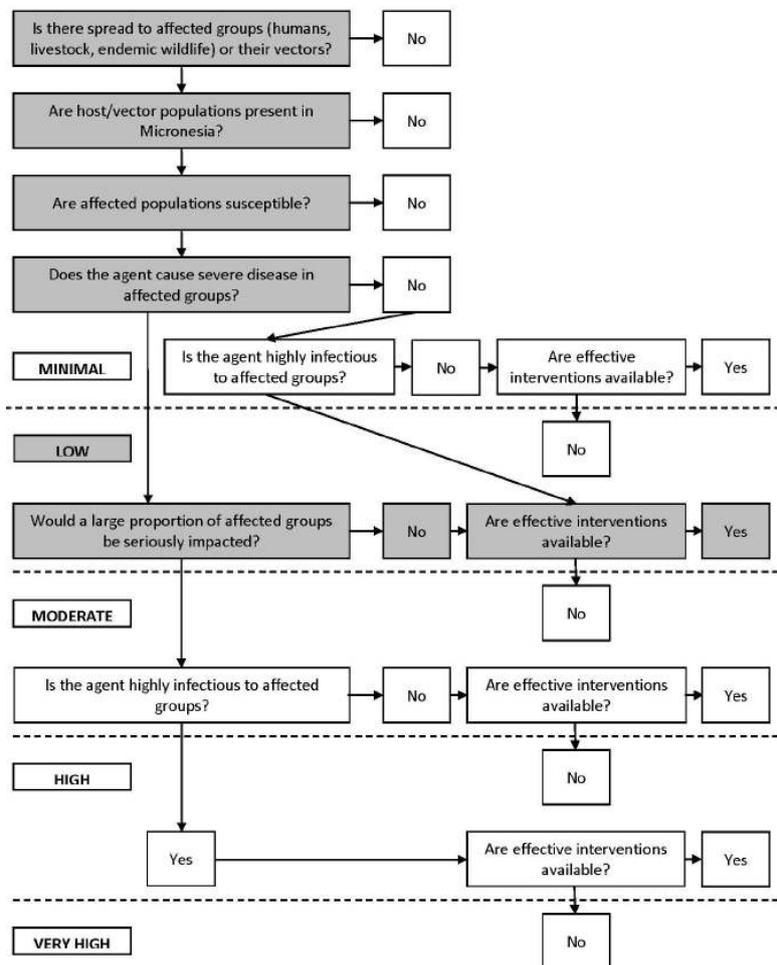
- 15 **Risk category:** Low

1 **Figure A5-33: Probability of Infection of *Yersinia pestis* (Plague) in the Micronesia Region**



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1 **Figure A5-34: Impact of infection with *Yersinia pestis* (Plague) in the Micronesia Region**



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
 5 assignment is considered, it is represented as light gray in the flow chart.

6 **TICK-BORNE ENCEPHALITIS** (described in Section A5.2.3.1)

7 **PROBABILITY OF INFECTION** (Figure A5-35)

8 **Is the agent associated with wildlife?** Yes, small rodents are important in the transmission cycle with
 9 incidental infection of larger mammals and birds.

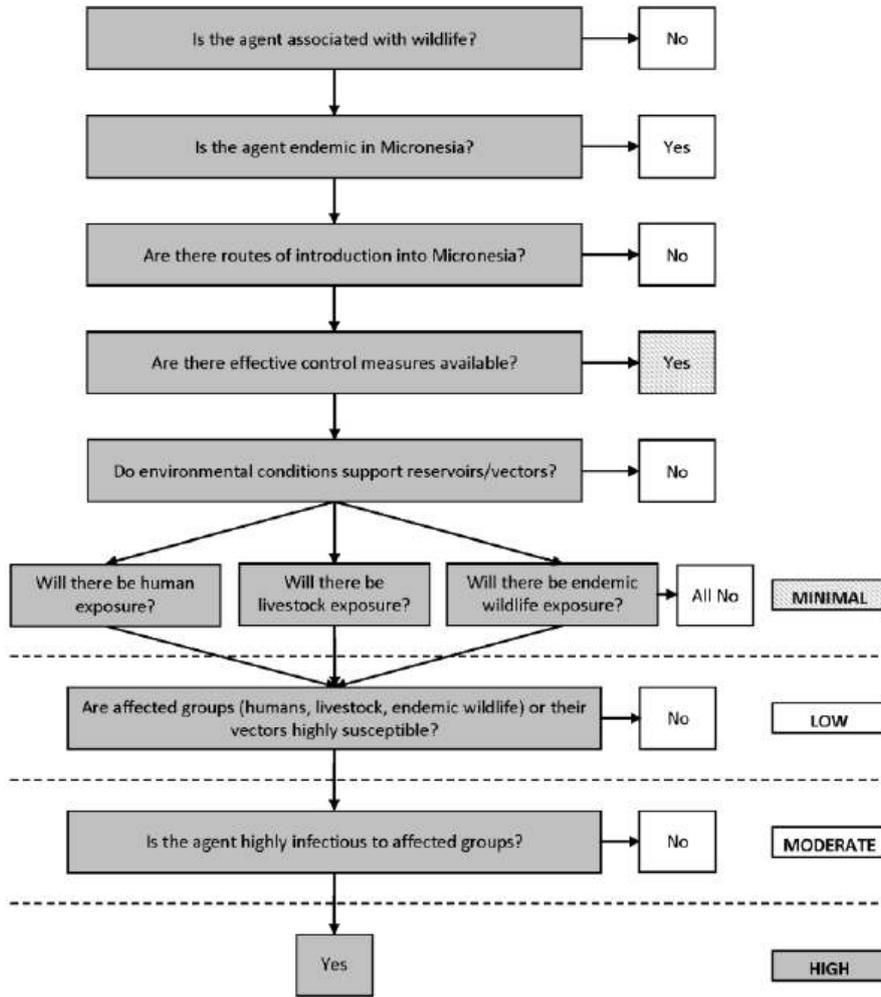
10 **Is the agent endemic in the Micronesia Region?** No, the virus has never been isolated in the Micronesia
 11 Region.

12 **Are there routes of introduction into the Micronesia Region?** Yes, infected ticks or stowaway rodents
 13 may be introduced via shipping or cargo planes.

- 1 **Are there effective control measures available?** Yes, a vaccine is available for mitigation of human
2 infections, but if the virus becomes established in rodent and tick populations, establishment is possible.
- 3 **Do environmental conditions support reservoirs/vectors?** Yes, the climate is appropriate and a genus
4 of competent ticks has been identified in Palau.
- 5 **Will there be human, livestock, or endemic wildlife exposure?** Yes, human, livestock, and endemic
6 wildlife exposure are possible.
- 7 **Is the agent highly infectious to affected populations?** Yes, humans and other mammals are highly
8 susceptible, but most infections are asymptomatic.
- 9 **Is the agent readily transmitted to affected populations via hosts or vectors?** Yes, the agent is readily
10 transmissible between rodents and ticks and between ticks and ticks.
- 11 **Risk category:** High
- 12 **IMPACT OF INFECTION** (Figure A5-36)
- 13 **Is there spread to affected populations?** Yes, the agent would be expected to spread readily via rodents
14 where appropriate tick species have been identified (e.g., Palau).
- 15 **Are wildlife hosts and/or vector populations present in the Micronesia Region?** Yes, rodents and
16 livestock are present and the vector is present in Palau.
- 17 **Are affected populations susceptible?** Yes, humans are very susceptible.
- 18 **Does the agent cause severe disease in affected populations?** No, TBEV does not cause severe disease
19 in a majority of humans.
- 20 **Alternative answer:** Yes, while many humans experience asymptomatic or mild disease symptoms,
21 others experience severe disease.
- 22 **Is the agent highly infectious to affected populations?** Yes.
- 23 **Are effective interventions available?** Yes, a vaccine is available for humans.
- 24 **Would a large proportion of affected populations be seriously impacted?** No, most cases are
25 asymptomatic.
- 26 **Risk category:** Low
- 27 **Alternative risk category:** Moderate

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Figure A5-35: Probability of Infection with TBEV in the Micronesia Region

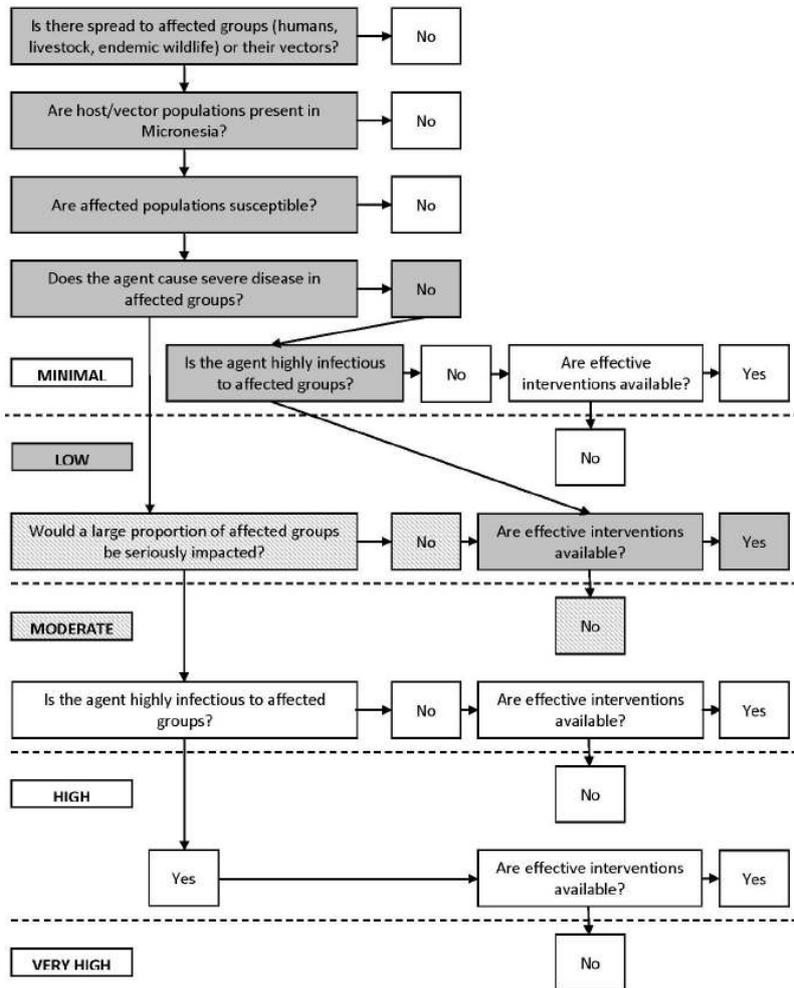


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Figure A5-36: Impact of Infection with TBEV in the Micronesia Region



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4 The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk
 5 assignment is considered, it is represented as light gray in the flow chart.

6 **Table A5-12: Summary of Risks for Introduction of Wildlife-Associated Pathogens into the**
 7 **Micronesia Region**

Pathogen	Probability of infection risk category	Alternative risk category	Impact of infection risk category	Alternative risk category	Comments
Hantaviruses	Moderate	Minimal	Low		
Rabies virus	Minimal		Low		

Pathogen	Probability of infection risk category	Alternative risk category	Impact of infection risk category	Alternative risk category	Comments
WNV	Minimal	High	High		Alternative risk associated with potential introduction of WNV into Hawai'i or Alaska
AIV	High		Moderate	Moderate	Risk category partially based on proximity to Asia. Introduction more likely from natural bird movement than from DoD-associated introductions.
JEV	High		Minimal	Low	
Avian malaria parasites (<i>Plasmodium</i> spp.)	High	Minimal	Moderate	Moderate	
Henipaviruses	Minimal	High	Moderate	Moderate	While the risk of introduction is low an alternative risk was considered for possible pathogen introduction via smuggling of bats or movement of infected bats in air or shipping cargo.
NDV	Minimal	High	Moderate	Moderate	The risk of NDV introduction is low, but possible.
<i>Yersinia pestis</i> (plague)	Minimal		Low		
Tick-borne encephalitis	High		Low	Moderate	

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2 **A5.3 DISCUSSION AND CONCLUSIONS**

3 Within this report, we have focused on wildlife-associated pathogens. Arthropod vectors, however,
4 should not be discounted in the overall risk assessment in this region. For example, *Aedes albopictus* is
5 an invasive mosquito species of Guam (GISIN 2010). Unfortunately, this species is thought to be a
6 competent vector for several distinct arboviruses (Gratz 2004). Table A5-10 outlines many other
7 mosquito species that occur on Guam and in CNMI.

1 **A5.3.1 General Threat of Wildlife-Associated Diseases**

2 Of the 1,415 infectious organisms (pathogens) known to cause disease in humans, the majority (61%)
3 are zoonotic, i.e., transmissible between humans and animals (Taylor et al. 2001; Jones et al. 2008), and
4 zoonotic pathogens are twice as likely to be associated with diseases that have recently emerged in
5 humans (Taylor et al. 2001). Considering these figures, along with the large number of exotic species
6 already established in many locations in the Micronesia Region, a general threat of wildlife-associated
7 diseases in this region is apparent. Many introduced species have, at a minimum, a potential to
8 introduce a novel pathogen to a new area. Furthermore, on islands with established host populations
9 (e.g., rats), the introduction of a single animal that has acquired a pathogen could (dependent on a
10 myriad of factors) potentially introduce this pathogen into a novel population.

11 **A5.4 RECOMMENDATIONS**

12 **A5.4.1 Adaptive Management**

13 Information on wildlife-associated pathogens is often incomplete so risk assessments and their
14 associated recommendations must be updated as new information becomes available. Moreover,
15 distributions of pathogens, hosts, and vectors can change in response to changing environmental
16 conditions, movements, or introductions. As conditions change, risk assessments need to be re-
17 evaluated to determine if risks and associated recommendations need to be updated.

18 Adaptive management has been widely used in natural resource management (Nichols and Williams
19 2006) but has direct application to biosecurity. It is framed within structured decision making and
20 emphasizes uncertainty about responses to management actions with the general objective being to
21 reduce that uncertainty in order to improve management (Williams et al. 2007). Thus, adaptive
22 management is an iterative learning process producing improved understanding and improved
23 management over time. In terms of biosecurity, initial measures to prevent introduction of wildlife-
24 associated diseases should be implemented with a surveillance and monitoring strategy to “test”
25 whether measures are performing adequately, with these measures subsequently adjusted to improve
26 biosecurity.

27 **A5.4.2 General Recommendations**

28 The importation of wildlife diseases into the Micronesia Region is a potential threat to human,
29 agriculture, and wildlife health in this region. Although it is clear that the risk of the establishment of
30 some pathogens is far greater than risks of others, a diversity of pathogens could have negative
31 consequences to the Micronesia Region if they are introduced onto islands that are free of the
32 pathogens in question. The importation of live animals (intentional or unintentional) is one of the
33 biggest risk factors associated with the introduction of wildlife-associated pathogens in the Micronesia
34 Region. Once established in this region, the movement of these pathogens to other islands in the
35 Micronesia Region may increase due to the close proximity of some of the islands and frequent
36 transportation events among islands. In general, prevention is more effective and more cost efficient
37 than eradication (Kingsford et al. 2009). Consequently, investment in prevention measures is a high
38 priority for reducing the risk of introduction of wildlife-associated diseases into this region.

1 **A5.4.3 Specific Recommendations**

2 Recently, it was suggested that the potential for importation of etiological agents causing zoonoses that
3 could pose a major public health threat warrants that enhanced surveillance be conducted on imported
4 wildlife in the United States (Pavlin et al. 2009). There is little doubt that this suggestion is warranted in
5 other regions, such as the Micronesia Region. Some specific recommendations to prevent the
6 importation of wildlife-associated diseases into the Micronesia Region include these:

- 7 • Strengthen USFWS inspections and interdiction capabilities.
- 8 • Extend training of customs personnel to be enhanced for wildlife surveillance and to recognize
9 taxonomic groups that are a large threat to pathogen introduction.
- 10 • Use employee-trained dogs to detect wildlife and wildlife products.
- 11 • Ideally, all trade in live wildlife and wildlife products should be illegal or, at a minimum, heavily
12 regulated and highly discouraged.
- 13 • Develop outreach programs to inform the public and military about the negative (and in some
14 cases, lethal) consequences of wildlife disease introductions.
- 15 • Stop existing wildlife populations from interacting with introduced wildlife at ports of entry.
- 16 • Conduct background surveys at ports of entry to ensure customs and quarantine personnel are
17 familiar with the local animals in the area.
- 18 • Develop a reference collection of plausible wildlife (i.e., taxidermy mounts) to aid in the
19 identification of incoming species. In addition, adequate resources (taxonomic keys,
20 microscopes) should be available for the assistance in taxonomic identifications.
- 21 • Set up an agreement with a genetics laboratory to identify species that cannot be identified
22 through general morphology. In some instances, a genetics laboratory might also be useful in
23 determining the origins of wildlife if an appropriate marker library has been developed for the
24 species in question.
- 25 • Develop action plans for inadvertent wildlife introductions.
- 26 • Randomly sample imports (e.g., cargo containers, ships, planes) for wildlife. This may include
27 actively trapping in the aforementioned vessels and containers to detect small, nocturnal, and
28 secretive species. Be aware that some wildlife species are nocturnal while others are diurnal. As
29 such, sampling programs may need to be modified to account for this behavioral ecology.
- 30 • Conduct periodic inspections of markets and pet shops for prohibited species.
- 31 • Utilize active rodent control methods in areas harboring incoming cargo.
- 32 • Establish surveillance/early detection programs for pathogens emerging in Pacific Rim countries.
- 33 • Establish isolated and/or captive populations of endemic wildlife to prevent extinction in
34 response to outbreaks.

1 **A5.5 ACKNOWLEDGMENTS**

2 We gratefully acknowledge the individuals listed below for their assistance during this project.

3 Barbara Alberti, U.S. National Park Service

4 Dallas Berringer, USDA-APHIS-PPQ

5 Earl Campbell and Arthur Taimanglo, U.S. Fish and Wildlife Service

6 Christian Eggleston and Joseph Schwagerl , Guam National Wildlife Refuge

7 Ann Brooke, Naval Facilities Engineering Command

8 Dan Vice, Lourdes Rivera, Jeff Flores , Maria Ridgeway and Larry Macaoay, USDA-APHIS Wildlife Services

9 Tom Poole and Diane Vice , Guam Department of Agriculture

10 Anu Gupta, Palau Conservation Society

11 Heather Ketebengang, Palau Conservation Society

12 James Eller, USDA Natural Resources Conservation Service

13 Ignacio Dela Cruz, CNMI Department of Lands and Natural Resources

14 Chipper Tellei, Palau

15 Fred Sengebau, Palau Bureau of Agriculture

16 Dave Burdick, Guam Bureau of Statistics

17 Patricia Shade, USDA Natural Resources Conservation Service

18 Paul Radely, CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife

19 James F. Saracco, The Institute for Bird Populations

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1 **A6 LIVESTOCK AND POULTRY DISEASES⁹**

2 **A6.1 SUMMARY**

3 The following risk assessment was prepared to identify the increased risks of poultry and livestock
4 disease agents entering the Micronesia Region as a result of the planned military relocation on Guam.
5 We used primary data sources whenever possible, supplemented by substantial literature review when
6 they were not, and used standard methods defined by the OIE.

7 We limited our consideration of the impacts to humans and pet dogs, cats, and birds to those that arise
8 from their association with livestock or poultry disease hazards. In interpreting our findings, it is also
9 important to note that we did not assess or define a baseline risk, but focused only on that incremental
10 change in risk attributable to the influx of people and the associated changes that will come during the
11 course of the relocation. The inevitable outcome of this approach is the paradox that we may conclude a
12 risk to be present or even significant, yet discount it from further consideration if there is not an
13 increase in risk that we can attribute to the military relocation. This is an unfavorable shortcoming of
14 the approach used and should not be overlooked.

15 Our key findings are summarized in Table A6-1 below and at the end of this document. An estimate
16 appears for each of the possible means (pathways) by which a given hazard might be introduced into
17 Guam or the Micronesia Region. We considered the various preventive measures that might be in place,
18 including regulations, prohibitions and inspection procedures, and which when effective, should
19 mitigate against a hazard (although in reality these measure are likely not currently fully functional and
20 without significant capacity building efforts will remain as such even for current import levels).
21 Conversely we provide an estimate for the possible illegal pathways that might bypass these measures,
22 including smuggling activities. If we assume that a hazard could be released, we estimated the likelihood
23 that animals will become exposed, thereby allowing for spread and establishment of the hazard. Finally,
24 we provide a combined estimate of risk that incorporates likelihood of hazard release and exposure,
25 with an estimate of consequences to Guam, the Micronesia Region, and the rest of the United States.

26 We found that in most cases regulations are in place to mitigate the likelihood of the hazard being
27 introduced. Further, we found that any incremental increase in risk for most hazards, specifically related
28 to the relocation, was relatively small. However, there are pathways where the increased traffic related
29 to the relocation may overwhelm the mitigations currently in place. Current mitigation measures are
30 already overwhelmed in most locations and in need of additional capacity support. In addition, these
31 same mitigation measures could be bypassed by illegal means in certain pathways, or if the measures
32 were inconsistently or ineffectively applied. Smuggling of poultry or the illegal importation of food and

⁹ This section was prepared by: 1)APHIS-Veterinary Services, Centers for Epidemiology and Animal Health, 2150 Centre Avenue, Building B, Fort Collins, Colorado 80526; 2) Veterinary Services, Western Region Office, Fort Collins, Colorado; and 3) Veterinary Services, National Center for Import and Export, Regionalization Evaluation Services, Raleigh, North Carolina. Suggested citation: Veterinary Services, Centers for Epidemiology and Animal Health. 2010. Livestock and poultry diseases. In Terrestrial plant and animal health risks associated with the U.S. military build-up in the Micronesian Region. United States Department of Agriculture, Animal and Plant Health Inspection Service. Washington, D.C.

1 other animal products would bypass the normal regulations and inspection procedures, as might the
 2 improper disposal of domestic and international garbage. Each of these hazards could result in the
 3 introduction and spread of foreign animal disease agents to susceptible domesticated and feral animals.
 4 In addition, their impact could extend beyond Guam and the Micronesia Region, posing a risk for spread
 5 to the rest of the United States that could impact trade with other countries. While the risks for any
 6 given hazard associated with the relocation are relatively low, it is these types of hazards that should
 7 receive attention as plans proceed.

8 **Table A6-1: Summary of Risk Analysis Results**

Pathway	Release Assessment			Consequence Assessment			Risk estimation
	Legal introduction	Illegal introduction	Exposure assessment	Guam	Micronesia Region	United States ^c	
Livestock ^a	Negligible	Negligible	N/A ^b	N/A	N/A	N/A	Negligible
Poultry	Negligible	Very low	Medium	Low	Low	Medium	Low
Non-poultry birds	Negligible	Very low	Very low	Low	Low	Medium	Very low
Cats and dogs	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Other animals ^d	Low	Low	Low	Very low	Very low	Medium	Low
Humans	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Animal products	Negligible	Low	Medium	Low	Low	Medium	Low
Garbage	Negligible	Very low	Medium	Low	Low	Medium	Low
Other cargo	Very low	N/A	Medium	Very low	Very low	Very low	Very low
Conveyances	Very low	N/A	Medium	Very low	Very low	Very low	Very low

9 ^a Domesticated equids.

10 ^b Not applicable. We conducted exposure and consequence assessments only for those pathways for which the
 11 release assessment result was non-negligible.

12 ^c Rest of the United States, other than Guam.

13 ^d Reptiles.

14

15 **A6.2 INTRODUCTION**

16 This analysis was prepared by USDA-APHIS, at the request of the DoD. The purpose of this analysis is to
 17 assess the likelihood that the military relocation will be associated with an increase in the risk of
 18 livestock or poultry infection in the Micronesia Region with a disease agent that is exotic to the region.
 19 For the purpose of this risk assessment, we define a disease agent as an etiologic agent of an OIE-
 20 notifiable disease of livestock or poultry (OIE 2010e).

21 While the scope of this risk analysis includes the entire Micronesia Region, many of the perspectives
 22 presented herein focus on Guam. The majority of DoD activities will occur directly on Guam, making this
 23 the area where consequences will be felt most immediately. In addition, Guam is the largest point of
 24 entry for the Micronesia Region, serving as both the gateway and bellwether for the rest of the Region;
 25 one assumption of our analysis is that exotic species issues significant in Guam are relevant throughout
 26 the Micronesia Region. Because Guam serves as a hub to the rest of the Micronesia Region, the risk to
 27 Guam serves as a proxy for the entire Micronesia Region. It may be convenient for importers to use

1 CNMI for transshipment of goods needed for the relocation on Guam. However, they would still need to
2 comply with CNMI regulations, which, for animal disease concerns, are similar to those in the rest of the
3 Micronesia Region. We consider impacts to individual islands in the Region if there is a specific concern
4 associated with the pathway.

5 We include impacts to human and companion animal health only as related to the livestock and poultry
6 disease agents that we consider. We consider wildlife and feral animals only as potential vehicles for
7 exposure or spread of disease agents or their vectors. It is important to note that livestock are culturally
8 important in the Micronesia Region, and cultural and societal impacts might be more significant than
9 economic consequences; however, this assessment does not take into consideration these intrinsic
10 values.

11 **A6.3 RISK ASSESSMENT**

12 **A6.3.1 Methods**

13 The methods we use in this risk analysis follow the guidelines outlined in the OIE Terrestrial Animal
14 Health Code for import risk analysis (OIE 2010c). An import risk analysis, as defined by the OIE, includes
15 a hazard identification step, followed by a risk assessment. The risk assessment components are release,
16 exposure, and consequence assessments, followed by risk estimation. Below, we briefly summarize the
17 methods we used for each step of this analysis. We used a qualitative approach in our analysis because
18 insufficient information is available for meaningful quantitative assessment.

19 **A6.3.1.1 Hazard Identification Methods**

20 For the purpose of this analysis, we define a hazard as a disease agent that causes clinical illness in
21 livestock or poultry, or an arthropod vector of such a disease agent. We limit disease agents to the
22 etiologic agents of OIE-notifiable diseases of livestock and poultry (OIE 2010e). Animal diseases are
23 listed as OIE-notifiable based on potential for rapid or international spread, zoonotic transmission, or
24 significant mortality or morbidity, by agreement of the World Assembly of OIE Delegates (OIE 2010b, a).
25 We define livestock and poultry as follows.

- 26 • Livestock: Domesticated ruminants (cattle, carabaos, sheep, and goats), domesticated swine
27 including feral swine, and domesticated equids (horses, mules, and asses).
- 28 • Poultry: Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants,
29 pigeons, quail, swans, and turkeys, including eggs for hatching (9 CFR § 93.100).

30 We excluded from our analysis hazards that are known or suspected to be present in the Micronesia
31 Region.

32 **A6.3.1.2 Pathways Risk Analysis Methods**

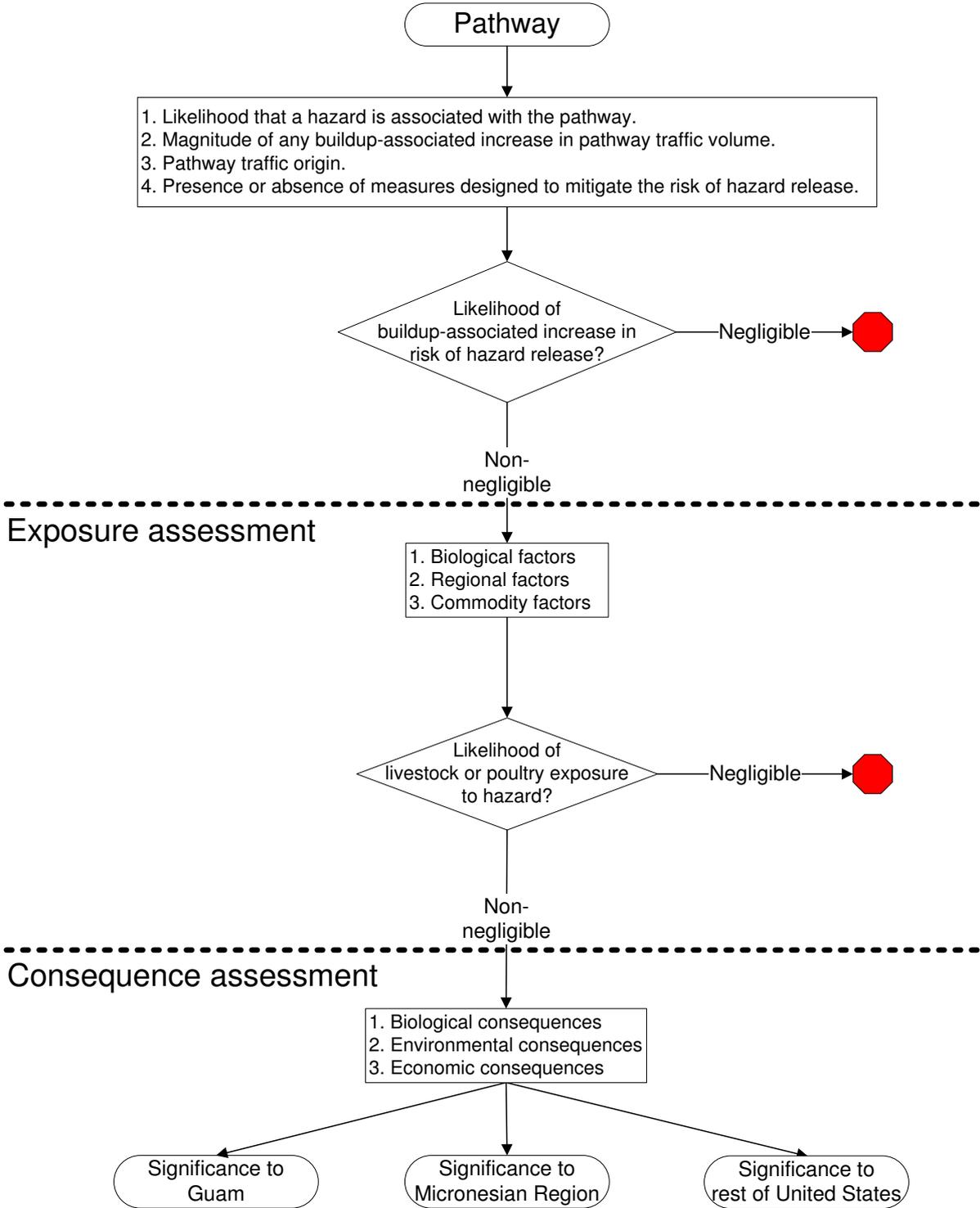
33 First, we identified and characterized pathways by which hazards could be released into the Micronesia
34 Region. Second, we determined which pathways are likely to increase in traffic volume as a direct or
35 indirect result of the military relocation. For each pathway likely to increase in traffic volume as a result

1 of the relocation, we performed a risk assessment, consisting of release, exposure, and consequence
2 assessments, as outlined in Figure A6-1.

3

1 **Figure A6-1: Risk Assessment: Release, Exposure, and Consequence Assessments**

Release assessment



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1 For each pathway likely to increase in traffic volume as a result of the relocation, we qualitatively
 2 assessed the likelihood that the military relocation will be associated with an increase in the risk of
 3 hazard release into the Micronesia Region through that pathway. Hazard release into the Micronesia
 4 Region by any of the pathways requires the presence of the hazard in the country of origin; the presence
 5 of the hazard in the pathway; and passage of the hazard through any mitigation procedures, such as
 6 inspection or quarantine. Therefore, for each release pathway, we based our likelihood estimation on:
 7 1) the likelihood that a hazard is associated with the pathway, 2) the magnitude of any relocation-
 8 associated anticipated increase in pathway traffic volume, 3) pathway traffic origin, and 4) the presence
 9 or absence of measures in place that are designed to mitigate the risk of hazard release.

10 Then, for each pathway for which the release assessment result was non-negligible, we qualitatively
 11 assessed the likelihood of exposure of livestock or poultry in the Micronesia Region to hazards released
 12 through that pathway. We based our likelihood estimation on: 1) biological factors, such as disease
 13 agent survival characteristics; 2) regional factors, such as cultural practices and livestock demographics;
 14 and 3) commodity factors, such as the intended use of imported animals.

15 We expressed our likelihood estimates for release and exposure qualitatively, as negligible, very low,
 16 low, medium, high, or very high. These categories are intended to indicate relative likelihoods among
 17 the pathways. The levels are described in Table A6-2.

18 **Table A6-2: Risk Assessment Estimation Terms and Definitions**

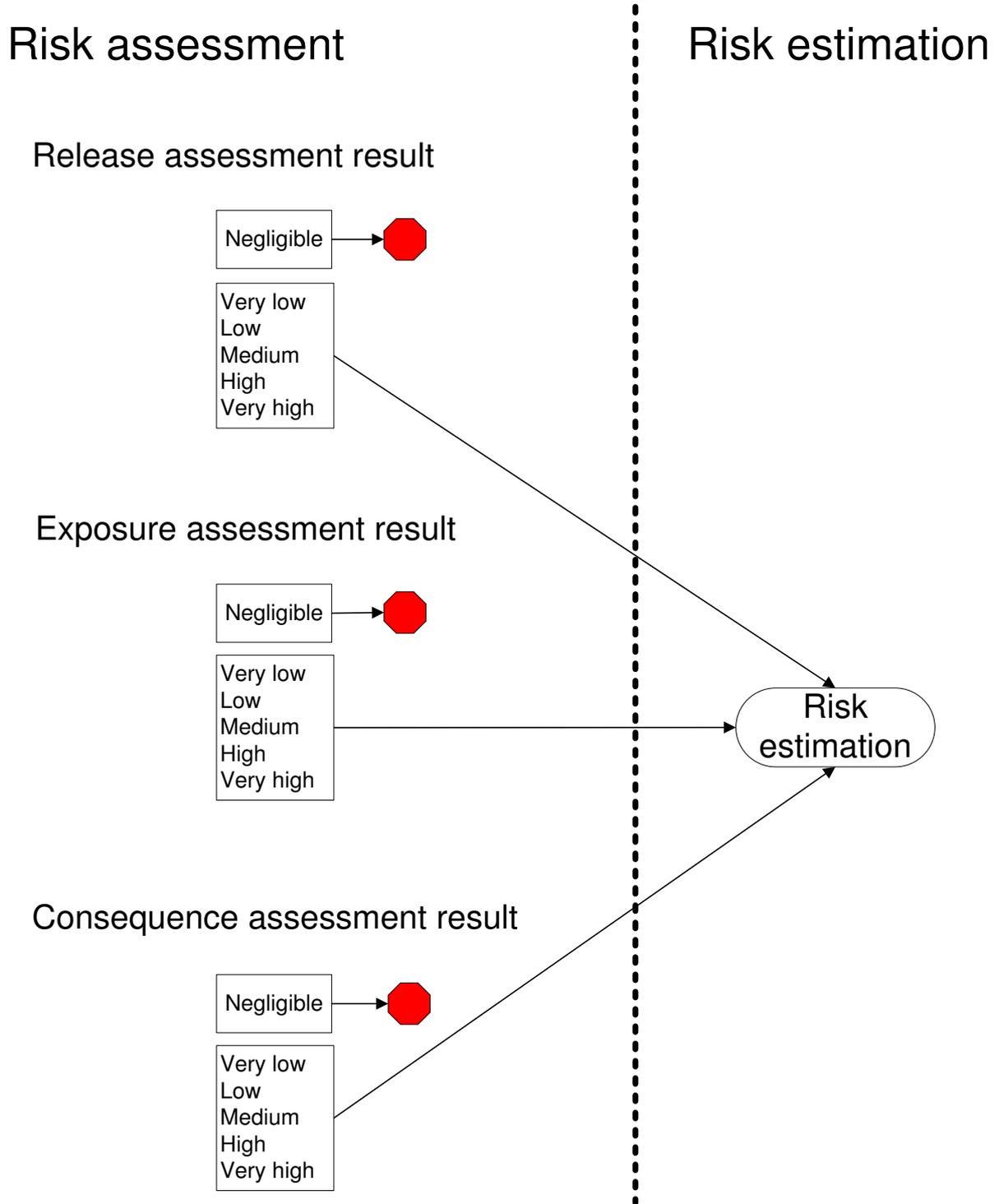
Term	Definition
Negligible	So rare that it does not merit consideration
Very Low	Very rare but cannot be excluded
Low	Rare but does occur
Medium	Occurs regularly
High	Occurs very often
Very High	Occurs extremely often

19
 20 For each pathway for which the exposure assessment result was non-negligible, we qualitatively
 21 evaluated the consequences of livestock or poultry exposure to hazards. The scope of the consequence
 22 assessment is limited to biologic, environmental, and economic consequences, in keeping with the OIE
 23 guidelines for import risk analysis (OIE 2010c). The biological consequences we considered include
 24 hazard characteristics, such as disease agent transmissibility; the number of susceptible host species;
 25 and the magnitude of impact of host species infection, in terms of morbidity and mortality. We
 26 considered biodiversity and impacts on environmental resources as environmental consequences of
 27 hazard exposure. The economic consequences we considered include the magnitude of production and
 28 trade losses and costs associated with surveillance and disease control as a result of host species
 29 exposure or infection.

30 We evaluated consequences in terms of significance to Guam, the Micronesia Region, and the rest of
 31 the United States, and expressed our results qualitatively as negligible, very low, low, medium, high, or
 32 very high. These categories are intended to indicate relative significance among the pathways.

1

Figure A6-2: Risk Estimation



2

3 For each pathway for which the consequence assessment result was non-negligible, we integrated the
4 results of the release, exposure, and consequence assessments to produce an overall measure of risk
5 posed by the pathway (Figure A6-2). We expressed risk levels qualitatively, as negligible, very low, low,

1 medium, high, or very high. These categories are intended to indicate relative risk levels among the
2 pathways.

3 **A6.3.1.3** *Animal Health Data Sources and Limitations*

4 The information evaluated for this assessment includes data gathered from relevant scientific literature
5 and other public sources, information provided to APHIS by the DoD, and information gathered by APHIS
6 during two site visits to the Micronesia Region in November 2009 and January 2010. For information
7 regarding livestock numbers and industry trends, we relied primarily on the most current USDA Census
8 of Agriculture (2007) (USDA-NASS 2009b, a).

9 During the site visits to the Micronesia Region, APHIS staff interviewed staff of the University of Guam as
10 well as federal and local government staff and agricultural industry representatives in Guam, CNMI,
11 Palau, and FSM. Agencies represented include GCQA, GDOA, PPQ, the Joint Guam Program Office, the
12 U.S. Army Veterinary Command, and NAVFAC Pacific. In addition, APHIS staff visited animal production
13 facilities, animal research facilities, maritime and air ports of entry, postal facilities, and garbage
14 handling facilities.

15 Veterinary and laboratory infrastructure is not well developed in the Micronesia Region, where no
16 formal, systematic surveillance of animal health occurs (Poole 2009; SPC 2010). Therefore, little
17 information is available regarding the status of animal health in the Micronesia Region. Our sources for
18 animal health information include the OIE databases Handistatus II and the World Animal Health
19 Information Database, which include sporadic reports for some island groups in the Micronesia Region
20 from 1997 to 2010 (OIE 2004, 2010h). We also sourced reports of convenience sampling-based surveys
21 of livestock health conducted in the 1990s in Guam, Palau, and FSM (Saville 1999; Duguies et al.
22 2000; Simms 2000).

23 Because data about tick interceptions from live animals, live plants, and inanimate articles arriving in
24 Guam and elsewhere in the Micronesia Region are sparse, we used data on ticks intercepted from
25 imports entering the United States to characterize the potential risks of tick-transporting pathways.
26 Databases we used include the USDA national tick survey database which includes records from 1969
27 through 2006, and the USDA-APHIS-PPQ pest interception database which includes records from 1989
28 through 2009, as well as published reports of tick surveys (USDA-APHIS-VS CEAH 2006; USDA-APHIS-PPQ
29 2010a). Data on mosquitoes in tropical climates were more widely available.

30 In general, the data supporting this analysis are sparse and incomplete. Thus, our conclusions should be
31 interpreted with caution, in the context of high levels of uncertainty.

32 **A6.3.1.4** *Assumptions*

33 We assume that current regulations and inspection and quarantine procedures designed to mitigate
34 hazard release are effectively enforced; and that the origins of pathway movement to the Micronesia
35 Region will not substantially change as a result of the military relocation. We realize that our first

1 assumption is not likely true, as is pointed out elsewhere within the MBP and this section. This is a
 2 unfortunate element of our risk assessment and may lead to less than ideal conclusions.

3 **A6.3.2 Hazard Identification**

4 We categorized our hazards as disease agents or vectors. Below, we list these hazards, further
 5 categorized based on whether they are known or suspected to be present in the Micronesia Region, or
 6 not known or suspected to be present in the Micronesia Region.

7 **A6.3.2.1 Disease Agents**

8 A list of disease agents that are known or suspected to be present in the Micronesia Region is presented
 9 in Table A6-3. Other disease agents might exist in the Micronesia Region, but where available data
 10 sources are not sufficient to allow us to conclude with confidence that they are present, we assume that
 11 they are not.

12 Because available data are inadequate to determine baseline and overall risk for the introduction of
 13 disease agents, our assessment is limited to the additional risk posed by the relocation on potential
 14 disease agents and their pathways. Similarly, we did not consider the risk for increased introduction of
 15 pathogens already known or believed to be present on Guam or in the Micronesia Region, nor new
 16 strains of these same pathogens. Thus, we did not consider these indigenous disease agents further in
 17 our analysis.

18 A list of disease agents that are not known or suspected to be present in the Micronesia Region is
 19 presented in Table A6-4. These disease agents are the focus of our analysis.

20 **Table A6-3: Disease Agents Known or Suspected To Be Present in the Micronesia Region**

Disease agent	Disease	References
<i>Multiple species</i>		
Bluetongue virus	Bluetongue	Duguies et al. 2000; OIE 2004
<i>Brucella melitensis</i>	Ovine and caprine brucellosis	Benkirane 2006
<i>Brucella suis</i>	Swine brucellosis	OIE 2010h
<i>Coxiella burnetii</i>	Q fever	Duguies et al. 2000; OIE 2004
<i>Leptospira</i> spp.	Leptospirosis	Saville 1999; Duguies et al. 2000; Simms 2000, OIE 2004
<i>Mycobacterium avium paratuberculosis</i>	Paratuberculosis	Saville 1999
Pseudorabies virus	Aujeszky's disease	Simms 2000
<i>Trichinella</i> spp.	Trichinellosis	Saville 1999; OIE 2004
<i>Domesticated ruminants</i>		
<i>Anaplasma</i> spp.	Bovine anaplasmosis	Duguies et al. 2000; OIE 2004
<i>Babesia</i> spp.	Bovine babesiosis	Duguies et al. 2000; OIE 2004
Bovine leukosis virus	Enzootic bovine leukosis	Saville 1999; Duguies et al. 2000; OIE 2004
Caprine arthritis/encephalitis virus	Caprine arthritis/encephalitis	Saville 1999
Infectious bovine rhinotracheitis/infectious pustular	Infectious bovine rhinotracheitis/infectious pustular	Saville 1999; Duguies et al. 2000; OIE 2004

Disease agent	Disease	References
vulvovaginitis virus	vulvovaginitis	
	<i>Domesticated swine</i>	
<i>Taenia solium</i>	Porcine cysticercosis	CFSPH 2005d
	<i>Domesticated equids</i>	
Equine herpesvirus-1	Equine rhinopneumonitis	Duguies et al. 2000
Equine influenza virus	Equine influenza	Duguies et al. 2000
Equine viral arteritis virus	Equine viral arteritis	OIE 2004
	<i>Poultry</i>	
<i>Chlamydia psittaci</i>	Avian chlamydiosis	Totten 2008
Gallid herpesvirus-2	Marek's disease	Duguies et al. 2000
Infectious bursal disease virus	Infectious bursal disease (Gumboro disease)	Saville 1999; Duguies et al. 2000
Infectious bronchitis virus	Avian infectious bronchitis	Saville 1999; Duguies et al. 2000
Infectious laryngotracheitis virus	Avian infectious laryngotracheitis	Duguies et al. 2000
<i>Mycoplasma gallisepticum</i>	Avian mycoplasmosis (<i>M. gallisepticum</i>)	Duguies et al. 2000
<i>Mycoplasma synoviae</i>	Avian mycoplasmosis (<i>M. synoviae</i>)	Duguies et al. 2000
<i>Pasteurella multocida</i>	Fowl cholera	(OIE 2008)

1

2 **Table A6-4: Disease Agents not Known or Suspected to be Present in the Micronesia Region**

Disease agent	Disease
	<i>Multiple species</i>
<i>Bacillus anthracis</i>	Anthrax
<i>Brucella abortus</i>	Brucellosis (<i>Brucella abortus</i>)
<i>Cochliomyia hominivorax</i>	New world screwworm myiasis
<i>Chrysomya bezziana</i>	Old world screwworm myiasis
Crimean Congo hemorrhagic fever virus	Crimean Congo hemorrhagic fever
<i>Echinococcus granulosus</i> ; <i>E. multilocularis</i>	Echinococcosis/hydatidosis
<i>Ehrlichia ruminantium</i>	Heartwater
Foot and mouth disease virus	Foot and mouth disease
JEV	Japanese encephalitis
<i>Leishmania</i> spp.	Leishmaniasis
Rabies virus	Rabies
Rift Valley fever virus	Rift Valley fever
Rinderpest virus	Rinderpest
Vesicular stomatitis virus	Vesicular stomatitis
WNV	West Nile fever
	<i>Domesticated ruminants</i>
Bovine spongiform encephalopathy agent	Bovine spongiform encephalopathy
Bovine viral diarrhea virus	Bovine viral diarrhea
<i>Brucella ovis</i>	Ovine epididymitis
<i>Campylobacter fetus venerealis</i> ; <i>C. fetus fetus</i>	Bovine genital campylobacteriosis
<i>Capripoxvirus</i>	Lumpy skin disease
<i>Chlamydophila abortus</i>	Enzootic abortion of ewes (ovine chlamydiosis)
Maedi-visna virus	Maedi-visna
Malignant catarrhal fever virus	Malignant catarrhal fever
<i>Mycobacterium bovis</i>	Bovine tuberculosis
<i>Mycoplasma agalactiae</i> ; <i>Mycoplasma</i> spp.	Contagious agalactia

Disease agent	Disease
<i>Mycoplasma capricolum capripneumoniae</i> ; <i>M. mycoides capri</i>	Contagious caprine pleuropneumonia
<i>Mycoplasma mycoides mycoides</i>	Contagious bovine pleuropneumonia
Nairobi sheep disease	Nairobi sheep disease
<i>Pasteurella multocida</i> subsp. <i>multocida</i>	Hemorrhagic septicemia
Peste des petits ruminants virus	Peste des petits ruminants
<i>Salmonella</i> Abortusovis	Paratyphoid abortion
Scrapie agent	Scrapie
Sheep pox and goat pox virus	Sheep pox and goat pox
<i>Theileria</i> spp.	Theileriosis
<i>Trichomonas foetus</i>	Trichomonosis
<i>Trypanosoma</i> spp. (African)	Trypanosomiasis (African animal)
<i>Domesticated swine</i>	
African swine fever virus	African swine fever
Classical swine fever virus	Classical swine fever
Nipah virus	Nipah virus encephalitis
Porcine reproductive and respiratory syndrome virus	Porcine reproductive and respiratory syndrome
Swine vesicular disease virus	Swine vesicular disease
Transmissible gastroenteritis virus	Transmissible gastroenteritis
<i>Domesticated equids</i>	
African horse sickness virus	African horse sickness
<i>Babesia caballi</i> and <i>Theileria equi</i>	Equine piroplasmosis
<i>Burkholderia mallei</i>	Glanders
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)
Equine infectious anemia virus	Equine infectious anemia
<i>Taylorella equigenitalis</i>	Contagious equine metritis
<i>Trypanosoma equiperdum</i>	Dourine
<i>Trypanosoma evansi</i>	Surra
<i>Poultry</i>	
Avian metapneumovirus	Turkey rhinotracheitis
Duck hepatitis virus types I, II, and III	Duck virus hepatitis
Exotic NDV	Exotic Newcastle disease
HPAIV	HPAI
<i>Salmonella</i> Gallinarum	Fowl typhoid
<i>Salmonella</i> Pullorum	Pullorum disease

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A6.3.2.2 Vectors

Several of the disease agents that we consider in our analysis can be transmitted by arthropod vectors, such as ticks, mosquitoes, or midges. Introduction and establishment of exotic vectors can increase the likelihood of disease agent transmission to a susceptible vertebrate host (Korch Jr. 1994), and can be associated with disease outbreaks. For example, *Dermacentor (Anocenter) nitens*, a tick species that had not been seen in Florida prior to 1958, was the primary vector for an equine piroplasmosis outbreak in Florida during the 1960s (Strickland and Gerrish 1964; Knowles et al. 1966; Becklund 1968; Holbrook 1969).

1 Based on our list of disease agents (see Table A6-4), we developed a list of vectors of those disease
 2 agents. As we did for disease agents, we categorized the vectors based on whether they are known or
 3 suspected to be present in the Micronesia Region, or not known or suspected to be present in the
 4 Micronesian Region.

5 A list of vectors that are known or suspected to be present in the Micronesia Region is presented in
 6 Table A6-5. We did not consider these vectors further in our analysis. Although other vectors might be
 7 present in the Micronesia Region, where available data sources are not sufficient to allow us to conclude
 8 with confidence that they are present, we assume that they are not.

9 **Table A6-5: Vectors Known or Suspected to be Present in the Micronesia Region**

Vector	Disease	References
Tick		
<i>Rhipicephalus (Boophilus) microplus</i>	Equine piroplasmiasis	Kohls 1953; Ueti et al. 2005; Wolf 2010
Mosquito^a		
<i>Aedes albopictus</i>	<i>Aedes</i> spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Eastern, Western, and Venezuelan), Japanese encephalitis, lumpy skin disease, Rift Valley fever, and vesicular stomatitis	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a; OIE 2009n, p, v, f; Pepin et al. 2010; Wolf 2010
<i>Ae. pandani</i>		
<i>Ae. rotanua</i>		
<i>Ae. vexans</i>		
<i>Anopheles indefinites</i>	<i>Anopheles</i> spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Western), Japanese encephalitis, and Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p, f; Wolf 2010
<i>Culex annulirostris</i>	<i>Culex</i> spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Eastern, Western, and Venezuelan), Japanese encephalitis, lumpy skin disease, Rift Valley fever, and West Nile fever	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a, 2009q; OIE 2009n, p, f; Pepin et al. 2010; Wolf 2010
<i>Cx. fusocephalus</i>		
<i>Cx. quinquefasciatus</i>		
<i>Cx. tritaeniorhynchus</i>		
Other arthropod^a		
Ceratopogonidae midges	Ceratopogonidae midges have been reported to transmit African horse sickness and vesicular stomatitis	CFSPH 2008g; OIE 2009f; Wolf 2010
<i>Culicoides guttifer</i>		
<i>C. peregrinus</i>		
<i>Simulium aureohirtum</i>	<i>Simulium</i> spp. (blackflies) have been reported to transmit vesicular stomatitis	OIE 2009v; Wolf 2010
<i>S. guamense</i>		
<i>Stomoxys calcitrans</i>	<i>Stomoxys</i> spp. have been reported to transmit equine infectious anemia and surra	CFSPH 2009n, i; OIE 2009t; Wolf 2010
<i>Tabanus striatus</i>	Tabanid flies have been reported to transmit equine infectious anemia, surra, and trypanosomiasis (African animal)	CFSPH 2009a, i; OIE 2009t; Wolf 2010

10 ^a Not all species of all families or genera transmit each of the etiologic agents of the diseases listed.
 11

12 A list of vectors that are not known or suspected to be present in the Micronesia Region is presented in
 13 Table A6-6. These vectors we considered further in our analysis.

1 **Table A6-6: Vectors Not Known or Suspected to be Present In the Micronesia Region**

Vector ^{a,b}	Disease	References
Tick		
<i>Amblyomma cajennense</i>	Equine piroplasmosis	OIE 2009c
<i>A. variegatum</i>	Heartwater; Nairobi sheep disease; theileriosis	Musisi et al. 1984; CFSPH 2007g, 2009l
<i>Amblyomma</i> spp.	Heartwater; theileriosis	CFSPH 2007g, 2009p
<i>Dermacentor (Anocentor) nitens</i>	Equine piroplasmosis	Roby and Anthony 1963
<i>D. marginatus</i>	Equine piroplasmosis	Friedhoff 1988
<i>D. nuttalli</i>	Equine piroplasmosis	Friedhoff 1988; Rüegg et al. 2007
<i>D. reticulatus</i>	Equine piroplasmosis	Friedhoff 1988
<i>D. silvarum</i>	Equine piroplasmosis	Friedhoff 1988
<i>Haemaphysalis intermedia</i>	Nairobi sheep disease	CFSPH 2009l
<i>Haemaphysalis</i> spp.	Theileriosis	CFSPH 2009p
<i>Hyalomma anatolicum subspecies anatolicum</i> and <i>excavatum</i>	Equine piroplasmosis	Neitz 1956; Friedhoff 1988; Zapf and Schein 1994; Kumar et al. 2007; Taylor et al. 2007
<i>Hy. dromedarii</i>	Equine piroplasmosis	Neitz 1956; Zapf and Schein 1994
<i>Hy. lusitanicum</i>	Equine piroplasmosis	Zapf and Schein 1994; Kahn and Line 2008
<i>Hy. marginatum</i>	Equine piroplasmosis	Neitz 1956; Friedhoff 1988; Taylor et al. 2007
<i>Hy. scupense (=Hy. detritum)</i>	Equine piroplasmosis	Enigk 1944; Taylor et al. 2007
<i>Hy. truncatum</i>	Equine piroplasmosis	De Waal and van Heerden 2004; Rothschild and Knowles 2007
<i>Hyalomma</i> spp.	African horse sickness; theileriosis	CFSPH 2009p; OIE 2009f
<i>Ornithodoros maroccanus (erraticus)</i>	African swine fever	Kahn and Line 2008
<i>O. porcinus porcinus (O. moubata porcinus)</i>	African swine fever	Kahn and Line 2008
<i>Rhipicephalus appendiculatus</i>	Nairobi sheep disease	CFSPH 2009l
<i>R. bursa</i>	Equine piroplasmosis	Enigk 1943; Neitz 1956; Taylor et al. 2007
<i>R. evertsi evertsi</i>	Equine piroplasmosis	Young and Purnell 1973, Potgieter et al. 1992, De Waal and van Heerden 2004
<i>R. pulchellus</i>	Nairobi sheep disease	CFSPH 2009l
<i>R. simus</i>	Nairobi sheep disease	CFSPH 2009l
<i>Rhipicephalus</i> spp.	African horse sickness; theileriosis	CFSPH 2009p; OIE 2009f
Mosquito		
<i>Aedes</i> spp.	African horse sickness; equine encephalomyelitis (Eastern, Western, and Venezuelan); Japanese encephalitis; lumpy skin disease; Rift Valley fever; vesicular stomatitis	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a; OIE 2009n, p, v, f; Pepin et al. 2010
<i>Anopheles</i> spp.	African horse sickness; equine encephalomyelitis (Western); Japanese encephalitis; Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p, f
<i>Coquilletidia perturbans</i>	Equine encephalomyelitis (Eastern)	CFSPH 2008a

Vector ^{a,b}	Disease	References
<i>Culex</i> spp.	African horse sickness; equine encephalomyelitis (Eastern, Western, and Venezuelan); Japanese encephalitis; lumpy skin disease; Rift Valley fever; West Nile fever	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a, 2009q; OIE 2009n, p, f; Pepin et al. 2010
<i>Culiseta melanura</i>	Equine encephalomyelitis (Eastern)	CFSPH 2008a
<i>Eretmapodites</i> spp.	Rift Valley fever	OIE 2009p; Pepin et al. 2010
<i>Mansonia</i> spp.	Equine encephalomyelitis (Venezuelan); Japanese encephalitis; Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p
<i>Ochlerotatus</i> spp.	Equine encephalomyelitis (Eastern); Japanese encephalitis; West Nile fever	Mackenzie 2007; CFSPH 2008a, 2009q
<i>Psorophora</i> spp.	Equine encephalomyelitis (Venezuelan)	CFSPH 2008a
Other arthropod		
<i>Atylotus</i> spp.	Surra	CFSPH 2009n; OIE 2009t
<i>Chrysops</i> spp.	Equine infectious anemia; surra	CFSPH 2009i, n
<i>Culicoides</i> spp.	African horse sickness; vesicular stomatitis	CFSPH 2008g; OIE 2009f
<i>Glossina</i> spp.	Trypanosomiasis (African animal)	CFSPH 2009a
<i>Haematopota</i> spp.	Surra	CFSPH 2009n
<i>Hybomitra</i> spp.	Equine infectious anemia	CFSPH 2009i
<i>Lutzomyia</i> spp.	Leishmaniasis; vesicular stomatitis	CFSPH 2009k; OIE 2009v
<i>Lyperosia</i> spp.	Surra	CFSPH 2009n; OIE 2009t
<i>Musca</i> spp.	Surra	CFSPH 2009n; OIE 2009t
<i>Phlebotomus</i> spp.	Leishmaniasis; vesicular stomatitis	CFSPH 2009k; OIE 2009v
Simuliidae	Vesicular stomatitis	OIE 2009v
<i>Stomoxys calcitrans</i>	Equine infectious anemia	CFSPH 2009i
<i>Stomoxys</i> spp.	Surra	CFSPH 2009n, OIE 2009t
Tabanidae	Trypanosomiasis (African animal)	CFSPH 2009a
<i>Tabanus</i> spp.	Equine infectious anemia; surra	CFSPH 2009i; OIE 2009t

1 ^a Species other than those listed in Table A6-5.

2 ^b Not all species of all families or genera transmit each of the etiologic agents of the diseases listed.

3 **A6.3.3 Pathways Risk Analysis**

4 Hazards can move into, through, or out of the Micronesia Region through any of numerous pathways,
5 including movement of infected live animals or contaminated cargo. Types of movement can be
6 categorized in terms of whether the movement is initiated by people (intentional movement),
7 proceeding through either legal or illegal means, or not initiated by people (accidental movement), such
8 as through natural spread or stowing away on conveyances. For the purpose of this analysis, stowaways
9 are animals, including arthropods, which are carried by, but are not biologically associated with, a
10 conveyance.

11 We defined pathways based on categories of traffic movement to which animal health import risk
12 mitigations are typically applied (CFR; 9 GARR 1, Division 1, Chapter 1; OIE 2010g; USDA-APHIS 2010b).
13 Table A6-7 lists the pathways that we considered feasible for transporting hazards along with the
14 expected direct and indirect effects of the military relocation on pathway traffic volume, based upon the
15 data and discussion elsewhere in this document. We excluded from further analysis pathways for which
16 traffic volume is not expected to increase as a result of the relocation.

1 **Table A6-7: Pathways and the Effect of the Military Relocation on Pathway Traffic Volume**

Pathway	Description	Effect of military Relocation on Pathway Traffic Volume
<i>Livestock</i>		
Domesticated ruminants	Cattle, carabaos, goats, and sheep	No effect
Swine	Domesticated swine, including feral swine	No effect
Domesticated equids	Horses, mules, and asses	Increase
Livestock germplasm	Semen, ova, and embryos of livestock	No effect
<i>Birds</i>		
Poultry	Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching	Increase
Non-poultry birds	All birds, except poultry	Increase
<i>Cats and dogs</i>		
	Domesticated cats, and domesticated dogs, including working dogs	Increase
<i>Other animals</i>		
Large mammals	Ungulates and carnivores, other than livestock and domesticated cats and dogs	No effect
Small mammals	Small mammals species common in the pet trade, including rodents, lagomorphs, and hedgehogs	Increase
Reptiles and amphibians	Lizards, snakes, turtles, tortoises, frogs, toads	Increase
<i>Humans</i>		
	People and their accompanying baggage	Increase
<i>Animal products</i>		
	Products of animal origin, including meat and meat products, milk and milk products, blood and blood products, skins, feathers, wool and hair, animal feed containing products of animal origin	Increase
<i>Garbage</i>		
	All waste material that is derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse that has been associated with any such material	Increase
<i>Other cargo</i>		
	Live plants and inanimate objects, excluding animal products and garbage	Increase
<i>Conveyances</i>		
	Aircraft, maritime vessels, and shipping containers	Increase

2

3 Detailed data on the trends in live animal imports are available elsewhere in this document. We do not
 4 expect demand for imports of domesticated ruminants or swine into the Micronesia Region to increase
 5 as a result of the relocation. The USDA Census of Agriculture documents the decline of livestock farming
 6 in Guam; both the number of farms and the numbers of cattle, carabaos, goats, and swine have
 7 decreased in Guam over the past decade, and the relocation will place additional negative pressure on
 8 animal agriculture through increased urbanization and competition for land resources (USDA-NASS
 9 2009a; U.S. Navy 2010a). Horseback riding is a popular adventure travel activity, and the adventure

1 travel industry is growing worldwide (Heyniger 2006). Therefore, increases in population and tourism in
2 the Micronesia Region may increase demand for animals associated with recreational activities,
3 particularly horseback riding. Livestock industries in the Micronesia Region have not adopted assisted
4 reproduction practices, such as artificial insemination or embryo transfer, to any degree and this is not
5 expected to change (Duguies et al. 2000; Poole 2009). We expect the demand for game fowl used in
6 cock fighting to increase during the military relocation, and therefore, imports of live poultry and
7 hatching eggs may increase as a result. The increase in the human population in the Micronesia Region
8 will likely be accompanied by an increase in demand for exotic pets, including birds, small mammals, and
9 reptiles.

10 The relocation will be associated with a substantial increase in maritime and air conveyance traffic to
11 the Micronesia Region. This traffic will support substantial increases in the volume of movement of
12 people, animal products, garbage, and other cargo.

13 **A6.3.3.1 Livestock**

14 Livestock can be moved legally or they can be smuggled onto Guam; due to geographic barriers,
15 accidental movement (straying) is not feasible.

16 Overall, livestock populations in the Region are declining (USDA-NASS 2009a, b). However, compared to
17 other islands in the Region, beef cattle production on Tinian is large scale, with over 1,000 animals
18 distributed among approximately 60 farms (USDA-NASS 2009b). The military is planning to increase
19 training activities on Tinian, related to the relocation.

20 Cattle producers on Tinian are interested in improving production and range management practices, as
21 well as increasing the size of their industry (Jimenez et al. 2009). Additionally, they are interested in
22 developing a certified slaughter industry so they can sell their beef throughout the Region. However,
23 current business opportunities for the beef cattle industry in Tinian are hampered by the lack of
24 veterinary infrastructure, meat inspection services, and, possibly, by expansion of military operations.

25 At present, Tinian cattle are raised on the lease-back area controlled by the military. Expansion of
26 training activities may result in reduced access to that land for grazing. This is a concern for Tinian
27 ranchers. In addition, there is a concern that training activities may include weapons training, which
28 could have a negative impact on cattle production (Jimenez et al. 2009).

29 While cattle production on Tinian may be impacted by military training activities, we do not expect that
30 the military relocation will directly or indirectly increase legal or illegal traffic volume to the Region in
31 most types of livestock, namely domesticated ruminants, swine, or their germplasm. Traffic volume in
32 domesticated equids (horses, mules, and asses) to Guam might increase as a result of the military
33 relocation. Therefore, we consider only those hazards associated with domesticated equids in the
34 release and exposure assessments of the livestock pathway. We consider only intentional movement of
35 domesticated equids to the Micronesia Region through legal means; smuggling of domesticated equids
36 to the Micronesia Region is infeasible due to geographic barriers.

A6.3.3.1.1 Hazards Associated with the Livestock Pathway

Domesticated equids can play three roles in the transport of hazards: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-8 lists hazards that are associated with domesticated equids through these three roles, including hazards for which domesticated equids may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-8: Hazards Associated with the Livestock Pathway (Domesticated Equids)

Hazard	Disease	Transport role ^a	References
Disease agent			
African horse sickness virus	African horse sickness	I	CFSPH 2006a, OIE 2009f
African swine fever virus	African swine fever	F	CFSPH 2010a
<i>Babesia caballi</i> and <i>Theileria equi</i>	Equine piroplasmiasis	I	CFSPH 2008b, OIE 2008i
<i>Burkholderia mallei</i>	Glanders	I	CFSPH 2007f, OIE 2008l
<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007l
<i>Echinococcus granulosus</i> ; <i>E. multilocularis</i>	Echinococcosis/hydatidosis	I	CFSPH 2009h
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a, OIE 2008g
Equine infectious anemia virus	Equine infectious anemia	I	OIE 2008h, CFSPH 2009i
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
JEV	Japanese encephalitis	I	CFSPH 2007h
<i>Leishmania</i> spp.	Leishmaniasis	I	CFSPH 2009k
<i>Mycobacterium bovis</i>	Bovine tuberculosis	I	CFSPH 2009c
Nipah virus	Nipah virus encephalitis	I	CDC
<i>Pasteurella multocida</i> serotypes 6:B and 6:E	Hemorrhagic septicemia	I	OIE 2009k
Rabies virus	Rabies	I	CFSPH 2009m
<i>Taylorella equigenitalis</i>	Contagious equine metritis	I	OIE 2008c, CFSPH 2009f
<i>Trypanosoma equiperdum</i>	Dourine	I	OIE 2008p, CFSPH 2009g
<i>Trypanosoma evansi</i>	Surra	I	OIE 2008q, CFSPH 2009n
<i>Trypanosoma</i> spp.	Trypanosomiasis (African animal)	I	CFSPH 2009a
Vesicular stomatitis virus	Vesicular stomatitis	I	CFSPH 2008g
WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector			
Tick^b			
<i>Amblyomma</i> spp.	Equine piroplasmiasis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
<i>Dermacentor</i> spp.	Equine piroplasmiasis	V	Kolonin 2009
<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009

Hazard	Disease	Transport role ^a	References
<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

^b Not all species of all genera feed on domesticated equids.

A6.3.3.1.2 Release Assessment: Livestock Pathway

Likelihood of Hazard Association

Infected domesticated equids are the primary source for the etiologic agents of African horse sickness, contagious equine metritis, dourine, equine infectious anemia, equine piroplasmosis, and glanders (CFSPH 2006a, 2007f, 2008b, 2009f, g, i). Domesticated equids can be infected with and serve as reservoirs for Nipah, rabies, Venezuelan equine encephalitis, and vesicular stomatitis viruses, but they are not the only, or the most important, hosts (CFSPH 2007j, 2008g, 2009m; OIE 2009u). Other hosts are epidemiologically more important than domesticated equids for harboring screwworms, *Echinococcus* spp., and *Leishmania* spp. parasites (Eckert and Deplazes 1999; CFSPH 2009k; OIE 2009q; Pavlin et al. 2009). Domesticated equids can be infected with, but do not serve as reservoirs for transmission of, *M. bovis*, and eastern equine encephalitis, Japanese encephalitis, western equine encephalitis, and WNV (Calisher 1994; CFSPH 2007h; 2009c, q).

African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically spread by domesticated animals, such as equids, which have been in contact with affected premises (CFSPH 2007e, 2009d, 2010a).

Domesticated equids are frequently reported hosts for tick species that are competent vectors for equine piroplasmosis, and less frequently host tick species that are competent vectors for heartwater (Estrada-Peña et al. 2004).

Traffic Volume

Detailed data on livestock imports are available elsewhere in this document. According to the Territorial Veterinarian of Guam, no livestock, including domesticated equids, have been imported to Guam over the last five years (Poole 2009). The equine industry on Guam is small; the USDA Census of Agriculture (2007) identified only two farms with horses on the island (USDA-NASS 2009a). The high cost of feed, most of which is imported, and the lack of services, such as farriers and equine practitioners, are cited as challenges to keeping horses on Guam (Earth.org 2009). If the volume of domesticated equid imports to Guam increases as a result of increased demand by the tourism industry, we expect the numbers to be very small. We do not expect the military relocation to be associated with an increase in traffic volume of domesticated equids to the rest of the Micronesia Region.

1 ***Traffic Origin***

2 Any domesticated equids imported onto Guam will likely originate in the mainland United States, due to
3 Federal regulations pertaining to importation of livestock, discussed below in mitigations. The United
4 States is free of African horse sickness, African animal trypanosomiasis, dourine, foot and mouth
5 disease, glanders, heartwater, Japanese encephalitis, Nipah virus encephalitis, screwworms, surra, and
6 Venezuelan equine encephalomyelitis (USDA-APHIS 2008b). Outbreaks of contagious equine metritis,
7 equine piroplasmiasis, and vesicular stomatitis have recently occurred in parts of the United States
8 (Webb et al. 1987; OIE 2008c; CFSPPH 2009f; OIE 2009c, v).

9 ***Mitigations***

10 APHIS regulations governing the importation of domesticated equids are set forth in 9 CFR Part 93.
11 These regulations pertain to the movement of horses, mules, asses, and zebras from foreign countries
12 into any of the 50 States, the Commonwealth of Puerto Rico, CNMI, the District of Columbia, and any
13 territories and possessions of the United States. Domesticated equids intended for importation into the
14 United States from any part of the world must be shipped directly to an approved port and be
15 quarantined at the port until negative results to specified tests, depending upon the country of origin,
16 are obtained and the equids are certified by the port veterinarian to be free from clinical evidence of
17 disease. In special cases, unapproved ports may be designated as quarantine stations by the APHIS
18 Administrator. No ports on Guam are approved for importation of livestock, and therefore, at this time,
19 horses intended for import to Guam must first enter through ports in the continental United States.

20 Prior to importation, each domesticated equid must be inspected by a veterinarian at the premises of
21 origin and found free of evidence of or exposure to communicable disease. Domesticated equids
22 intended for import to the United States from regions affected by screwworm, contagious equine
23 metritis, and Venezuelan equine encephalomyelitis are subject to inspection or treatment procedures
24 specified in 9 CFR § 93.308. Imported domesticated equids, with limited exceptions for those originating
25 in certain countries, cannot enter the United States until they have been tested for equine infectious
26 anemia, equine piroplasmiasis, dourine, and glanders by an official test with negative results. Before a
27 horse imported from any part of the world is released from the port of entry into the United States, an
28 inspector may require the horse and its accompanying equipment to be disinfected as a precautionary
29 measure against the introduction of foot and mouth disease or any other disease dangerous to the
30 livestock of the United States (9 CFR § 93.314).

31 APHIS regulations pertaining to interstate movement of domesticated equids are set forth in 9 CFR §§ 71
32 and 75. Animals, including domesticated equids, affected with any communicable disease are generally
33 prohibited from interstate movement. Domesticated equids affected with equine piroplasmiasis,
34 dourine, glanders, contagious equine metritis, or screwworms may not be moved interstate.
35 Domesticated equids that have tested positive on an official test for equine infectious anemia are
36 prohibited from moving interstate, except under limited circumstances.

37 Specific regulations regarding the importation of live animals onto Guam can be found in the Guam
38 Administrative Rules and Regulations (9 GARR 1, Division 1, Chapter 1). No animals that are affected

1 with or have been exposed to an infectious, contagious, or communicable disease or ectoparasites or
2 which originated in an area under state or federal quarantine shall be permitted to be introduced into
3 Guam. Horses are subject to specific mitigations to prevent the entry of equine infectious anemia, and
4 Eastern, Western, and Venezuelan equine encephalomyelitis viruses.

5 ***Summary***

6 Traffic volume in domesticated equids to Guam might increase as an indirect result of the military
7 relocation (increased demand for recreational activities). However, we expect that the increase in traffic
8 volume will be very small. Due to federal regulations governing the importation of livestock,
9 domesticated equids intended for importation to Guam are highly likely to originate in the continental
10 United States, which is free of most of the hazards for which domesticated equids are the primary
11 source. The risk of importation or interstate movement of hazards for which domesticated equids might
12 play a significant role in transporting to Guam is mitigated by APHIS and Guam territorial regulations.

13 ***Livestock Pathway Release Assessment***

14 The increased risk of release of hazards into the Micronesia Region due to the military relocation
15 through the livestock pathway is negligible.

16 ***Livestock Pathway Risk Estimation***

17 Because the increased risk of release of hazards into the Micronesia Region due to the military
18 relocation through the livestock pathway is negligible, we conclude that the military relocation-
19 associated overall risk for the livestock pathway is negligible.

20 **A6.3.3.2 Poultry**

21 For the purpose of this risk assessment, poultry are chickens, doves, ducks, geese, grouse, guinea fowl,
22 partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching. In this
23 pathway, poultry can be moved legally or illegally; due to geographic barriers and characteristics of
24 these species, we do not consider accidental movement (straying, migration, or stowing away) feasible.

25 We expect the popularity of cock fighting to temporarily increase during the military relocation because
26 most temporary workers are expected to come from the Philippines (U.S. Navy 2010a). Cock fighting is
27 very popular in the Philippines and is a major source of entertainment for Filipino immigrants in the
28 continental United States (Bautista 1998). Additionally, previous waves of temporary construction-
29 associated immigration from the Philippines have resulted in increased fight attendance (Sgambelluri et
30 al. 2009).

31 Federal regulations and APHIS policy restrict importation of live poultry, poultry products, and hatching
32 eggs from regions affected by exotic Newcastle disease (END) or HPAI subtype H5N1; several of these
33 regions include Asia-Pacific countries (9 CFR §§ 93.201 and 94.6). Live poultry permitted to enter the
34 United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a
35 quarantine facility on the mainland United States (9 CFR § 93.209). Importers bear the cost of these
36 import requirements. The importation of hatching eggs is restricted from countries affected by END,

1 which includes the Philippines and several other Asia-Pacific countries (9 CFR § 93.209). These
 2 regulations reduce the practicality of importing foreign poultry (including hatching eggs and game cocks)
 3 to Guam from Asia-Pacific countries.

4 Experts believe the worldwide movement of people and their demand for familiar, culturally important
 5 foods and traditional items leads to the smuggling of poultry, particularly hatchlings and hatching eggs
 6 (Rosenthal 2006). Temporary foreign workers related to the relocation are expected to come primarily
 7 from Asia-Pacific countries where cock fighting is popular (Jimenez et al. 2009; Poole 2009). These
 8 workers may be tempted to smuggle fighting fowl onto Guam in order to circumvent import
 9 requirements. We expect that the military relocation will increase the volume of illegal traffic in live
 10 poultry, particularly chickens and chicken eggs for hatching.

11 Because of increased urbanization and competition for land resources on Guam, the relocation will place
 12 additional negative pressure on animal agriculture; therefore, we do not expect shipments of live
 13 poultry for commercial purposes to increase. Nor do we expect that the increased number of military
 14 personnel or their dependents will result in increased importation of pet poultry species. The high cost
 15 of shipping and health certification relative to the perceived value of these birds is likely a deterrent to
 16 bringing pet poultry to Guam. For example, the cost of shipping a bird from Hawai'i to Guam, including
 17 fees for health certification, shipping box, and air freight, exceeds \$75.00 (Poole 2009). In addition,
 18 military regulations prohibit poultry in private housing (U.S. Army 2008).

19 **A6.3.3.2.1 Hazards Associated with the Poultry Pathway**

20 Poultry can transport hazards in three roles: they can be infected hosts, they can be contaminated with
 21 disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table
 22 A6-9 lists hazards that are associated with the poultry pathway, including hazards for which poultry may
 23 serve as dead-end hosts or play a minor or theoretical role in transmission.

24 **Table A6-9: Hazards Associated with the Poultry Pathway**

Hazard	Disease	Transport role ^a	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
Avian metapneumovirus	Turkey rhinotracheitis	I	OIE 2009w
<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007l
Duck hepatitis virus types I, II, and III	Duck virus hepatitis	I	OIE 2008d
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a, OIE 2008g
Exotic NDV	Exotic Newcastle disease	I	CFSPH 2008d
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I	OIE 2009m, CFSPH 2010b, USGS 2010
<i>Salmonella Gallinarum</i>	Fowl typhoid	I	OIE 2008k, CFSPH 2009j

Hazard	Disease	Transport role ^a	References
<i>Salmonella Pullorum</i>	Pullorum disease	I	OIE 2008k, CFSPH 2009j
WNV	West Nile fever	I	CFSPH 2009q
Vector			
Tick ^b			
<i>Amblyomma</i> spp.	Equine piroplasmiasis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmiasis; theileriosis	V	Kolonin 2009
<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmiasis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

1 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

2 ^b Not all species of all genera feed on poultry.

3

4 **A6.3.3.2.2 Release Assessment: Poultry Pathway**

5 **Likelihood of Hazard Association**

6 Infected poultry are the primary source for the etiologic agents of avian metapneumovirus, duck virus
7 hepatitis, fowl typhoid, and pullorum (OIE 2008d, k; CFSPH 2009j; OIE 2009w). Poultry can be infected
8 with and serve as reservoirs for END, HPAI, equine encephalomyelitis, and WNV, but they are not the
9 only reservoir hosts (Calisher 1994; Falcon 2004; CFSPH 2009q; OIE 2009u; CFSPH 2010b). Infestation of
10 poultry with screwworms occurs, but is rarely reported (OIE 2009q; USDA-APHIS 2009c).

11 African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically
12 spread by domesticated animals, such as poultry, which have been in contact with affected premises
13 (CFSPH 2007e, 2009d, 2010a).

14 Commercial poultry raised in confinement are unlikely to be infested by ixodid ticks; however,
15 gamefowl, pet, and exhibition poultry may have opportunities to encounter ticks. Hyalomma ticks were
16 removed from partridge (*Perdix perdix*) offered for importation into the United States in the 1960s
17 (USDA-APHIS-PPQ 2010a).

18 **Traffic Volume and Origin**

19 Data on poultry imports are presented elsewhere in this document. We do not expect the military
20 relocation to be associated with an increase of legally imported poultry to Guam or the rest of the
21 Micronesia Region. Due to import regulations, most poultry breeding stock will likely continue to be
22 imported from the continental United States and Hawai'i. The United States is free of African swine
23 fever, classical swine fever, END, foot and mouth disease, HPAI, screwworms, and Venezuelan equine
24 encephalomyelitis (USDA-APHIS 2008b).

25 Illegal importation of live poultry, including hatching eggs, is known to occur (Poole 2009). The increased
26 interest in cock fighting, related to the number of temporary workers from the Philippines and other

1 areas where cock fighting is legal, may result in an increase in smuggling of poultry and hatching eggs.
2 END is widespread in Asia, and HPAI is present in some areas as well.

3 ***Mitigations***

4 Federal regulations and APHIS policy restrict importation of live poultry, poultry products, and hatching
5 eggs from regions affected by END or HPAI H5N1, including the Philippines and several other Asian
6 countries, and from free regions that may import and commingle live poultry originating in an END-
7 affected region (9 CFR § 92, 9 CFR § 93, 9 CFR §94). Legal poultry imports must be accompanied by an
8 import permit issued by APHIS and be received and inspected at an approved port of entry with
9 quarantine facilities. Approved bird quarantine facilities are located in New York, Miami, and Los
10 Angeles. Birds are quarantined for 30 days, during which they are tested for certain communicable
11 diseases. Since the implementation of quarantine requirements in 1972, introductions of END through
12 legal importation of live birds declined substantially and were essentially eliminated after the
13 requirements for approval of private quarantine facilities were strengthened in 1979 (USDA-APHIS-VS
14 2005).

15 A 2002 modification to the Animal Welfare Act made interstate trade of a bird or birds for the purpose
16 of fighting illegal, regardless of the law in the destination state, including Guam (USDA-APHIS-VS 2003a).
17 However, this amendment does not restrict the possession of fighting fowl for breeding or as show
18 birds. In response to the changes to the Animal Welfare Act, United Airlines stopped accepting
19 shipments of live adult poultry in 2007, although the airline continues to carry day-old poultry and
20 hatching eggs (Huemer 2007). United Airlines provides air freight service to the Micronesia Region.

21 Guam territorial regulations require all imported birds and hatching eggs to be accompanied by an entry
22 permit and a health certificate approved by the chief livestock sanitary officer, or a state or federal
23 veterinarian (9 GARR 1 § 1110). The health certificate must be issued within 10 days prior to shipment
24 attesting that the bird has been found free of ectoparasites and symptoms of transmissible disease. No
25 poultry affected by or exposed to an infectious, contagious, or communicable disease or ectoparasites
26 during state or federal quarantine shall be permitted on Guam and will be returned to the point of origin
27 or destroyed.

28 Guam requires imported poultry to 1) originate from flocks and hatcheries free of pullorum disease or
29 with a pullorum controlled status; in the latter case birds must be serologically negative for pullorum
30 disease within 30 days of entry; 2) be vaccinated for NDV between 30 and 60 days prior to shipment; 3)
31 be free of symptoms of Newcastle disease or other communicable diseases at the time of shipping; and
32 4) have a health certificate issued by an accredited veterinarian (9 GARR 1 § 1110). Requirements 2, 3,
33 and 4 above do not apply to hatching eggs and day-old poultry accompanied by an affidavit from the
34 shipper stating that the flock of origin has not been exposed to and is free of Newcastle disease within
35 60 days period prior to shipment. All poultry and hatching eggs shall be shipped in new (unused)
36 containers and inspected by the territorial veterinarian or deputy prior to entry into Guam.

1 Guam has additional quarantine requirements for birds from the continental United States to prevent
2 the introduction of WNV. These birds are required to be quarantined for a minimum of seven days in an
3 approved quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof
4 cage on Guam (Poole 2009).

5 USPS regulations prohibit the mailing of hatchling (day-old) poultry vaccinated for Newcastle disease.
6 Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to
7 the addressee within 72 hours of hatching (USPS 2009).

8 ***Summary***

9 The number of live poultry legally imported to Guam is unlikely to change as a result of the military
10 relocation, but the number of illegally imported live poultry is likely to increase by an unknown quantity
11 in response to demand for fighting cocks. The number of illegally imported hatching eggs may increase
12 as well. The risk of hazard release through legal entry of live poultry to Guam is reduced by inspection
13 and quarantine measures required by federal and territorial regulations. Illegally imported poultry
14 bypass mitigations intended to reduce the likelihood of release of hazards.

15 ***Poultry Pathway Release Assessment***

16 The increased risk of release of hazards into the Micronesia Region due to the military relocation
17 through legal movement of poultry is negligible.

18 The increased risk of release of hazards into the Micronesia Region due to the military relocation
19 through illegal movement of poultry is very low.

20 **A6.3.3.2.3 *Exposure Assessment: Poultry Pathway***

21 ***Biological Factors***

22 Most poultry disease agent hazards are present in the feces or secretions of infected birds and are
23 spread primarily through direct contact between birds. People, other animals, vehicles, and equipment
24 can become contaminated with poultry feces or secretions and can carry disease agents from one
25 location to another; END, e.g., is readily transmitted on fomites (CFSPH 2008d).

26 ***Regional Factors***

27 Chickens are the primary poultry species raised on Guam (USDA-NASS 2009a). Since the disappearance
28 of commercial layer operations on Guam, imports of day-old chicks have declined and most chicken
29 imports supply birds to small, backyard flocks for domestic consumption or to cock fighting operations
30 (Poole 2009). Like on other islands in the Micronesia Region, a sizeable population of feral chickens
31 roams freely on Guam (Poole 2009; GTIS 2010). Epidemiologic investigations of outbreaks around the
32 world have shown the close proximity of backyard flocks, feral chickens, and cockfighting operations to
33 be related to spread of an introduced poultry disease (Awan et al. 1994; Swayne and King 2003; Falcon
34 2004). Outdoor housing and contact with feral and wild birds makes biosecurity for backyard flocks
35 problematic. Similarly, cock fighting operations facilitate the spread of poultry diseases through the
36 frequent movement and commingling of birds. END and HPAI can be spread through direct contact

1 between live birds or contact between live birds and contaminated objects such as dead birds or
2 contaminated hatching eggs.

3 If live poultry infected with an arbovirus, such as JEV or WNV, are imported to Guam or elsewhere in the
4 Micronesia Region, the disease agent could be transmitted to an existing competent mosquito vector,
5 such as *Aedes albopictus* or *Culex quinquefasciatus*, potentially resulting in establishment of the disease
6 agent (Reeves and Rudnick 1951; Mitchell et al. 1993; Lounibos 2002).

7 Guam's existing livestock population and number of imported live poultry are both small, making
8 contact between livestock and imported live poultry unlikely. Therefore, imported live poultry are
9 unlikely to have contact with and serve as fomites for exposure of livestock to African swine fever,
10 classical swine fever, and foot and mouth disease viruses.

11 **Summary**

12 Poultry imported to Guam are most likely destined for premises on which poultry already exist and have
13 exposure to feral chickens and their disease agents. Contact between livestock and imported poultry is
14 much less likely. Competent mosquito vectors for arboviruses are present in the Micronesia Region, and
15 imported live poultry infected with an arbovirus could serve as a source to infect mosquitoes.

16 **Poultry Pathway Exposure Assessment**

17 The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the
18 poultry pathway is medium.

19 **A6.3.3.2.4 Consequence Assessment: Poultry Pathway**

20 END and HPAI are hazards of high consequence associated with imported live poultry; therefore, these
21 agents are the focus of the consequence assessment for the poultry pathway. Introduction of
22 arboviruses from the importation of infected live birds, especially JEV and WNV, would have minimal
23 effects on poultry populations, though the consequence to native wild bird populations and humans
24 could be significant.

25 **Biological Consequences**

26 END and HPAI are two of the most severe poultry diseases in the world and their animal health
27 consequences are significant. For both diseases, morbidity and mortality rates vary according to the
28 strain of virus, but morbidity may approach 100% and mortality may approach 90% in susceptible
29 chickens (CFSPH 2008d, 2010b).

30 Human health consequences of END are minor and generally limited to conjunctivitis, though rare
31 serious opportunistic infections may occur in those with compromised immune systems (CFSPH 2008d).
32 Humans are not normally susceptible to infection with avian strains of influenza and the risk from HPAI
33 is therefore generally low to most people (CFSPH 2010b). However, on rare occasions, influenza viruses
34 of avian origin have become more efficient at infecting humans, causing three pandemics within the
35 past century (Rappole and Hubálek 2006). The spectrum and severity of AI symptoms in humans

1 depends on the specific viral subtype (Capua and Alexander 2004; Hirst et al. 2004) and range from
2 typical human influenza-like symptoms (e.g., fever, cough, sore throat, and muscle aches) or
3 uncomplicated eye infections, to pneumonia, acute respiratory distress and life-threatening
4 complications. In 1997, a virulent avian subtype, H5N1, was first identified as the cause of severe, yet
5 sporadic influenza illness in humans. Human cases of H5N1 have since been reported in Asia, Africa, the
6 Pacific, Europe, and the Near East according to the WHO (WHO 2010a). Indonesia and Vietnam have
7 reported the highest number of human H5N1 cases to date with mortalities of up to 60%, especially in
8 individuals hospitalized late in the course of their illness. Nearly all confirmed human cases have
9 resulted from direct contact to poultry or their excreta (WHO, CDC 2010b), with little evidence for
10 human-to-human transmission. To date, human cases of H5N1 remain rare.

11 The introduction of WNV and JEV would have minimal effects on poultry (Ghosh and Basu 2009; OIE
12 2010d). Experimental studies have shown that poultry rapidly develop an antibody response capable of
13 neutralizing the virus. Infection in chickens is typically asymptomatic or with minimal clinical signs and
14 pathology, and no mortality (Senne et al. 2000).

15 Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical
16 cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because
17 of the small number of horses in Guam and relatively low importance of this industry, and the
18 availability of effective vaccines to protect horses against JEV and WNV, we conclude that the biological
19 consequences of introduction of WNV or JEV to the livestock and poultry industries are negligible.

20 Guam's native birds have been driven nearly to extinction (Savidge et al. 1992). Exposure to END, HPAI,
21 or WNV could have severe negative consequences to the remaining population.

22 As in the continental United States, the major impact of WNV establishment would be to humans. Once
23 established in a tropical environment and in the absence of preventive measures, spread would be
24 expected to be rapid among human populations with no prior exposure or immunity, as would be the
25 case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of
26 asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild
27 febrile disease; however about one of every hundred infected may develop severe neurological disease
28 with mortality rates as high as 14% (Madden 2003).

29 Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to
30 children. While asymptomatic infection can occur, approximately 30% of Japanese encephalitis cases are
31 fatal and nearly half result in permanent neurological sequelae (Ghosh and Basu 2009). However, any
32 such introduction might well be short lived. In 1990, a rare introduction of Japanese encephalitis on
33 Saipan ended as the population of susceptible pigs which serve as amplifying hosts became infected and
34 developed immunity, and Japanese encephalitis has not recurred (Paul et al. 1993).

35 ***Environmental Consequences***

36 Environmental consequences of END or HPAI in poultry primarily result from the disposal of large
37 numbers of carcasses due to death from disease or depopulation of flocks. Disposal of large amounts of

1 litter and manure can also be problematic. Because Guam and the rest of the Micronesia Region lack
2 large commercial poultry farms, disposal activities are unlikely to create a significant environmental
3 impact.

4 On Guam, conservation programs maintain captive breeding populations of the endangered Guam rail,
5 Micronesian kingfisher, and Marianas crow (Beauprez and Brock 1999). Guam and other islands of the
6 Micronesia Region provide the only habitat for several critically endangered bird species (Sherley and
7 Lowe 2000). Introduction of END, HPAI, or other high mortality avian diseases could have a catastrophic
8 effect on the very small populations of the Micronesia Region's endangered bird species, potentially
9 resulting in extinction.

10 The spread of WNV in the continental United States has caused a marked decline in the number of
11 particular bird species in entire regions, such as the American crow and eastern bluebirds (Rappole et al.
12 2000). Native bird populations on Guam have been severely diminished as a result of invasive species
13 and feral cats (Poole 2009); thus WNV, as with END and HPAI, could decimate remaining populations.

14 ***Economic Consequences***

15 The assessment of economic consequences is largely based on historical experience of END or HPAI
16 outbreaks in the United States, which can be characterized as having either relatively limited disease
17 spread or relatively extensive disease spread.

18 The outbreaks in 2002-2003 in Arizona, Nevada, and Texas could each be considered representative of a
19 relatively limited outbreak. Arizona and Texas each had only one premise on which infection was
20 detected; 10 infected premises were identified in Nevada. Approximately \$3.5 million were spent on
21 eradication efforts in Arizona; \$6.2 million in Nevada; and \$4.2 million in Texas (USDA-APHIS-VS 2005).

22 Eradication efforts for the extensive 2002-2003 END outbreak in California were labor intensive and
23 expensive (USDA-APHIS-VS 2005). Ultimately, birds from 920 premises in California tested positive for
24 the disease, and nearly 4 million birds were depopulated. More than \$160 million was spent on
25 eradication efforts. More than 1,500 personnel were recruited from various federal, state, county, and
26 metropolitan agencies to participate in disease control activities.

27 Information from the 2002-2003 outbreaks can be used to characterize the effects of an extensive END
28 outbreak on U.S. trade. Immediately following the confirmation of END in the United States in 2002,
29 trading partners imposed trade restrictions on live birds; fresh, frozen, or chilled poultry meat; and
30 hatching eggs from the United States (USDA-APHIS-VS 2005). At the peak of the incident, 46 countries
31 had imposed restrictions. The direct trade impacts were calculated from October 2002 to September
32 2003 for five categories of product: live poultry (other than ducks and geese), ducks and geese, poultry
33 meat and offal, hatching eggs, and table eggs. The total estimated cost of the poultry restrictions for the
34 roughly 12 month period of the END eradication effort was \$121 million, approximately 7% of the trade
35 recorded during that period. The trade losses were relatively low due to the regionalization approach
36 taken by most countries, in which imports of live birds and products were banned from only areas
37 adjacent to affected areas and/or affected areas alone.

1 Therefore, in the event of a poultry disease outbreak on U.S. islands in the Micronesia Region, involving
2 a significant hazard like END or HPAI, countries would likely use a regionalization approach, in order to
3 reduce the wider trade impacts to the United States as a whole. The local effect of trade restrictions is
4 not likely to be significant to Guam or the rest of the Micronesia Region, where no commercial poultry
5 export trade occurs.

6 Release and establishment of WNV or JEV would be expected to result in little or no economic loss to
7 the poultry industry or to the few remaining equine operations on Guam; however, significant cost
8 would be incurred for human public health and mosquito vector surveillance, and for vector control to
9 prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California
10 (population 1.3 million) resulted in 163 reported human cases and a response that included emergency
11 aerial spray to control vectors. Costs for aerial spray totaled just over \$700,000 and when added to
12 estimated medical costs and patients' loss in productivity, the total economic impact was estimated at
13 \$2.98 million (Barber et al. 2010).

14 ***Summary***

15 Guam's native birds have been driven nearly to extinction by predation, but conservation programs are
16 operating in the Region and exposure to END, HPAI, or WNV could have severe negative consequences
17 on their attempts to preserve avifauna biodiversity in the Micronesia Region. The islands of the
18 Micronesia Region are connected to each other, Hawai'i, and the continental United States by air and
19 sea transportation, so the appearance of END or HPAI in the Region poses a threat of introduction into
20 North America. The economic impact of trade bans due to a poultry disease outbreak in the Micronesia
21 Region is likely to be insignificant to Guam and rest of the region, which lacks commercial poultry
22 industries, but potentially significant to the rest of the United States. Regionalization policies would
23 likely reduce the trade consequences at the national level. Human health on Guam and other islands of
24 the Micronesia Region could likewise be impacted by exposure to WNV, JEV, or other arboviruses
25 released as a result of the importation of infected birds, though those risks appear limited and
26 manageable.

27 ***Poultry Pathway Consequence Assessment***

28 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
29 the Micronesia Region through the poultry pathway is low.

30 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
31 exposure to hazards released into the Micronesia Region through the poultry pathway is low.

32 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
33 hazards released into the Micronesia Region through the poultry pathway is medium.

34 ***Poultry Pathway Risk Estimation***

35 Because the increased risk of release of hazards into the Micronesia Region due to the military
36 relocation through the poultry pathway is very low, the risk of exposure of livestock and poultry is

1 medium, and the significance of consequences of livestock and poultry exposure is low, we conclude
 2 that the military relocation-associated overall risk for the poultry pathway is low.

3 **A6.3.3.3 Non-poultry Birds**

4 In this pathway, we consider the movement of birds other than poultry as previously defined in this
 5 document. Non-poultry birds moved in this pathway may be intended for zoological collections or
 6 research, or to be used as pets, performing birds, or commercial birds, which are defined as birds
 7 imported for resale, breeding, public display, or any other purpose except those already mentioned (9
 8 CFR § 93.100). Birds in this pathway may be moved through legal or illegal means. We do not consider
 9 accidental movement of non-poultry birds in our analysis because it is not expected to increase with the
 10 relocation. The risk posed by free-living birds is considered elsewhere in this document.

11 Birds are the fourth most common type of pet owned by U.S. households behind dogs, cats, and
 12 freshwater fish (APPMA 2008). Rates of pet bird ownership in the United States have remained steady
 13 for the past two decades at approximately 6% of households. Although few data are available regarding
 14 rates of pet bird ownership by military families, one survey of 184 military families found at least 7%
 15 reported keeping a pet bird (Anderson 1985). The sample for the survey was drawn from the population
 16 of military families recently transferred to duty stations in Hawai'i; roughly 16% of pet-owning military
 17 families brought their pets with them in the transfer and 41% had acquired their pet after transferring.
 18 Residents of military base housing on Guam are permitted to keep non-poultry pet birds (VETCOM
 19 2009). Therefore, we expect the military relocation to result in an increase in the number of non-poultry
 20 pet birds legally imported to the island as pets or to be sold as pets.

21 Worldwide, the illegal trade in live birds is substantial and profitable (Wyler and Sheikh 2009). The
 22 United States is considered one of the largest markets for illegal wildlife from around the world and wild
 23 birds are major commodities (Wyler and Sheikh 2009). According to the USFWS, U.S. demand for
 24 illegally imported live wild animals is driven primarily by demand for exotic pets and tourist souvenirs
 25 (Wyler and Sheikh 2009). Because the military relocation will expand the human population of Guam,
 26 demand for live birds for personal use might increase and result in increased illegal traffic of live birds.

27 **A6.3.3.3.1 Hazards Associated with the Non-poultry Birds Pathway**

28 Non-poultry birds can transport hazards in three roles: they can be infected hosts, they can be
 29 contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of
 30 disease agents. Table A6-10 lists hazards that are associated with the non-poultry birds pathway,
 31 including hazards for which non-poultry birds may serve as dead-end hosts or play a minor or theoretical
 32 role in transmission.

33 **Table A6-10: Hazards Associated With the Non-Poultry Birds Pathway**

Hazard	Disease	Transport role ^a	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007I

	Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
	<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007l
	Exotic NDV	Exotic Newcastle disease	I	CFSPH 2008d
	Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a, OIE 2008g
	Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
	HPAIV	HPAI	I	OIE 2009m, CFSPH 2010b, USGS 2010
	JEV	Japanese encephalitis	I	CFSPH 2007h, Mackenzie 2007, OIE 2010d
	<i>Salmonella Gallinarum</i>	Fowl typhoid	I	OIE 2008k, CFSPH 2009j
	<i>Salmonella Pullorum</i>	Pullorum disease	I	OIE 2008k, CFSPH 2009j
	WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector				
	Tick ^b			
	<i>Amblyomma</i> spp.	Equine piroplasmiasis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmiasis; theileriosis	V	Kolonin 2009
	<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmiasis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

1 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

2 ^b Not all species of all genera feed on non-poultry birds.

3

4 **A6.3.3.3.2 Release Assessment: Non-poultry Birds Pathway**

5 **Likelihood of Hazard Association**

6 Like poultry, other birds can be infected with and serve as reservoirs for equine encephalomyelitis, END,
7 HPAI, and WNV, but they are not the only reservoir hosts (Calisher 1994; Falcon 2004; CFSPH 2009q; OIE
8 2009u; CFSPH 2010b). Infected birds can serve as sources for the etiologic agents of fowl typhoid and
9 pullorum. Infestation of birds with screwworms occurs, but is rarely reported (OIE 2009q, USDA-APHIS
10 2009c).

11 African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically
12 spread by birds which have been in contact with affected premises, though it is difficult to definitively
13 link birds as a primary source for spread in outbreaks and their role remains theoretical.

14 Psittacines (parrots, cockatiels, parakeets, budgerigars, and other parrot-like pet birds), the most
15 popular pet birds in the United States, are uncommon hosts for vector hazards (Estrada-Peña et al.
16 2004, Estrada-Peña 2008). A variety of songbirds are captured and moved around the world in the caged
17 bird trade, and some of these birds, particularly the buntings, sparrows, finches, and weavers of the
18 families Emberizidae, Passeridae, and Ploceidae, are frequent hosts for European, Asian, or African ticks
19 (Estrada-Peña et al. 2004). However, only two records of tick interceptions from imported pet birds
20 were found in the USDA national tick survey database (USDA-APHIS-PPQ 2010a).

1 ***Traffic Volume***

2 According to the Territorial Veterinarian, the number of pet birds brought to Guam in recent years
3 averages less than twelve birds annually (Poole 2009). If, as we expect, the number of pet birds and
4 commercial birds imported to the island will increase relative to the increase in the human population,
5 the number of birds brought to Guam through legal means will remain small.

6 While no reliable estimates of illegal live pet bird import volumes are publicly available, analysts agree
7 that demand for illegal wildlife in the United States is likely to parallel U.S. demand for legal wildlife
8 (Wyler and Sheikh 2009). We assume this trend to be similarly true for Guam; thus demand for illegal
9 live pet bird imports would also be expected to remain small.

10 ***Traffic Origin***

11 Due to strict federal regulations, live birds imported legally to Guam as a result of the relocation are
12 likely to originate from the mainland United States. The United States is free of African swine fever,
13 classical swine fever, END, foot and mouth disease, heartwater, HPAI, Japanese encephalitis,
14 screwworms, and Venezuelan equine encephalomyelitis (USDA-APHIS 2008b).

15 Most smuggled live birds seized by U.S. officials between 2004 and 2008 originated from Mexico,
16 Central America, and South America, but smuggled birds have also been intercepted from Japan, Hong
17 Kong, and Indonesia (USDA-APHIS 2006; USFWS 2009a).

18 ***Mitigations***

19 USDA defines pet birds as those that are imported for the personal pleasure of their owners and are not
20 intended for resale (USDA-APHIS 2009a). Commercial birds are those imported for resale, breeding,
21 public display, or other similar purpose.

22 Birds not of U.S. origin must be accompanied by an import permit and be received and inspected by
23 USDA personnel at an approved port of entry with quarantine facilities. Approved bird quarantine
24 facilities are located in New York, Miami, and Los Angeles. Birds are quarantined for 30 days, during
25 which they are tested for certain communicable diseases. USDA maintains trade restrictions on the
26 importation of live birds from countries affected by HPAI H5N1 including certain countries in Africa,
27 Europe, and Asia (USDA-APHIS 2009a).

28 Importation of exotic birds into the United States must comply with APHIS and USFWS requirements.
29 Certain exotic birds are protected by CITES and the Wild Bird Conservation Act (Beissinger 2001). CBP
30 and the USFWS enforce the international trade regulations related to exotic birds. The USFWS requires
31 an importation permit and the Wild Bird Conservation Act limits imports to two birds per year, per
32 person, and that person must have been continuously residing outside the continental United States for
33 at least one year.

34 All birds entering the territory of Guam must be accompanied by an import permit and an official health
35 certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian. The health

1 certificate must be issued within 10 days prior to shipment attesting that the bird(s) have been found
2 free of ectoparasites and symptoms of transmissible diseases. Animals should have a leg band number
3 identifying the scientific name of the animal. Any animal found to be clinically affected or recently
4 exposed to any infectious, contagious, or communicable disease or infested with ectoparasites shall be
5 returned to their point of origin or destroyed (9 GARR 1, Division 1, Chapter 1).

6 Regulations for the importation of pet birds (all birds except poultry) are found under Title 9 of the
7 Guam Administrative Rules and Regulations, in chapter 2, §2101 and §2102 and require pet shops and
8 importers to keep a record of each sale made for at least 90 days and make the record available to
9 GDOA, if a quarantine is placed on the premises by the territorial veterinarian.

10 Guam has introduced additional quarantine requirements for the importation of birds from the
11 continental United States to prevent the introduction of WNV. These regulations are similar to the ones
12 in place in Hawai'i. All birds are required to be quarantined a minimum of seven days in an approved
13 quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage on
14 Guam (Poole 2009).

15 According to USPS regulations, non-poultry birds cannot be transported via the mail (USPS 2009).

16 Illegal imports, by their very nature, are difficult to describe and quantify. Illegally imported birds and
17 hatching eggs would need to enter Guam via boat or airplane. Both birds and hatching eggs may be
18 carried on private vessels or fishing boats and are relatively easy to conceal. Hatching eggs may be
19 carried in a suitcase, and can therefore be brought into Guam via commercial flights. GCQA attempts to
20 enforce the regulations, mitigating the risks by these pathways.

21 Military personnel and families are unlikely to smuggle birds to Guam. However, it is possible that the
22 increased population will lead to an increase in customers for pet shops on Guam. It is then possible that
23 unscrupulous pet shop owners may attempt to acquire birds from illicit sources. Private boats or fishing
24 vessels may be involved in supplying such trade.

25 It is assumed that foreign workers will be traveling to Guam by air, given the time involved in sea travel
26 from many of the countries that will be providing workers. United Airlines is reportedly planning to
27 increase flight frequencies to the Philippines to accommodate the workers (Arnaldo 2010).

28 Opportunities for smuggling live birds on a commercial airline are present, though limited. Therefore, it
29 is assumed that immigrant workers will also be unlikely to smuggle non-poultry birds into Guam.

30 However, hatching eggs may be smuggled on board flights, as they are small and easily concealed in
31 luggage. It is possible that private or fishing vessels may be involved in smuggling non-poultry birds for
32 commercial sale. However, it is unlikely that the foreign workers would be supporting such efforts,
33 because under the requirements of their contracts, involvement in an illegal activity such as smuggling
34 will have serious consequences if they are caught.

1 **Summary**

2 The number of live non-poultry birds imported to Guam is currently small, and may increase slightly as a
3 result of the military relocation, due to demand in the pet trade. The risk of hazard release through legal
4 entry of live non-poultry birds to Guam is reduced by inspection and quarantine measures required by
5 federal and territorial regulations. Illegally imported live non-poultry birds bypass mitigations intended
6 to reduce the likelihood of release of hazards.

7 **Non-poultry Birds Pathway Release Assessment**

8 The increased risk of release of hazards into the Micronesia Region due to the military relocation
9 through legal movement of non-poultry birds is negligible. Currently, pet birds arriving to Guam are to
10 be quarantined by the owner at the owner’s home. The Guam territorial veterinarian insures that a
11 double mosquito netted quarantine cage is provided pet owner for this purpose, but regulating the
12 quarantine period is not feasible at this time. The situation could be improved by developing a bird
13 quarantine facility at GDOA and insure compliancy with current import regulations.

14 The increased risk of release of hazards into the Micronesia Region due to the military relocation
15 through illegal movement of non-poultry birds is very low.

16 **A6.3.3.3 Exposure Assessment: Non-poultry Birds Pathway**

17 **Biological Factors**

18 Deliberate or accidental release of imported non-poultry birds provides another potential route of
19 exposure of livestock or poultry to hazards or opportunities for dissemination of vector hazards in
20 suitable habitats for establishment. Sightings of non-native songbirds by U.S. birders have been
21 attributed to accidental escape or deliberate release by importers, breeders, and disinterested pet
22 owners (Craves 2008).

23 **Regional Factors**

24 Birds smuggled to Guam or CNMI could readily be dispersed throughout the Micronesia Region.

25 **Summary**

26 We expect the smuggling of non-poultry birds to be an infrequent event; however, once released, the
27 opportunities for exposure of livestock and poultry are present, though the overall risk is considered to
28 be very low.

29 **Non-poultry Birds Pathway Exposure Assessment**

30 The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the
31 non-poultry birds pathway is very low.

1 **A6.3.3.4 Consequence Assessment: Non-poultry Birds Pathway**

2 **Biological Consequences**

3 Non-poultry pet birds may carry and serve as reservoir hosts for many of the same diseases as poultry,
4 including equine encephalomyelitis, END, HPAI, and WNV viruses (Calisher 1994, Falcon 2004, CFSPH
5 2009q, OIE 2009u, CFSPH 2010b). Infected birds can serve as sources for the etiologic agents of fowl
6 typhoid and pullorum. Infestation of birds with screwworms occurs, but is rarely reported (OIE 2009q,
7 USDA-APHIS 2009c); these birds can also serve as fomites for the spread of African swine fever, classical
8 swine fever, and foot and mouth disease viruses (CFSPH 2007e, 2009d, 2010a). The consequences would
9 be most significant from the resultant release and exposure of END and HPAI, which may cause
10 mortality approaching 100% for poultry on Guam.

11 **Environmental and Economic Consequences**

12 Release of infected non-poultry birds may result in similar environmental and economic consequences
13 as for infected poultry.

14 **Non-poultry Birds Pathway Consequence Assessment**

15 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
16 the Micronesia Region through the non-poultry birds pathway is low.

17 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
18 exposure to hazards released into the Micronesia Region through the non-poultry birds pathway is low.

19 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
20 hazards released into the Micronesian Regio through the non-poultry birds pathway is medium.

21 **Non-poultry Birds Pathway Risk Estimation**

22 Because the increased risk of release of hazards into the Micronesia Region due to the military
23 relocation through the non-poultry birds pathway is very low, the risk of exposure of livestock and
24 poultry is very low, and the significance of consequences of livestock and poultry exposure is low, we
25 conclude that the military relocation-associated overall risk for the livestock pathway is very low.

26 **A6.3.3.4 Cats and Dogs**

27 The domesticated cats and dogs moved in this pathway may be pets or serve as working animals
28 performing tasks to assist or entertain people. Specifically, we consider the effect of the military
29 relocation on risk to livestock and poultry health through movement of military working dogs and pet
30 cats and dogs kept by military or civilian personnel to Guam. Discussion of impacts to human and
31 companion animal health is limited to the livestock and poultry hazards associated with dogs and cats.

32 Cats and dogs are the most common types of pets owned by U.S. households (APPMA 2008). According
33 to the 2007 American Pet Products Manufacturers Association survey, 39% of U.S. households keep at
34 least one dog, and 34% keep at least one cat. Rates of cat and dog ownership among U.S. households
35 have increased slightly over the past two decades. Although few data are available regarding rates of

1 pet cat and dog ownership by military personnel, one survey of 184 military families found 34% reported
 2 keeping at least one dog and 18% reported keeping at least one cat (Anderson 1985). The sample for the
 3 survey was drawn from the population of military families who had recently transferred to duty stations
 4 in Hawai'i, where, similar to Guam, quarantine is required for dogs and cats imported from regions
 5 affected by rabies. Roughly 16% of the pet-owning military families in this survey brought their pets with
 6 them in the transfer, undeterred by quarantine requirements. Residents of military base housing on
 7 Guam are permitted to keep two pet dogs or cats (VETCOM 2009).

8 Currently, there are seven military working dogs on the Navy base and 16 on Andersen AFB (U.S. Navy
 9 2009f). The number of military working dogs present on Guam will probably increase along with the
 10 military relocation (VETCOM 2009).

11 Dog fighting is an illegal activity occurring on Guam (Taijeron 2009) despite recently implemented
 12 regulations making dog fighting a felony. Additionally, the U.S. Army recently issued a memo banning
 13 "aggressive or potentially aggressive" dogs from military housing (US Army 2008, CDC 2010c). Therefore,
 14 we do not anticipate an increase in imports of dogs for fighting associated with the military relocation.

15 We expect the military relocation will result in increased numbers of domesticated cats and dogs being
 16 moved through legal means to Guam. Illegal introduction of dogs or cats to Guam might occur via
 17 private vessels, such as cruising or fishing vessels, which occasionally carry companion animals aboard
 18 (Sgambelluri et al. 2009), but we do not expect this traffic to increase as a result of the military
 19 relocation.

20 **A6.3.3.4.1 Hazards Associated with the Cats and Dogs Pathway**

21 Domesticated cats and dogs can transport hazards in three roles: they can be infected hosts, they can be
 22 contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of
 23 disease agents. Table A6-11 lists hazards that are associated with domesticated cats and dogs through
 24 these three roles, including hazards for which these animals may serve as dead-end hosts or play a
 25 minor or theoretical role in transmission.

26 **Table A6-11: Hazards Associated With the Cats and Dogs Pathway**

Hazard	Disease	Transport role ^a	References
Disease agent			
African horse sickness virus	African horse sickness	I	CFSPH 2006a, OIE 2009f
African swine fever virus	African swine fever	F	CFSPH 2010a
<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007I
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007I
<i>Echinococcus granulosus</i> ; <i>E. multilocularis</i>	Echinococcosis/hydatidosis	I	OIE 2008e, CFSPH 2009h
Equine encephalomyelitis virus (Venezuelan)	Equine encephalomyelitis (Venezuelan)	I	OIE 2009u
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I	USGS 2010

Hazard		Disease	Transport role ^a	References
	<i>Leishmania</i> spp.	Leishmaniasis	I	Dantas-Torres 2007, OIE 2008n, CFSPH 2009k
	Rabies virus	Rabies	I	CDC 2008a, CFSPH 2009m
	<i>Salmonella</i> Pullorum	Pullorum disease	I	CFSPH 2009j
	<i>Trypanosoma</i> spp. (African)	Trypanosomiasis (African animal)	I	CFSPH 2009a
	<i>Trypanosoma evansi</i>	Surra	I	OIE 2008q, CFSPH 2009n
Vector				
	Tick ^b			
	<i>Amblyomma</i> spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Dermacentor</i> spp.	Equine piroplasmosis	V	Kolonin 2009
	<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
	<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

1 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

2 ^b Not all species of all genera feed on cats or dogs.

3

4 **A6.3.3.4.2 Release Assessment: Cats and Dogs Pathway**

5 **Likelihood of Hazard Association**

6 Domesticated dogs and cats can be infected with and serve as reservoirs for rabies (CFSPH 2009m; CDC
7 2010g). Domesticated dogs and cats, among many other mammalian hosts, can harbor screwworms,
8 *Echinococcus* spp., *Leishmania* spp., and *Trypanosoma* spp. parasites (Barr et al. 1991; Bradley et al.
9 2000; Jenkins et al. 2000; USDA-APHIS 2000; Beard et al. 2003a; Dantas-Torres 2007; CFSPH 2009k; OIE
10 2009q, t). Cats and dogs are susceptible to infection with HPAI virus, although the significance of their
11 roles in transmission of the virus has not been elucidated (CFSPH 2010b). Dogs can be infected with
12 African horse sickness and Venezuelan equine encephalomyelitis viruses, and both cats and dogs can be
13 infected with *Salmonella* Pullorum, but most sources suggest that dogs and cats do not play a significant
14 role in the maintenance or spread of these hazards (CFSPH 2006a, 2008a, 2009j).

15 African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically
16 spread by domesticated animals which have been in contact with affected premises (CFSPH 2007e,
17 2009d, 2010a). Theoretically, this would include dogs and cats, though it is difficult to definitively link
18 dogs or cats as a primary source for spread in prior outbreaks.

19 Dogs are common hosts for several tick species that are competent vectors of equine piroplasmosis and
20 heartwater (Estrada-Peña et al. 2004). In a few instances, hazard ticks, specifically *Amblyomma* spp.,
21 have been found on dogs imported to the United States (James and Freier 2004; USDA-APHIS-VS CEAH
22 2006). Hazard ticks are infrequently collected from domesticated cat hosts, perhaps because the
23 grooming behavior of cats limits tick attachment (Hart 1990).

1 **Traffic Volume**

2 We were unable to find data on the importation to Guam of civilian pets, except for FY 2002 (Table A6-
3 12) (GovGuam 2002; Campbell 2010c). The number of cats and dogs imported to Guam annually is low,
4 with estimates ranging from 10 to 100 animals a year (Poole 2009). As described elsewhere in this
5 document, the military and civilian population on Guam will grow during the military relocation, and
6 some people will bring pet cats and dogs with them. A 1985 survey suggests that many pet owners
7 choose not to bring their pets with them when transferring to an overseas assignment, after considering
8 the time, expense, and animal’s physiologic stress associated with shipping and quarantine procedures
9 (Anderson 1985). Based upon the anticipated increase in the number of military and civilian families,
10 U.S. household pet ownership rates, and the estimate of the rate of pets accompanying transferring
11 military personnel, we estimate that at least 500 additional pet cats and dogs will be imported over the
12 course of the relocation.

13 Due to the increased military presence on Guam, it is likely that the number of military working dogs will
14 increase (VETCOM 2009). Estimates are not available, because decisions on redeployment have not yet
15 been made, but the number of additional dogs is expected to be small.

16 **Traffic Origin**

17 The majority of past imports originated from the continental United States and Australia, with a few
18 animals imported from Japan and CNMI (USDA-APHIS-PPQ 1997).

19 **Table A6-12: Country of Origin and Total Numbers of Cats and Dogs**
20 **Imported to Guam, 2002**

Country of origin	Cats	Dogs
United States	0	53
Australia	20	54
Japan	4	4
CNMI	0	2
Total	24	113

21 Source: GovGuam 2002; Campbell 2010c
22

23 It is unusual for military personnel to have two consecutive assignments outside of the continental
24 United States (VETCOM 2009). Therefore, most of the cats and dogs imported due to the relocation will
25 come from the continental United States or Hawai’i. Civilian personnel employed by the military are also
26 likely to come mostly from the continental United States or Hawai’i (VETCOM 2009). Guam territorial
27 import regulations for cats and dogs, which are discussed below, are likely to dissuade or prevent many
28 foreign temporary workers from bringing pets with them to Guam, except workers from regions
29 unaffected by rabies, including Japan, Australia, and New Zealand.

30 Of the more than one million tourists that visit Guam yearly, 80% come from Japan. Japanese tourists
31 average a three night stay on the island, making it unlikely that they will bring any pets with them (Mok

1 and Iverson 2000). The time and expense of pet quarantine is likely to deter tourists from most other
2 areas from traveling with their pets to Guam.

3 The United States is free of most of the livestock and poultry disease agents that can be associated with
4 cats and dogs (see Table A6-11), with the exception of *Echinococcus* spp., *Leishmania* spp., and rabies
5 (USDA-APHIS 2008b).

6 **Mitigations**

7 Under 42 CFR § 71.51, cats and dogs imported to the United States are subject to inspection at ports of
8 entry and may be denied entry if they have evidence of an infectious disease that can be transmitted to
9 humans. Dogs imported to the United States, with limited exceptions, must be accompanied by a
10 certificate for rabies vaccination; imported cats are not required to be vaccinated for rabies. The entry
11 of pets from areas affected by screwworms is subject to APHIS regulations (9 CFR § 93.600), requiring a
12 health certificate stating that the dog was examined and found to be free of screwworm infestation
13 within 5 days of export (USDA 2000; USDA-APHIS 2009c; 9 CFR § 93.600).

14 Guam's restrictions on the importation of cats and dogs are even more stringent than federal
15 requirements and include additional specific quarantine requirements to protect its rabies-free status.
16 Cats and dogs must enter Guam through A.B. Won Pat International Airport or the maritime port of Apra
17 Harbor. All cats and dogs must be accompanied by documentation including an entry permit, a health
18 certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine
19 kennel reservation. They must also have identification, comply with all quarantine procedures, and
20 undergo rabies vaccination and testing prior to arrival (9 GARR 1, Division 1, Chapter 1). Dogs must have
21 a rabies vaccination certificate dated no less than 30 days and no more than one year prior shipment;
22 and a certificate of immunization against distemper, hepatitis, leptospirosis, parainfluenza, parvovirus,
23 coronavirus, and bordetella. Cats must have a certificate of immunization for feline distemper, feline
24 viral rhinotracheitis, calicivirus, panleukopenia, and chlamydia (9 GARR 1, Division 1, Chapter 1).

25 The importation of pets to Guam is regulated by GDOA (5 GCA § 60108). Title 10 Guam Code Annotated
26 Chapter 34 Article 3 states that animals imported are to complete a maximum of 120-day confinement
27 in a commercial quarantine facility. Animals may undergo 30 days of quarantine if they meet pre- and
28 post-arrival requirements, including the administration of two doses of rabies vaccine; the presence of
29 an adequate protective antibody titer against rabies based on a fluorescent antibody virus neutralization
30 (FAVN) rabies test as tested by the GDOA quarantine program; and a properly implanted identification
31 microchip (GCA 2010b). A five-day quarantine program is available for pets if the FAVN test is conducted
32 by an eligible laboratory no less than 120 days or more than 12 months prior to arrival on Guam (GDOA
33 2007b). Under certain conditions, pets may qualify for the option of home quarantine (GDOA 2009).

34 Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for
35 counties on the Mexican border) can be quarantined on Guam. Animals originating from elsewhere
36 must be quarantined in Hawai'i prior to arrival on Guam. Cats and dogs originating from rabies-free

1 areas, such as Hawai'i, New Zealand, Australia, and the United Kingdom, will be exempted from
2 quarantine if they comply with all other requirements.

3 Other import regulations for cats and dogs are included in the Guam Administrative Rules and
4 Regulations, Title 9, Division 1, Chapter 1, § 1109. All cats and dogs originating from Africa, Asia, or
5 islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) must have a certificate from
6 the national chief livestock sanitary officer stating that the animals originated in a state, country, or
7 other political subdivision officially declared free of surra, African animal trypanosomiasis, and
8 leishmaniasis.

9 Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the
10 custody of the carrier at a designated inspection area at the port of entry until the animal is sent back
11 (maximum 72 hours) or humanely disposed of. In addition, the carrier is fined between \$500 and \$1,000
12 for transporting the animal without an entry permit (GDOA, GCA 2010b).

13 The U.S. military has published rules and regulations for the importation of cats and dogs. These
14 regulations include the federal and state requirements, and are published in the Quarantine Regulations
15 of the Armed Forces (DoD 1992). General requirements for the admission of cats and dogs include
16 these: 1) all animals arriving in the United States are subject to inspection by a public health or military
17 quarantine officer; 2) animals will require testing and confinement when they do not appear in good
18 health or in the event that they have been exposed during shipment to a sick or dead animal suspected
19 to have a communicable disease; 3) unsanitary containers of cats and dogs arriving in the United States
20 must be cleaned and disinfected before the animal can be admitted; and 4) a valid rabies certificate is
21 required for dogs. The military requires dogs to be vaccinated for rabies and inspected at the port in
22 accordance with Quarantine Regulations (DoD 1992). In addition, all pets belonging to military personnel
23 must meet the requirements for importation to Guam.

24 GDOA does not operate a quarantine facility for imported cats and dogs. One private veterinary clinic on
25 Guam maintains a quarantine facility. The military has one veterinary clinic and a boarding and
26 quarantine facility at Andersen AFB and another veterinary treatment facility at the Navy base (USMA
27 2008). The Andersen AFB facility maintains 14 canine and 6 feline quarantine kennels. A new Navy
28 facility will be constructed to include space for 10 military working dogs, a veterinary examination area,
29 an outdoor dog wash, and 4 quarantine runs (U.S. Navy 2009f). The kennel will be fenced and the
30 building and gate will have an intrusion detection system to avoid escape or intrusion of other animals
31 into the kennel. The facilities are designed to prevent disease transmission between dogs. Solid waste
32 will go to the Navy landfill.

33 Since the Vietnam War era, when many military working dogs could not return to the United States after
34 deployment due to the threat of introduction of exotic diseases, veterinary care and treatment for
35 military working dogs has significantly improved (English 2000). Following the 1990-1991 Persian Gulf
36 conflict, the health records of 118 military working dogs were reviewed and none indicated evidence of
37 zoonotic disease (Burkman et al. 2001). More recent studies have shown that few military working dogs

1 are exposed to infectious diseases and that the major cause of mortality is natural death or euthanasia
2 associated with advanced age (Moore et al. 2001; Evans et al. 2007).

3 ***Summary***

4 The number of domesticated cats and dogs imported to Guam is likely to increase as result of the
5 military relocation. Most of these animals are likely to originate from the continental United States,
6 which is free of most of the poultry and livestock disease hazards for which domesticated cats and dogs
7 are epidemiologically significant sources. The one important exception is rabies, which is present in the
8 continental United States. However, the risk of importation or interstate movement of hazards for which
9 domesticated cats and dogs might play a significant role in transporting to Guam is mitigated by U.S.
10 military and Guam territorial regulations.

11 ***Cats and Dogs Pathway Release Assessment***

12 The increased risk of release of hazards into the Micronesia Region due to the military relocation
13 through the cats and dogs pathway is negligible.

14 ***Cats and Dogs Pathway Risk Estimation***

15 Because the increased risk of release of hazards into the Micronesia Region due to the military
16 relocation through the cats and dogs pathway is negligible, we conclude that the military relocation-
17 associated overall risk for the cats and dogs pathway is negligible.

18 **A6.3.3.5 *Other Animals***

19 In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry
20 health through the movement of terrestrial vertebrates, other than livestock, birds, cats, dogs, and
21 humans, into the Micronesia Region. These animals include non-domesticated mammals, reptiles, and
22 amphibians that might be intended for pets, food, zoological collections, research, or commercial trade.
23 Animals intended for any of these purposes may be moved through legal or illegal means. We do not
24 consider accidental movement of these animals in this analysis, because the risk posed by free-living
25 non-domesticated animals is considered elsewhere in this document. In this section, discussion of risk to
26 human and companion animal health is limited to the livestock and poultry hazards associated with
27 these animals; information on other hazards is addressed elsewhere in this document.

28 With certain exceptions, live non-domesticated animals may legally enter the United States through
29 Guam (Jenkins 2007; Jenkins et al. 2007). However, in the USFWS Law Enforcement Management
30 Information System (LEMIS) database we found no records of importation of large exotic mammals to
31 Guam between 2006 and 2008 (USFWS 2009a). On Guam, animal agriculture is in decline, due in part to
32 competition for land use and the relatively high cost of feed, most of which must be imported (Poole
33 2009); these conditions probably also limit the potential for game ranching and the establishment or
34 expansion of zoological collections. Therefore, we do not expect that the military relocation will alter
35 this trend and increase traffic volume in large non-domesticated mammals, such as carnivores or hooved
36 animals.

1 On the other hand, the U.S. live animal trade in small mammals, reptiles, and amphibians has grown
 2 significantly since the 1990s, driven in part by the increasing popularity of exotic pets and demand for
 3 traditional foods and medicines (Jenkins 2007; TRAFFIC 2008). The United States is the leading import
 4 market in this global trade, receiving millions of animals each year (Bergman 2009; Pavlin et al. 2009).
 5 Worldwide, illegal trade in these animals is also substantial and profitable, though challenging to
 6 quantify (Wyler and Sheikh 2009). The larger human population resulting from the military relocation
 7 will likely increase demand for exotic pets and for traditional foods and medicines, and therefore,
 8 increase pathway traffic volume in small mammals and reptiles through either legal or illegal means.

9 **A6.3.3.5.1 Hazards Associated with the Other Animals Pathway**

10 The groups of terrestrial vertebrates considered in this pathway are limited to species common in the
 11 pet or wildlife trade, which have been associated with pathogen or vector hazards. These are small
 12 mammals (rodents, lagomorphs, and hedgehogs), and reptiles and amphibians (lizards, snakes, turtles,
 13 tortoises, frogs, and toads).

14 Small mammals, reptiles, and amphibians can transport hazards in three roles: they can be infected
 15 hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to
 16 tick vectors of disease agents. Table A6-13 lists hazards that are associated with these animals through
 17 these three roles, including hazards for which these animals may serve as dead-end hosts or play a
 18 minor or theoretical role in transmission.

19 **Table A6-13: Hazards Associated with the Other Animals Pathway (Small Mammals,**
 20 **Reptiles, and Amphibians)**

Hazard	Disease	Transport role ^a	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007I
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007I
<i>Echinococcus granulosus</i> ; <i>E. multilocularis</i>	Echinococcosis/hydatidosis	I	OIE 2008e, CFSPH 2009h
Equine encephalomyelitis viruses (Western and Venezuelan)	Equine encephalomyelitis (Western and Venezuelan)	I	CFSPH 2008a, OIE 2009u
Foot and mouth disease virus	Foot and mouth disease	F	Thomson et al. 2003, CFSPH 2007e
HPAIV	HPAI	I	USGS 2010
JEV	Japanese encephalitis	I	CFSPH 2007h
Rabies virus	Rabies	I	OIE 2008o, CFSPH 2009m
<i>Salmonella Pullorum</i>	Pullorum disease	I	CFSPH 2009j
<i>Trypanosoma evansi</i>	Surra	I	CFSPH 2009n
<i>Trypanosoma</i> spp. (African)	Trypanosomiasis (African animal)	I	CFSPH 2009a
Vesicular stomatitis virus	Vesicular stomatitis	I	OIE 2009v

Hazard		Disease	Transport role ^a	References
	WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector				
	Tick ^b			
	<i>Amblyomma</i> spp.	Equine piroplasmosis; heartwater; theileriosis	V	Kolonin 2009
	<i>Dermacentor</i> spp.	Equine piroplasmosis	V	Kolonin 2009
	<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
	<i>Ornithodoros</i> spp.	African swine fever	V	Kahn and Line 2008
	<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

1 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

2 ^b Not all species of all genera feed on other animals.

3

4 **A6.3.3.5.2 Release Assessment: Other Animals Pathway**

5 **Likelihood of Hazard Association**

6 Small mammals, reptiles, and amphibians can carry a variety of disease agents, either mechanically, as in
7 the case of rodents spreading African swine fever, classical swine fever, or foot and mouth disease virus
8 (CFSPH 2007e, 2009d, 2010a), or as biological hosts. All mammals are susceptible to screwworm
9 infestation and rabies virus infection (CFSPH 2007l, 2009m). Rodents are intermediate hosts of
10 *Echinococcus* species, and are reservoir hosts of Venezuelan equine encephalomyelitis virus (CFSPH
11 2008a; OIE 2008e). HPAI virus, Salmonella Pullorum, WNV, and JEV infections occur primarily in avian
12 species but can also occur in rodents (CFSPH 2007h; Cardona et al. 2009; CFSPH 2009j, q; USGS 2010).
13 The etiologic agents of surra and African animal trypanosomiasis have a wide host range that includes
14 most domesticated mammals and some wild species, including rodents (CFSPH 2009n, a). Vesicular
15 stomatitis affects primarily livestock, although evidence of infection has been detected in rodents
16 (CFSPH 2008g). Although birds are the main reservoir hosts of Eastern and Western equine
17 encephalomyelitis viruses, other animals including reptiles and amphibians can be infected with these
18 viruses (CFSPH 2008a). JEV infections have also been reported to occur in reptiles and amphibians
19 (CFSPH 2007h).

20 The increased international movement of reptiles for the pet trade has been cited as a high risk pathway
21 for introduction of exotic ticks and pathogens to new geographic locations (Burrige and Simmons
22 2003). Members of the genera *Amblyomma*, *Dermacentor*, *Haemaphysalis*, *Hyalomma*, and
23 *Ornithodoros* frequently parasitize reptiles, particularly terrestrial chelonians, snakes, and lizards, in
24 tropical regions (Pietzsch et al. 2006). Numerous ticks, primarily exotic species of *Amblyomma* and
25 *Hyalomma*, have been found on reptiles imported to the United States, sometimes after the animals had

1 reached their destinations within the country (Burridge and Simmons 2003; USDA-APHIS-VS CEAH 2006).
2 There is evidence that exotic ticks introduced with imported reptiles could be infected with organisms
3 pathogenic to domestic livestock populations (Pietzsch et al. 2006). For example, *E. ruminantium*, the
4 causative agent of heartwater, was detected in *Amblyomma sparsum* ticks collected from tortoises
5 imported to the United States (Burridge et al. 2000).

6 ***Traffic Volume and Origin***

7 The largest group of mammals imported to the United States from 2004 to 2008 was rodents, and the
8 number of rodents imported during those years steadily increased from nearly 40,000 animals in 2004
9 to more than 240,000 in 2007 alone (USFWS 2009a). These imported rodents, which include popular
10 pets such as rats, mice, hamsters, and gerbils, were almost exclusively bred and raised in captivity
11 (USDA-APHIS-VS CEAH 2010). Lagomorphs (rabbits and hares) were also among the top four most
12 frequently imported groups of animals from 2004 to 2008, although the total number of imported
13 lagomorphs declined during that period of time (USFWS 2009a; USDA-APHIS-VS CEAH 2010). Imported
14 rabbits and hares, like rodents, were almost exclusively bred and raised in captivity, and were imported
15 for commercial purposes or as personal pets.

16 The international trade in reptiles and amphibians has grown dramatically in the last decade, and the
17 U.S. pet trade is recognized as a major consumer of live reptiles and amphibians (Burridge and Simmons
18 2003). LEMIS records show that the United States imported an average of 1.5 million reptiles and
19 amphibians in more than 8,000 shipments per year during 2004 to 2008 (USFWS 2009a). In contrast to
20 the small mammal trade, most shipments of reptiles and amphibians imported to the United States
21 include specimens captured from the wild (USFWS 2009a).

22 Data are unavailable to quantify the number of small mammals, reptiles, and amphibians imported to
23 Guam or the Micronesia Region, although there is evidence that importation of these animals occurs,
24 through both legal and illegal means. Pet stores exist in Guam, CNMI, and FSM, where small mammals,
25 reptiles, and amphibians may be purchased (Vice 2010a). Several species of exotic snakes and turtles
26 have been discovered in the Micronesia Region in recent years; their presence has been attributed to
27 release by visitors on fishing vessels or by citizens returning from foreign travel (Buden et al. 2001, Vice
28 2010a).

29 As a result of USFWS requirements for most imported wildlife traffic to pass through designated ports
30 on the mainland United States or Hawai'i, most small animals, reptiles, and amphibians shipped to
31 Guam for the legal pet trade likely originate in or transit through the continental United States or
32 Hawai'i (Wyler and Sheikh 2009). LEMIS records show that the Port of Guam received no direct
33 shipments of live small mammals, reptiles, or amphibians from non-U.S. sources from 2006 to 2008,
34 with the exception of one shipment of turtles originating in Hong Kong, which was refused entry (USFWS
35 2009a). Countries in Africa and southeast Asia represent the top ten most commonly declared countries
36 of origin for reptile and amphibian shipments to the United States (USFWS 2009a). Illegal trade in
37 wildlife is identified as an economically significant activity in southeast Asia (TRAFFIC 2008).

1 **Mitigations**

2 Importation of wild mammals, reptiles, and amphibians into the United States is regulated by the
3 USFWS, whose major concern is compliance with the CITES agreement, which is intended to ensure that
4 international trade in animals does not threaten the survival of endangered species. Beyond CITES
5 regulations, no governmental agency in the United States has complete jurisdiction or comprehensive
6 import regulations for wild mammals, reptiles, or amphibians. According to USFWS regulations,
7 importers must declare animal shipments to USFWS inspectors at the port of entry and make the
8 animals available for visual inspection prior to removing them from the port. The USFWS reportedly
9 inspects approximately 25% of declared wildlife shipments at the U.S. border (Wyler and Sheikh 2009).

10 Other federal agencies regulate imports of certain wild animal species through a patchwork of controls.
11 Importation of African rodents into the United States is prohibited by Centers for Disease Control and
12 Prevention restrictions intended to prevent the spread of monkeypox (CDC 2003). The Department of
13 Health and Human Services regulates importation and sale of small freshwater turtles to prevent the
14 spread of Salmonella bacteria to humans (21 CFR § 1240.62) (CDC 2007c). Since 1991, federal
15 regulations intended to prevent the spread of foot and mouth disease have restricted the importation of
16 hedgehogs (all members of the family Erinaceidae) (9 CFR § 93.700-707). Importation of leopard
17 tortoises (*Geochelone pardalis*), African spurred tortoises (*Geochelone sulcata*), and Bell's hingeback
18 tortoises (*Kinixys belliana*) into the United States is prohibited and interstate movement of these three
19 species is restricted to prevent the spread of exotic ticks (9 CFR § 93.701 and 9 CFR § 74.1) (USDA-APHIS
20 2001).

21 Live animals entering the territory of Guam must be accompanied by an import permit and an official
22 health certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian.
23 Animals imported to Guam are subject to inspection and quarantine, and any animal found to be
24 clinically affected or recently exposed to any infectious, contagious, or communicable disease or
25 infested with ectoparasites shall be returned to its point of origin or destroyed (9 GARR 1, Division 1,
26 Chapter 1). It is unclear to what extent these regulations are enforced for small mammals, reptiles, or
27 amphibians legally imported to Guam for the pet trade.

28 **Summary**

29 The larger human population resulting from the military relocation will likely increase demand for exotic
30 pets and for traditional foods and medicines, and therefore, we expect a slight increase in pathway
31 traffic volume in small mammals and reptiles.

32 Caged, captive-bred small mammals are unlikely to encounter livestock or poultry pathogens or host
33 ticks of importance to livestock. Although the role of small mammals in the introduction of hazards
34 listed in Table A6-13 to new regions is theoretically possible, we found no documentation of release of
35 hazards through importation of captive-bred rodents or lagomorphs. The Centers for Disease Control
36 and Prevention ban on importation of African rodents indirectly reduces the risk of introduction of
37 livestock diseases endemic in Africa, such African swine fever, foot and mouth disease, and
38 trypanosomiasis, through the small mammal pathway.

1 The United States is a major importer of reptiles and amphibians, and import records show that many of
2 these animals are captured from the wild in African countries. The primary hazards of concern
3 associated with reptiles or amphibians are tick vectors of several livestock pathogens, including the
4 etiologic agent of heartwater, which is endemic to regions of Africa. Reptiles are frequently parasitized
5 by several species of hazard ticks exotic to the Micronesia Region, and current mitigations are not
6 sufficient to prevent importation of tick-infested reptiles to the United States (Burridge and Simmons
7 2003). Illegal introductions of reptiles into the Micronesia Region have been reported (Buden et al.
8 2001; Vice 2010a).

9 ***Other Animals Pathway Release Assessment***

10 The increased risk of release of hazards into the Micronesia Region due to the military relocation
11 through intentional movement of reptiles (legal or illegal) is low.

12 The increased risk of release of hazards into the Micronesia Region due to the military relocation
13 through intentional movement of non-domesticated mammals and amphibians is negligible.

14 **A6.3.3.5.3 Exposure Assessment: Other Animals Pathway**

15 ***Biological Factors***

16 Amblyomma ticks known to be capable of transmitting heartwater are generally hardy, long-lived
17 species that attach to their reptile hosts for prolonged periods of time, possibly weeks to months
18 (Petney et al. 1987). The etiologic agent of heartwater, *E. ruminantium*, has been shown to persist in
19 these ticks for up to 15 months (Ilemobade 1976). These characteristics are favorable for both tick and
20 pathogen to survive transit with their imported reptile host to a new environment where susceptible
21 hosts may be present.

22 Populations of exotic ticks, including heartwater vectors, have become established in Florida, after
23 introduction via imported tick-infested reptiles (Burridge et al. 2000). After arrival in Florida, the ticks
24 apparently were disseminated from reptile importers to breeders, zoos, wildlife theme parks, pet stores,
25 and private hobbyists. Intentional release and subsequent establishment of exotic reptiles in the United
26 States has been documented, providing evidence of another plausible route for introduction and
27 establishment of exotic tick species (Brown et al. 1995).

28 ***Regional Factors***

29 There are several examples of exotic ticks successfully invading tropical island ecosystems. Originating in
30 Southeast Asia, the cattle fever tick *R. (B). microplus* has spread throughout the tropics, including islands
31 such as Guam, the Mariana Islands, Puerto Rico, and the U.S. Virgin Islands (Jongejan and Uilenberg
32 2004). The tropical bont tick *Amblyomma variegatum*, along with heartwater, has become established in
33 several Caribbean islands, presumably following introduction with imported cattle from West Africa in
34 the 18th or 19th century (Jongejan and Uilenberg 2004).

35 The presence of suitable habitat for tick survival in the Micronesia Region strongly influences the
36 likelihood that an introduced exotic tick species will become established and therefore, the likelihood

1 that a domesticated animal will be exposed to an exotic tick or tick-borne disease. Two essential factors
2 that control habitat suitability for ticks are the presence of hosts and a favorable environment (Keirans
3 and Durden 2001).

4 Among the most significant tick pests of livestock, ticks of the genera *Amblyomma*, *Hyalomma*, and
5 *Rhipicephalus*, in general, are well-adapted to tropical environments (Rajput et al. 2006). More specific
6 statements about candidates for establishment in the Micronesia Region, based upon habitat suitability,
7 cannot be made with certainty, because there is limited data on tick distributions throughout the
8 tropics, and much of the information about tick distributions in the Micronesia Region is anecdotal or
9 outdated.

10 Maintenance of water balance is essential to tick survival. In tropical environments, ticks seek sheltered,
11 humid microenvironments, generally woodlands and grasslands, to avoid desiccation (Sonenshine and
12 Mather 1994). Human alteration of natural communities and ecological changes at a local level are
13 factors that contribute to movement or emergence of tick populations and tick-borne disease (Korch Jr.
14 1994). When human pressures on the local environment are relaxed to allow lush growth of vegetation,
15 such as through reforestation or allowing cultivated fields to lie fallow, expansions of tick populations
16 have occurred (Sonenshine and Mather 1994). Conversely, habitat modification by destroying
17 vegetation through mowing or burning is a proven method of reducing tick populations (Piesman and
18 Gray 1994).

19 The military relocation in Guam is likely to reduce favorable tick habitat by altering vegetation on the
20 island. Construction activities associated with the military relocation are expected to result in loss of
21 woodlands and grasslands in Guam. For example, in Guam, construction could result in clearing of more
22 than 600 hectares of limestone forest, approximately 3.5% of existing limestone forest (U.S. Navy 2009f,
23 i). Estimates of potential impact also include clearing of almost 200 hectares of scrub, shrub, and
24 tangantangan forest; and approximately 8 hectares of savanna (U.S. Navy 2009i).

25 A tick requires a suitable host as a blood source which is needed for development and reproduction.
26 Host availability may be more important than climate in determining tick abundance (Estrada-Peña
27 2008, Randolph 2008). Introduced predators and land use changes in Guam limit the populations of
28 small mammals, birds, and large hoofed mammals, three important groups of vertebrate hosts for ticks.
29 Due to the presence of BTS, there are areas in Guam that lack all native vertebrates except for a few
30 species of small lizards (Rodda and Savidge 2007). Most species of birds have been extirpated from
31 Guam as a result of BTS predation, and small mammals are less numerous than before the arrival of the
32 snake (Rodda and Savidge 2007). The USDA Census of Agriculture documents the decline of livestock
33 farming in Guam; both the number of farms and the numbers of cattle, carabaos (*Bubalus bubalis*),
34 goats, and swine have decreased in Guam over the past decade (USDA-NASS 2009a).

35 Although Guam's populations of farmed hoofed mammals are in decline, wild hoofed mammals are
36 thriving and serve as hosts for introduced ticks. Feral populations of carabaos, Philippine deer (*Cervus*
37 *marianus*), and swine are present and increasing in Guam (Specht 2003; Wiles 2005). In Guam,

1 carabaos and deer are frequently infested by R. (B.) microplus ticks (Kohls 1953). Bovids and cervids, in
2 general, are preferred as hosts for numerous species of ticks (Kolonin 2009).

3 Because Guam serves as a distribution point for the rest of the Micronesia Region, exotic ticks
4 introduced to Guam could be disseminated elsewhere in the Region. The distribution of suitable
5 vertebrate hosts for ticks, particularly birds and small mammals, differs on other islands of the
6 Micronesia Region from that in Guam, and other islands may provide more suitable habitat for
7 introduced ticks than Guam.

8 **Summary**

9 Given the opportunity through introduction, exotic tick species currently existing in tropical areas may
10 extend their distributions to the Micronesia Region. In Guam, availability of vertebrate hosts and
11 suitable microclimate environments are limiting factors to the likelihood of establishment of exotic tick
12 species. The low density of some groups of vertebrate hosts for ticks may reduce the likelihood that
13 some exotic tick species, if introduced, will find suitable hosts and establish a population in Guam. The
14 military relocation is predicted to result in development in some woodlands and grasslands in Guam,
15 and therefore, remove some habitat suitable for ticks and their vertebrate hosts. There is no indication
16 that the military relocation will create a more favorable environment for tick establishment, and
17 therefore, the military relocation is unlikely to increase the risk of exposure of domesticated animals to
18 exotic ticks or tick-borne disease.

19 **Other Animals Pathway Exposure Assessment**

20 The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the
21 intentional movement of reptiles is low.

22 **A6.3.3.5.4 Consequence Assessment: Other Animals Pathway**

23 The two potential adverse events caused by the introduction of tick-infested reptiles are introduction of
24 an exotic tick-borne disease carried by an exotic tick, or establishment of an exotic tick species that
25 serves as a more effective vector of endemic disease, or causes more severe physical damage to hosts
26 than endemic ticks. *Ehrlichia ruminantium*, the etiologic agent of heartwater, a tick-borne disease of
27 ruminants, is a hazard of high consequence associated with imported reptiles; therefore, this agent is
28 the focus of the consequence assessment for this pathway.

29 **Biological Consequences**

30 Mortality due to infection with *E. ruminantium* in naive populations of ruminants may be high; mortality
31 rates of 40, 60, and 90% have been observed in calves, adult cattle, and goats, respectively (Kasari et al.
32 2010). *Ehrlichia ruminantium* is not thought to be zoonotic (CFSPH 2007g). Heartwater is readily
33 introduced into new regions in infected animals or ticks, and therefore, the presence of heartwater in
34 Guam would increase the risk of introducing this disease into the rest of the Micronesia Region, Hawai'i,
35 or the continental United States (CFSPH 2007g). If heartwater is introduced into the continental United
36 States, critical factors of tick vectors, suitable environment, and susceptible hosts are present to support
37 establishment of the disease (Kasari et al. 2010).

1 The direct effects of tick infestation of livestock, such as dermatitis, anemia, and loss of condition, due
2 to new tick/host interactions, are difficult to predict. Parasitism of cattle by the heartwater vector
3 *Amblyomma variegatum* is associated with bovine dermatophilosis, a severe skin disease with
4 significant impact on tropical animal health and production (Morrow et al. 1996).

5 ***Environmental Consequences***

6 Chemical control using acaricides continues to be the primary means of tick control and eradication
7 (Kunz and Kemp 1994). Intensive use of these products on livestock has led to resistance in ticks to
8 several classes of pesticides. Environmental concerns, particularly the persistence of pesticide residues
9 in the environment and their effects on non-target species, have been raised regarding the use of
10 pesticides on livestock. The environmental costs of area-wide or large-scale host applications of
11 acaricides may be unacceptable (Kunz and Kemp 1994).

12 Fatal heartwater infections have been reported in water buffalo and several species of deer and
13 antelope (Peter et al. 2002). Presumably, Philippine deer and feral carabaos on Guam would be
14 susceptible to infection, suffer high mortality, and serve as reservoirs, but confirmation is lacking.

15 ***Economic Consequences***

16 Historically, the United States has responded to the establishment of exotic tick species by mounting
17 eradication campaigns. These programs are expensive and require long-standing efforts, exemplified by
18 ongoing attempts to eradicate *Amblyomma variegatum* from the Caribbean. To date, control efforts
19 have reduced the numbers of ticks on some islands and eradicated them from others, but complete
20 eradication throughout the Caribbean remains elusive (CFSPH 2007g). Creating and executing a
21 successful tick eradication program in the present era is a difficult, if not impossible, task due to several
22 challenges: acaricide resistance, the abundance of white-tailed deer and other wildlife hosts, restrictions
23 on the use of pesticides, cost, and public attitudes (George et al. 2002).

24 Heartwater is a serious constraint to livestock production in areas of the world where it is endemic
25 (CFSPH 2007g). The greatest direct economic losses due to heartwater in endemic areas are attributable
26 to tick control costs, milk revenue loss, and livestock treatment costs (Mukhebi et al. 1999). In 1993,
27 USDA estimated that, if heartwater became established in the United States, the value of potential
28 livestock losses could total \$494 million over five years (USDA-APHIS 1993). In addition to direct losses,
29 introduction of heartwater into the continental United States would likely result in severe indirect
30 economic effects due to trade restrictions. In the event of a heartwater disease outbreak on U.S. island
31 territories, such as Guam or CNMI, countries would likely use a regionalization approach, imposing
32 restrictions on ruminants from the affected area only. The effect of regionalization would most likely
33 reduce the trade consequences at the national level. The local effect of trade restrictions for live
34 ruminants is not likely to be significant to Guam or the rest of the Micronesia Region, where no
35 commercial ruminant export trade occurs.

1 **Summary**

2 Importation of reptiles is a recognized pathway for introduction and establishment of exotic ticks and
3 exotic tick-borne diseases of livestock, such as heartwater. Establishment of exotic tick species or
4 introduction of heartwater in Guam, the rest of the Micronesia Region, or the rest of the United States
5 poses a significant threat in terms of biological, environmental, and economic consequences.

6 **Other Animals Pathway Consequence Assessment**

7 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
8 the Micronesia Region through intentional movement of reptiles is very low.

9 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
10 exposure to hazards released into the Micronesia Region through intentional movement of reptiles is
11 very low.

12 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
13 hazards released into the Micronesia Region through the intentional movement of reptiles is medium.

14 **Other Animals Pathway Risk Estimation**

15 Because the increased risk of release of hazards into the Micronesia Region due to the military
16 relocation through the intentional movement of reptiles is low, the risk of exposure of livestock and
17 poultry is low, and the significance of consequences of livestock and poultry exposure to Guam, the rest
18 of the Micronesia Region, and the rest of the United States is low, we conclude that the military
19 relocation-associated overall risk from reptiles is low.

20 **A6.3.3.6 Humans**

21 In this pathway, we consider the effect of the military relocation on risk to livestock and poultry health
22 through the movement of people into the Micronesia Region. The number of people travelling into the
23 Region will increase as a result of the military relocation. Discussion of risk to human health is limited to
24 the livestock and poultry hazards associated with people.

25 In this section, we do not cover objects potentially carried by humans, such as animal products or
26 smuggled live birds. Those are covered in the animal products and poultry pathways, respectively.

27 **A6.3.3.6.1 Hazards Associated with the Humans Pathway**

28 People can transport hazards in three roles: they can be infected hosts, they can be contaminated with
29 disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Baggage
30 or other personal belongings accompanying travelers can be contaminated with disease agents or
31 transport tick vectors. Animal products can also be carried in baggage or personal belongings; this
32 possibility is covered in the animal products pathway. Table A6-14 lists hazards that are associated with
33 people or their accompanying baggage through the roles associated with humans, including hazards for
34 which humans may serve as dead-end hosts or play a minor or theoretical role in transmission.

1

Table A6-14: Hazards Associated with the Humans Pathway

Hazard		Disease	Transport role ^a	References
	Disease agent			
	African swine fever virus	African swine fever	F	CFSPH 2010a
	<i>Bacillus anthracis</i>	Anthrax	I	CFSPH 2007a
	<i>Brucella abortus</i>	Brucellosis (<i>Brucella abortus</i>)	I	CFSPH 2009b, OIE 2009a
	<i>Burkholderia mallei</i>	Glanders	I	CFSPH 2007f
	<i>Campylobacter fetus venerealis</i> ; <i>C. fetus fetus</i>	Bovine genital campylobacteriosis	I	OIE 2008b
	<i>Chlamydomphila abortus</i>	Enzootic abortion of ewes (ovine chlamydiosis)	I	OIE 2008f
	<i>Chrysomya bezziana</i>	Old world screwworm myiasis	I	CFSPH 2007l, OIE 2009q
	Classical swine fever virus	Classical swine fever	F	CFSPH 2009d, OIE 2009h
	<i>Cochliomyia hominivorax</i>	New world screwworm myiasis	I	CFSPH 2007l, OIE 2009q
	Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a
	Exotic NDV	Exotic Newcastle disease	I, F	CFSPH 2008d
	Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
	HPAIV	HPAI	I, F	CFSPH 2010b
	JEV	Japanese encephalitis	I	OIE 2010d
	<i>Leishmania</i> spp.	Leishmaniasis	I	CFSPH 2009k
	<i>Mycobacterium bovis</i>	Bovine tuberculosis	I	CFSPH 2009c, OIE 2009b
	Nipah virus	Nipah virus encephalitis	I	CFSPH 2007j, WHO 2009e
	Rabies virus	Rabies	I	OIE 2008o
	Rift Valley fever virus	Rift Valley fever	I	OIE 2009p, WHO 2010i
	<i>Salmonella</i> Gallinarum	Fowl typhoid	F	Shivaprasad 2003
	<i>Salmonella</i> Pullorum	Pullorum disease	F	Shivaprasad 2003
	<i>Trypanosoma</i> spp. (African)	Trypanosomiasis (African animal)	I	OIE 2008r
	Vesicular stomatitis virus	Vesicular stomatitis	I	OIE 2009v
	WNV	West Nile fever	I	OIE 2008s
	Vector			
	Tick ^b			
	<i>Amblyomma</i> spp.	Equine piroplasmiasis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Dermacentor</i> spp.	Equine piroplasmiasis	V	Kolonin 2009
	<i>Haemaphysalis</i> spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
	<i>Hyalomma</i> spp.	African horse sickness; equine piroplasmiasis; theileriosis	V	Kolonin 2009
	<i>Rhipicephalus</i> spp.	African horse sickness; equine piroplasmiasis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

2 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.3 ^b Not all species of all genera feed on humans.

4

1 **A6.3.3.6.2 Release Assessment: Humans Pathway**

2 **Likelihood of Hazard Association**

3 Infected humans can serve as reservoirs for transmission of Leishmania parasites to other mammals.
4 Worldwide, the incidence of human leishmaniasis is widespread and increasing, with 1 to 2 million
5 estimated new cases each year according to the WHO. Spread of leishmaniasis is facilitated by
6 international travel, and cases have been identified among military personnel after their return to the
7 United States from deployment to the Middle East (Aronson et al. 2006).

8 Infected humans can potentially serve as sources of transmission of *Bacillus anthracis* (CFSPH 2007a),
9 *Brucella abortus* (CFSPH 2007d), *Burkholderia mallei* (CFSPH 2007f), *Mycobacterium bovis* (CFSPH
10 2009c), or Nipah (CFSPH 2007j), rabies (CFSPH 2009m), Rift Valley fever (CFSPH 2007k), Venezuelan
11 equine encephalomyelitis (CFSPH 2008a), and vesicular stomatitis viruses (CFSPH 2008g), though the
12 role of humans in transmission of these disease agents is either theoretical or rarely reported. Other
13 hosts are epidemiologically more important than humans for harboring *Campylobacter fetus* bacteria
14 and screwworms (CFSPH 2009o). Human infection with trypanosomes that cause African animal
15 trypanosomiasis is very rare (OIE 2008r). Humans are generally thought to be dead-end hosts for
16 *Echinococcus* parasites and Eastern and Western equine encephalomyelitis, Japanese encephalitis, and
17 WNV (CFSPH 2007h, 2008a, 2009h).

18 Human infection with END or HPAI viruses can occur, but people play a more important role as fomites,
19 particularly by carrying the disease agents on contaminated clothing, than as infected hosts. African
20 swine fever, classical swine fever, and foot and mouth disease viruses and *Salmonella* bacteria can be
21 mechanically spread by people, clothing, or other personal belongings, which have been in contact with
22 affected premises (Sellers 1971; Pharo 2001; Sanchez et al. 2002; CFSPH 2009d, 2010a).

23 Ticks, including heartwater vectors *Amblyomma variegatum* and *A. hebraeum*, have been intercepted
24 from international travelers and their baggage arriving in the United States (Burrige et al. 2002; USDA-
25 APHIS 2009a).

26 **Traffic Volume and Origin**

27 Population summary information for the Micronesia Region can be found elsewhere in this document,
28 including expected increases in population from off-island individuals. Details concerning traffic volume
29 and origin information in this section may be found elsewhere in this document unless specifically
30 referenced below.

31 Significant increases in traffic will occur for military personnel and their dependents, who will be
32 assigned a tour of duty on Guam, either directly from other areas of the United States, or by way of the
33 United States for those being reassigned from current overseas locations. Hence, the impact to Guam
34 from additional military personnel and dependents will be from exposures common to the entire United
35 States which is free of foot and mouth disease, African swine fever, classical swine fever, END,
36 screwworms, Venezuelan equine encephalomyelitis, and HPAI.

1 The construction process will bring significant foreign labor forces to Guam. Foreign temporary workers
2 will include mainly small numbers of H1 professional and larger numbers of H2-B non-agricultural
3 workers. Direct impacts will be from a temporal influx of as many as 23,000 foreign, non-immigrant
4 temporary workers to support the relocation. We are assuming that the majority will be coming from
5 the Philippines, based on past worker recruitment patterns for Guam. In the past, the military has
6 preferred to hire Filipino workers because they are conversant in English. Smaller numbers of
7 managerial (H1) positions will be expected to come from Japan and Korea, in addition to the continental
8 United States or Hawai'i.

9 In-migrant workers are those who enter Guam from the Freely Associated States, including FSM, Palau,
10 and RMI, and thus share similar work status to Guam residents and are considered distinct from foreign
11 workers. They would be expected to marginally increase in numbers; however, their impact would be
12 minimal since they share common exposures in the Micronesia Region to those presently on Guam.

13 In terms of temporary visitors, Guam accommodates over one million tourists every year, primarily from
14 Japan, Korea, Taiwan, Hong Kong, and the Philippines, but also from the rest of the United States.
15 However, we have no reason to expect a significant increase in temporary visitors, specifically related to
16 the relocation.

17 The majority of tourism originates from Asia and the rest of the United States. Travel between Guam
18 and areas known to pose a risk for disease-carrying ticks in baggage or attached to returning travelers,
19 including Africa and the Caribbean, is not common. This is not expected to change with the military
20 relocation.

21 Guam has been subject to waves of illegal immigration in past decades, primarily from Asia. However,
22 intense efforts on the part of the Immigration and Naturalization Service to crack down on those
23 attempting to enter the United States through Guam or CNMI were effective in reversing this trend and
24 there is no reason to believe illegal trafficking of humans will increase with the military relocation
25 (1999).

26 ***Mitigations***

27 All international flights are channeled to the international airport on Guam. GCQA has customs
28 jurisdiction, and passengers from flight arrivals go through GCQA inspections.

29 All flights from Guam to the mainland United States go through Hawai'i where all passengers and cargo
30 are treated as foreign arrivals by Honolulu PPQ inspectors. In Hawai'i, all passengers, officers, and crew
31 members arriving by commercial aircraft or vessel and carrying plants, animals, microbial cultures, or
32 soil must complete the mandatory agricultural declaration form and submit the imported items for
33 inspection.

34 Currently U.S. CBP declaration forms for arriving international passengers collect information that
35 enables customs officials to identify those travelers who have been in recent contact with livestock or
36 poultry and to require disinfection of shoes and clothing or other steps as necessary to prevent disease

1 spread. The effectiveness of this measure will depend on awareness of the animal disease outbreak
2 status in countries of origin or embarkation and the ability of GCQA staff to rapidly adapt procedures
3 accordingly.

4 ***Summary***

5 Traffic volume for temporary visitors is unlikely to increase as a result of the military relocation. Nor do
6 we expect a change in travel patterns to areas that would increase risk for hazard introduction from
7 returning travelers or their baggage.

8 Military personnel and dependents will arrive directly from other parts of the United States, or after
9 having spent time in the rest of the United States following previous overseas deployment (Jimenez et
10 al. 2009). We assume that the time spent in other areas of the United States between deployments
11 would be sufficient to allow for the development of symptoms from most infections acquired while
12 overseas and thus allow for diagnosis and treatment. Thus, the risks that they will bring to Guam will
13 largely reflect those present in the rest of the United States and are considered to be negligible.

14 We expect a significant increase in temporary workers, with the majority expected to come from the
15 Philippines. A number of livestock diseases of concern are present in this area. However, the likelihood
16 of introduction via humans as fomites is mitigated by the inspection processes in place.

17 Current customs procedures allow for identification of international passengers that report recent
18 contact with livestock or poultry or presence on farms. If, as we believe, procedures are in place to
19 identify passengers arriving from areas with ongoing outbreaks of foot and mouth disease, END, HPAI,
20 and similar hazards, and exposure to farms, the risk will be negligible.

21 ***Humans Pathway Release Assessment***

22 The increased risk of release of hazards into the Micronesia Region due to the military relocation
23 through the legal movement of people is negligible.

24 The increased risk of release of hazards into the Micronesia Region due to the military relocation
25 through the illegal movement of people is negligible.

26 ***Humans Pathway Risk Estimation***

27 Because the increased risk of release of hazards into the Micronesia Region due to the military
28 relocation through the movement of people is negligible, we conclude that the military relocation-
29 associated overall risk for the human pathway is negligible.

30 **A6.3.3.7 *Animal Products***

31 In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry
32 health through the movement of animal products into the Micronesia Region. For the purpose of this
33 analysis, animal products are defined as products of animal origin, including meat and meat products,
34 milk and milk products, blood and blood products, skins, feathers, wool and hair, and animal feed

1 containing products of animal origin. Animal products may be moved through legal or illegal means. The
 2 volume of animal products moving into the Region will increase as a result of the military relocation, due
 3 to increased numbers of people travelling into Guam and demands for animal products by a larger
 4 population.

5 **A6.3.3.7.1 Hazards Associated with the Animal Products Pathway**

6 Animal products can transport hazards as fomites. Table A6-15 lists hazards that can be associated with
 7 animal products, including hazards for which animal products may serve as only a minor or theoretical
 8 source.

9 **Table A6-15: Hazards Associated with the Animal Products Pathway**

Hazard	Disease	Transport role ^a	References
Disease agent			
African horse sickness virus	African horse sickness	F	(CFSPH 2006a, OIE 2009f)
African swine fever virus	African swine fever	F	(OIE 2009g, CFSPH 2010a)
<i>Babesia caballi</i> and <i>Theileria equi</i>	Equine piroplasmiasis	F	(CFSPH 2008b)
<i>Bacillus anthracis</i>	Anthrax	F	(CFSPH 2007a)
Bovine spongiform encephalopathy agent	Bovine spongiform encephalopathy	F	(CFSPH 2007c)
<i>Brucella abortus</i>	Brucellosis (<i>Brucella abortus</i>)	F	(CFSPH 2009b)
<i>Capripoxvirus</i>	Lumpy skin disease	F	(OIE 2009o)
Classical swine fever virus	Classical swine fever	F	(CFSPH 2009d, OIE 2009h)
Duck hepatitis virus types I, II, and III	Duck virus hepatitis	F	(Kahn and Line 2008)
<i>Echinococcus granulosus</i> ; <i>E. multilocularis</i>	Echinococcosis/hydatidosis	F	(CFSPH 2009h)
Equine encephalomyelitis virus (Eastern)	Equine encephalomyelitis (Eastern)	F	(CFSPH 2008a)
Exotic DV	Exotic Newcastle disease	F	(CFSPH 2008d)
Foot and mouth disease virus	Foot and mouth disease	F	(CFSPH 2007e, OIE 2009j)
HPAIV	HPAI	F	(OIE 2009m, CFSPH 2010b)
Maedi-visna virus	Maedi-visna	F	(CFSPH 2007i)
<i>Mycoplasma agalactiae</i> ; <i>Mycoplasma</i> spp.	Contagious agalactia	F	(CFSPH 2009e)
<i>Mycobacterium bovis</i>	Bovine tuberculosis	F	(CFSPH 2009c)
Nairobi sheep disease virus	Nairobi sheep disease	F	(CFSPH 2009l)
Porcine reproductive and respiratory syndrome virus	Porcine reproductive and respiratory syndrome	F	(FAO 2007b)
Rabies virus	Rabies	F	(CFSPH 2009m)
Rift Valley fever virus	Rift Valley fever	F	(CFSPH 2007k)
Rinderpest virus	Rinderpest	F	(CFSPH 2008e)
<i>Salmonella</i> Abortusovis	Paratyphoid abortion	F	(CFSPH 2005b)
<i>Salmonella</i> Gallinarum	Fowl typhoid	F	(CFSPH 2009j)
<i>Salmonella</i> Pullorum	Pullorum disease	F	(CFSPH 2009j)
Scrapie agent	Scrapie	F	(OIE 2009e)
Sheep and goat pox viruses	Sheep and goat pox	F	(CFSPH 2008f)
Swine vesicular disease virus	Swine vesicular disease	F	(CFSPH 2007m, OIE 2009r)

Hazard	Disease	Transport role ^a	References
<i>Theileria</i> spp.	Theileriosis	F	(OIE 2009s)
Transmissible gastroenteritis virus	Transmissible gastroenteritis	F	(Cook et al. 1991)
<i>Trypanosoma evansi</i>	Surra	F	(CFSPH 2009n)
<i>Trypanosoma</i> spp. (African)	Trypanosomiasis (African animal)	F	(OIE 2008r)
WNV	West Nile fever	F	(CFSPH 2009q)
Vector			
Ticks ^b		V	

1 ^a Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

2 ^b See Table A6-6. Not all species of all genera are associated with animal products.

3

4 **A6.3.3.7.2 Release Assessment: Animal Products Pathway**

5 **Likelihood of Hazard Association**

6 A variety of animal products, including milk, eggs, meat, blood, and other tissues, can serve as disease
7 agent sources. The disease agents listed in Table A6-15 have been detected in animal products, and
8 could at least theoretically be transported to the Micronesia Region in animal products. Such products
9 can enter the Micronesia Region in cargo, mail, or passenger baggage.

10 However, many of these disease agents are spread to susceptible species primarily through routes other
11 than direct exposure to contaminated animal products. For example, African horse sickness virus,
12 Capripoxvirus, Eastern equine encephalomyelitis virus, Nairobi sheep disease virus, Rift valley fever
13 virus, WNV, and the etiologic agents of equine piroplasmiasis, surra, African animal trypanosomiasis, and
14 theileriosis are spread primarily by vectors (CFSPH 2006a, 2007k, 2008a, b, OIE 2008r, CFSPH 2009l, q, n,
15 OIE 2009f, o, s). Other disease agents are spread primarily through close contact with infected animals;
16 these agents include Brucella abortus, duck hepatitis virus, END virus, HPAI virus, sheep and goat pox
17 viruses, rinderpest virus, porcine reproductive and respiratory syndrome (PRRS) virus, and Salmonella
18 Abortusovis, Gallinarum, and Pullorum (CFSPH 2005b, 2008d, f, e; Kahn and Line 2008; CFSPH 2009b, j,
19 OIE 2009m; CFSPH 2010b). Rabies is usually transmitted in saliva through bites from an infected animal
20 (CFSPH 2009m).

21 *Bacillus anthracis* transmission in animals occurs by ingestion or inhalation of spores; in humans, spread
22 is primarily through cutaneous contact, such as with contaminated hides or skins, or through ingestion
23 of contaminated meat (CFSPH 2007a). *Mycobacterium bovis* is transmitted through ingestion or
24 inhalation, or through breaks in the skin (CFSPH 2009c). The most common route of human infection
25 with *M. bovis* is through aerosol inhalation, or ingestion of contaminated dairy products (CFSPH 2009c).
26 Contaminated milk or colostrum is a primary source of transmission of Maedi-visna virus and the
27 *Mycoplasma* spp. that cause contagious agalactia (CFSPH 2007i, 2009e).

28 *Echinococcus granulosus* and *E. multilocularis* are spread primarily through ingestion of contaminated
29 tissues. The bovine spongiform encephalopathy agent is spread primarily through ingestion of
30 contaminated tissues, or feed that contains ruminant-derived protein (Sejvar et al. 2008). The scrapie

1 agent is transmitted through ingestion of contaminated blood, tissues, or secretions including milk
2 (Sejvar et al. 2008, OIE 2009e).

3 African swine fever, classical swine fever, foot and mouth disease, and swine vesicular disease viruses
4 are readily spread to swine through ingestion of contaminated meat, typically through garbage feeding
5 (OIE 2009g, h, j, r). foot and mouth disease virus can also be spread through ingestion of contaminated
6 milk (OIE 2009j).

7 The duration that disease agents remain viable in animal products varies by agent and environmental
8 conditions. For example, African swine fever virus can remain viable in blood at 4°C for 18 months, in
9 meat at 4°C for 5 months, in salted dried ham for more than 4 months, and in frozen carcasses for years
10 (CFSPH 2010a). Similarly, classical swine fever virus can remain infectious for three months in
11 refrigerated meat, more than 4 years in frozen meat, and more than 6 months in cured and smoked
12 meats (CFSPH 2009d). Foot and mouth disease virus is inactivated in animal muscle as pH decreases to
13 less than 6.5 after death, but can survive in chilled lymph nodes and bone marrow (CFSPH 2007e). Foot
14 and mouth disease virus in milk can be inactivated by heating at 100°C for more than 20 minutes, but is
15 not inactivated by low-temperature pasteurization (72°C for 15 seconds) (CFSPH 2007e). Swine vesicular
16 disease virus can remain viable in ham for 6 months, dried sausage for more than 1 year, and processed
17 intestinal casings for more than 2 years (OIE 2009r). *Bacillus anthracis* spores can remain viable for
18 decades on processed animal products such as dried hides or wool, and for 10 years in milk (CFSPH
19 2007a).

20 Imported meat has been confirmed or strongly implicated as a disease agent source. For example,
21 classical swine fever virus was detected in frozen meat imported into Switzerland from China in 1993
22 and from Romania in 1994 (Krassnig et al. 1995). Imported meat was identified as the most likely disease
23 agent source in a foot and mouth disease outbreak in the United Kingdom in 2001 and classical swine
24 fever outbreaks in Germany and Switzerland in the 1990s (Hofmann and Bossy 1998; Fritzeimer et al.
25 2000; DEFRA 2002). Imported unpasteurized cheese has been identified as a source of *Mycobacterium*
26 *bovis* in the United States (Winters et al. 2005; Harris et al. 2007; Kinde et al. 2007).

27 Hides, skins, hair, or wool are animal products that are plausible as transport vehicles for ticks. Ticks
28 reside on the hide or skin of living animals; however, the host becomes unattractive once the animal is
29 slaughtered and the tick is no longer able to ingest blood. There is evidence that some partially fed
30 ixodid ticks will detach from a recently slaughtered animal to seek a living host (Ergönül 2007). The
31 USDA national tick survey and PPQ pest interception databases include records of nearly 100
32 interceptions of vector ticks on hides, skins, hair, or wool (James and Freier 2004; USDA-APHIS-VS CEAH
33 2006; USDA-APHIS-PPQ 2010a). The tick collection reports do not indicate whether the ticks were alive
34 or dead at the time of collection, or whether the hides were raw or processed. Exotic ticks of the genera
35 *Rhipicephalus* and *Hyalomma* were the ticks identified most commonly in association with hides and
36 skins.

37 Illegal imports, by their nature, are difficult to describe and quantify. However, immigrant workers have
38 been reported to carry prohibited animal products in their accompanying baggage. For example,

1 immigrant construction workers have reportedly carried eggs and animal products for medicinal
2 purposes (Sgambelluri et al. 2009). Studies conducted in Taiwan and the United Kingdom agreed that a
3 large percentage of illegally introduced meat and meat products were introduced by passengers coming
4 from Asian countries (Shih et al. 2005; Hartnett et al. 2007). We have no data on the amount of animal
5 products seized at the A.B. Won Pat International Airport. However, during our site visit, agents from
6 GCQA seized products containing meat, animal feed of foreign origin, and smuggled live animals during
7 inspections conducted at the airport. Passenger baggage inspections are targeted toward flights deemed
8 high risk, such as those from the Philippines (Jimenez et al. 2009). In our visit to A.B. Won Pat
9 International Airport, the level of staffing was adequate to handle the number of inspections conducted
10 given the volume of passenger traffic and passenger baggage inspections were supported with dog
11 teams. However, infrastructure needed for operational support was lacking. For example, none of the
12 four x-ray machines were operational, and not all passenger baggage could be screened. Since current
13 staffing levels are operating at maximum capacity for conducting inspections, additional passenger
14 traffic associated with the relocation will require additional resources.

15 Animal products are likely more frequently smuggled in passenger baggage than via maritime cargo
16 routes. In cargo routes, prohibited agricultural products are commonly smuggled by misidentification of
17 contraband on manifests, such as relabeling of prohibited items as permitted goods (Wyler and Sheikh
18 2009). Increases in cargo and passenger traffic volume and potential changes in the location of trading
19 partners related to the relocation may contribute to an increase in the rate of prohibited animal
20 products entering Guam. The risk associated with food is mainly limited to demand for specialty foods
21 since the major exporters of these products to the Micronesia Region are from countries free of major
22 livestock diseases of importance, such as the United States, Australia, and New Zealand as detailed
23 elsewhere in this document. In addition, there have been reports of animal products such as pet food
24 from prohibited sources being found in local stores on Guam (Jimenez et al. 2009). These products are
25 generally less expensive than similar products from the United States, Australia, or New Zealand, which
26 might contribute to their appeal, especially for lower paid military personnel or their dependents
27 (Jimenez et al. 2009).

28 Because the United States is free of many diseases of concern, such as foot and mouth disease and
29 classical swine fever, domestic mail does not pose a risk for introduction of these agents; however, mail
30 from foreign locations may pose such a risk. All mail originating in the United States and most
31 international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i, before
32 being sent to Guam. However, it is unclear to what degree foreign mail destined for Guam is inspected
33 in Honolulu. While Guam postal officials seem to rely on Hawai'i Department of Agriculture inspectors to
34 inspect this mail (Ericksen 2010; Shimizu 2010a), postal officials in Hawai'i seem to believe that GCQA is
35 carrying out these inspections (Gonzalez 2010). During the first site visit, we were advised that all
36 foreign mail that had passed through the Hawai'i facility was considered domestic mail, and was not
37 inspected in Guam. Furthermore, because it was domestic mail, GCQA inspectors could not open any
38 first class mail, even if it obviously contained agricultural products. Postal Service employees may notify
39 GCQA when they suspect non-first class mail to contain illegal plants or animals, and GCQA may obtain a
40 search warrant (Jimenez et al. 2009).

1 Evidence of smuggling activities via domestic mail comes from pilot studies conducted by USDA showing
2 that a large number of packages leaving Hawai'i for the mainland United States contained undesirable
3 organisms (Miller et al. 1992). We do not have estimates on the volumes and types of seized
4 commodities but several models have assessed that the risk of introduction of meats via mail is
5 relatively small compared with the risk from other pathways such as passenger baggage. A study in
6 Great Britain estimated that less than 0.5% of the total weight of illegal meat imports entered via post or
7 courier (Hartnett et al. 2007).

8 The recent outbreaks of foot and mouth disease in Asia and Europe are a reminder of the vulnerability
9 of the Micronesia Region to exotic animal diseases. Factors such as proximity to regions with endemic
10 disease, large amounts of boat traffic, larger population, and a large influx of tourists elevate the risk for
11 the illegal introduction of pathogens in animal products into Guam and the Micronesia Region. The
12 illegal importation of animal products provides a pathway around biosecurity controls and may allow
13 contaminated animal products to enter Guam.

14 Risk of illegal introduction of pathogens in animal products will come primarily from Asian regions,
15 particularly from the Philippines, as the movement of people and products to Guam will increase as a
16 result of the military relocation (Jimenez et al. 2009). A clear example of the potential threat is classical
17 swine fever, which occurs in several countries in Asia, including the Philippines (OIE 2009h; 2010h).

18 ***Traffic Volume***

19 Summary data for military and civilian imports may be found elsewhere in this document.

20 We do not have data on the expected increase in the volume of foreign imports of animal products
21 resulting from the potential 45% expansion in Guam's population during the military relocation. As a
22 proxy, we reviewed the population increase and corresponding increase in food commodity imports
23 between 1990 and 2009. Over this period, the population increased 34% (U.S. Navy 2009f). This was
24 associated with a more than a 200% increase in the total volume of imports of commodities; total
25 imports of eggs remained stable, while imports of meat and dairy products increased 125 and 450%,
26 respectively (GTIS 2010).

27 Detailed information for human travel may be found in the human pathways section.

28 ***Traffic Origin***

29 According to data provided by the Guam Bureau of Statistics and Plans for 2009, the major import
30 partners for all imported commodities to Guam, as measured in terms of U.S. dollar value, were the rest
31 of the United States (50%), Japan (14%), Western Europe (France, Italy and Switzerland) (13%), and
32 other Asian countries or regions (16%) (including China, Korea, Taiwan, Hong Kong, Singapore, Thailand,
33 and the Philippines). Food commodities and non-alcoholic beverages represented the largest
34 commodity group, making up over 30% of all imports in 2009 (BSP 2009b).

35 However, most animal product imports to Guam originate in the continental United States and the
36 majority of foreign imports of animal products are from New Zealand and Australia (GovGuam 2002;

1 Campbell 2010c). In FY 2009, imports from the continental United States accounted for more than
2 85% of meat products, 98% of eggs and egg products, and 75% of dairy products. Data for imports of
3 animal products and byproducts from foreign sources over the period 2005 to 2009 were obtained from
4 the Global Trade Atlas (GTIS 2010). Limited veterinary services and lack of slaughter facilities throughout
5 the Micronesia Region limit commercial trade in locally produced animal products, including meat, eggs,
6 and milk.

7 Specialty egg products, such as salted eggs and balut (embryonated, salted eggs) for which imports are
8 not restricted, have been exclusively imported from Asia (Japan, the Philippines, Taiwan, and Thailand),
9 but overall import volumes are small and have remained constant over the last decade.

10 It is expected that during the military relocation there will be an increase in the Asian population,
11 primarily workers from the Philippines (U.S. Navy 2009f), and that some immigrant workers will remain
12 on Guam after the construction phase is completed (U.S. Navy 2009g). Hence, there may be an increase
13 in demand for animal products from Asian countries. However, we assume that increase in demand will
14 have minimal impact on the origin of animal products. It is also assumed that during the construction
15 phase food services will be provided by contractors to foreign employees and those products will be
16 sourced from U.S. suppliers. Additionally, while Filipinos constitute a large segment of the immigrant
17 population working abroad, which is true for all of the United States, including Guam, historically there
18 is no evidence that an associated demand for foreign animal products has contributed to the
19 introduction of animal disease.

20 The relocation will increase the number of pets, primarily cats and dogs, on Guam. Most commercial pet
21 food that is imported into Guam is produced in and imported from the continental United States, and
22 foreign imports must comply with federal regulations for the processing of commercial animal food.

23 The Defense Commissary Agency provides groceries to military personnel, retirees and their dependents
24 (Melton 2009). All perishable food products procured by the Defense Commissary Agency, including
25 meat, eggs, and fresh dairy products, come to Guam from elsewhere in the United States. All meat
26 products procured by the Defense Commissary Agency require USDA certification and are sourced from
27 Nebraska. The amount of locally sourced food items is limited and provided by less than 20 local
28 retailers or businesses. Most suppliers of locally procured food products are from CNMI (Saipan and
29 Rota) (DeCA 2009, Melton 2009).

30 Information on origin of human travelers can be found in the human pathways section.

31 ***Mitigations***

32 Federal rules and regulations for the import of animal products are included in the USDA-APHIS-PPQ
33 Animal Product Manual and 9 CFR (USDA-APHIS 2010a). Guam laws and regulations are contained in the
34 Guam Administrative Rules and Regulations and the Guam Code Annotated (Supreme Court of Guam,
35 Compiler of Laws, Guam Administrative Rules and Regulations
36 <http://www.justice.gov.gu/compileroflaws/gar.html>).

1 Various sections of 9 CFR regulate importation of meat, poultry meat and eggs, animal byproducts, milk
2 and milk products, hides, skins, wool, hair, animal feed, and garbage. Most regulations restrict
3 importation from countries known to be affected with specific diseases of concern, including African
4 swine fever, classical swine fever, swine vesicular disease, foot and mouth disease, rinderpest, bovine
5 spongiform encephalopathy, HPAI H5N1, and END. Animal products are also restricted for anthrax and
6 animal disease vectors, including ticks. Furthermore, the Animal Product Manual cites regulations
7 administered by APHIS as well as certain Food Safety and Inspection Service requirements that must be
8 met in order to import certain animal products and byproducts and makes reference to other agencies
9 such as the Food and Drug Administration, whose requirements must also be followed (9 CFR § 94,
10 USDA-APHIS 2010a). Like live animals, animal products must be imported into the United States through
11 an approved port (9 CFR § 92, 9 CFR § 93, 9 CFR § 94, 9 CFR § 95,).

12 In addition to federal regulations, several Guam territorial laws and regulations are applicable. These
13 may be found in the Government Code of Guam Public Law (1956) and the Guam Administrative Rules
14 and Regulations. Regulations covered by these two documents pertain primarily to issues of food safety,
15 including import regulations that require milk pasteurization and grade standards. Additionally, the
16 Guam Administrative Rules and Regulations provide rules for processing garbage used to feed any
17 livestock species (26 GARR 14).

18 Importation of animal skin to Guam is limited to inspected tanned and chromed leather hides, which, in
19 contrast to untreated skins from freshly slaughtered animals, would be unlikely to harbor ticks (Ergönül
20 2006).

21 In 2008, 8,985 cargo documents (cargo manifests) were reviewed and cleared, and 19,180 cargo
22 inspections were conducted by GCQA inspectors, representing more than 19% of incoming cargo. Data
23 provided by the Maritime port indicate that two shipments for the FY 2009 contained prohibited meat.
24 Also, officials from GCQA have reported the entry of high risk cargo including eggs from Japan, China
25 and Korea (Sgambelluri et al. 2009).

26 The U.S. Army and Air Force have veterinarians who provide food safety and inspection services. Food
27 purchased by the military comes to the warehouse in the military port where it is inspected by military
28 veterinarians prior to distribution.

29 International flights to Guam arrive at A.B. Won Pat International Airport. GCQA has customs jurisdiction
30 and passengers from arriving flights go through GCQA inspections. Passenger inspections are targeted
31 towards flights considered to be high risk for importation of prohibited animal products, including flights
32 originating from Korea, China, the Philippines, Palau, and CNMI (Sgambelluri et al. 2009; Taijeron 2009).
33 Approximately 9% of passengers from high risk flights have their baggage inspected. GCQA detector dog
34 teams trained to detect agricultural products conduct regular operations in arrival halls at the airport.
35 Four dogs work two shifts for morning and night flights. Detection of undeclared items may result in
36 flight delays and fines up to \$1,000.

1 All seized goods containing animal products are destroyed. In the past, the use of x-ray machines
2 permitted the rapid screening of 100% of passenger baggage. At the time of our visit in November 2009,
3 four x-ray machines were present at the airport, but they were not functioning. While the use of x-ray
4 machines is important for detecting prohibited agricultural products, use of dogs can increase detection
5 by as much as two-fold (Shih et al. 2005). Overall, studies have found that the combined use of detector
6 dogs with x-ray screening results in 85% of meat products being detected (Pharo 2001). It is not clear
7 that there are sufficient functional x-ray units and detector dogs on Guam to achieve this level of
8 efficacy, however.

9 All flights from Guam to the mainland United States go through Hawai'i where all passengers and cargo
10 are treated as foreign arrivals by Honolulu PPQ inspectors. In Hawai'i, all passengers and crew members
11 arriving by commercial aircraft or vessel who are carrying plants, animals, microbial cultures, or soil
12 must complete a mandatory agricultural declaration form and submit the items for inspection.
13 Movement of plant products between Guam and the rest of the United States is restricted; however,
14 movement of animal products from Guam to the rest of the United States is considered a domestic
15 movement and, therefore, is not restricted.

16 Most military personnel and their dependents will be relocated to Guam from the mainland United
17 States and therefore will not pose a risk for introduction of contaminated animal products. In addition,
18 the military has procedures in place to mitigate the risk of introduction of prohibited animal products
19 into Guam. According to personnel at Andersen AFB, no cargo has ever been rejected (Hicks 2010). If the
20 regulations are properly enforced and inspections are performed appropriately, the risk should be
21 adequately mitigated.

22 ***Summary***

23 The volume of imports of animal products, including food commodities, animal feed, and hides and
24 skins, will increase with the military relocation. Most animal product imports to Guam originate in the
25 continental United States, New Zealand, and Australia, areas free from most hazards considered in this
26 assessment that could be associated with animal products. Federal and territorial regulations and
27 inspection procedures provide further mitigation against hazards for legal imports. However,
28 interdiction of smuggled products is unlikely to be 100% and increased demand for such products is
29 likely.

30 Despite current inspection procedures and GCQA fines for violations, passengers continue to bring high-
31 risk animal products into Guam. The predicted large influx of immigrant workers and progressive
32 increase in the number of tourists originating from Asian countries is likely to increase the volume of
33 smuggled animal products and the likelihood of introduction of livestock or poultry disease agents
34 associated with animal products. Passenger baggage passenger may be an important pathway of
35 introduction of contaminated animal products. In addition, there may be gaps in inspection of
36 international mail destined for the Region and animal products may therefore enter the Micronesia
37 Region through the mail.

1 ***Animal Products Pathway Release Assessment***

2 The increased risk of release of hazards into the Micronesia Region due to the military relocation
3 through legal movement of animal products is negligible.

4 The increased risk of release of hazards into the Micronesia Region due to the military relocation
5 through illegal movement of animal products is low.

6 **A6.3.3.7.3 Exposure Assessment: Animal Products Pathway**

7 ***Biological Factors***

8 Contaminated meat and other animal products may readily serve as fomites for the spread of a number
9 of important viruses, including African swine fever, classical swine fever, foot and mouth disease, HPAI,
10 and END viruses (Thomas et al. 2008). Livestock and poultry on Guam could be infected with these
11 viruses through being fed uncooked contaminated meat or poultry products, such as in table scraps or
12 other garbage. Many of these same issues and factors will also apply to the garbage pathway, a
13 discussion of which follows; they will be discussed there in additional detail.

14 ***Regional Factors***

15 Throughout the Micronesia Region, pigs are often reared in backyards and fed meat scraps. Feral swine
16 and poultry are present throughout the Region. Contaminated animal products could end up in waste
17 that is intentionally fed to pigs or disposed of where feral swine and poultry can access it.

18 Feral animals and birds contribute to spread where there is access to garbage or landfills by dropping
19 scraps in proximity to other livestock or feral animals (Hartnett et al. 2007), which is discussed in greater
20 detail in the garbage pathway section that follows.

21 ***Commodity Factors***

22 Illegal introduction of specialty and culture-specific foods, including meat and eggs, may increase in
23 volume, with the influx of workers. The high cost of importing commercial feed may also serve as an
24 incentive for illegal importation of animal products.

25 ***Summary***

26 Livestock and poultry on Guam may be exposed to animal disease agents through the feeding of
27 contaminated meat or poultry products. The presence of backyard poultry and swine, feral poultry and
28 swine, and garbage-fed swine operations increases the opportunities for exposure and subsequent
29 spread.

30 ***Animal Products Exposure Assessment***

31 The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the
32 animal products pathway is medium.

1 **A6.3.3.7.4 Consequence Assessment: Animal Products Pathway**

2 **Biological Consequences**

3 Spread of HPAI and END can be enhanced by the presence of feral and backyard free-ranging chickens.
4 Morbidity may approach 100% and mortality may be as high as 90% for both diseases in susceptible
5 chickens (CFSPH 2008d, 2010b). A similar situation is present with respect to feral swine and the swine
6 diseases of concern. Spread by similar means could occur with exposure of swine, cattle, pigs, sheep,
7 goats, and carabaos to foot and mouth disease virus, resulting in significant morbidity (CFSPH 2007e).

8 Because these disease agents are exotic to the United States, their introduction into Guam would likely
9 result in severe restriction of movement of animals and animal products from Guam to the rest of the
10 United States.

11 **Environmental Consequences**

12 In the face of an outbreak of an exotic livestock or poultry disease, such as END, classical swine fever, or
13 foot and mouth disease, it is likely that steps would be implemented to control or eradicate the disease,
14 which may include depopulation of sick and exposed animals as well as feral animals in the area.
15 Disposal of large numbers of carcasses, as well as litter and manure, would adversely impact the
16 environment, e.g. by leaching contaminants into the soil.

17 **Economic Consequences**

18 Control of even limited outbreaks could be costly. For example, Arizona and Texas each had only one
19 premises on which END infection was detected in 2002-2003; 10 infected premises were identified in
20 Nevada. Approximately \$3.5 million were spent on eradication efforts in Arizona, \$4.2 million in Texas,
21 and \$6.2 million in Nevada (USDA-APHIS-VS 2005).

22 Even more significant may be the possibility of trade restrictions being imposed by other countries on
23 trade in animals or animal products from the rest of the United States. Restrictions on trade from
24 anywhere in the United States could remain in place until steps are taken to regionalize Guam, which
25 would likely involve restricting the current free movement of animals and animal products from Guam
26 to the rest of the United States and through the Micronesia Region.

27 While livestock are not economically important to inhabitants of Guam and the rest of the Micronesia
28 Region, as evidenced by the total value of agricultural sales, estimated at \$2.8 million, and the size of
29 the agricultural sector as compared to other sectors, approximately 0.52% of the total workforce (USDA-
30 NASS 2009a), they are culturally important. Cultural and societal impacts might be more significant than
31 the economic consequences; however, this assessment does not take into consideration these intrinsic
32 values.

33 **Summary**

34 We expect the illegal importation of meat or other animal products contaminated with exotic livestock
35 or poultry disease agents to be a rare occurrence; however, once present in the Micronesia Region,

1 there are opportunities for exposure of livestock and poultry. Consequences of an outbreak of a disease
2 exotic to the United States would be significant.

3 ***Animal Products Pathway Consequence Assessment***

4 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
5 the Micronesia Region through the animal products pathway is low.

6 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
7 exposure to hazards released into the Micronesia Region through the animal products pathway is low.

8 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
9 hazards released into the Micronesia Region through the animal products pathway is medium.

10 ***Animal Products Pathway Risk Estimation***

11 Because the increased risk of release of hazards into the Micronesia Region due to the military
12 relocation through the animal products pathway is low, the risk of exposure of livestock and poultry is
13 medium, and the significance of consequences of livestock and poultry exposure is low, we conclude
14 that the military relocation-associated overall risk for the animal products pathway is low.

15 **A6.3.3.8 *Garbage***

16 Imported garbage includes refuse generated during a voyage, rejected cargo, and prohibited items
17 removed from passenger baggage at ports of entry. The main potential sources of garbage arriving in
18 the Micronesia Region are military aircraft and maritime vessels, private yachts, commercial airlines, and
19 civilian maritime vessels engaged in fishing or carrying passengers and cargo. Imported garbage may
20 enter the Micronesia Region through legal or illegal channels.

21 The relocation is expected to bring additional people, aircraft, cargo and cargo ships, and military ships
22 from foreign countries (U.S. Navy 2010a). Therefore, we expect the military relocation to result in an
23 increased volume of imported garbage, including rejected cargo and seizures of prohibited items from
24 passenger baggage.

25 **A6.3.3.8.1 *Hazards Associated with the Garbage Pathway***

26 Garbage can transport hazards in two roles: it can be, or be contaminated with, a disease agent and
27 serve as a fomite; or it can harbor vectors of disease agents. In this analysis, we consider garbage to be a
28 potential source of all hazards (see Table A6-4 and Table A6-6), including hazards for which garbage may
29 serve as only a minor or theoretical source.

30 **A6.3.3.8.2 *Release Assessment: Garbage Pathway***

31 ***Likelihood of Hazard Association***

32 Any of the hazards listed in Tables A6-4 and A6-6 could at least theoretically be transported to the
33 Micronesia Region in or as garbage. For many of these hazards, garbage is not a major means of spread.
34 However others, in particular disease agents associated with animal products, are readily spread

1 through contact with garbage. For example, contaminated meat in garbage is a well known source of
2 transmission of African swine fever, classical swine fever, foot and mouth disease, and swine vesicular
3 disease viruses, typically through garbage feeding to swine (OIE 2009g, h, j, r).

4 Garbage, including imported garbage, has been confirmed or strongly implicated as a disease agent
5 source in several outbreaks of African swine fever, classical swine fever, and foot and mouth disease.
6 Feeding swine with imported garbage that contains uncooked pork is the most common means of
7 introduction of African swine fever virus into uninfected swine herds in African swine fever-free regions
8 outside of Africa (EFSA 2010). For example, an African swine fever outbreak in Portugal in 1957 was
9 attributed to feeding of swine with contaminated garbage from an international flight (EFSA 2010).
10 Ship's garbage fed to swine was identified as the most likely source of foot and mouth disease virus in
11 foot and mouth disease outbreaks in California in the 1920s (USDA-APHIS-VS CEAH 1994). Illegally
12 imported ship's garbage fed to swine was implicated as a source of classical swine fever virus in an
13 outbreak in New Zealand in 1933 (Davidson 2002). Discarded food scraps in garbage sourced from a
14 naval shore base were identified as the most likely source of classical swine fever virus in a classical
15 swine fever outbreak in New Zealand in 1953 (Watt and Wallace 1954). More recently, discarded meat
16 fed to swine was identified as the most likely disease agent source in classical swine fever outbreaks in
17 Germany in the 1990s and an foot and mouth disease outbreak in the United Kingdom in 2001
18 (Fritzemeier et al. 2000; DEFRA 2002).

19 The duration that disease agents remain infectious in the environment varies by agent and
20 environmental conditions. Garbage can provide a dark, moist environment rich in organic matter that is
21 conducive to survival of some disease agents. For example, AIVs can survive for weeks in cool, moist
22 environments that contain organic matter (OIE 2009m). *Echinococcus* species can remain viable for
23 weeks to months in dark, moist environments (CFSPH 2009h). END virus can survive for weeks in
24 contaminated litter or soil (CFSPH 2008d). As noted above, African swine fever, classical swine fever, and
25 swine vesicular disease viruses can remain viable in dried meats and other animal products for months
26 to years. In contrast, other disease agents, such as the etiologic agents of dourine, heartwater, and
27 Japanese encephalitis, are much less stable outside of living hosts (CFSPH 2007h; OIE 2009i, l).

28 Accumulated garbage and trash provides food and harborage for rodents and breeding grounds for
29 arthropod vectors, including *Culex* and *Aedes* species mosquitoes, thereby potentiating risk for Japanese
30 encephalitis and dengue outbreaks (Gratz 1999a; Gratz 1999b).

31 ***Traffic Volume***

32 We expect the volume of garbage arriving in Guam to increase as a result of the relocation-associated
33 increase in the volume of movement of people and conveyances to Guam. The current system for
34 disposal of garbage in Guam appears to be working at capacity, and likely will not be able to
35 accommodate an increase in demand for capacity.

1 ***Traffic Origin***

2 Garbage imported into the Micronesia Region can be derived from a wide variety of sources, including
3 animal and plant products from regions of origin, embarkation, or transit of people and conveyances
4 arriving in the Region. Additionally, according to data provided by the Guam Bureau of Statistics and
5 Plans for 2009, the major import partners for all imported animal products to Guam were the United
6 States (50%), Japan (14%), Western Europe (France, Italy and Switzerland) (13%) and other Asian
7 countries or regions (16%) (including China, Korea, Taiwan, Hong Kong, Singapore, Thailand, and the
8 Philippines). After these animal products are used, they would be discarded as garbage and represent
9 the potential sources of disease agents. Additionally, garbage generated during training and military
10 exercises in Tinian is transported back to Guam. This is problematic, since it may contribute to the
11 spread of both agricultural disease agents and invasive species. For this reason, current federal
12 regulations prohibit such movement.

13 ***Mitigations***

14 Details on the regulation of garbage and solid waste are presented elsewhere in this document.

15 For federal regulatory purposes, the term “garbage” refers to all waste material that is derived in whole
16 or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other
17 refuse that has been associated with any such material (9 CFR §94).

18 Importation of garbage from all foreign countries except Canada into the United States is prohibited and
19 movement of garbage from Hawai’i, Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin
20 Islands, RMI, and Palau to any other State is prohibited with few exceptions. We note, however, that the
21 garbage generated during training and military exercises in Tinian is transported back to Guam.

22 Garbage is regulated if it is on or removed from a conveyance that has been in any port outside the
23 United States and Canada within the previous 2 years. Garbage generated during international or
24 interstate movements, including food scraps, table refuse, galley refuse, food wrappers or packaging
25 materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters,
26 or dining rooms, is regulated; this also includes meals and other food that were available for
27 consumption by passengers and crew on an aircraft but were not consumed (9 CFR § 94).

28 While on board a conveyance, all regulated garbage must be contained in tight, covered, leak-proof
29 receptacles. For Guam and CNMI, this generally extends to territorial waters, 12 nautical miles offshore.
30 If unloaded, regulated garbage must be moved under the direction of an inspector to an approved
31 facility for incineration, sterilization, or grinding into an approved sewage system (9 CFR § 94). Within
32 the Micronesia Region, port demand for waste reception facilities is highest in Guam (Nawadra et al.
33 2002). Waste, including regulated garbage, from large merchant vessels is generally not accepted in
34 Guam, and the commercial port generally does not accept waste from international vessels. At the
35 commercial port, commercial marinas, and fisheries wharves in Guam, waste is collected by private
36 waste collection companies under compliance agreements with APHIS and is subject to Port Authority
37 and government policies and regulations. In general in the Micronesia Region, waste from international

1 vessels that contains food waste is treated as quarantine regulated garbage. In Guam, regulated garbage
2 and rejected cargo seized from international vessels are incinerated.

3 Solid waste generated on land can be broadly categorized as municipal, commercial, or industrial.
4 Domestic solid waste generated on Pacific islands, including islands of the Micronesia Region, has been
5 estimated to include large proportions of packaging waste, food waste, and garden waste (WHO 1996).
6 Municipal, commercial, and industrial waste in Guam is disposed of at Ordot Dump, an unlined,
7 uncapped landfill that is scheduled to be closed in 2011 (GSWRIC 2010). A new landfill is under
8 construction. Household food waste is fed to pigs and chickens, or used as fertilizer (Nawadra et al.
9 2002). Quarantine and hospital waste is incinerated (Nawadra et al. 2002).

10 DoD waste is disposed of at the Navy Sanitary Landfill located on the Navy base, or at a landfill located
11 at Andersen AFB (U.S. Navy 2010a). At both of these landfills, waste is buried daily. Wood, such as
12 crates, and other green waste at the Andersen AFB landfill is shredded; the shredded waste is used for
13 landscaping on and off base. Waste from Navy ships berthed at Apra Harbor is disposed of at the Navy
14 Sanitary Landfill.

15 ***Summary***

16 Garbage is a potential source of introduction and spread of several hazards. The volume of international
17 and domestic garbage arriving in Guam is expected to increase as a result of the military relocation. As
18 risk increases with additional volumes of animal products imported, so too will the risk from the garbage
19 created from illegal imports of animal products. Despite the strength of regulations that serve to
20 mitigate risk, we conclude that some residual additional risk of hazard release remains.

21 ***Garbage Pathway Release Assessment***

22 The increased risk of release of hazards into the Micronesia Region due to the military relocation
23 through legal movement of imported garbage is negligible.

24 The increased risk of release of hazards into the Micronesia Region due to the military relocation
25 through illegal movement of imported garbage is very low.

26 **A6.3.3.8.3 Exposure Assessment: Garbage Pathway**

27 ***Biological Factors***

28 Disease agents associated with animal products are readily spread through contact with garbage. Fomite
29 spread of African swine fever, classical swine fever, foot and mouth disease, and swine vesicular disease
30 viruses from contaminated meat in garbage is well known to occur, typically exposing livestock through
31 garbage feeding to swine (OIE 2009g, h, j, r). Similarly, feeding uncooked chicken or other fowl
32 contaminated with HPAI or END viruses to poultry can result in poultry infection with these viruses
33 (Thomas et al. 2008).

1 **Regional Factors**

2 The relocation is expected to bring additional people, airplanes, cargo and cargo ships, and potentially
3 additional military ships from foreign countries. Increased garbage, seizures from baggage, and rejected
4 commodities can reasonably be expected. This increase may overburden the system to the point where
5 it cannot adequately address the risk these items may pose to Guam.

6 Pigs and poultry are the two production animal species of importance on Guam and are most likely to be
7 fed uncooked food waste, given the high cost of importing commercial feed and limited space for
8 garbage disposal on the island. Other livestock exposure to food waste is generally considered to be
9 limited to accidental access to improperly disposed of waste.

10 The feeding of garbage (as defined above) to swine is regulated by USDA (9 CFR § 166). While feeding
11 personal household garbage is not restricted, any garbage collected from other premises, including
12 restaurants, must be cooked and handled as described in the regulations. These regulations are not
13 currently enforced for backyard swine on Guam, leaving this pathway open.

14 Feral animals may be exposed to contaminated garbage while foraging in landfills. Scavenger species can
15 frequent landfills, including primarily feral pigs, but also dogs, cats, and birds. Landfills are fenced to
16 inhibit wind dispersal and to exclude animals from accessing the landfill. However, fencing is not always
17 fully effective. Although the military landfills have a perimeter fence, they may need a redesign or
18 upgrading to ensure that they are feral pig proof. Certain birds, in particular gulls (the black-headed gull,
19 *Larus ridibundus*) are scavengers at landfills and may carry meat scraps offsite, increasing risk of
20 exposure of other animals, including livestock and other feral animals (Hartnett et al. 2007).

21 **Summary**

22 The expected increase in the volume of garbage imported into Guam may overburden the waste
23 disposal system in Guam to the point at which it cannot adequately mitigate the risk that imported
24 garbage poses to livestock and poultry health on Guam. We expect importation of garbage containing
25 meat or other animal products contaminated with livestock or poultry disease agents to be a rare
26 occurrence, generally as importation of prohibited garbage; however, once garbage is imported,
27 opportunities for exposure of livestock and poultry are present. In addition, items illegally moved into
28 Guam as passenger baggage may end up in garbage fed to swine. The Swine Health Protection
29 regulations are not enforced on Guam, providing a pathway for disease agents to enter the swine
30 population.

31 **Garbage Pathway Exposure Assessment**

32 The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the
33 garbage pathway is medium.

1 **A6.3.3.8.4 Consequence Assessment: Garbage Pathway**

2 **Biological Consequences**

3 While the biological consequences are dependent on disease agent exposure to poultry or livestock on
4 Guam, END, HPAI, or foot and mouth disease virus, if introduced, could be spread widely by fomites.
5 Chickens are very susceptible to END and HPAI, experiencing significant mortality as a consequence of
6 infection. The presence of feral and backyard free-ranging chickens would likely enhance spread. For
7 both diseases, morbidity and mortality rates vary according to the strain of virus, but morbidity may
8 approach 100% and mortality may approach 90% in susceptible chickens (CFSPH 2008d, 2010b). Spread
9 by similar means could occur with exposure of swine cattle, pigs, sheep, goats, and carabaos to foot and
10 mouth disease virus, resulting in significant morbidity though generally low mortality (CFSPH 2007e).

11 Because these disease agents are exotic to the United States, their introduction into Guam would likely
12 result in severe restriction of movement of animals and animal products from Guam to the rest of the
13 United States.

14 **Environmental Consequences**

15 The volume of international and domestic garbage arriving in Guam is expected to increase as a result of
16 the military relocation. Such an increase would tax existing resources for disposal. In the face of an
17 outbreak of an exotic disease, such as END, classical swine fever, or foot and mouth disease, it is likely
18 that steps would be implemented to control or eradicate the disease, which may include depopulation
19 of sick and exposed animals as well as feral animals in the area. Disposal of large numbers of carcasses,
20 as well as litter and manure, would adversely impact the environment, e.g. by leaching contaminants
21 into the soil.

22 **Economic Consequences**

23 Control of even limited outbreaks would be costly. For example, Arizona and Texas each had only one
24 premise on which END infection was detected in 2002-2003; 10 infected premises were identified in
25 Nevada. Approximately \$3.5 million were spent on eradication efforts in Arizona, \$4.2 million in Texas,
26 and \$6.2 million in Nevada (USDA-APHIS-VS 2005).

27 Even more significant may be the possibility of trade restrictions being imposed by other countries on
28 trade in animals or animal products from the rest of the United States. Restrictions on trade from
29 anywhere in the United States could remain in place until steps are taken to regionalize Guam, which
30 would likely involve restricting the current free movement of animals and animal products from Guam
31 to the rest of the United States and through the Micronesia Region.

32 While livestock are not economically important to inhabitants of Guam and the rest of the Micronesia
33 Region, as evidenced by the total value of agricultural sales, estimated at \$2.8 million, and the size of
34 the agricultural sector as compared to other sectors, approximately 0.52% of the total workforce (USDA-
35 NASS 2009a), they are culturally important. Cultural and societal impacts might be more significant than
36 the economic consequences; however, this assessment does not take into consideration these intrinsic
37 values.

1 **Summary**

2 In a worst case scenario, an outbreak of a foreign animal disease such as END, HPAI, or foot and mouth
3 disease in the Micronesia Region poses a threat of introduction into Hawai'i or the continental United
4 States, given the interconnections between the islands of the Micronesia Region to each other, Hawai'i,
5 and the continental United States by air and sea. The economic impact of trade bans due to a poultry or
6 livestock disease outbreak in the Micronesia Region is likely to be insignificant to Guam and rest of the
7 Region, which lacks commercial livestock and poultry industries, as evidenced by the limited value of
8 agricultural sales and size of the agricultural workforce, but significant to the rest of the United States
9 (USDA-NASS 2009a). Regionalization policies would likely reduce the trade consequences at the national
10 level.

11 **Garbage Pathway Consequence Assessment**

12 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
13 the Micronesia Region through the garbage pathway is low.

14 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
15 exposure to hazards released into the Micronesia Region through the garbage pathway is low.

16 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
17 hazards released into the Micronesia Region through the garbage pathway is medium.

18 **Garbage Pathway Risk Estimation**

19 Because the increased risk of release of hazards into the Micronesia Region due to the military
20 relocation through the garbage pathway is very low, the risk of exposure of livestock and poultry is
21 medium, and the significance of consequences of livestock and poultry exposure is low, we conclude
22 that the military relocation-associated overall risk for the garbage pathway is low.

23 **A6.3.3.9 Other Cargo**

24 In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry
25 health through the movement of cargo other than live animals, animal products, or garbage into the
26 Micronesia Region. Mail is considered within this pathway. We expect that pathway traffic volume in
27 cargo moved through legal or illegal means will increase as a result of the military relocation, due to
28 demands for consumer goods by a larger population.

29 **A6.3.3.9.1 Hazards Associated with the Other Cargo Pathway**

30 Cargo can transport hazards in two roles: it can be, or be contaminated with, a disease agent and serve
31 as a fomite; or it can harbor vectors of disease agents. In this analysis, we consider cargo to be a
32 potential source of all hazards (Table A6-4 and Table A6-6), including hazards for which other cargo may
33 serve as only a minor or theoretical source.

1 **A6.3.3.9.2 Release Assessment: Other Cargo**

2 ***Likelihood of Hazard Association***

3 Although ticks have a biotic requirement for living hosts, they are only intermittent parasites. Most tick
4 species spend the majority of their lifecycle free within the environment, and ticks at all lifecycle stages
5 have been reported to survive off the host for long periods of time, sometimes for months or years
6 (Randolph 2004). Ticks have been found on a wide variety of other inanimate articles offered for
7 importation. The USDA national tick survey database and PPQ pest interception database include
8 records of approximately 50 tick interceptions on various articles, ranging from construction materials to
9 pottery to wood packing materials (USDA-APHIS 2009a). The PPQ pest interception database includes
10 records of more than 80 instances of ticks having been transported to the United States on a wide
11 variety of imported live plants and plant material such as cut flowers, dried herbs, or handicrafts. There
12 is no distinguishable pattern in these interceptions. Most of the interceptions were of *R. sanguineus*, a
13 cosmopolitan tick species already present in the Micronesia Region, but exotic ticks of the genera
14 *Amblyomma*, *Dermacentor*, *Haemaphysalis*, and *Hyalomma* were also found. In general, it is possible for
15 ticks to be associated with almost any article, but considering the large number of articles that enter the
16 United States each day, relatively few interceptions have been recorded. Ticks have occasionally been
17 intercepted from the hides and skins of recently slaughtered animals.

18 In the 1990s, the majority of interceptions of non-indigenous mosquito species occurred around seaport
19 areas. Multiple studies have identified such interceptions (Whelan 1998; Whelan et al. 2001; Derraik
20 2004; Frampton 2005). Past and current data show that cargo containers are a pathway for the
21 successful introduction of non-indigenous mosquitoes at seaports (Lounibos 2002). Lounibos noted that
22 most successful mosquito invaders arrived by ship as larvae in containers or cargo (Lounibos 2002). It
23 takes approximately five to 15 days for a ship to travel to Guam from an Asian (China, Korea, Japan,
24 Indonesia, Malaysia, Philippines, Singapore), Oceanic (Australia and New Zealand), or American seaport.
25 It is likely that any adult mosquitoes aboard will die or disperse before the ship reaches Guam. However,
26 modern vessels can transport containers and cargo, which can carry a large number of propagules
27 (Frampton 2005).

28 Container shipping and the global used tire industry have contributed to the increased geographic
29 distribution of selected mosquito species (Frampton 2005). Approximately 75% of mosquitoes
30 intercepted on board cargo vessels were found in used machinery or used tires on board ships (Derraik
31 2004). Live mosquito larvae have also been found in tires and other salvage equipment brought back
32 from combat areas in the Pacific (Frampton 2005). Examples of recent introductions of non-indigenous
33 mosquitoes associated with the transport of used tires have occurred in Europe (Romi et al. 1997;
34 Schaffner 2004; Roiz et al. 2007). There are numerous reports of the importation of exotic mosquito
35 species to Australia (Whelan 1991, 1995; Whelan 1998; Lamche et al. 2004; Nguyen and Whelan 2007),
36 and sea containers have been proposed as a potential pathway for the introduction of mosquitoes into
37 Australia and New Zealand (Derraik and Calisher 2004). On a global scale, many insect vector invasions
38 go unnoticed because of a lack of adequate surveillance.

1 To better understand the risk associated with the movement of containers, we utilized data published in
2 New Zealand where a strict surveillance system, including exhaustive cargo inspection and a detailed
3 recording of findings, was implemented at ports of entry (Border Management Group 2003). New
4 Zealand received an annual total of 260,000 loaded sea containers in 2003. More than 11,000 sea
5 containers were inspected by New Zealand's Ministry of Agriculture and Forestry. In the review, it was
6 found that approximately one in five containers contained some form of contamination, and that most
7 of the contamination was inside rather than outside the containers. Vehicles and machinery accounted
8 for 33% of product seizures, with nearly 29% of all vehicles intercepted requiring treatment. Cane ware
9 and used tires that require mandatory fumigation on arrival accounted for 24% of seizures. The Pacific
10 Islands were the region with the highest incidence of risky cargo (72%) and contamination in loaded
11 (40%) and unloaded (22%) containers. Nearly half of empty containers (45.8%) arriving in New Zealand
12 came from the Pacific Islands. Organisms, of which 40% were insects, were found in 6.1% of loaded
13 containers and 1.3% of unloaded containers. Approximately 40% of the containers had live organisms.
14 Organisms were found on the inside and outside of containers (Gadgil et al. 1999). A total of nine
15 containers held mosquitoes, four of them with live specimens (Border Management Group 2003).

16 Despite past occurrence of outbreaks of arboviral diseases on Guam, such as Japanese encephalitis, the
17 occurrence of arboviral diseases in Guam in the last 30 years is rare and mostly related to low-level
18 sporadic transmission of dengue viruses (Gubler 2003). WNV and JEV are pathogens of importance
19 based on the relatively high prevalence of these diseases in parts of the world. They can be introduced
20 via adult infected mosquitoes or eggs and immature forms, as the mosquitoes have been shown to
21 vertically transmit the viruses to their offspring (Rosen et al. 1989; Baqar et al. 1993). It is not always
22 clear whether recent introduction of these arboviruses is due primarily to mosquitoes or to infected
23 birds or humans travelling into new areas, and thereby introducing virus to the local mosquitoes.
24 Humans remain infectious with JEV for a short period of time making transmission back to biting
25 mosquitoes unlikely (Fischer et al. 2009); thus, there is reason to assume that arriving infected
26 mosquitoes have been the source for spread of JEV, similar to the pattern seen with the reintroduction
27 of dengue and spread through the Micronesia Region (Paul et al. 1993; Gubler 2002). The current level
28 of surveillance on Guam is not sufficient for detection and interception of infested cargo, particularly for
29 mosquito eggs and larvae; nor does a surveillance system exist in seaport areas for the detection of
30 newly introduced non-indigenous vectors.

31 As to *Culicoides* species (biting midges), a 2007 assessment of risk for the importation of bluetongue
32 into Ireland from the United Kingdom estimated the risk of transportation of parous infected *Culicoides*
33 in vehicles or containers or in hay straw or plants to be low. There is no evidence from the literature that
34 such accidental transportation of *Culicoides* has ever occurred or that parous female midges could
35 survive the transport conditions (Duignan et al. 2007).

36 ***Traffic Volume***

37 Additional data on cargo imports are presented elsewhere in this document. Guam depends on imports
38 from foreign nations. In the last decade, the total number of sea lift containers increased over 35%

1 (103,000 in 2007) and it is expected to reach 190,000 (84% increase) at the peak of the military
2 relocation.

3 ***Traffic Origin***

4 In 2009, more than half of the total dollar value of imports to Guam came from the United States (53%),
5 with about 30% and 13% coming from Asia and Europe, respectively (BSP 2009b; Ferrier 2009; Guam
6 Visitors Bureau 2009).

7 ***Mitigations***

8 GCQA serves as the primary filter for goods that represent a threat to the agriculture of the island.
9 Agents from GCQA are responsible for inspecting and clearing imports from all vessels, cargo and people
10 entering Guam, whether from the mainland United States or foreign countries. If GCQA agents discover
11 any plants, plants materials, insects or certain types of animal products, they will refer the material to
12 USDA-APHIS-PPQ for further inspection.

13 GCQA requires a manifest from the shipping agent for all incoming cargo. Upon arrival the shipper holds
14 imported goods against a bond. GCQA will always inspect certain types of cargo considered to be of high
15 risk before granting entry. Most of the inspection activities apply only to shipments entering Guam from
16 foreign sources. Inspections are complemented by the use of an x-ray machine. Container inspection
17 takes 30 minutes and most commodity inspections occur during two consecutive weekdays coinciding
18 with the arrival of the majority of domestic cargo from the United States. Low staffing levels relative to
19 the large volume of goods entering Guam do not allow for inspection of all cargo. Instead GCQA relies
20 on documentation such as a manifest for identification and internal inspection of high risk containers. All
21 declared items that include animals, animal products and byproducts, and propagative plant materials
22 are considered risk goods and GCQA agents will inspect them. Holds are placed on shipments of interest
23 that are fully inspected and remain unloaded until cleared. In 2008, 8,985 cargo documents (cargo
24 manifests) were reviewed and cleared and 19,180 cargo inspections were conducted by GCQA; that
25 represents inspection of over 19% of all incoming cargo shipments. Inspections conducted in Guam
26 during fiscal year 2009 found live insects in one cargo shipment. However, we do not know the number
27 of containers that were opened and inspected. We do not have information on the species, number of
28 specimens intercepted, and whether they were dead or alive (GCQA 2009). In Guam, inspections are
29 more stringent for outbound than inbound cargo due to the lack resources and infrastructure (Brown
30 2010a).

31 Military maritime and airport facilities are subject to GCQA inspection, but such inspections are limited
32 due to the lack of staff and difficulties getting permission from military command. GCQA is currently
33 establishing cooperative agreements with military bases that will clarify each agency's inspection and
34 interception responsibilities. Although Guam is a territory of the United States, it is outside of CBP
35 jurisdiction.

36 Relocation of military and dependents to Guam will occur mostly from the mainland United States. If
37 some personnel are transferred from foreign locations, the military has procedures in place to mitigate

1 the risk of introduction of arthropod vectors via this route. Military Customs Inspections inspectors are
2 responsible for implementation of federal customs statutes for transfer of military personnel and goods
3 from overseas destinations into a territory within U.S. jurisdiction. These inspectors will conduct
4 inspections on aircraft arriving from foreign destinations for the presence of insects in cabin areas and
5 spray when necessary. Air Force Joint Instruction (AFJI) 48-104, the Quarantine Regulations of the
6 Armed Forces (DoD 1992), incorporate regulations to mitigate the risk of introduction and dissemination
7 of arthropod vectors by movement of vessels, aircraft, and other transport of the Armed Forces arriving
8 at or leaving installations in the United States and foreign countries, ports or other facilities where
9 arthropod vector-borne diseases are known to exist. The information on the materials and procedures
10 for disinsection can be found in the Military Entomology Operational Handbook (NAVFAC M0-310,
11 Army TM 5-632, Air Force AFM 91-16) (U.S. Navy 1972; USAPHC 2010).

12 ***Summary***

13 The military relocation is expected to be accompanied by a significant increase in cargo imports to
14 Guam. Cargo will likely come from the United States rather than countries of concern for ticks carrying
15 exotic livestock disease. This fact, along with inspection, should adequately mitigate the risk for release
16 of disease-carrying ticks through the movement of cargo.

17 Low numbers of mosquito vectors have been identified hitchhiking on cargo in numerous studies,
18 primarily focused on tires and equipment. Because we expect an increase in cargo coming into the
19 Micronesia Region as a result of the relocation, the probability of introduction of vectors will likely
20 increase concurrently. While vectors may be introduced, the likelihood that an introduced mosquito will
21 be infected with an animal disease agent is reported in multiple studies to be less than 0.1% (Nasci and
22 Mitchell 1996; Kramer and Bernard 2001; O'Leary et al. 2004; Reisen et al. 2004).

23 ***Other Cargo Pathway Release Assessment***

24 The increased risk of release of hazards into the Micronesia Region due to the military relocation
25 through the movement of cargo other than live animals, animal products, or garbage is very low.

26 **A6.3.3.9.3 Exposure Assessment: Other Cargo**

27 ***Biological Factors***

28 Increased risk for the exposure of livestock or poultry to hazards via mosquitoes introduced by this
29 pathway would require an infected mosquito to find its way aboard a conveyance and survive to release
30 a disease agent on Guam. Alternatively, an adult mosquito could lay eggs on that conveyance, and pass
31 the agent along to its offspring through its eggs. The eggs would hatch and complete the cycle to
32 production of adult mosquitoes that will require exposure to a susceptible animal on Guam and in most
33 cases, a competent alternative mosquito host present on the island to maintain infection. Fewer than a
34 dozen mosquito species were reported in the Micronesia Region at the beginning of the 20th century,
35 and no major disease vectors were present. However, in the course of the last century, this number
36 increased four-fold with the introduction of exotic species, such as *Aedes albopictus* and *Aedes aegypti*
37 (Reeves and Rudnick 1951) and numerous *Culex* species, which may be competent alternative hosts for

1 the etiologic agents of several arboviral diseases of human and animal importance (Lounibos 2002), in
2 particular WNV and JEV (Mitchell et al. 1993).

3 **Regional Factors**

4 Mosquitoes released on Guam may be able to bite and infect susceptible populations of wild birds such
5 as pigeons and Eurasian tree sparrows (*Passer montanus*) that are abundant on Guam, and other known
6 susceptible passerine birds, e.g. the Micronesian starling (*Aplonis opaca*) and the Marianas crow (*Corvus*
7 *kubaryi*). There is evidence of the establishment of exotic vectors as a result of accidental introduction
8 related to human activity; however, circumstantial evidence of a disease outbreak via infected vectors
9 has only been seen in the case of malaria (Lounibos 2002). In the case of WNV, spread is more likely to
10 occur from introduction of an infected live bird transmitting the disease agent to an established
11 competent mosquito vector, such as *Aedes albopictus*, *Ae. vexans* and *Ochlerotatus japonicus* (Turell et
12 al. 2005).

13 Backyard and feral pigs serve as amplifying hosts for JEV and are present in sufficient numbers to
14 establish an outbreak, as occurred in 1990 on Saipan (Paul et al. 1993).

15 **Summary**

16 Mosquitoes released on Guam will be able to bite and infect susceptible populations of wild birds,
17 transmitting arboviruses, including WNV and JEV. Competent alternative mosquito vectors are present
18 on Guam, Saipan, and potentially other islands of the Micronesia Region and could sustain infection.
19 Susceptible populations of domestic and feral pigs are present and can serve as amplifying hosts for JEV.
20 Thus, we conclude that the factors necessary for exposure are present.

21 **Other Cargo Pathway Exposure Assessment**

22 The risk of exposure of livestock or poultry to vector hazards released into the Micronesia Region
23 through the movement of cargo other than live animals, animal products, or garbage is medium.

24 **A6.3.3.9.4 Consequence Assessment: Other Cargo**

25 **Biological Consequences**

26 The predominant impacts from the introduction of WNV and JEV would be to humans and to native wild
27 bird populations, with minimal effects on poultry (Ghosh and Basu 2009; OIE 2010d). WNV is a threat to
28 the native wildlife population and may have profound effects on native wild bird populations, resulting
29 in elimination of some susceptible species. Native bird populations on Guam have been severely
30 diminished as a result of invasive species and feral cats and the expected impacts of WNV on remaining
31 native bird populations might result in elimination of some species. Experimental studies have shown
32 that poultry rapidly develop an antibody response capable of neutralizing the virus. Infection in chickens
33 is typically asymptomatic or with minimal clinical signs and pathology, and no mortality (Senne et al.
34 2000).

35 Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical
36 cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because

1 of the small number of horses in Guam and relatively low importance of this industry, and the
2 availability of effective vaccines to protect horses against the viruses, we conclude that the biological
3 consequences for introduction of WNV or JEV to the livestock and poultry industries are negligible.

4 As in the continental United States, the major impact of WNV establishment would be to humans. Once
5 established in a tropical environment and in the absence of preventive measures, spread would be
6 expected to be rapid among human populations with no prior exposure or immunity, as would be the
7 case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of
8 asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild
9 febrile disease; however about one of every hundred infected may develop severe neurological disease
10 with mortality rates as high as 14% (Madden 2003).

11 Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to
12 children. Annually, up to 50,000 cases of Japanese encephalitis are reported worldwide and more than
13 15,000 deaths are reported in eastern and southern Asia. While asymptomatic infection can occur,
14 approximately 30% of Japanese encephalitis cases are fatal and nearly half result in permanent
15 neurological sequelae (Ghosh and Basu 2009). However, any such introduction might well be short lived.
16 In 1990, a rare introduction of Japanese encephalitis on Saipan ended as the population of susceptible
17 pigs which serve as amplifying hosts had been infected and developed immunity, and has not recurred
18 (Paul et al. 1993).

19 ***Environmental Consequences***

20 Native bird populations on Guam have been severely diminished as a result of invasive species and feral
21 cats (Poole 2009). WNV, as with END and HPAI viruses, could decimate remaining populations.

22 ***Economic Consequences***

23 Release and establishment of WNV or JEV would be expected to result in little or no economic loss to
24 the poultry industry or to the few remaining equine operations on Guam; however, significant cost
25 would be incurred for human public health and mosquito vector surveillance, and for vector control to
26 prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California
27 (population 1.3 million) resulted in 163 reported human cases and a response that included emergency
28 aerial spray to control vectors. Costs for aerial spray totaled just over \$700,000 and when added to
29 estimated medical costs and patients' loss in productivity, the total economic impact was estimated at
30 \$2.98 million (Barber et al. 2010).

31 ***Other Cargo Pathway Consequence Assessment***

32 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
33 the Micronesia Region through the other cargo pathway is very low.

34 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
35 exposure to hazards released into the Micronesia Region through the other cargo pathway is very low.

1 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
2 hazards released into the Micronesia Region through the other cargo pathway is very low.

3 ***Other Cargo Pathway Risk Estimation***

4 Because the increased risk of release of hazards into the Micronesia Region due to the military
5 relocation through the other cargo pathway is very low, the risk of exposure of livestock and poultry is
6 medium, and the significance of consequences of livestock and poultry exposure is very low, we
7 conclude that the military relocation-associated overall risk for the other cargo pathway is very low.

8 **A6.3.3.10 Conveyances**

9 In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry
10 health through the movement of conveyances, in which vector hazards are transported at large (in the
11 absence of vertebrate hosts), into the Micronesia Region. For the purpose of this analysis, conveyances
12 are defined as aircraft, maritime vessels, and shipping containers. Vector hazards include mosquitoes,
13 ticks, and other arthropods (see Table A6-6). The relocation will be associated with a substantial
14 increase in conveyance traffic to the Micronesia Region.

15 **A6.3.3.10.1 Hazards Associated with the Conveyances Pathway**

16 Conveyances can transport vectors of disease agents. In this analysis, we consider other conveyances to
17 be a potential source of all vectors (see Table A6-6), including vectors for which conveyances may serve
18 as only a minor or theoretical source.

19 **A6.3.3.10.2 Release Assessment: Conveyances Pathway** 20 ***Likelihood of Hazard Association***

21 Ticks have been found at large in conveyances, including airplanes and containers (USDA-APHIS 2009a).
22 Recently, a soft tick of seabirds, *Carios capensis* (previously, *Ornithodoros capensis*), was identified as a
23 competent vector for transmission of WNV in New Zealand (Spurr and Sandlant 2004; Hutcheson et al.
24 2005). It is not known whether the species currently inhabits Guam or other islands in the Micronesia
25 Region, though it has been sporadically reported in the past (Kohls 1957); it does occur in Hawai'i
26 (Alicata 1948) and seabirds carrying the tick might find their way aboard conveyances.

27 The origin of most military personnel coming to Guam as a result of the relocation will be the
28 continental United States, and for workers, the Philippines (Jimenez et al. 2009), areas of little concern
29 for importation of most important animal disease-transmitting tick species aboard conveyances to
30 Guam. Import records confirm that cargo is most likely to be coming from the United States. While there
31 is evidence of ticks successfully establishing in tropical island ecosystems, introduction is more likely to
32 occur as a result of introduction of infested animals into the region and is considered in the livestock
33 and cats and dogs pathways.

34 Large flies from the Philippines and much of Asia may find their way aboard vessels. Blowflies, including
35 the Old World screwworm (*Chrysomya* spp.), could theoretically reproduce on aircraft, ships, or boats.
36 However, reproduction requires rotting flesh or other sources of filth in which to lay eggs and to

1 maintain optimal temperature, and a prolonged number of days to complete the life cycle (Bram and
2 George 2000). This is a less likely scenario on commercial airlines, commercial ships or military
3 conveyances not transporting animals. The lack of reproduction will reduce the vector numbers at the
4 destination.

5 Based on historical evidence, mosquito vectors are the most likely vectors to be introduced into a new
6 area via this pathway. In 1961, the U.S. Public Health Service published comprehensive survey findings
7 of insects found in aircraft over a 13 year period. Among the more than 20,000 insects were 92 species
8 of mosquito, 51 of which were not known to be present in the United States, Hawai'i, or Puerto Rico.
9 Since then several similar reports have echoed these findings (Gratz et al. 2000). Mosquito species
10 commonly intercepted from flights of Asiatic origin include *Culex pipiens*, *Culex quinquefasciatus*, *Culex*
11 *tritaeniorhynchus*, *Ochlerotatus japonicus*, *Aedes albopictus*, *Aedes aegypti*, and *Anopheles subpictus*
12 *indefinitus* (Joyce 1961; Takahashi 1984; Goh et al. 1985). The variety of mosquitoes on Guam and
13 throughout the Micronesia Region increased nearly six-fold from just prior to World War II to the end of
14 the Vietnam War, and may be traced to increased air and maritime traffic associated with the rapid
15 deployment of troops and equipment (Savidge 1984).

16 The survival of mosquitoes in aircraft in empirical and experimental situations has been extensively
17 studied. Laird (Laird 1947) reported that mosquitoes can survive an air journey under a variety of
18 conditions. He reviewed several studies regarding the ability of mosquitoes to survive air travel. The
19 longest survival period recorded aboard aircraft was 6-1/2 days. Furthermore, adult and newly hatched
20 mosquitoes can survive and go on to breed and lay eggs in other locations (Laird 1947). Mosquitoes tend
21 to remain aboard an airliner despite multiple stopovers. Flights from major Asian countries to Guam are
22 on average less than 5 hours. The cabin in modern commercial aircraft is pressurized and kept at an
23 ambient temperature, which implies that mosquitoes aboard will be able to survive for the duration of
24 the flight.

25 Adult insects travel almost exclusively within the fuselage. It seems that they are attracted more to the
26 illuminated cabins than to the baggage compartments. The exterior surface and wheel housing are of
27 lesser importance (Goh et al. 1985). Several researchers (Sullivan 1958; Russell 1987) have studied
28 mosquito survival rates under various conditions in different compartments of jet aircraft. Russell has
29 shown that *Cx. quinquefasciatus* can survive on a wheel bay during the course of an international flight
30 despite high altitude and external temperatures of less than -40°C.

31 A recent U.S. study determined an average of 0.1 mosquitoes may be found aboard an inbound flight
32 (Board on Environmental Studies and Toxicology 2002). In the same study, the average number of
33 insects recovered per plane ranged from one to 20 and the average percentage of infected aircraft
34 ranged from 10 to 100%.

35 The primary areas of concern for the risk of introduction of mosquito species to Guam are Southeast
36 Asia, Japan, and other Pacific Islands. In a 1974 Japanese study, Joyce and colleagues examined 36
37 passenger and seven cargo aircraft, with over half originating in China or Southeast Asia. A total of 24%

1 carried pests, including numerous mosquitoes, mainly in aircraft originating from Bangkok, Manila, and
2 Hong Kong, which may be attributed to the high prevalence of mosquitoes in these areas (Joyce 1961).

3 The regular occurrence of airport malaria in the United States and Europe suggests that aircraft are a
4 potential pathway for introduction of exotic mosquitoes and vector-borne diseases (Gratz et al. 2000).
5 There is at least one report of airport dengue fever in a German couple who travelled to Hawai'i in 1998
6 (Jelinek et al. 1998). According to the authors, the most plausible explanation is that the couple was
7 bitten by one or more infected mosquitoes on an aircraft in Hawai'i that originated in an Asian country.

8 By contrast, adult mosquitoes are rarely intercepted on maritime vessels. Of the invasive pests and
9 exotic mosquitoes that are intercepted, most are found in containers or commodities, such as tires or
10 plants. Therefore, the role of maritime conveyances in the introduction of exotic mosquito species is
11 mainly the transport of infested goods and materials. As additional evidence, decades of seaport and
12 vessel surveillance in Honolulu have not detected adult or larval mosquitoes aboard sea conveyances
13 (Joyce 1961); other studies have reported low prevalence of people complaining of mosquitoes and
14 other biting insects aboard ferries (Mouchtouri et al. 2008).

15 ***Traffic Volume***

16 The military relocation is expected to increase the volume of maritime and air traffic in the Micronesia
17 Region. Additional data on conveyances are presented elsewhere in this document.

18 ***Traffic Origin***

19 Import records confirm that conveyances carrying cargo are most likely to be coming from the United
20 States, rather than countries of concern for ticks carrying exotic livestock disease, though Asia is an area
21 of concern for the risk of introduction of mosquito species. In 2009, more than half of the imported
22 cargo shipments came from the United States (53%), with about 30% and 13% coming from Asia and
23 Europe respectively (BSP 2009b; Ferrier 2009; Guam Visitors Bureau 2009).

24 ***Mitigations***

25 Mosquitoes can be introduced via ships as either eggs, larvae, or adults travelling inside boat cabins or
26 shipping containers. Of the invasive pests and exotic mosquitoes that are intercepted, most are found in
27 containers or commodities, such as tires or plants, rather than uncontained on maritime vessels. Hitch-
28 hiking adult mosquitoes tend to die after a few days. The great distances between the Micronesia
29 Region and the continents of Asia and North America further diminish the probability of adult mosquito
30 survival (Joyce 1961). Additionally, modern ocean-going vessels have enclosed water supplies and
31 covered lifeboats, and offer very little in the way of mosquito breeding possibilities.

32 Currently in Guam, as with the rest of the United States, commercial aircraft are not disinfected, nor are
33 there specific surveillance activities in place for the detection of mosquitoes in aircraft (Jimenez et al.
34 2009). These circumstances coupled with the expected increase in the number of commercial and
35 military flights to Guam mean that there is an increased risk for introduction of invasive mosquitoes.

1 Presently, the major risk is flights from Asian countries due to the abundance and diversity of mosquito
2 fauna (WHO 1995; Gratz et al. 2000).

3 As for military planes, Military Customs Inspections inspectors are trained to look for prohibited animals
4 and animal products, and will conduct inspection activities in planes arriving from foreign destinations
5 for the presence of insects in cabin areas and spray when necessary. Air Force Joint Instruction (AFJI) 48-
6 104, the Quarantine Regulations of the Armed Forces (DoD 1992), incorporate regulations to mitigate
7 the risk of introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and
8 other transport of the Armed Forces arriving at or leaving installations in the United States and foreign
9 countries, ports, or other facilities where arthropod vector-borne diseases are known to exist. The
10 information on the materials and procedures for disinsection can be found in the Military Entomology
11 Operational Handbook (NAVFAC M0-310, Army TM 5-632, Air Force AFM 91-16) (U.S. Navy 1972,
12 USAPHC 2010).

13 There may be specific issues related to contamination of equipment brought into Guam by the military
14 related to exercises or deployments. The military has specific decontamination procedures designed to
15 mitigate this risk.

16 ***Summary***

17 The number of conveyances coming into Guam is expected to rise due to the relocation. Mosquito
18 vectors have been identified hitchhiking on cargo in numerous studies, primarily focused on tires and
19 equipment. However, the number of mosquitoes found is very low. In addition, it is not clear that
20 infected mosquitoes have ever been the vehicle for introduction of an animal disease agent into a
21 disease-free country, although there is reason to believe that infected mosquitoes on aircraft and on
22 cargo may have spread arboviruses of human significance, including dengue virus and JEV (Mackenzie et
23 al. 2004).

24 Because we expect an increase in conveyances coming into the Micronesia Region as a result of the
25 relocation, the probability of introduction of vectors will likely increase concurrently. While vectors may
26 be introduced, the likelihood that the introduced mosquito will be infected with an animal disease agent
27 is reported in multiple studies to be less than 0.1% (Nasci and Mitchell 1996; Kramer and Bernard 2001;
28 O'Leary et al. 2004; Reisen et al. 2004).

29 As described in elsewhere in the document, imports and people associated with the buildup are most
30 likely to be coming from the United States rather than countries of concern for ticks carrying exotic
31 livestock disease. But over time and in a broader consider, including both civilian and military imports,
32 this may change to some degree. While there is evidence of ticks successfully establishing in tropical
33 island ecosystems, introduction is most likely to occur as a result of importation of infested animals
34 (George et al. 2002).

1 **Conveyances Pathway Release Assessment**

2 The increased risk of release of vector hazards into the Micronesia Region due to the military relocation
3 through the conveyances pathway is very low.

4 **A6.3.3.10.3 Exposure Assessment: Conveyances Pathway**

5 **Biological Factors**

6 Increased risk for exposure of livestock or poultry to disease agents via mosquitoes introduced by this
7 pathway would require an infected mosquito to find its way aboard a conveyance and survive to release
8 a disease agent on Guam. Alternatively an adult mosquito could, in some instances, lay eggs on that
9 conveyance, and pass the agent along to its offspring through its eggs. The eggs would hatch and
10 complete the cycle to production of adult mosquitoes that will require exposure to a susceptible animal
11 on Guam and in most cases, a competent alternative mosquito host present on the island to maintain
12 infection. Fewer than a dozen mosquito species were reported in the Micronesia Region at the
13 beginning of the 20th century, and no major disease vectors were present. However, in the course of
14 the last century, this number increased four-fold with the introduction of exotic species, such as *Aedes*
15 *albopictus* and *Aedes aegypti* (Reeves and Rudnick 1951) and numerous *Culex* species, which may be
16 competent alternative hosts for the etiologic agents of several arboviral diseases of human and animal
17 importance (Lounibos 2002), in particular WNV and JEV (Mitchell et al. 1993).

18 The risk for exposure of livestock or poultry to disease agents via introduced ticks is discussed elsewhere
19 in this document.

20 **Regional Factors**

21 Mosquitoes released onto Guam may be able to bite and infect susceptible populations of wild birds
22 such as pigeons and Eurasian tree sparrows (*Passer montanus*) that seem to be abundant on Guam and
23 other known susceptible passerine birds, e.g. the Micronesian starling (*Aplonis opaca*) and the Marianas
24 crow (*Corvus kubaryi*). There is evidence for the establishment of exotic vectors as a result of accidental
25 introduction from antropogenic activities; however, circumstantial evidence of a disease outbreak via
26 infected vectors was only in the case of malaria (Lounibos 2002). In the case of WNV spread is more
27 likely to occur from introduction of an infected live bird transmitting the disease agent to an established
28 competent mosquito vector, such as *Aedes albopictus*, *Ae. vexans* and *Ochlerotatus japonicus* (Turell et
29 al. 2005).

30 Backyard and feral pigs serve as amplifying hosts for JEV and are present in sufficient numbers to
31 establish an outbreak, as occurred in 1990 on Saipan (Paul et al. 1993).

32 **Summary**

33 Mosquitoes released on Guam will be able to bite and infect susceptible populations of wild birds,
34 transmitting arboviruses, including WNV and JEV. Competent alternative mosquito vectors are present
35 on Guam, Saipan, and potentially other islands of the Micronesia Region to sustain infection. Susceptible

1 populations of domestic and feral pigs are present which may serve as amplifying hosts for JEV. Thus, we
2 conclude that the factors necessary for exposure are present.

3 ***Conveyances Pathway Exposure Assessment***

4 The risk of exposure of livestock or poultry to vector hazards into the Micronesia Region through the
5 movement of conveyances is medium.

6 **A6.3.3.10.4 Consequence Assessment: Conveyances Pathway**

7 ***Biological Consequences***

8 The predominant impacts from the introduction of WNV and JEV would be to humans and to native wild
9 bird populations, with minimal effects on poultry (Ghosh and Basu 2009; OIE 2010d). Experimental
10 studies have shown that poultry rapidly develop an antibody response capable of neutralizing the virus.
11 Infection in chickens is typically asymptomatic or with minimal clinical signs and pathology, and no
12 mortality (Senne et al. 2000).

13 Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical
14 cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because
15 of the small number of horses in Guam and relatively low importance of this industry, and the
16 availability of effective vaccines to protect horses against JEV and WNV, we conclude that the biological
17 consequences for introduction of WNV or JEV to the livestock and poultry industries are negligible.

18 As in the continental United States, the major impact of WNV establishment would be to humans. Once
19 established in a tropical environment and in the absence of preventive measures, spread would be
20 expected to be rapid among human populations with no prior exposure or immunity, as would be the
21 case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of
22 asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild
23 febrile disease; however about one of every hundred infected may develop severe neurological disease
24 with mortality rates as high as 14% (Madden 2003).

25 Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to
26 children. Annually, up to 50,000 cases of Japanese encephalitis are reported worldwide and more than
27 15,000 deaths are reported in eastern and southern Asia. While asymptomatic infection can occur,
28 approximately 30% of Japanese encephalitis cases are fatal and nearly half result in permanent
29 neurological sequelae (Ghosh and Basu 2009). However, any such introduction might well be short lived.
30 In 1990, a rare introduction of Japanese encephalitis on Saipan ended as the population of susceptible
31 pigs which serve as amplifying hosts became infected and developed immunity, and Japanese
32 encephalitis has not recurred (Paul et al. 1993).

33 ***Environmental Consequences***

34 The spread of WNV in the continental United States has caused a marked decline in the number of
35 particular bird species in entire regions, such as the American crow and eastern bluebirds (Rappole et al.

1 2000). Native bird populations on Guam have been severely diminished as a result of invasive species
2 and feral cats (Poole 2009). WNV, as with END and HPAI viruses, could decimate remaining populations.

3 ***Economic Consequences***

4 Release and establishment of WNV or JEV would be expected to result in little or no economic loss to
5 the poultry industry or to the few remaining equine operations on Guam; however, significant cost
6 would be incurred for human public health and mosquito vector surveillance, and for vector control to
7 prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California
8 (population 1.3 million) resulted in 163 reported human cases and a response that included emergency
9 aerial spray to control vectors. Costs for aerial spray totaled just over \$700,000 and when added to
10 estimated medical costs and patients' loss in productivity, the total economic impact was estimated at
11 \$2.98 million (Barber et al. 2010).

12 ***Conveyances Pathway Consequence Assessment***

13 The significance of the consequences to Guam of livestock or poultry exposure to hazards released into
14 the Micronesia Region through the conveyances pathway is very low.

15 The significance of the consequences to the rest of the Micronesia Region of livestock or poultry
16 exposure to hazards released into the Micronesia Region through the conveyances pathway is very low.

17 The significance of the consequences to the rest of the United States of livestock or poultry exposure to
18 hazards released into the Micronesia Region through the conveyances pathway is very low.

19 ***Conveyances Pathway Risk Estimation***

20 Because the increased risk of release of hazards into the Micronesia Region due to the military
21 relocation through the conveyances pathway is very low, the risk of exposure of livestock and poultry is
22 medium, and the significance of consequences of livestock and poultry exposure is very low, we
23 conclude that the military relocation-associated overall risk for the conveyances pathway is very low.

24 **A6.4 DISCUSSION AND CONCLUSIONS**

25 A summary of our risk analysis results is presented in Table A7-16.

26 We found that any incremental increase in risk for most hazards, specifically related to the relocation,
27 was relatively small in all pathways considered, yet highest in those that afforded opportunities to
28 thwart existing mitigations via illegal movements. We found that in most cases there were measures in
29 place to mitigate the likelihood of the hazard being introduced. However, these same mitigation
30 measures could be bypassed by illegal means in certain pathways, or if the measures were inconsistently
31 or ineffectively applied. Smuggling of poultry or the illegal importation of food and other animal
32 products would bypass the regulations, as might the improper disposal of domestic and international
33 garbage. These actions could result in the introduction and spread of foreign animal disease agents to
34 susceptible domestic and feral animals. The impact of an outbreak could extend beyond Guam and the
35 Micronesia Region, posing a risk for spread to the rest of the United States that could impact trade with

1 other countries. These pathways should receive the most attention as plans proceed. Initial
 2 recommendations follow at the end of this document and are supplemented more extensively in
 3 preceding sections.

4 **Table A7-16: Summary of Risk Analysis Results**

Pathway	Release assessment		Exposure assessment	Consequence assessment			Risk estimation
	Legal introduction	Illegal introduction		Guam	Micronesia Region	United States ^c	
Livestock ^a	Negligible	Negligible	N/A ^b	N/A	N/A	N/A	Negligible
Poultry	Negligible	Very low	Medium	Low	Low	Medium	Low
Non-poultry birds	Negligible	Very low	Very low	Low	Low	Medium	Very low
Cats and dogs	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Other animals ^d	Low	Low	Low	Very low	Very low	Medium	Low
Humans	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Animal products	Negligible	Low	Medium	Low	Low	Medium	Low
Garbage	Negligible	Very low	Medium	Low	Low	Medium	Low
Other cargo	Very low	N/A	Medium	Very low	Very low	Very low	Very low
Conveyances	Very low	N/A	Medium	Very low	Very low	Very low	Very low

5 ^a Domesticated equids.

6 ^b Not applicable. We conducted exposure and consequence assessments only for those pathways for which the
 7 release assessment result was non-negligible.

8 ^c Rest of the United States, other than Guam.

9 ^d Reptiles.

10

11 In interpreting these results, it is important to note that we did not define a baseline risk, but focused
 12 only on that incremental change in risk attributable to the influx of people and the associated changes
 13 that will come during the course of the relocation. The inevitable outcome of this approach is the
 14 paradox that we may conclude a risk to be present or even significant, yet discount it from further
 15 consideration if there is not an increase in risk that we can attribute to the military relocation. For
 16 example, introduction of a disease hazard by the movement of people to and from Guam, who might
 17 unknowingly carry the hazard on their clothing or body, is always a possibility. Yet, if there is not an
 18 increase in people coming to Guam from areas at high risk for exposing them to the hazard as a
 19 consequence of the military relocation, that risk would not be considered further in this assessment. We
 20 also limited our consideration of the impacts to humans and pet dogs, cats, and non-poultry birds, to
 21 those consequences that arise from their association with livestock or poultry disease hazards. Thus,
 22 there are disease hazards of primary human health importance that are not considered here because
 23 they have no association with livestock or poultry health.

24 We based our risk assessment on available data and information that we believe to be accurate to the
 25 period during which it was collected but which could be subject to change. Data were lacking in a
 26 number of areas. In those cases, we supplemented with published reports from other parts of the world,
 27 where available. We assumed that mitigations, including inspection practices and regulatory
 28 enforcement, were consistently applied and that resources were adequate, at a minimum, to meet

1 current demands. Finally, there are related aspects to our risk assessment, including wildlife hazards or
2 those risks arising from introduction of invasive species that are not considered here, but are discussed
3 in other sections of the document. We encourage the reader to review those sections as well.

4 **A6.5 RECOMMENDATIONS**

5 The introduction of many of the diseases of livestock and poultry considered in this risk assessment
6 could have major consequences to animal and human health throughout the Micronesia Region and far
7 reaching impact on trade to the rest of the United States. While federal, territorial, and military
8 regulations serve to mitigate against introduction of hazards, the influx of people and goods associated
9 with the military relocation will strain current systems for inspection and interdiction of illegal goods.
10 We have reason to suspect that there may be current deficiencies in the ability of GCQA personnel to
11 appropriately inspect cargo, passenger baggage, and conveyances. Further, with the expected arrival of
12 increased numbers of pet dogs and cats, we suspect that current resources for inspection and follow-up
13 will be overwhelmed.

14 Currently, there is no ongoing surveillance for livestock and poultry disease on Guam. Therefore, it is
15 difficult to know what disease agents are already present in the Region and to identify the introduction
16 of an exotic disease agent. A lack of a diagnostic laboratory in the Region also diminishes the ability to
17 detect disease agents. Rapid detection is critical in order to mount a timely response to new disease
18 introductions, especially in the case of the highly transmissible exotic diseases considered in this
19 assessment.

20 Specific recommendations to mitigate the risk of release of livestock and poultry disease hazards include
21 measures to address the need for additional resources and improvements in surveillance and
22 communication, and to ensure adequate inspection and follow-up.

23 **A6.5.1 Staffing and Infrastructure**

24 **Ensure sufficient staffing to accomplish all necessary inspection and quarantine activities in the**
25 **Micronesia Region.** Staffing levels will become further strained as a consequence of the military
26 relocation as the workload at airports, maritime ports, and mail facility increases. Quarantine officers
27 must be adequately trained in all aspects of their jobs and should receive periodic refresher training.

28 **Ensure availability of necessary equipment.** Equipment necessary for effective safeguarding must be
29 available to quarantine officers. X-ray machines must be provided where needed. All equipment must be
30 maintained in working order over the long term.

31 **Provide detector dogs and handlers.** An adequate number of teams must be available at airports for
32 screening passenger baggage for animal products.

33 **Ensure there are appropriate resources** to implement response plans.

1 **A6.5.2 Point-of-entry Activities (Cleaning, Inspection, Treatment)**

2 **Carry out inspection of all arriving conveyances, military and non-military, for illegal animals or animal**
3 **products.** In the case of military vessels, either PPQ specialists must be made available to inspect
4 military vessels, or GCQA officers must be allowed to inspect military vessels.

5 **Establish an effective mail inspection system on Guam.** For international mail arriving via Hawai'i,
6 either ensure adequate level of inspection in Hawai'i or else carry out inspection in Guam. Establish
7 effective working relationships to ensure that safeguarding personnel can carry out their
8 responsibilities. Safeguarding personnel must have sufficient access to the postal facility.

9 **A6.5.3 Regulations, Guidelines, and Compliance**

10 **Systematically review all guidelines and SOPs** relevant to livestock or poultry disease. Ensure that they
11 are clear, complete and detailed. Develop guidelines or SOPs where they are lacking.

12 **Enforce full compliance** with all applicable existing federal and territorial regulations, guidelines, and
13 SOPs, and harmonize military guidelines and SOPs with those requirements.

14 **Develop a hazard response plan** in coordination with military and civilian public health authorities for
15 those diseases with serious animal health and zoonotic potential.

16 **A6.5.4 Education and Training**

17 **Provide adequate education** about the potential negative consequences of the introduction of an exotic
18 livestock or poultry disease, especially with respect to smuggled animal products.

19 **Facilitate training/education programs** regarding changes in livestock and poultry hazards for
20 inspectors.

21 **Reinforce enforcement of existing regulations**, such as these:

- 22 • Health certificates must accompany imported livestock and such livestock is subject to health
23 inspection by the territorial veterinarian and quarantine if needed.
- 24 • Imported poultry and eggs must be quarantined, and inspected, and poultry must be vaccinated
25 by the territorial veterinarian for Newcastle disease prior to entry to Guam in accordance with
26 Title 9 of the Guam Administrative Rules and Regulations (9 GARR 1, Division 1, Chapter 1). Use
27 USDA-APHIS-VS import permits for restricted animal products.
- 28 • Enforce Guam Administrative Rules and Regulations requiring a permit, health certificate, and
29 inspection for imported reptiles (9 GARR 1, Division 1, Chapter 1).
- 30 • Enforce current Swine Health Protection regulations requiring cooking of certain types of waste
31 prior to feeding to pigs (9 CFR § 166).

1 **A6.5.5 Additional Safeguarding Practices**

2 **Develop a system of routine systematic surveillance** for livestock and poultry diseases and vector
3 hazards.

4 **Develop situational monitoring** for the occurrence of foreign animal diseases.

5 **Develop procedures** that will allow GCQA and GDOA to react to changing risks posed by arriving
6 travelers, cargo, and conveyances, based on countries of origination or embarkation.

7 **A6.6 ACKNOWLEDGMENTS**

8 We gratefully acknowledge the individuals listed below for their assistance during this project, in
9 particular preparation of Section A6.6 of this terrestrial RA.

10 Paul Bassler, Guam Department of Agriculture

11 Dallas Berringer, USDA-APHIS-PPQ

12 Anne Brooke and Mark Cruz, Naval Facilities Engineering Command

13 Ignacio Dela Cruz, CNMI Department of Lands and Natural Resources

14 Lawrence Duponcheel, Northern Marianas College-Cooperative Research, Extension and Education
15 Service

16 David Fletcher, U.S. Army Veterinary Corps

17 Shawn Gumataotao, Office of the Governor of Guam

18 Nate Hawley, U.S. Fish and Wildlife Service; and CNMI Department of Lands and Natural Resources

19 William Melton, U.S. Department of Defense, Defense Commissary Agency

20 Darlene Merfalen, Guam Customs and Quarantine Agency

21 Joel Miles, Palau Ministry of Natural Resources, Environment, and Tourism, Bureau of Agriculture

22 Ben Pangelinan, Raffaele Sgambelluri, Annette Shimizu, Philip Taijeron and Dennis Santo Tomas, Guam
23 Customs and Quarantine Agency

24 Tom Poole, Guam Department of Agriculture

25 Columb Rigney, USDA-APHIS-PPQ

26 James Stanford, U.S. Geological Survey

27 Dan Vice and Dana Lujan, USDA-APHIS-Wildlife Services

- 1 John Wichep, FSM Department of Resources and Development
- 2 We would also like to thank all of the individuals who spent time answering our questions and providing
- 3 us information while we were in the Micronesia Region and in follow-up conversations. All of your
- 4 contributions are greatly appreciated.
- 5

1 Editors Note: The following sections (A7 through A25) consider some species which either are known invasive species or
2 potential invasive species to micronesia and/or hawai'i. These sections should not be considered as comprehensive for all
3 potential invasive species for the region. These lists should in fact be considered as generic and if fact they actually include
4 species that are already established in parts of the region or which are native to sections of the region. There are various
5 established resources which include information on invasive species for both Micronesia and Hawai'i and these resources
6 should be utilized by policy makers and managers when considering best management practices (for example see the issg ias
7 data set at: <http://www.issg.org/>).
8

9 **A7 EXOTIC PLANT PESTS WITH THE POTENTIAL TO BE INTRODUCED INTO THE**
10 **MICRONESIA REGION**

11 This list contains some plant pests that would cause damage to agricultural crops and native plant
12 species in the Micronesia and Hawai'i if permitted to establish. Structural wood pests, stored-grain
13 pests, and pests of plant pollinators are also included. Shaded rows on the following pages indicate
14 species associated with WPM.

Species	Distribution	Host(s)	References
ARTHROPODS			
Mites			
Mites not only cause direct feeding damage but also frequently vector plant pathogens. Mites are minute and thus difficult to detect. Due to high fecundity and short life cycles, they easily adapt to diverse environmental conditions and can rapidly develop resistance to pesticides (Jeppson et al. 1975, Ochoa 2005). Mites are mainly moved on infested plant materials.			
Acari: Eriophyidae			
<i>Aceria guerreronis</i> Keifer	Africa, Central and South America, India, Sri Lanka United States	<i>Cocos nucifera</i>	(Fernando et al. 2003, Navia et al. 2005, Lawson-Balagbo et al. 2007)
<i>Aceria sheldoni</i> (Ewing)	Africa, Argentina, Australia, Brazil, China, Hawai'i, Southern Europe, United States, Southeast Asia	<i>Citrus</i> spp.	(CAB 1980, Childers and Achor 1999, Hong et al. 2006)
<i>Aceria tulipae</i> (Keifer)	Brazil, China, Cuba, Egypt, Europe, India, Mexico, New Zealand, Thailand, United States	Poaceae, <i>Allium</i> spp., <i>Tulipa</i> spp.	(Somsen and Sill Jr. 1970, Perring 1996, Hong et al. 2006)
<i>Aculops lycopersici</i> (Massee)	Africa, Asia, Australia, Canada, Central and South America, China, Europe, Hawai'i, Melanesia, Mexico, United States	Solanaceae	(CABI 1987, Hong et al. 2006, CABI 2007)

<i>Phyllocoptura oleivora</i> (Ashmead)	Africa, Australia, Caribbean, Central and South America, Cook and Fiji Islands, Hawai'i, Mexico, Middle East, United States, Southeast Asia, Southern Europe	<i>Citrus</i> spp.	(CAB 1970, Jeppson et al. 1975, Hong et al. 2006)
Acari: Laelapidae			
<i>Tropilaelaps clareae</i> Delfinado and Baker	South and Southeast Asia, Philippines	<i>Apis mellifera</i>	(ISSG 2010)
Acari: Tenuipalpidae			
<i>Brevipalpus chilensis</i> Baker	Argentina, Chile	<i>Actinidia chinensis</i> , <i>Ampelopsis</i> spp., <i>Annona cherimola</i> , <i>Citrus limon</i> , <i>Diospyros kaki</i> , <i>Ficus</i> spp., <i>Ligustrum</i> spp., <i>Pyrus communis</i>	(Jeppson et al. 1975, González 1989, Prado 1991, Navia and Mendonça 2005, Figueroa 2008)
<i>Brevipalpus lewisi</i> McGregor	Australia, Bulgaria, Egypt, Iran, Japan, Lebanon, Mexico, United States	<i>Citrus</i> spp., <i>Juglans</i> spp., <i>Pistacia</i> spp., <i>Punica granatum</i>	(Baker et al. 1975, Jeppson et al. 1975, Childers et al. 2003, Navia and Mendonça 2005, Namaghi 2010)
<i>Raoiella indica</i> (Hirst)	Caribbean, India, Malaysia, Mauritius, Middle East, Réunion, Philippines	Arecaceae, Musaceae, Zingiberaceae	(Peña et al. 2006, Vásquez et al. 2008, ISSG 2009)

	Venezuela		
Acari: Tetranychidae			
<i>Amphitetranynchus viennensis</i> (Zacher)	Europe, Middle East	<i>Ficus carica</i> , <i>Plumeria</i> spp.	(Bolland et al. 1998, Navia and Mendonça 2005)
<i>Tetranychus evansi</i> Baker & Pritchard	Africa, Caribbean, Hawai'i, Mediterranean, South America, United States	Solanaceae, <i>Amaranthus</i> spp., <i>Ipomoea batatas</i> , <i>Passiflora foetida</i> , <i>Psidium guajava</i>	(Tsagkarakou et al. 2007, Migeon and Dorkeld 2010)
INSECTS			
Coleoptera: Bostrichidae			
These beetles are important pests of living trees and forest products (Liu et al. 2008). Bostrichids are often moved in WPM, timber, and furniture.			
<i>Dinoderus minutus</i> (F.)	Africa, Caribbean, China, CNMI, Germany, Guam, Israel, Japan, South America, Southeast Asia, United States	<i>Bambusa</i> spp., <i>Dendrocalamus</i> spp., <i>Manihot</i> spp., <i>Phyllostachys</i> spp.	(Chûjô 1958, Stone 1970, Buchelos 1991, CABI 2007, PIER 2010)
<i>Dinoderus ocellaris</i> Stephens	India, New Guinea, Philippines	<i>Bambusa</i> spp.	(Tanaka 1927, Atkinson 1936, Stone 1970, Spilman 1982, CABI 2007, Rajendran and Kumar 2008)
<i>Heterobostrychus aequalis</i> (Waterhouse)	Cuba, India, Indonesia, Madagascar, CNMI, Guam, Malaysia, New Guinea, Philippines, Sri Lanka, Suriname, United States	<i>Albizia</i> spp., <i>Bambusa</i> spp., <i>Canarium</i> spp., <i>Cassia</i> spp., <i>Dalbergia</i> spp., <i>Dendrocalamus</i> spp., <i>Endospermum</i> spp., <i>Leucaena</i> spp., <i>Mangifera</i> spp., <i>Morus</i> spp., <i>Poinciana</i> spp.,	(Chûjô 1958, Stone 1970, Woodruff and Fasulo 2006, Benker 2008)

<i>Heterobostrychus brunneus</i> (Murray)	Sub-Saharan Africa, United States	<i>Pterocarpus</i> spp., <i>Sterculia</i> spp., <i>Tectona</i> spp., <i>Terminalia</i> spp. <i>Albizia</i> spp., <i>Bambusa</i> spp., <i>Canarium</i> spp., <i>Cedrela</i> spp., <i>Dendrocalamus</i> spp., <i>Endospermum</i> spp., <i>Leucaena</i> spp., <i>Mangifera</i> spp., <i>Pterocarpus</i> spp., <i>Sterculia</i> spp., <i>Tectona</i> spp., <i>Terminalia</i> spp.	(Stone 1970, Selander 1986, Pasek 2000, Haack 2006, Schabel 2006, PIER 2010)
<i>Heterobostrychus hamatipennis</i> (Lesne)	China, France, Hawai'i, India, Japan, Madagascar, Malaysia, Mauritius, Philippines, Thailand	<i>Acacia catechu</i> , <i>Bambusa</i> spp., <i>Bombax ceiba</i> , <i>Garuga pinnata</i> , <i>Lithocarpus calanthiformis</i> , <i>Paulownia tomentosa</i>	(Hutacharern and Tubtim 1995, Wang et al. 1998, Fassotte 2005, Halbert 2007, Aberlenc 2008, Benker 2008)
<i>Lyctus africanus</i> Lesne	Africa, India, Israel, Japan, Southeast Asia	<i>Bambusa</i> spp., <i>Dendrocalamus</i> spp.	(Stone 1970, Halperin and Geis 1999, Rajendran and Kumar 2008)
<i>Sinoxylon anale</i> Lesne	Australia, Brazil, China, India, Indonesia, New Zealand, Philippines, Saudi Arabia, Sri Lanka, Southeast Asia, United States, Venezuela	<i>Acacia</i> spp., <i>Albizia</i> spp., <i>Casuarina</i> spp., <i>Dalbergia</i> spp., <i>Delonix</i> spp., <i>Eucalyptus</i> spp.	(Stone 1970, Argaman 1987, Pasek 2000, Teixeira et al. 2002, Karnkowski 2006, CABI 2007, Krehan 2007)

<i>Sinoxylon conigerum</i> Gerstaecker	China, India, Israel, Italy, Japan, South America, Southeast Asia, Spain, Sub-Saharan Africa, United States, Vietnam	<i>Bambusa</i> spp., <i>Hevea</i> spp., <i>Manihot</i> spp.	(Stone 1970, Filho et al. 2006, Haack 2006, Karnkowski 2006, CABI 2007, Benker 2008)
<i>Sinoxylon crassum</i> Lesne	East Africa, India, Pakistan, Southeast Asia	<i>Acacia</i> spp., <i>Albizia</i> spp., <i>Bambusa</i> spp., <i>Cassia</i> spp.	(Stebbing 1914, Stone 1970, Singh and Bhandari 1987, Rathore 1995, Gul and Bajwa 1997, Pasek 2000, Krehan 2007)
<i>Sinoxylon pugnax</i> Lesne	Afghanistan, East Africa, India, New Guinea	<i>Prosopis</i> spp.	(Lesne 1904, Allen 2007b, CABI 2007, PIER 2010)

Coleoptera: Cerambycidae

These beetles are extremely important wood boring pests of live trees. Adults feed on flowers, foliage, and bark; larvae destructively bore into wood (Gillott 1995). Cerambycids are often moved on nursery stock and in WPM.

<i>Anoplophora chinensis</i> (Forster)	China, Hawai'i, Korea, Malaysia, Myanmar, Vietnam	<i>Citrus</i> spp., <i>Cryptomeria japonica</i> , <i>Ficus</i> spp., <i>Hibiscus</i> spp., <i>Mallotus</i> spp.	(CABI/EPPO 1997a, Benker 2008)
<i>Ceresium flavipes</i> (F.)	China, Hong Kong, Philippines, Southeast Asia, Taiwan	<i>Artocarpus</i> spp., <i>Casuarina</i> spp., <i>Citrus</i> spp., <i>Hevea</i> spp., <i>Streblus</i> spp.	(Samuelson and Gressitt 1965, Stone 1970, Allen 2001, Allen and Humble 2002)
<i>Curtomerus flavus</i> (F.)	Caribbean, Central and South America, Hawai'i, Japan, Marquesas Islands, Philippines, United States	<i>Acacia</i> spp., <i>Bidens</i> spp., <i>Eucalyptus</i> spp., <i>Leucaena leucocephala</i> , <i>Nicotiana tabacum</i> , <i>Psidium</i> spp., <i>Sapindus</i>	(Linsley 1963, Gressitt and Davis 1972, Sugiura et al. 2008, Peck 2009)

		spp.	
<i>Psacotheta hilaris</i> (Pascoe)	China, Japan, Taiwan	<i>Ficus</i> spp., <i>Morus</i> spp.	(Allen and Humble 2002, CABI 2007, EPPO 2008)
<i>Rhytidodera bowringii</i> White	China	<i>Anacardium</i> spp., <i>Mangifera</i> spp.	(Stone 1970, FAO 2006b, NAPPO 2006, CABI 2007)
<i>Stromatium barbatum</i> (F.)	Bangladesh, East Africa, India, Myanmar, Pakistan, Sri Lanka	<i>Acacia</i> spp., <i>Bauhinia</i> spp., <i>Citrus</i> spp., <i>Coffea</i> spp., <i>Eriobotrya</i> spp., <i>Grevillea</i> spp., <i>Rosa</i> spp., <i>Tectona</i> spp.	(Stone 1970, CAB 1985, Singh and Bhandari 1987, Phukan et al. 1995, Thakur 1999, Pasek 2000)
<i>Xylotrechus chinensis</i> (Chevrolat)	China, Japan, Korea, Taiwan	<i>Morus</i> spp.	(Gressitt 1951, Benker 2008)
<i>Xystracera globosa</i> (Olivier)	Australia, Caribbean, Egypt, Hawai'i, Israel, Madagascar, Mauritius, New Guinea, Southeast Asia	<i>Acacia</i> spp., <i>Acracarpus</i> spp., <i>Adenanthera</i> spp., <i>Adina</i> spp., <i>Albizia</i> spp., <i>Bauhinia</i> spp., <i>Cassia</i> spp., <i>Duabanga</i> spp., <i>Grewia</i> spp., <i>Haematoxylon</i> spp., <i>Paraserianthes</i> spp., <i>Parkia</i> spp., <i>Salmalia</i> spp., <i>Samanea</i> spp., <i>Xylia</i> spp.	(Mathew 1987, Friedman et al. 2008)
Coleoptera: Curculionidae			
<i>Hypothenemus hampei</i>	Hawai'i, Africa, South and Central America	Rubiaceae	(Vega et al. 2009; Burbano et al. 2011)

Coleoptera: Chrysomelidae			
There are over 35,000 described species of Chrysomelids (leaf beetles). Adults feed on leaves and flowers, and larvae feed on leaves, roots, or stems (Gillott 1995). Leaf beetles are often moved in infested plant material, particularly in ornamental plants.			
<i>Brontispa longissima</i> Gestro	Australia, Cambodia, China, Indonesia, Laos, Malaysia, The Maldives, Myanmar, New Guinea, Philippines, Singapore, Taiwan, Thailand, Vietnam	Arecaceae	(Sankaran 2007, ISSG 2009)
<i>Diabrotica balteata</i> Leconte	Central America, Mexico, South America, United States	Cucurbitaceae, <i>Ipomoea</i> spp., <i>Manihot esculenta</i> , <i>Phaseolus vulgaris</i> , Solanaceae	(Peña and Waddill 1982, CABI 2007)
<i>Diabrotica undecimpunctata</i> Mannerheim	Bermuda, Canada, Central America, Mexico, United States	Cucurbitaceae, <i>Ipomoea</i> spp., <i>Phaseolus vulgaris</i>	(Foster and Brust 1995, CABI 2007)
<i>Diabrotica virgifera</i> LeConte	Canada, Central America, Europe, Mexico, United States	Cucurbitaceae, <i>Glycine max</i> , <i>Helianthus annuus</i> , <i>Zea mays</i>	(CABI/EPPO 1997d, EPPO 2006a, Ciosi et al. 2008, Gray et al. 2009, Meinke et al. 2009)
<i>Microtheca ochroloma</i> Stål	South America, United States	<i>Brassica</i> spp., <i>Raphanus sativus</i> , <i>Rosa</i> spp., <i>Zea mays</i>	(Balsbaugh Jr. 1978, Fasulo 2010)

Coleoptera: Curculionidae

There are over 40,000 species in Curculionidae. Most larvae and adults feed on plant parts including fruits, nuts, stems, and roots. Many Curculionids are very serious plant pests. For example, the red palm weevil, *Rhynchophorus ferrugineus*, a devastating pest of various palm species, has been introduced into several parts of the world; it is not known to occur in Micronesia.

<i>Diaprepes abbreviatus</i> (L.)	Caribbean, United States	<i>Carica papaya</i> , <i>Citrus</i> spp., <i>Ipomoea batatas</i> , <i>Psidium guajava</i> , <i>Saccharum officinarum</i> , <i>Solanum tuberosum</i>	(Ascunce et al. 2009, Weissling et al. 2009)
<i>Metamasius callizona</i> (Chevrolat)	Guatemala, Mexico, United States	Bromeliaceae, <i>Ananas comosus</i>	(Cooper 2008, Frank and Fish 2008, Larson and Frank 2009)
<i>Rhynchophorus ferrugineus</i> (Olivier)	Africa, Asia, Australia, India, Middle East, Spain	Arecaceae, especially <i>Cocos nucifera</i> and <i>Phoenix</i> spp.	(Kehat 1999, CABI 2007)
<i>Rhynchophorus palmarum</i> (L.)	Caribbean, Central and South America, Mexico	Arecaceae	(EPPO 2005a)
Coleoptera: Nitidulidae			
The small hive beetle (<i>Aethina tumida</i>) feeds on pollen and honey, burrowing through honey combs and causing damage to bee colonies. Small hive beetles can be transported in infested fruits, packages of bees, hive equipment, and soil (Neumann and Elzen 2004).			
<i>Aethina tumida</i> Murray	Africa, Australia, Canada, Egypt, Mexico, Portugal, United States	<i>Apis mellifera</i> , <i>Bombus</i> spp.	(Neumann and Elzen 2004)
Coleoptera: Scarabaeidae			
Scarabaeid adults can be serious foliage-feeding pests; larvae damage plant roots (Gillott 1995). These beetles may be introduced in infested propagative material.			
<i>Oryctes rhinoceros</i> (L.)	Asia, Australia, Fiji, Guam, Hawai'i, Indonesia, Palau, Southeast Asia, New Guinea,	Arecaceae	(ISSG 2010)

	Tonga, Vanuatu, Wallis		
<i>Papuana</i> spp.	Papua New Guinea, Solomon Islands, Vanuatu, Fiji and Kiribati	<i>Colocasia, Musa, Canna, Xanthosoma, Solanum, Pandanus, Angiopteris, and Cocos</i>	(SPC 1987; Aloalii et al. 1980)
<i>Cyclocephala pasadenae</i> (Casey)	Hawai'i, Mexico, United States	Poaceae	(Bauernfeind 2001, Jameson et al. 2009, Ratcliffe 2009)

Coleoptera: Scolytidae

Scolytids are very small wood boring beetles (Anderson and Burgin 2002). They complete almost their entire life cycle in the bark or the wood of trees (Rudinsky 1962), making them difficult to detect. Of the total tree mortality in the United States caused by insects, more than 60% is attributable to species of Scolytidae. Scolytidae often vector plant pathogenic fungi. Scolytidae are most frequently intercepted in WPM, but may also be moved in propagative materials and wooden handicrafts.

<i>Coccotrypes dactyliperda</i> (F.)	Australia, Cuba, Egypt, Hawai'i, India, Israel, Japan, Mexico, Panama, South America, Southeast Asia, Sudan, United States	Arecaceae	(Wood 1982, Atkinson and Peck 1994, El-Sherif et al. 1998, Holzman et al. 2009)
<i>Cyrtogenius brevior</i> (Eggers)	Japan	<i>Dipterocarpus</i> spp., <i>Mangifera</i> spp.	(Bright and Skidmore 1997, Brockhoff et al. 2003)
<i>Hypocryphalus mangiferae</i> Eggers	Brazil	<i>Mangifera</i> spp.	(Stone 1970, Haack 2001, CABI 2007)
<i>Hypothenemus birmanus</i> (Eichhoff)	Singapore	<i>Manilkara</i> spp.	(Stone 1970, Haack 2001, CABI 2007)
<i>Xyleborinus saxeseni</i> (Ratzeburg)	Australia, Ecuador, South Africa, United	<i>Eucalyptus</i> spp., <i>Juglans</i> spp., <i>Persea</i> spp.	(Stone 1970, Brockhoff et al. 2003, HEAR 2004, CABI 2007, Haack and Petrice 2009)

	States		
<i>Xyleborus affinis</i> Eichhoff	Africa, Brazil, United States	<i>Dracaena</i> spp., <i>Juglans</i> spp. <i>Macadamia</i> spp., <i>Saccharum</i> spp.	(Stone 1970, Brockerhoff et al. 2003, HEAR 2004, CABI 2007)
<i>Xyleborus glabratus</i> Eichhoff	Bangladesh, India, Japan, Myanmar, Taiwan, United States	Lauraceae, including <i>Persea americana</i>	(Rabaglia et al. 2006, Fraedrich et al. 2007, Cognato 2008, Harrington et al. 2008, Mayfield et al. 2008, Goldberg and Heine 2010)
<i>Xyleborus perforans</i> (Wollaston)	Africa, Asia, New Guinea, Philippines, South America	<i>Citrus</i> spp., <i>Cocos</i> spp., <i>Eucalyptus</i> spp., <i>Mangifera</i> spp., <i>Persea</i> spp.	(Stone 1970, Brockerhoff et al. 2003)
<i>Xyleborus similis</i> Ferrari	Africa, Asia, Australia, FSM, New Guinea, United States	<i>Artocarpus</i> spp., <i>Durio</i> spp., <i>Ficus</i> spp., <i>Mangifera</i> spp., <i>Theobroma</i> spp.	(Stone 1970, Brockerhoff et al. 2003, HEAR 2004, Rabaglia et al. 2006, CABI 2007)
<i>Xyleborus volvulus</i> (F.)	United States	<i>Acacia</i> spp., <i>Bauhinia</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Terminalia</i> spp.	(Stone 1970, Brockerhoff et al. 2003, CABI 2007)
<i>Xylosandrus crassiusculus</i> (Motschulsky)	Africa, Hong Kong, United States	<i>Coffea</i> spp., <i>Eucalyptus</i> spp., <i>Persea</i> spp.	(Stone 1970, Bright and Skidmore 1997, Brockerhoff et al. 2003, HEAR 2004, LaBonte et al. 2005, CABI 2007)
<i>Xylosandrus morigerus</i> (Blandford)	Asia, Europe, Africa, United States, Mexico, Central America, South America, Australia, Guam, CNMI, FSM	<i>Coffea</i> spp., <i>Dendrobium</i> spp., <i>Persea</i> spp., <i>Tectona</i> spp., <i>Theobroma</i> spp.	(Stone 1970, Bright and Torres 2006, CABI 2007)

Diptera: Tephritidae			
Larvae feed inside a large variety of fruit, causing serious crop damage. Fruit flies are introduced into new areas in infested fruit (White and Elson-Harris 1992).			
<i>Bactrocera cucurbitae</i> (Coquillett)	Asia, Guam, Hawai'i, Kenya, Mauritius, New Guinea, Tanzania	Cucurbitaceae, <i>Carica papaya</i> , <i>Phaseolus vulgaris</i> , <i>Vigna unguiculata</i>	(ISSG 2010)
<i>Bactrocera dorsalis</i> (Hendel)	Asia, French Polynesia, Hawai'i	<i>Annona squamosa</i> , <i>Capsicum</i> spp., <i>Solanum lycopersicon</i> , <i>Mangifera indica</i> , <i>Musa paradisiaca</i> , <i>Psidium guajava</i>	(USDA-APHIS-PPQ 1982, Allwood et al. 1999, SPC 2002, Iwaizumi 2004, Aketarawong et al. 2007, Chen et al. 2007)
<i>Bactrocera frauenfeldi</i> (Schiner)	Australia, FSM, Kiribati, Nauru, New Guinea, Palau, RMI, Solomon Islands	<i>Achras sapota</i> , <i>Annona muricata</i> , <i>Artocarpus</i> spp., <i>Averrhoa carambola</i> , <i>Barringtonia edulis</i> , <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Diospyros</i> spp., <i>Eugenia uniflora</i> , <i>Fortunella japonica</i> , <i>Inocarpus fagifer</i> , <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Psidium guajava</i> , <i>Syzygium malaccense</i> , <i>Terminalia</i> spp., <i>Trichosanthes cucumerina</i>	(Hollingsworth et al. 2003, GDOA 2005, Sengebau et al. 2005)

<i>Bactrocera invadens</i> Drew, Tsuruta, & White	Africa, Bhutan, Sri Lanka	<i>Annona</i> spp., <i>Carica papaya</i> , <i>Chrysophyllum albidum</i> , <i>Citrullus lanatus</i> , <i>Citrus</i> spp., <i>Cucumis</i> spp., <i>Diospyros montana</i> , <i>Dracaena steudneri</i> , <i>Eriobotrya japonica</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Persea americana</i> , <i>Psidium guajava</i> , <i>Sclerocarya birrea</i> , <i>Spondias cytherea</i> , <i>Solanum lycopersicum</i> , <i>Strychnos meliodora</i> , <i>Terminalia catappa</i>	(Drew et al. 2005, Mwatawala et al. 2006, White 2006, Drew et al. 2007, Rwomushana et al. 2008)
<i>Bactrocera latifrons</i> (Hendel)	China, Hawai'i, India, Japan, Laos, Malaysia, Pakistan, Sri Lanka, Taiwan, Thailand	<i>Baccaurea motleyana</i> , <i>Capsicum annuum</i> , <i>Solanum</i> spp.	(White and Elson-Harris 1992, Shimizu et al. 2007)
<i>Bactrocera occipitalis</i> (Bezzi)	Brunei, Malaysia, Palau, Philippines	<i>Mangifera indica</i> , <i>Psidium guajava</i>	(Drew and Hancock 1994, CABI/EPPO 1997b, Iwaizumi 2004, GDOA 2005, Sengebau et al. 2005, Chen et al. 2007)
<i>Bactrocera philippinensis</i> Drew and Hancock	Palau, Philippines	<i>Artocarpus communis</i> , <i>Averrhoa carambola</i> , <i>Carica papaya</i> , <i>Citrus</i>	(Drew and Hancock 1994, CABI/EPPO 1997b, Iwaizumi 2004, GDOA 2005, Sengebau et al. 2005, Chen et al. 2007, USDA NRCS 2009)

		<i>madurensis</i> , <i>Mangifera indica</i> , <i>Pouteria duklitan</i> , <i>Psidium guajava</i> , <i>Syzygium malaccensis</i>	
<i>Bactrocera scutellata</i> (Hendel)	China, Japan, Malaysia, Taiwan, Thailand	Solanaceae, <i>Cucumis sativa</i> , <i>Cucurbita</i> spp., <i>Trichosanthes</i> spp.	(Ohno et al. 2006, CDFA 2009)
<i>Bactrocera synnephes</i> (Hendel)	China, Philippines, Taiwan, Thailand	<i>Diplocyclos palmatus</i> , <i>Luffa cylindrica</i> , <i>Melothria formosana</i>	(Chang et al. 2003, Ohno and Tamura 2008)
<i>Bactrocera tryoni</i> (Froggatt)	Australia, Cook Islands, French Polynesia, New Caledonia, Pitcairn	<i>Annona</i> spp., <i>Capsicum frutescens</i> , <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Ficus</i> spp., <i>Mangifera indica</i> , <i>Morus</i> spp., <i>Musa acuminata</i> , <i>Opuntia ficus-indica</i> , <i>Passiflora</i> spp., <i>Persea americana</i> , <i>Phoenix dactylifera</i> , <i>Psidium</i> spp., <i>Solanum</i> spp.	(White and Elson-Harris 1992, ISSG 2009)
<i>Bactrocera zonata</i> (Saunders)	Egypt, India, Indonesia, Laos, Libya, Mauritius, Middle East, Sri	<i>Carica papaya</i> , <i>Citrus</i> spp., <i>Mangifera indica</i> , <i>Momordica</i>	(White and Elson-Harris 1992, White 2006, Duyck et al. 2008)

	Lanka, Thailand, Vietnam	<i>charantia</i> , <i>Phoenix dactylifera</i> , <i>Psidium guajava</i> , <i>Punica granatum</i> , <i>Terminalia catappa</i>	
<i>Ceratitis capitata</i> (Wiedemann)	Australia, Hawai'i, Mediterranean, North Africa, South America, United States	<i>Carica</i> spp., <i>Diospyros</i> spp., <i>Mangifera</i> spp., <i>Musa</i> spp., <i>Persea</i> spp.	(ISSG 2010)
<i>Ceratitis rosa</i> Karsch	Sub-Saharan Africa	<i>Capsicum frutescens</i> , <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Ficus carica</i> , <i>Garcinia mangostana</i> , <i>Litchi chinensis</i> , <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Psidium guajava</i> , <i>Solanum</i> spp.	(White and Elson-Harris 1992, Duyck et al. 2008)
Hemiptera: Aleyrodidae			
Aleyrodidae (whiteflies) damage plants through direct feeding and also vector plant viruses. Whiteflies are introduced to new areas on infected plant material (Martin et al. 2000). After introduction into a new area whitefly populations often undergo rapid population growth (Byrne and Bellows Jr. 1991).			
<i>Aleurotrachelus trachoides</i> (Back)	Caribbean, FSM, Guyana, Peru, Réunion, Tahiti	<i>Annona</i> spp., <i>Bidens pilosa</i> , <i>Capsicum frutescens</i> , <i>Casuarina</i> spp., <i>Datura</i> spp., <i>Dioscorea</i> spp., <i>Duranta erecta</i> ,	(Mound and Halsey 1978, Peña and Bennett 1995, SPC 2005)

		<i>Ipomoea batatas</i> , <i>Morinda citrifolia</i> , <i>Solanum</i> spp., <i>Tectona grandis</i> , <i>Piper metisticum</i> (host)	
<i>Paraleyrodes pseudonaranjiae</i> Martin	Bermuda, China, Hawai'i, United States	<i>Annona glabra</i> , <i>Calophyllum inophyllum</i> , <i>Citrus</i> spp., <i>Mangifera indica</i> , <i>Morinda citrifolia</i> , <i>Rhododendron pulchrum</i>	
<i>Trialeurodes vaporariorum</i> (Westwood)	Africa, Australia, Canada, Central and South America, Caribbean, Mexico, Hawai'i, Europe, South Asia, United States	<i>Brassica oleracea</i> , <i>Citrus</i> spp., <i>Cucurbita</i> spp., <i>Diospyros</i> spp., <i>Hibiscus</i> spp., <i>Ipomoea</i> spp., <i>Lonicera</i> spp., <i>Nerium oleander</i> , <i>Passiflora</i> spp., <i>Persea americana</i> , <i>Pittosporum eugenioides</i> , <i>Psidium guajava</i> , <i>Rhododendron</i> spp., <i>Solanum</i> spp.	(Mound and Halsey 1978, Martin et al. 2000, McKee et al. 2009)
Hemiptera: Aphididae			
Aphids are small insects, often with broad host ranges, and move readily with imported horticultural commodities (Messing et al. 2007). Aphids cause direct feeding damage and vector many plant viruses.			
<i>Acyrtosiphon ilka</i> Mordvilko	Middle East, Mediterranean, Southern Russia	Asteraceae, Brassicaceae, Linaceae,	(Blackman and Eastop 2000)

		Papaveraceae, Thymelaeaceae	
<i>Acyrtosiphon kondoi</i> Shinji	Argentina, Asia, Australia, Chile, Hawai'i, New Zealand, United States	Fabaceae	(Rethwisch 1989, Blackman and Eastop 2000)
<i>Aphis coreopsidis</i> (Thomas)	North, Central, and South America	Asteraceae, Malvaceae	(Blackman and Eastop 1994)
<i>Aphis menthaeradicis</i> Cowen	United States	<i>Artemisia</i> spp., <i>Aster</i> spp., <i>Mentha</i> spp., <i>Taraxacum</i> spp.	(Blackman and Eastop 2000)
<i>Aphis nasturtii</i> Kaltenbach	Asia, Chile, Ethiopia, Europe, Kenya, North America, South Africa	Solanaceae, Brassicaceae, Polygonaceae	(Blackman and Eastop 2000)
<i>Aulacorthum circumflexum</i> (Buckton)	Hawai'i	<i>Pinopsida</i> spp., <i>Pteridophyta</i> spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Aulacorthum magnoliae</i> (Essig & Kuwana)	China, India, Japan, Korea	Cucurbitaceae, <i>Citrus</i> spp.	(Blackman and Eastop 2000)
<i>Aulacorthum solani</i> (Kaltenbach)	Africa, Asia, Australia, Central America, Europe, South America, United States	<i>Glycine max</i> , <i>Solanum tuberosum</i>	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Brachycaudus helichrysi</i> (Kaltenbach)	Africa, Asia, Central America, Europe, New Zealand, South America, United States	Asteraceae, Boraginaceae, Cucurbitaceae, Fabaceae, Polygonaceae, Rosaceae, Saxifragaceae,	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)

		Scrophulariaceae	
<i>Cavariella aegopodii</i> (Scopoli)	Asia, Australia, Europe, Hawai'i	Apiaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Cerataphis orchidearum</i> (Westwood)	Africa, Asia, Central America, Hawai'i	Orchidaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Dysaphis apiifolia</i> (Theobald)	Africa, Australia, Central Asia, Europe, Middle East, North and South America	Apiaceae	(Blackman and Eastop 2000)
<i>Dysaphis foeniculus</i> (Theobald)	Africa, Australia, Mediterranean, Middle East, North and South America, South Asia	Apiaceae, Polygonaceae	(Blackman and Eastop 2000)
<i>Dysaphis tulipae</i> (Boyer de Fonscolombe)	India, Jordan, United Kingdom, United States	Araceae, Iridaceae, Liliaceae, Musaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Greenidea mangiferae</i> Takahashi	Taiwan	<i>Euphoria longans</i> , <i>Mangifera indica</i>	(Blackman and Eastop 2000)
<i>Greenidea psidii</i> van der Goot	Asia, Central America, Hawai'i, United States	Clusiaceae, Juglandaceae, Loranthaceae, Lythraceae, Moraceae, Myrtaceae, Rhamnaceae, Rutaceae	(Beardsley 1995, Blackman and Eastop 2000, Halbert 2004, Pérez Hidalgo et al. 2009)
<i>Hyadaphis coriandri</i> (Das)	Africa, Central and South Asia, Mediterranean, Middle East, Peru, United	Amaranthaceae, Apiaceae, Fabaceae, Lamiaceae	(Blackman and Eastop 2000)

	States		
<i>Hyadaphis foeniculi</i> (Passerini)	Egypt, Europe, Middle East, South America, United States	<i>Daucus carota</i> , <i>Foeniculum vulgare</i> , <i>Petroselinum</i> spp., <i>Solanum tuberosum</i> , <i>Viburnum</i> spp.	(Smith and Cermeli 1979, CABI 2007, Kavallieratos et al. 2007, Kaygin et al. 2009)
<i>Hyperomyzus lactucae</i> (L.)	Australia, Central and South Asia, Europe, Hawai'i, Japan, Mediterranean, Middle East, North and South America	<i>Sonchus</i> spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Macrosiphoniella sanborni</i> (Gillette)	Asia, Central America, Europe, South America, United States	Asteraceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Macrosiphum euphorbiae</i> (Thomas)	Africa, Asia, Australia, Canada, Central America, Europe, Mexico, New Zealand, South America, United States	Solanaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Macrosiphum rosae</i> (L.)	Africa, Asia, Australia, Canada, Europe, Mexico, New Zealand, South America, United States	Dipsacaceae, Onagraceae, Rosaceae, Valerianaceae	(Blackman and Eastop 2000, CABI 2007)
<i>Melanaphis sacchari</i> (Zehntner)	Australia, Central and South America, Hawai'i,	Poaceae	(Blackman and Eastop 2000, White et al. 2001)

	South Africa, Southeast Asia, United States		
<i>Melanaphis sorghi</i> (Theobald)	Africa, Asia, Middle East	<i>Saccharum</i> spp., <i>Sorghum</i> spp., <i>Zea mays</i>	(Blackman et al. 1990)
<i>Metopolophium dirhodum</i> (Walker)	Africa, Australia, Japan, North and Central America, West and Central Asia	Poaceae	(Blackman and Eastop 2000, CABI 2007)
<i>Metopolophium festucae</i> (Theobald)	Europe	Poaceae	(Blackman and Eastop 2000)
<i>Myzus ascalonicus</i> Doncaster	Canada, Europe, New Zealand, Russia, United States	Polyphagous on many vegetable crops including <i>Allium</i> spp., <i>Beta vulgaris</i> , <i>Fragaria</i> spp., <i>Solanum</i> spp.	(Hill 1983, CABI 2007, Verbeek et al. 2010)
<i>Myzus ornatus</i> Laing	Africa, Australia, Central America, Europe, Mediterranean, South America, United States	Asteraceae, Bignoniaceae, Labiatae, Polygonaceae, Primulaceae, Rosaceae, Violaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Neotoxoptera oliveri</i> (Essig)	Africa, Australia, Bermuda, Brazil, Korea, Mexico, New Zealand, Panama, Pakistan, Portugal, United States	<i>Allium cepa</i> , <i>Stellaria media</i> , <i>Viola</i> spp.	(Blackman and Eastop 2000)
<i>Ovatus</i>	Africa, Europe,	Lamiaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)

<i>Crataegarius</i> (Walker)	Hawai'i, Mexico, United States		
<i>Patchiella</i> <i>reaumuri</i> (Kaltenbach)	Bulgaria, Balkan States, Hawai'i, Solomon Islands, Turkey, Western Europe	Araceae	(Blackman and Eastop 2000)
<i>Pemphigus</i> <i>populitransversus</i> Riley	Azores, North and South America, South Africa	Brassicaceae	(Blackman and Eastop 2000)
<i>Rhopalosiphoninus</i> <i>latysiphon</i> (Davidson)	Africa, Australia, Europe, Hawai'i, North and South America, South Asia	Apocynaceae, Convolvulaceae, Iridaceae, Liliaceae, Myrtaceae, Poaceae, Rosaceae, Solanaceae, Urticaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Rhopalosiphoninus</i> <i>staphylaeae</i> (Koch)	Africa, Australasia, Europe, North America, Peru	Iridaceae, Liliaceae	(Blackman and Eastop 2000)
<i>Rhopalosiphum</i> <i>padi</i> (L.)	Africa, Asia, Australia, Canada, Europe, Mexico, Hawai'i, New Zealand, Puerto Rico, South America, United States	Cyperaceae, Iridaceae, Juncaceae, Poaceae, Typaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Schizaphis</i> <i>graminum</i> (Rondani)	Africa, Asia, North, Central and South America, Southern Europe	Poaceae	(Blackman and Eastop 2000)

<i>Schizaphis rotundiventris</i> (Signoret)	Africa, Asia, Australia, Hawai'i, Southern Europe, United States	Arecaceae, Cyperaceae	(Blackman and Eastop 2000)
<i>Sipha flava</i> (Forbes)	Azores, Western hemisphere	Arecaceae, Cyperaceae	(Beardsley et al. 1992, Blackman and Eastop 2000)
<i>Sitobion luteum</i> (Buckton)	Australia, Central and South America, Europe, Fiji, Hawai'i, India, Madagascar, Mauritius, Singapore, Tahiti, United States	Orchidaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
<i>Sitobion miscanthi</i> (Takahashi)	Australia, Cook Islands, Fiji, Hawai'i, Southeast Asia, Tahiti, Tonga	Poaceae, Polygonaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
<i>Tetraneura nigriabdominalis</i> (Sasaki)	Africa, Asia, Australia, Europe, New Zealand, South America, United States	Poaceae	(Blackman and Eastop 2000)
<i>Tetraneura ulmi</i> (L.)	Eastern Siberia, Europe, North America, West and Central Asia	Poaceae	(Blackman and Eastop 2000)
<i>Therioaphis trifolii</i> (Monell)	Asia, Australia, Hawai'i, Japan, Mexico, South Africa, South America, United States	<i>Astragalus</i> spp., <i>Lotus</i> spp., <i>Medicago</i> spp., <i>Melilotus</i> spp., <i>Onobrychis</i> spp., <i>Ononis</i> spp., <i>Trifolium</i> spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)

<i>Toxoptera odinae</i> (van der Goot)	Asia, Sub-Saharan Africa	Anacardiaceae, Araliaceae, Caprifoliaceae, Ericaceae, Pittosporaceae, Rubiaceae, Rutaceae	(Blackman and Eastop 2000)
<i>Wahlgreniella nervata</i> (Gillette)	Africa, England, Hawai'i, North and South America, Pakistan	<i>Rosa</i> spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Hemiptera: Coccidae			
Coccidae (soft scale insects) often live in concealed places on plants and are frequently transported on commodities and plant materials (Miller et al. 2002). Many scale insects are major agricultural pests and have caused serious problems when introduced into new areas (Miller et al. 2005).			
<i>Ceroplastes actiniformis</i> Green	Brazil, Canary Islands, Egypt, India, Indonesia, Israel, Sri Lanka	Polyphagous	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Ceroplastes brevicauda</i> Hall	Africa	<i>Citrus</i> spp., <i>Coffea</i> spp.	Ben-Dov et al. (2009) (Miller and Miller 2003)
<i>Ceroplastes cirripediformis</i> Comstock	Caribbean, Hawai'i, Indonesia, Mexico, South America, Southern Europe, United States	<i>Citrus</i> spp., <i>Ipomoea batatas</i> , <i>Mangifera indica</i> , <i>Passiflora edulis</i> , <i>Psidium guajava</i> , <i>Solanum melongena</i>	(Ben-Dov et al. 2009)
<i>Ceroplastes destructor</i> Newstead	Africa, Australia, India, New Guinea, New Zealand	<i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Diospyros kaki</i> , <i>Psidium guajava</i>	(Miller and Miller 2003, CABI 2007, Ben-Dov et al. 2009)
<i>Ceroplastes floridensis</i> Comstock	Africa, Australia, Caribbean, Central and	Polyphagous on tropical fruits in at least 69 plant	(Ben-Dov et al. 2009)

	South America, Europe, Hawai'i, United States, West, South, and Southeast Asia	families	
<i>Ceroplastes grandis</i> Hempel	South America	<i>Citrus</i> spp., <i>Diospyros kaki</i> , <i>Psidium guajava</i> , <i>Punica granatum</i>	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Ceroplastes japonicus</i> Green	Central and East Asia, England, France, Italy, Russia	<i>Citrus</i> spp.	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Ceroplastes pseudoceriferus</i> Green	South and East Asia	<i>Citrus</i> spp., <i>Mangifera indica</i> , <i>Psidium guajava</i>	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Eulecanium tiliae</i> (L.)	Canada, Europe, South Asia, United States	Polyphagous	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Milviscutulus mangiferae</i> (Green)	Africa, Australia, Central and South America, Hawai'i, Israel, Mexico, Caribbean, Asia, United States	Orchidaceae, <i>Ananas</i> spp., <i>Artocarpus</i> spp., <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Eugenia</i> spp., <i>Ficus</i> spp., <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Psidium guajava</i>	(Miller and Miller 2003, CABI 2007, Ben-Dov et al. 2009)
<i>Parthenolecanium persicae</i> (F.)	Asia, Australia, Europe, FSM, Hawai'i, North and South America	<i>Citrus</i> spp., <i>Diospyros kaki</i> , <i>Persea americana</i> , <i>Ficus carica</i> , <i>Magnolia grandiflora</i> , <i>Mangifera indica</i> , <i>Rosa</i> spp.	(Miller and Miller 2003, Ben-Dov et al. 2009)

<i>Philephedra tuberculosa</i> Nakahara & Gill	Africa, Caribbean, Central and South America, Mexico, United States	<i>Annona</i> spp., <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Pouteria sapota</i> , <i>Psidium guajava</i>	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Protopulvinaria pyriformis</i> (Cockerell)	Caribbean, Central and South America, Israel, Mexico, Southern Europe, United States	<i>Carica papaya</i> , <i>Citrus</i> spp., <i>Hibiscus sinensis</i> , <i>Mangifera indica</i> , <i>Musa cavendishi</i> , <i>Passiflora</i> spp., <i>Persea americana</i> , <i>Plumeria</i> spp., <i>Psidium guajava</i>	(Miller and Miller 2003, Ben-Dov et al. 2009)
<i>Pulvinaria floccifera</i> (Westwood)	Australia, Canada, Caribbean, Europe, Mexico, South Africa, South America, Southeast Asia, United States	<i>Citrus</i> spp., <i>Nerium</i> spp., <i>Psidium guajava</i>	(Ben-Dov et al. 2009)
<i>Saissetia miranda</i> (Cockerell & Parrott)	Caribbean, Central and South America, Hawai'i, India, Indonesia, Mexico, South Africa, South Pacific Islands, United States	<i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Mangifera indica</i> , <i>Nerium oleander</i> , <i>Persea americana</i> , <i>Plumeria</i> spp., <i>Psidium guajava</i>	(Ben-Dov et al. 2009)
<i>Saissetia neglecta</i> De Lotto	Caribbean, Central and South America,	<i>Annona muricata</i> , <i>Citrus</i> spp., <i>Coffea arabica</i> ,	(Ben-Dov et al. 2009)

	Mexico, United States, Vanuatu	<i>Mangifera indica</i> , <i>Manihot esculenta</i> , <i>Manilkara zapota</i> , <i>Musa</i> spp., <i>Psidium guajava</i> , <i>Tamarindus indica</i>	
<i>Vinsonia stellifera</i> (Westwood)	Africa, Australia, Caribbean, Netherlands, New Guinea, South America, Southeast Asia, Taiwan, United States	<i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Eugenia jambos</i> , <i>Garcinia mangostana</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Persea americana</i> , <i>Plumeria acutifolia</i>	(Ben-Dov et al. 2009)
Hemiptera: Diaspididae			
There are over 2,500 species of Diaspididae (armored scales) worldwide (Gillott 1995). These insects damage trees and shrubs and are moved to new areas in infested propagative material.			
<i>Aulacaspis tubercularis</i> Newstead	Africa, Asia, Australia, Central America, India, South America, United States	<i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Cucurbita</i> spp., <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Pittosporum undulatum</i>	(Miller et al. 2005, CABI 2007)
<i>Auscalaspis yasumatsu</i> Takagi	Caribbean, CNMI, France, Guam, Hong Kong, New Zealand, Palau, Singapore, Taiwan, United States	Cycadaceae, Stangeriaceae, Zamiaceae	(ISSG 2010)
<i>Aonidiella aurantii</i> (Maskell)	Africa, Australia, Caribbean, FSM, Melanesia,	<i>Acacia</i> spp., <i>Agave</i> spp., <i>Ambrosia</i>	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)

	Mexico, Middle East, South America, South Asia, United States, Western Europe	<i>artemisifolia</i> , <i>Artocarpus</i> spp., <i>Bambusa</i> spp., <i>Brassica nigra</i> , <i>Capsicum frutescens</i> , <i>Carica papaya</i> , <i>Casuarina</i> spp., <i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Cucurbita pepo</i> , <i>Cycas</i> spp., <i>Diospyros kaki</i> , <i>Ficus</i> spp., <i>Hibiscus</i> spp., <i>Jasminum</i> spp., <i>Mangifera indica</i> , <i>Musa sapientum</i> , <i>Nerium oleander</i> , <i>Pandanus tectorius</i> , <i>Persea americana</i> , <i>Poinsettia</i> spp., <i>Psidium guajava</i>	
<i>Chrysomphalus aonidum</i> (L.)	Africa, Australia, Caribbean, Central and South America, China, Europe, FSM, Hawai'i, Melanesia, Mexico, Middle East, South Asia, Taiwan, Vietnam, United States	<i>Acacia</i> spp., <i>Annona</i> spp., <i>Artocarpus</i> spp., <i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Cycas</i> spp., <i>Diospyros kaki</i> , <i>Dodonaea viscosa</i> , <i>Garcinia</i> spp., <i>Gardenia</i> spp., <i>Hibiscus</i> spp., <i>Heliconia</i> spp., <i>Ficus</i> spp., <i>Mangifera indica</i> , <i>Musa</i> spp.,	(Miller et al. 2005, Ben-Dov et al. 2009)

		<i>Nerium oleander</i> , <i>Opuntia</i> spp., <i>Pandanus</i> spp., <i>Persea americana</i> , <i>Phoenix dactylifera</i> , <i>Plumeria</i> spp., <i>Psidium guajava</i> , <i>Punica granatum</i>	
<i>Diaspidiotus perniciosus</i> (Comstock)	Africa, Canada, Europe, Hawai'i, South America, Southeast Asia, United States	<i>Actinidia chinensis</i> , <i>Cannabis sativa</i> , <i>Citrus</i> spp., <i>Diospyros kaki</i>	(Miller et al. 2005, Ben-Dov et al. 2009)
<i>Diaspis boisduvalii</i> Signoret	Africa, Asia, Australia, Canada, Caribbean, Central and South America, Europe, Hawai'i, Mexico, Palau, United States	<i>Agave</i> spp., <i>Ananas comosus</i> , <i>Cattleya</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Garcinia mangostana</i> , <i>Heliconia</i> spp., <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Pandanus</i> spp., <i>Persea americana</i> , <i>Phoenix</i> spp., <i>Strelitzia</i> spp., <i>Vanda</i> spp.	(Miller et al. 2005, Ben-Dov et al. 2009)
<i>Fiorinia theae</i> Green	Caribbean, Central and South America, Mexico, South and East Asia	<i>Camellia</i> spp., <i>Citrus</i> spp., <i>Olea</i> spp., <i>Spondias</i> spp.	(Miller et al. 2005, Ben-Dov et al. 2009)
<i>Gymnaspis aechmeae</i> Newstead	Argentina, Caribbean, Costa Rica, Europe,	Bromeliaceae, <i>Ananas comosus</i> , <i>Cymbidium</i> spp.	(Miller et al. 2005, Ben-Dov et al. 2009)

	Hawai'i, United States		
<i>Lepidosaphes ulmi</i> (L.)	Australia, Canada, China, Europe, Hawai'i, India, Middle East, North Africa, South Africa, South America, Taiwan, United States	<i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Diospyros kaki</i> , <i>Ginkgo</i> spp., <i>Persea</i> spp., <i>Ficus carica</i> , <i>Nerium oleander</i> , <i>Olea europaea</i> , <i>Punica granatum</i>	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)
<i>Lindingaspis rossi</i> (Maskell)	Africa, Australia, Hawai'i, Mexico, New Zealand, New Caledonia, Philippines, Samoa, South America, South and East Asia, Southern Europe, United States	<i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Cycas</i> spp., <i>Eucalyptus</i> spp., <i>Garcinia</i> spp., <i>Macadamia ternifolia</i> , <i>Mangifera indica</i> , <i>Nerium oleander</i>	(Miller et al. 2005, Ben-Dov et al. 2009)
<i>Parlatoria oleae</i> (Colvée)	Australia, Mexico, Northern Africa, South America, Southern Asia, Southern Europe, United States	<i>Acacia</i> spp., <i>Citrus</i> spp., <i>Dianthus</i> spp., <i>Diospyros kaki</i> , <i>Eriobotrya japonica</i> , <i>Hibiscus syriacus</i> , <i>Jasminum</i> spp., <i>Mangifera indica</i> , <i>Nerium</i> spp., <i>Olea europaea</i> , <i>Oryza sativa</i> , <i>Phoenix</i> spp., <i>Punica granatum</i>	(Miller et al. 2005, Ben-Dov et al. 2009)
<i>Pinnaspis aspidistrae</i> (Signoret)	Africa, Canada, Caribbean, Central and South America,	<i>Acacia</i> spp., <i>Annona</i> spp., <i>Citrus</i> spp., <i>Cocos nucifera</i> ,	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)

	Europe, FSM, Hawai'i, Melanesia, Mexico, Philippines, United States	<i>Cordyline terminalis</i> , <i>Cymbidium</i> spp., <i>Cycas</i> spp., <i>Dracaena</i> spp., <i>Heliconia</i> spp., <i>Hibiscus rosasinensis</i> , <i>Jatropha integerrima</i> , <i>Mangifera indica</i> , <i>Musa paradisiaca</i> , <i>Pandanus odoratissimus</i> , <i>Persea</i> spp., <i>Piper</i> spp., <i>Plumeria acutifolia</i> , <i>Portulaca lutea</i> , <i>Psidium guajava</i> , <i>Solanum</i> spp.	
<i>Unaspis citri</i> (Comstock)	Africa, Australia, Caribbean, Central and South America, FSM, Hawai'i, Melanesia, Mexico, Southeast Asia, United States	<i>Acacia</i> spp., <i>Ananas</i> spp., <i>Annona muricata</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Euonymus</i> spp., <i>Hibiscus</i> spp., <i>Mangifera</i> spp., <i>Musa</i> spp., <i>Persea americana</i> , <i>Psidium guajava</i>	(Miller et al. 2005, Ben-Dov et al. 2009)
Hemiptera: Keriidae			
Kerriidae (Iac scales) are mainly tropical and subtropical in distribution (Gillott 1995) and can be spread to new areas in infested propagative material. They can be serious pests of various plant species.			
<i>Paratachardina lobata</i> (Chamberlin)	Christmas Island, India, Sri Lanka, United States	<i>Acacia</i> spp., <i>Annona</i> spp., <i>Artocarpus</i>	(Howard et al. 2004, Ben-Dov et al. 2009)

		<i>heterophyllus</i> , <i>Bambusa vulgaris</i> , <i>Casuarina</i> spp., <i>Citrus</i> spp., <i>Dimocarpus</i> <i>longan</i> , <i>Diospyros</i> spp., <i>Garcinia</i> spp., <i>Gardenia</i> spp., <i>Litchi</i> <i>sinensis</i> , <i>Mangifera indica</i> , <i>Manilkara</i> spp., <i>Persea</i> spp., <i>Psidium</i> spp., <i>Solanum</i> spp.	
<i>Paratachardina pseudolobata</i> Kondo & Gullan	United States	<i>Mangifera indica</i>	(Ben-Dov et al. 2009, ISSG 2009)
Hemiptera: Miridae			
Many mirids cause severe feeding damage to vegetables, fruits, flowers, and forage crops (Gillott 1995). They are often moved in infested plant materials.			
<i>Lygus hesperus</i> Knight	Canada, United States	<i>Daucus carota</i> , <i>Solanum lycopersicum</i>	(Scott 1977, CABI 2007)
<i>Lygus lineolaris</i> Palisot de Beauvois	Canada, Central America, Mexico, United States	Polyphagous. Hosts include <i>Brassica</i> spp., <i>Cucumis sativus</i> , <i>Dahlia</i> spp., <i>Phaseolus vulgaris</i> , <i>Prunus</i> spp., <i>Solanum</i> spp.	(Young 1986, CABI 2007)
Hemiptera: Orthzeziidae			
Orthzeziidae can live on almost any host plant part, including the roots (Triplehorn and Johnson 2005). These insects can be moved to new areas on infested plant materials.			
<i>Insignorthezia</i>	Africa, Australia,	<i>Artemisia</i> spp.,	(Ben-Dov et al. 2009, ISSG 2009)

<i>insignis</i> (Browne)	Canada, Caribbean, Central and South America, China, Europe, Hawai'i, India, Indonesia, Japan, Malaysia, Mexico, Sri Lanka, Taiwan, United States	<i>Citrus</i> spp., <i>Coffea</i> spp., <i>Euphorbia</i> spp., <i>Geranium</i> spp., <i>Ipomoea</i> spp., <i>Lantana</i> spp., <i>Oxalis</i> spp., <i>Solanum</i> spp., <i>Viola</i> spp.	
Hemiptera: Pseudococcidae			
Pseudococcidae (mealybugs) often attain high population densities, killing their host plants by depleting sap, injecting toxins, transmitting viruses, and/or excreting honeydew (Williams and Granara de Willink 1992). They are moved on infested plant materials.			
<i>Balanococcus poae</i> (Maskell)	New Zealand	Poaceae	(Miller et al. 2002, Ben-Dov et al. 2009)
<i>Dysmicoccus grassii</i> (Leonardi)	Caribbean, Central and South America, France, Italy, Malaysia, Mexico, Nigeria	<i>Ananas comosus</i> , <i>Annona squamosa</i> , <i>Artocarpus</i> spp., <i>Carica papaya</i> , <i>Coffea arabica</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Passiflora edulis</i> , <i>Persea</i> spp., <i>Punica granatum</i> , <i>Sechium edule</i> , <i>Theobroma cacao</i>	(Ben-Dov et al. 2009)
<i>Dysmicoccus</i> sp. nr. <i>bispinosus</i>	Caribbean, Central America, Mexico, Puerto Rico, South America	<i>Acacia</i> spp., <i>Coffea</i> spp., <i>Citrus</i> spp., <i>Dieffenbachia</i> spp., <i>Inga</i> spp., <i>Musa</i> spp., <i>Psidium guajava</i> ,	(Williams and Granara de Willink 1992, Rung et al. 2007)

		<i>Solanum</i> spp.	
<i>Dysmicoccus texensis</i> (Tinsley)	Central America, Mexico, South America, Trinidad and Tobago, United States	<i>Acacia</i> spp., <i>Coffea</i> spp.	(Williams and Granara de Willink 1992, Santa-Cecília et al. 2002, Miller et al. 2005, Bigger 2009)
<i>Exallomochlus hispidus</i> (Morrison)	Southeast Asia	<i>Annona muricata</i> , <i>Artocarpus heterophyllus</i> , <i>Citrus maxima</i> , <i>Cocos nucifera</i> , <i>Dimocarpus longan</i> , <i>Durio</i> spp., <i>Garcinia mangostana</i> , <i>Manilkara zapota</i> , <i>Nephelium lappaceum</i> , <i>Psidium guajava</i> , <i>Saccharum officinarum</i> , <i>Theobroma cacao</i>	(Miller et al. 2002, Ben-Dov et al. 2009)
<i>Ferrisia malvastra</i> (McDaniel)	Australia, Caribbean, Hawai'i, India, Israel, Mexico, New Guinea, South Africa, South America, United States	<i>Ambrosia artemisifolia</i> , <i>Arachis hypogaea</i> , <i>Brassica rapa</i> , <i>Citrus paradisi</i> , <i>Gossypium hirsutum</i> , <i>Macadamia</i> spp., <i>Manihot esculenta</i> , <i>Persea americana</i> , <i>Phaseolus vulgaris</i> , <i>Punica granatum</i> , <i>Solanum</i> spp., <i>Tectona grandis</i>	(Ben-Dov et al. 2009)

<i>Geococcus coffeae</i> Green	Africa, Australia, Caribbean, Central and South America, FSM, Hawai'i, Mexico, New Guinea, Southeast Asia, United States, Western Europe	<i>Ananas comosus</i> , <i>Dioscorea</i> spp., <i>Acacia koa</i> , <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Colocasia esculenta</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Nerium oleander</i> , <i>Theobroma cacao</i>	(Miller et al. 2002, Ben-Dov et al. 2009)
<i>Phenacoccus gossypii</i> Townsend & Cockerell	Caribbean, Japan, Mexico, South America, Southern Europe, United States	<i>Capsicum annuum</i> , <i>Gossypium</i> spp., <i>Helianthus</i> spp., <i>Lantana</i> spp., <i>Mangifera indica</i> , <i>Phaseolus vulgaris</i> , <i>Solanum lycopersicum</i>	(Ben-Dov et al. 2009)
<i>Phenacoccus parvus</i> Morrison	Africa, Australia, Caribbean, Central and South America, India, Indonesia, Israel, Mexico, New Caledonia, Thailand, United States	<i>Actinidia deliciosa</i> , <i>Capsicum</i> spp., <i>Cucumis sativus</i> , <i>Lantana camara</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Psidium guajava</i> , <i>Saccharum officinarum</i> , <i>Solanum</i> spp.	(Ben-Dov et al. 2009)
<i>Phenacoccus solani</i> Ferris	Caribbean, Central and South America, Hawai'i, India, Italy, Kiribati, North America, RMI, Southern Africa, West and	<i>Artemisia heterophylla</i> , <i>Aster</i> spp., <i>Brassica oleracea</i> , <i>Centaurea diffusa</i> , <i>Chenopodium</i> spp., <i>Chrysanthemum</i>	(Ben-Dov et al. 2009)

	Southeast Asia	<i>morifolium</i> , <i>Citrus aurantifolia</i> , <i>Dendrobium</i> spp., <i>Euphorbia</i> spp., <i>Helianthus</i> spp., <i>Lantana camara</i> , <i>Narcissus</i> spp., <i>Raphanus sativus</i> , <i>Solanum</i> spp., <i>Viola</i> spp.	
<i>Planococcus ficus</i> (Signoret)	Caribbean, Middle East, South America, South Asia, Southern Africa, Southern Europe, United States	<i>Bambusa</i> spp., <i>Ficus</i> spp., <i>Mangifera indica</i> , <i>Nerium oleander</i> , <i>Persea americana</i> , <i>Phoenix dactylifera</i> , <i>Punica granatum</i> , <i>Theobroma cacao</i>	(Ben-Dov et al. 2009)
<i>Planococcus kraunhiae</i> (Kuwana)	China, Japan, Korea, Philippines, Taiwan, United States	<i>Actinidia</i> spp., <i>Agave americana</i> , <i>Artocarpus lanceolata</i> , <i>Casuarina stricta</i> , <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Cucurbita moschata</i> , <i>Diospyros kaki</i> , <i>Ficus carica</i> , <i>Musa basjoo</i> , <i>Nerium indicum</i> , <i>Pyrus ussuriensis</i>	(Ben-Dov et al. 2009)
<i>Planococcus minor</i> (Maskell)	Australia, Caribbean, Central America, FSM, Guam, Mexico, South	<i>Acacia</i> spp., <i>Aleurites moluccana</i> , <i>Ananas comosus</i> , <i>Annona</i> spp.,	(Miller et al. 2002, Ben-Dov et al. 2009)

	America, Southeast Asia, Taiwan	<i>Artocarpus</i> spp., <i>Brassica</i> spp., <i>Capsicum</i> spp., <i>Citrus</i> spp., <i>Cocos</i> <i>nucifera</i> , <i>Coffea</i> spp., <i>Colocasia</i> <i>esculenta</i> , <i>Cucumis</i> spp., <i>Cucurbita</i> spp., <i>Heliconia</i> spp., <i>Hibiscus</i> spp., <i>Ipomoea</i> spp., <i>Leucaena</i> spp., <i>Manihot</i> <i>esculenta</i> , <i>Mangifera indica</i> , <i>Mimosa</i> spp., <i>Musa</i> spp., <i>Pandanus</i> spp., <i>Passiflora edulis</i> , <i>Persea</i> <i>americana</i> , <i>Plumeria rubra</i> , <i>Psidium guajava</i> , <i>Saccharum</i> <i>officinarum</i> , <i>Solanum</i> spp., <i>Tectona grandis</i> spp., <i>Theobroma</i> <i>cacao</i>	
<i>Pseudococcus</i> <i>calceolariae</i> (Maskell)	Africa, Australia, Caribbean, China, Europe, Indonesia Mexico, United States, South America	<i>Brassica</i> spp., <i>Citrus</i> spp., <i>Helianthus</i> spp., <i>Hibiscus</i> spp., <i>Nerium oleander</i> , <i>Persea indica</i> , <i>Solanum</i> spp., <i>Theobroma</i>	(CABI 2007, Ben-Dov et al. 2009)

		<i>cacao</i> , <i>Trifolium</i> spp.	
<i>Pseudococcus cryptus</i> Hempel	Caribbean, Central and South America, FSM, Hawai'i, Middle East, Palau, Southeast Asia	<i>Ananas sativa</i> , <i>Annona muricata</i> , <i>Artocarpus</i> spp., <i>Bambusa</i> spp., <i>Cocos nucifera</i> , <i>Coffea</i> spp., <i>Citrus</i> spp., <i>Garcinia mangostana</i> , <i>Litchi chinensis</i> , <i>Mangifera indica</i> , <i>Moringa oleifera</i> , <i>Musa</i> spp., <i>Pandanus</i> spp., <i>Passiflora foetida</i> , <i>Persea americana</i> , <i>Psidium guajava</i> , <i>Punica granatum</i>	(Ben-Dov et al. 2009)
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller	Canada, Caribbean, Central and South America, FSM, Hawai'i, Mexico, Southeast Asia, Taiwan, United States	<i>Ananas comosus</i> , <i>Annona</i> spp., <i>Carica papaya</i> , <i>Cereus</i> spp., <i>Coccinia grandis</i> , <i>Cocos</i> spp., <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Cucumis melo</i> , <i>Cucurbita</i> spp., <i>Ficus</i> spp., <i>Gossypium</i> spp., <i>Ipomoea</i> spp., <i>Lantana camara</i> , <i>Litchi chinensis</i> , <i>Mangifera indica</i> , <i>Musa</i> spp., <i>Persea</i> spp., <i>Psidium guajava</i> , <i>Punica</i>	(Ben-Dov et al. 2009)

		<i>granatum</i> , <i>Solanum</i> spp., <i>Zea mays</i> , <i>Zingiber officinale</i>	
<i>Pseudococcus landoi</i> (Balachowsky)	Caribbean, Central America, Mexico, South America	<i>Artocarpus altilis</i> , <i>Coffea</i> spp., <i>Heliconia</i> spp., <i>Manihot esculenta</i> , <i>Musa</i> spp., <i>Passiflora</i> spp., <i>Phaseolus lunatus</i> , <i>Schinus terebinthifolius</i> , <i>Theobroma cacao</i> , <i>Yucca elephantipes</i>	(Ben-Dov et al. 2009)
<i>Pseudococcus longispinus</i> (Targioni Tozzetti)	Africa, Asia, Australia, Caribbean, Central and South America, Europe, Hawai'i, Mexico, New Zealand, United States	<i>Acacia</i> spp., <i>Ananas comosus</i> , <i>Annona muricata</i> , <i>Artocarpus</i> spp., <i>Averrhoa carambola</i> , <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Cocos nucifera</i> , <i>Coffea</i> spp., <i>Colocasia esculenta</i> , <i>Cycas</i> spp., <i>Ficus carica</i> , <i>Garcinia mangostana</i> , <i>Hibiscus</i> spp., <i>Jasminum</i> spp., <i>Mangifera indica</i> , <i>Manihot esculenta</i> , <i>Musa</i> spp., <i>Nephelium lappaceum</i> , <i>Nerium oleander</i> ,	(CABI 2007, Ben-Dov et al. 2009)

		<i>Opuntia</i> spp., <i>Pandanus</i> spp., <i>Persea americana</i> , <i>Plumeria rubra</i> , <i>Psidium guajava</i> , <i>Solanum</i> spp.	
<i>Pseudococcus viburni</i> (Signoret)	Canada, Caribbean, Central and South America, Europe, Hawai'i, Mexico, Middle East, New Zealand, South Africa, Southeast Asia, United States	<i>Allium sativum</i> , <i>Ananas comosus</i> , <i>Annona</i> spp., <i>Brassica</i> spp., <i>Carica papaya</i> , <i>Citrus</i> spp., <i>Cucurbita</i> spp., <i>Diospyros kaki</i> , <i>Ficus</i> spp., <i>Eugenia jaborcaba</i> , <i>Helianthus</i> spp., <i>Litchi cinensis</i> , <i>Mangifera indica</i> , <i>Manihot esculenta</i> , <i>Nerium oleander</i> , <i>Opuntia</i> spp., <i>Passiflora</i> spp., <i>Solanum</i> spp., <i>Tamarix</i> spp., <i>Theobroma cacao</i> , <i>Zingiber officinale</i>	(CABI 2007, Ben-Dov et al. 2009)
<i>Puto barberi</i> (Cockerell)	Caribbean, Venezuela	<i>Bougainvillea glabra</i> , <i>Cajanus</i> spp., <i>Citrus</i> spp., <i>Coffea arabica</i> , <i>Geranium</i> spp., <i>Hibiscus</i> spp., <i>Lantana camara</i> , <i>Manihot</i>	(Miller et al. 2002, Ben-Dov et al. 2009)

		<i>esculenta, Persea americana, Physalis micondroi, Psidium guajava, Tamarix spp., Theobroma cacao</i>	
<i>Rhizoeus americanus</i> (Hambleton)	Caribbean, Central and South America, Italy, Mexico, Thailand, United States	<i>Chrysanthemum</i> spp., <i>Coffea arabica</i> , <i>Dieffenbachia</i> spp., <i>Euphorbia</i> spp., <i>Ficus nitida</i> , <i>Hibiscus rosa-sinensis</i> , <i>Lantana</i> spp., <i>Melaleuca leucadendron</i> , <i>Musa</i> spp., <i>Paspalum</i> spp., <i>Phoenix loureirii</i> , <i>Physalis pubescens</i>	(Ben-Dov et al. 2009)
<i>Rhizoeus cacticans</i> (Hambleton)	Australia, Canary Islands, Central and South America, Europe, United States	<i>Aloe</i> spp., <i>Bromus</i> spp., <i>Caesalpinia pulcherrima</i> , <i>Coffea</i> spp., <i>Cyperus rotundus</i> , <i>Fragaria</i> spp., <i>Opuntia</i> spp.	(Ben-Dov et al. 2009)
<i>Rhizoeus dianthi</i> Green	Australia, Canada, Europe, New Zealand, United States	<i>Chrysanthemum</i> spp., <i>Dianthus</i> spp., <i>Lantana</i> spp., <i>Pelargonium</i> spp., <i>Solanum sodomaeum</i> , <i>Yucca afoifolia</i>	(Ben-Dov et al. 2009)
<i>Rhizoeus falcifer</i> Kunckel	Australia, Caribbean,	<i>Chrysanthemum frutescens</i> , <i>Citrus</i>	(Ben-Dov et al. 2009)

d'Herculis	Europe, Mexico, North Africa, South Africa, Suriname, United States	<i>sinensis</i> , <i>Coffea</i> spp., <i>Convolvulus</i> spp., <i>Cynodon dactylon</i> , <i>Geranium</i> spp., <i>Hibiscus</i> spp., <i>Iris</i> spp., <i>Matthiola</i> spp., <i>Passiflora edulis</i> , <i>Phoenix</i> spp., <i>Prunus persica</i> , <i>Solanum</i> spp., <i>Theobroma cacao</i>	
<i>Ripersiella hibisci</i> (Kawai & Takagi)	Caribbean, China, Hawai'i, Japan, Taiwan, United States	<i>Carex</i> spp., <i>Hibiscus rosa-sinensis</i> , <i>Nerium oleander</i> , <i>Phoenix</i> spp.	(Miller et al. 2002, Ben-Dov et al. 2009)
<i>Vryburgia brevicurvis</i> (McKenzie)	Australia, Europe, Israel, United States	Asclepiadaceae, <i>Gerbera</i> spp., <i>Solanum tuberosum</i> , <i>Taraxacum officinale</i> , <i>Trifolium</i> spp.	(Ben-Dov et al. 2009)

Hemiptera: Psyllidae

The toxic saliva of psyllids may cause galling and stunting of plants (Gillott 1995). These small insects also transmit viruses and phytoplasmas. *Diaphorina citri* vectors 'Candidatus Liberibacter asiaticus', the phytoplasma that causes Huanglongbing (citrus greening) in *Citrus* spp. (Gottwald et al. 2007).

<i>Diaphorina citri</i> Kuwayama	Australia, Central and South America, Guam, Hawai'i, Southeast Asia, United States	<i>Citrus</i> spp.	(Grafton-Cardwell et al. 2006, ISSG 2010)
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Hemiptera: Triozidae

Trioziidae (jumping plant lice) are small insects that feed on plants, causing galling and stunting (Gillott 1995). The potato psyllid, *Bactericera cockerelli*, feeds on

plants in 20 different plant families, favoring solanaceous plants (Abdullah 2008). Some Triozid species (especially the one included in the assessment) vector disease caused fastidious bacteria (<i>Candidatus Liberibacter solanacearum</i>). There are multiple strains/biotypes of both the Triozid, and the vectored bacteria (Pers Comm. Barbour).			
<i>Bactericera cockerelli</i> (Sulc)	Central America, Mexico, New Zealand, United States, Europe	Polyphageous, favoring Solanaceae	(Abdullah 2008)
Hymenoptera: Formicidae			
At least 90 ant species have been introduced into the Pacific Region, many by human activities (McGlynn 1999); they have had devastating impacts, reducing agricultural productivity and biodiversity (O'Dowd et al. 2003, Krushelnycky et al. 2005, Lester et al. 2009, Savage et al. 2009) and affecting human health. Red imported fire ants (<i>Solenopsis invicta</i>) sting people, often causing severe allergic reactions, and can make public areas, such as parks, unsafe for people (ISSG 2010). Ants are often moved on nursery stock and in many other items, including WPM, shipping containers, soil, construction materials, and vehicles.			
<i>Acromyrmex octospinosus</i> (Reich)	Caribbean, South America		(ISSG 2009)
<i>Lasius neglectus</i> Van Loon, Boomsma, & Andrásfalvy	Europe, Georgia, Kyrgyzstan, Turkey, Uzbekistan		(Seifert 2000, Schultz and Seifert 2005, ISSG 2009)
<i>Linepithema humile</i> (Mayr)	Australia, Bermuda, Hawai'i, Japan, Mexico, New Zealand, South Africa, South America, United Arab Emirates, United States, Western and Southern Europe		(Suarez et al. 2001, Holway et al. 2002, Krushelnycky et al. 2005)
<i>Monomorium pharaonis</i> (L.)	Africa, Asia, Australia, Europe, Galápagos Islands, Hawai'i, North, Central and South		(ISSG 2009)

	America		
<i>Myrmica rubra</i> (L.)	Australia, Canada, Europe, United States		(Grodén et al. 2005, CABI 2007, ISSG 2009)
<i>Solenopsis invicta</i> Buren	Australia, Caribbean, New Zealand, South America, United States		(Vinson 1997, Holway et al. 2002, Morrison et al. 2004b)
<i>Solenopsis richteri</i> Forel <i>Solenopsis papuana</i> Emery	South America, United States American Samoa, Fiji, New Zealand, Hawai'i, United States	<i>Cocos, Colocasia</i>	(ISSG 2009) (SPREP 2000, ISSG 2009)
<i>Tapinoma melanocephalum</i> (Fabricius) <i>Wasmannia auropunctata</i> (Roger)	Australia, Brazil, Canada, Caribbean, Costa Rica, Japan, United States Africa, Caribbean, Central and South America, Galápagos Islands, Hawai'i, New Caledonia, North America, Solomon Islands, Tahiti, Vanuatu		(Holway et al. 2002, Wetterer and Porter 2003)

Lepidoptera: Bedelliidae

Native species in Hawai'i and also found in Fiji

<i>Bedelliidae</i> spp.	Hawai'i and Fiji	Ipomoea	(Englberger, personal communication)
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Lepidoptera: Gelechiidae

There are over 4,000 species of Gelechiidae. Larvae cause damage by boring into plant stems, seeds, fruit, flowers, and tubers (Gillott 1995). These small moths

are often moved to new areas in infested plant material.			
<i>Tuta absoluta</i> (Meyrick)	North Africa, South America, Southern Europe	Solanaceae	(EPPO 2005b; CABI/EPPO 2009)
Lepidoptera: Gracillariidea			
The family Gracillariidea contains species of small moths, the larvae of which are leaf miners (Gillott 1995). <i>Marmara gulosa</i> larvae make serpentine mines in the rind of citrus fruits, making the fruit unsellable in the fresh market (Kirkland 2009).			
<i>Marmara gulosa</i> Guillén and Davis	United States	<i>Capsicum</i> <i>annuum</i> , <i>Citrus</i> spp., Cucurbitaceae, <i>Persea</i> <i>americana</i> , <i>Prunus</i> spp., <i>Vitis</i> spp.	(Kirkland 2009)
Lepidoptera: Limacodidae			
Limacodidae (nettle caterpillars) often have stinging hairs or spines, which may cause allergies in humans. Some species feed on palms (Barlow 1982) while other species are abundant in hardwood forests. Limacodidae can be moved to new areas on infested plant material.			
<i>Darna pallivitta</i> (Moore)	China, Hawai'i, Indonesia, Malaysia, Taiwan, Thailand	Arecaceae, Poaceae, <i>Adenostemma</i> spp., <i>Breynia</i> spp., <i>Cordyline</i> <i>terminalis</i> , <i>Ficus</i> spp., <i>Macadamia</i> <i>integrifolia</i>	(Robinson et al. 2001, Nagamine and Epstein 2007, Conant et al. 2008, Jang et al. 2009)
Lepidoptera: Noctuidae			
Noctuid larvae may cause severe damage to many plant species (Barlow 1982). Noctuids are moved to new areas on infested plant material and can be attracted to cargo and conveyances during night loading.			
<i>Autographa californica</i> Speyer	Malaysia, United States	<i>Medicago sativa</i> , <i>Mentha piperita</i> , <i>Solanum</i> <i>lycopersicum</i>	(Pearson et al. 1988, CABI 2007)
<i>Copitarsia corruda</i>	Colombia,	<i>Alstroemeria</i>	(Pogue and Simmons 2008, Gómez et al. 2009)

Pogue & Simmons	Ecuador, Peru	spp., <i>Ammi</i> spp., <i>Asparagus</i> spp., <i>Aster</i> spp., <i>Brassica</i> spp., <i>Callistephus</i> spp., <i>Iris</i> spp., <i>Limonium</i> spp., <i>Lysimachia</i> spp.	
Lepidoptera: Papilionidae			
The lime swallowtail, <i>Papilio demoleus</i> , is a pest of citrus nursery stock. Larvae are capable of defoliating entire nursery groves (Lewis 2009). Larvae can be moved on citrus nursery stock and adults may be deliberately introduced through the hobby trade.			
<i>Papilio demoleus</i> L.	Australia, Caribbean, Indonesia, Middle East, Southern Asia	Rutaceae, Fabaceae	(Guerrero et al. 2004, Eastwood et al. 2006, Lewis 2009)
Lepidoptera: Tineidae			
Tineid larvae are concealed feeders that often mine into plant parts (Gillott 1995). Tineoid moths can be moved to new areas on infested plant materials.			
<i>Opogona sacchari</i> (Bojer)	Africa, Brazil, Caribbean, China, Central America, Europe, Hawai'i, United States	<i>Alpinia</i> spp., <i>Ananas comosus</i> , <i>Bambusa</i> spp., <i>Begonia</i> spp., <i>Bougainvillea</i> spp., <i>Cordyline</i> spp., <i>Dieffenbachia</i> spp., <i>Dracaena</i> spp., <i>Euphorbia</i> <i>pulcherrima</i> , <i>Gloxinia</i> spp., <i>Heliconia</i> spp., <i>Musa</i> spp., <i>Philodendron</i> spp., <i>Saccharum</i> <i>officinarum</i>	(CABI/EPP0 1997f, Nishida 2002, Wang et al. 2008a)

Lepidoptera: Tortricidae			
Larvae of tortricids cause damage by mining into fruits, seeds, and bark, or by defoliating plants (Gillott 1995). Tortricids can be moved to new areas in infested plant material. The light brown apple moth (<i>Epiphyas postvittana</i>) is a significant horticultural and agricultural pest in both its native and introduced ranges and is highly polyphagous with at least 500 host plant species in 121 families.			
<i>Epiphyas postvittana</i> (Walker)	Australia, Hawai'i, Ireland, New Zealand, United Kingdom, United States	Polyphagous, including fruits and cut flowers	(Suckling and Brockerhoff 2010)
Lepidoptera: Yponomeutidae			
Yponomeutidae are small moths. Larvae may be miners, web builders, or exposed feeders (Gillott 1995). <i>Acrolepiopsis</i> species mine into the leaves of <i>Allium</i> spp., which severely weakens the plant (CABI 2007).			
<i>Acrolepiopsis assectella</i> (Zeller)	Algeria, Asia, Canada, Europe, Hawai'i	<i>Allium</i> spp.	(CABI 2007, CABI/EPPO 2007, Jenner et al. 2010)
<i>Acrolepiopsis sapporensis</i> (Matsumura)	East Asia, Hawai'i	<i>Allium</i> spp.	(Landry 2007)
Thysanoptera: Phlaeothripidae			
Thrips damage plants by direct feeding and by vectoring plant viruses. Thrips are extremely difficult to detect in consignments, particularly in bulky shipments (Lewis 1997). Many of the thrips associated with grasses (Poaceae) are readily transported in straw as well as with grass seeds (Mound and Teulon 1995). The habit of crawling into confined spaces makes some species enter packaged goods (Palmer et al. 1989).			
<i>Holopothrips tabebuia</i> Cabrera & Segarra	Caribbean, United States	<i>Amphitecna latifolia</i> , <i>Schefflera actinophylla</i> , <i>Tabebuia</i> spp.	(Gilman and Watson 1994, Cabrera and Segarra 2008, Michel et al. 2008)
<i>Chaetanaphothrips signipennis</i> (Bagnall)	Africa, Australia, Brazil, Fiji, Hawai'i, Honduras, India, Indonesia, New Guinea, Panama, Philippines, Sri	<i>Anthurium palmatum</i> , <i>Alocasia</i> spp., <i>Citrus</i> spp., <i>Cordyline terminalis</i> , <i>Dracaena</i> spp.,	(Lewis 1973, CAB 1981, Denmark and Osborne 1985, Hara et al. 2002, Hussain and Annamalai 2006)

	Lanka, United States	<i>Maranta leuconeura</i> , <i>Musa</i> spp., <i>Phaseolus vulgaris</i> , <i>Solanum lycopersicum</i> , <i>Strelitzia reginae</i>	
<i>Frankliniella cephalica</i> (Crawford)	Caribbean, Central America, Japan, Mexico, United States	<i>Amaranthus spinosus</i> , <i>Ambrosia artemisifolia</i> , <i>Bidens</i> spp., <i>Citrus</i> spp., <i>Commelina diffusa</i> , <i>Euphorbia</i> spp., <i>Heterotheca subaxillaris</i> , <i>Ipomoea</i> spp., <i>Lantana camara</i> , <i>Mangifera indica</i> , <i>Morrenia odorata</i> , <i>Taraxacum officinale</i> , <i>Youngia japonica</i>	(Jeppson 1989, Lamberts and Crane 1990, Nakahara 1997, Masumoto and Okajima 2004, Childers and Nakahara 2006, Ohnishi et al. 2006)
<i>Frankliniella intonsa</i> (Trybom)	Canada, Europe, Israel, New Zealand, South and East Asia, Turkey, United States	Solanaceae	(Nakahara 1997, CABI/EPPO 1999a, Nakahara and Footitt 2007)
<i>Frankliniella occidentalis</i> (Pergande)	Australia, Canada, Caribbean, Central and South America, Europe, Hawai'i, Japan, Korea, Malaysia, Middle East, Mexico,	Cucurbitaceae, <i>Allium cepa</i> , <i>Citrus</i> spp., <i>Daucus carota</i> , <i>Fragaria</i> spp., <i>Gossypium</i> spp., <i>Phaseolus</i> spp., <i>Solanum lycopersicum</i>	(CABI/EPPO 1997e, 1999b, CABI 2007, Funderburk et al. 2009)

	New Zealand, Sri Lanka, Southern Africa, United States		
<i>Scirtothrips dorsalis</i> Hood	Australia, Hawai'i, New Guinea, Solomon Islands, South Africa, South and East Asia, United States	Fabaceae, <i>Allium cepa</i> , <i>Actinidia chinensis</i> , <i>Camellia sinensis</i> , <i>Capsicum</i> spp., <i>Citrus</i> spp., <i>Fragaria</i> spp., <i>Gossypium hirsutum</i> , <i>Hevea brasiliensis</i> , <i>Hydrangea</i> spp., <i>Mangifera</i> spp., <i>Nelumbo</i> spp., <i>Ricinus</i> spp., <i>Rosa</i> spp.	(CABI/EPPO 1997i, Silagyi and Dixon 2006, Funderburk et al. 2009)
MOLLUSKS			
Snails and slugs can cause considerable damage to agriculture and horticulture (Godan 1983) by causing direct feeding damage, and by vectoring or indirectly facilitating the entry of plant pathogens. They can also vector pathogens to humans. Mollusks are often intercepted on WPM. They are also likely to be introduced on agricultural and horticultural commodities, containers and conveyances, vehicles and equipment, items that were stored outdoors, and in potting media (Cowie 2001).			
<i>Achatina fulica</i>	FSM (except Chuuk and Yap), RMI, Palau, Guam, CNMI, American Samoa, French Polynesia, Hawai'i, New Caladonia, Papua New Guinea, Samoa, Vanuatu and Wallis and Fortuna	A wide variety fruit and vegetable crops	(SPC 1999)

<i>Allopeas clavulinum</i> (Potiez and Michaud) [Subulinidae]	American Samoa, East Africa, Fiji, Hawai'i, Japan, United States	Polyphagous	(Auffenberg and Stange 1988, SPREP 2000, Cowie et al. 2008)
<i>Allopeas micra</i> (d'Orbigny) [Subulinidae]	American Samoa, Europe, Galápagos Islands, Hawai'i, United States	Polyphagous	(Auffenberg and Stange 1988; SPREP 2000; Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Arion ater</i> (L.) [Arionidae]	Canada, Europe, United States	Polyphagous	(Godan 1983)
<i>Arion hortensis</i> Férussac [Arionidae]	Australia, Europe, Russia	Polyphagous	(Godan 1983)
<i>Arion intermedius</i> Normand [Arionidae]	Australia, Azores, Canada, Chile, Europe, Hawai'i, New Zealand, North Africa, South Africa, United States	<i>Coleus</i> spp., <i>Datura</i> spp., <i>Iris</i> spp., <i>Solanum tuberosum</i> , <i>Tulipa</i> spp.	(Godan 1983, Cowie 2001, Glen and Moens 2002, Quinteiro et al. 2005, Cádiz and Gallardo 2007, Mc Donnell et al. 2009)
<i>Arion lusitanicus</i> (Mabille) [Arionidae]	Southern Europe	<i>Beta vulgaris</i> , <i>Brassica</i> spp., <i>Fragaria ananassa</i> , <i>Lactuca sativa</i>	(Grimm and Pail 2001, Kozłowski 2005, Weidema 2006, Kozłowski 2007)
<i>Arion rufus</i> (L.) [Arionidae]	Canada, Europe, United States	Polyphagous	(Godan 1983)
<i>Beckianum beckianum</i> (Pfeiffer) [Subulinidae]	Caribbean, Central and South America, Hawai'i, United States	Polyphagous	(SPREP 2000, DPI 2003, Cowie et al. 2008)
<i>Bradybaena fruticum</i> (Mabille) [Bradybaenidae]	Europe	Polyphagous	(Godan 1983, Staikou et al. 1990)
<i>Candidula</i>	Australia,	Polyphagous	(Godan 1983, Baker 1986a)

<i>intersecta</i> (Poiret) [Hygromiidae] <i>Cathaica fasciola</i> (Draparnaud) [Bradybaenidae]	Europe, Mediterranean China	Polyphagous	(Barker 2002)
<i>Cepaea hortensis</i> (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Kozłowski et al. 2006)
<i>Cepaea nemoralis</i> (L.) [Helicidae]	Canada, Europe, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Cerņuella cisalpina</i> (Rossmässler) [Hygromiidae]	Europe, Mediterranean, United States	Polyphagous	(Mack 2003, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Cerņuella</i> (<i>Xerocincta</i>) <i>neglecta</i> (Draparnaud) [Hygromiidae]	Australia, Europe, Mediterranean	Polyphagous	(Godan 1983, Baker 1986a)
<i>Cerņuella virgata</i> (Da Costa) [Hygromiidae]	Australia, Europe, Israel, Mediterranean, Turkey	Polyphagous	(Pomeroy 1967, Godan 1983, Baker 1986a, AFPMB 2008, Roll et al. 2009)
<i>Cochlicella acuta</i> (Müller) [Cochlicelidae]	Australia, Bermuda, Europe, Mediterranean, United States	Grains	(Godan 1983, Baker 1986a)
<i>Cochlicella barbara</i> (L.) [Cochlicelidae]	Australia, Bermuda, Europe, Japan, Mediterranean, South Africa	Polyphagous	(Godan 1983, Baker 1986a, AFPMB 2008)
<i>Cochlicella conoidea</i> (Draparnaud) [Cochlicelidae]	France, Italy, Morocco, Portugal, Spain	Polyphagous	(Godan 1983, AFPMB 2008)

<i>Cochlicella ventrosa</i> (Férussac) [Cochlicelidae]	Australia	Polyphagous	(Pomeroy 1967, Godan 1983)
<i>Cryptomphalus aspersus</i> (Müller) [Helicidae]	Australia, Central and South America, Hawai'i, Mediterranean, United States, Western Europe	Polyphagous	(Godan 1983, Smith 1989, Cowie 2001, Cowie et al. 2008)
<i>Cryptozona belangiri</i> (Deshayes) [Ariophantidae]	India	Polyphagous	(Godan 1983, Srivastava 1992)
<i>Cryptozona bistrialis</i> (Beck) [Ariophantidae]	India	Polyphagous	(Godan 1983, Raut and Ghose 1984, Srivastava 1992)
<i>Cryptozona semirugata</i> (Beck) [Ariophantidae]	India	Polyphagous	(Godan 1983, Srivastava 1992)
<i>Deroceras caruanae</i> (Pollonera) [Agriolimacidae]	Australia, Europe, North and South America, South Africa	Polyphagous	(Godan 1983, Smith 1989)
<i>Deroceras laeve</i> (Müller) [Agriolimacidae]	Africa, Europe, Fiji, Hawai'i, New Caledonia, United States	Polyphagous	(Godan 1983, Smith 1989, Cowie 1997, Cowie 2001)
<i>Deroceras reticulatum</i> (Müller) [Agriolimacidae]	Australia, Central and South America, Europe, Hawai'i, United States	Polyphagous	(Godan 1983, Smith 1989, Cowie 2001)
<i>Eobania vermiculata</i> (Müller) [Helicidae]	Europe, Mediterranean, South Africa, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)

<i>Helicella itala</i> (L.) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Nordsieck 2009)
<i>Helicella neglecta</i> (Draparnaud) [Hygromiidae]	Australia	Polyphagous	(Pomeroy 1967, Godan 1983)
<i>Helix aperta</i> (Born) [Helicidae]	Australia, Europe, United States	Polyphagous	(Godan 1983, Smith 1989)
<i>Helix cincta</i> (Müller) [Helicidae]	Greece, Israel, Italy, Romania, Turkey	Polyphagous	(Delivering Alien Invasive Species Inventories for Europe 2009, Roll et al. 2009)
<i>Helix lucorum</i> (L.) [Helicidae]	France, Greece, Italy, Turkey, Ukraine	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Hygromia cinctella</i> (Draparnaud) [Hygromiidae]	Europe, Mediterranean	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Lehmannia marginata</i> (Müller) [Limacidae]	Europe, Japan	Polyphagous	(Godan 1983, Tanaka et al. 2001)
<i>Lehmannia valentiana</i> (Férussac) [Limacidae]	Australia, Central and South America, Europe, Hawai'i, Israel, Japan, United States	Polyphagous	(Godan 1983, Cowie 2001)
<i>Limacus flavus</i> (L.) [Limacidae]	Cook Islands, Europe, Hawai'i, United States, Vanuatu	Polyphagous	(Godan 1983, Cowie 2001)
<i>Limax cinereoniger</i> (Wolf) [Limacidae]	Australia, Europe	Polyphagous	(Godan 1983, Shoab and Cagan 2004)
<i>Limax maximus</i> (L.) [Limacidae]	Australia, Africa, Europe, Hawai'i, United States	Fruit crops	(Godan 1983, Cowie 1997)
<i>Limax tenellus</i>	Europe, Hawai'i,	Polyphagous	(Godan 1983, Cowie 2001, Suominen et al. 2003)

(Müller) [Limacidae] <i>Microxeromagna armillata</i> (Lowe) [Hygromiidae]	United States Australia, Europe, Israel, Mediterranean, Turkey	Polyphagous	(Zhao et al. 2004, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Monacha cantiana</i> (Montagu) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Schultes 2009)
<i>Monacha cartusiana</i> (Müller) [Hygromiidae]	France, Greece, Israel, Italy, Spain	Polyphagous	(Godan 1983, AFPMB 2008)
<i>Monacha syriaca</i> (Ehrenberg) [Hygromiidae]	Greece, Italy, Turkey	Polyphagous	(Godan 1983, AFPMB 2008)
<i>Opeas mauritanum</i> (Pfeiffer) [Subulinidae]	Hawai'i, Mauritius, United States	Polyphagous	(Tryon et al. 1906, Godan 1983, SPREP 2000)
<i>Opeas pumilum</i> (Pfeiffer) [Subulinidae]	South America, United States	Polyphagous	(Godan 1983, Auffenberg and Stange 1988)
<i>Otala lactea</i> (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Mienis 1999)
<i>Otala punctata</i> (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Mienis 1999)
<i>Oxychilus alliaris</i> (Miller) [Oxychilidae]	Europe, Hawai'i, United States	Polyphagous	(Godan 1983, Cowie 1997, Cowie 2001)
<i>Oxychilus cellarius</i> Müller [Oxychilidae]	Canada, Europe, Hawai'i, South Africa, United States	Polyphagous	(Godan 1983, Cowie 1997, Giusti and Manganelli 1997)
<i>Oxychilus draparnaudi</i> (Beck)	Europe, Africa, United States	Greenhouse crops	(Godan 1983, Giusti and Manganelli 1997)

[Oxychilidae]			
<i>Parmarion martensi</i> Simroth [Ariophantidae]	American Samoa, Cambodia, Hawai'i, Indonesia, Japan, Malaysia, Singapore, Taiwan, Vietnam	Polyphagous	(Liao and Wang 1999, Cowie 2001, Hollingsworth et al. 2007)
<i>Rumina decollata</i> (L.) [Subulinidae]	Europe, Mexico, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Succinea tenella</i> Morelet [Succineidae]	Asia, Europe, Hawai'i, United States	Polyphagous	(Hayes et al. 2007, Cowie et al. 2008)
<i>Theba pisana</i> (Müller) [Helicidae]	Australia, Bermuda, Canary Islands, Europe, Mediterranean, South Africa, United States	Vegetables and <i>Citrus</i> spp.	(Godan 1983, Baker 1986a, Cowie et al. 2009)
<i>Trochoidea elegans</i> (Gmelin) [Hygromiidae]	Europe, Mediterranean	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Trochoidea pyramidata</i> (Draparnaud) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
<i>Xerolenta obvia</i> (Menke) [Hygromiidae]	Europe, Turkey	Polyphagous	(Shoab and Cagan 2004, Nordsieck 2009)
<i>Xeropicta derbentina</i> (Krynicky) [Hygromiidae]	Greece, Italy, Turkey	Polyphagous	(AFPMB 2008)
<i>Xerotricha conspurcata</i> (Draparnaud) [Hygromiidae]	Europe, Mediterranean, United States	Polyphagous	(Delivering Alien Invasive Species Inventories for Europe 2009)

<i>Zonitoides arboreus</i> (Say) [Gastrodontiidae]	Canada, Caribbean, China, Hawai'i, Israel, Mexico, Philippines, South America, United States	Orchidaceae	(Godan 1983, Cowie 1997, Roll et al. 2009)
<i>Zonitoides nitidus</i> (Müller) [Gastrodontiidae]	Asia, Europe, North America	Orchidaceae	(Godan 1983, Porcelli and Parenzan 1988)

NEMATODES

Nematodes are estimated to cause agricultural losses that exceed 100 billion dollars annually worldwide (Veech and Dickson 1987, Koenning et al. 1999). Soilborne plant parasitic nematodes feed on plant roots causing yellowing, stunting, root deformation, resulting in reduced crop yields and plant death (Perry and Moens 2006). Some nematodes damage above ground plant parts. *Bursaphelenchus cocophilus* infects coconut (*Cocos nucifera*) roots, stems, and leaves, causing red ring disease which can result in crop losses as high as 80 to 98% (Dean 1979). The most likely pathways of introduction for nematodes include plant roots and tubers, growing media, WPM, and articles contaminated with soil (Chen et al. 2004, Perry and Moens 2006). The baggage and footwear of international travelers have also been shown to be pathways for introduction of pest nematodes (Hockland et al. 2008).

<i>Bursaphelenchus aberrans</i> Fang et al.	China, Thailand	Unknown – described from WPM	(Tomiczek et al. 2003, Gu et al. 2006)
<i>Bursaphelenchus arthuri</i> Burgermeister, Gu and Braasch	Korea, Taiwan	Unknown – described from WPM	(Gu et al. 2006)
<i>Bursaphelenchus chengi</i> Li et al.	Taiwan	Unknown – described from WPM	(Li et al. 2008)
<i>Bursaphelenchus cocophilus</i> (Cobb) Baujard	Caribbean, Central and South America, Mexico	Arecaceae, <i>Attalea cohune</i> , <i>Cocos nucifera</i> , <i>Elaeis guineensis</i> , <i>Phoenix</i> spp., <i>Roystonea regia</i>	(Brammer and Crow 2001, Griffith et al. 2005, GDOA 2005)
<i>Bursaphelenchus macromucronatus</i> Gu, Zheng, Braasch	India, Taiwan	Unknown – described from WPM	(Gu et al. 2008b)

& Burgermeister			
<i>Bursaphelenchus obeche</i> Braasch, Zhen, Burgermeister & Lin	Unknown	Unknown – described from WPM	(Gu et al. 2008a)
<i>Bursaphelenchus sinensis</i> Palmisano, Ambrogioni, Tomiczek & Brandstetter	China	Unknown – described from WPM	(Palmisano et al. 2004)
<i>Bursaphelenchus singaporensis</i> Gu, Zhang, Braasch & Burgermeister	East Asia	Unknown – described from wWPM	(Gu et al. 2006)
<i>Meloidogyne mayaguensis</i> Rammah & Hirschmann	Brazil, Caribbean, United States, West and South Africa	<i>Apium graveolens</i> , <i>Beta vulgaris</i> , <i>Bidens pilosa</i> , <i>Brassica oleracea</i> , <i>Capsicum annuum</i> , <i>Citrullus lanatus</i> , <i>Cucurbita</i> spp., <i>Nicotiana tabacum</i> , <i>Petroselinum crispum</i> , <i>Psidium guajava</i> , <i>Solanum</i> spp.	(SON 2003a, De Waele and Elsen 2008, Randig et al. 2009)
<i>Pratylenchus coffeae</i> (Zimmermann) Filipjev & Schuurmans Stekhoven	Africa, Australia, Caribbean, Central and South America, Fiji, Hawai'i, Kiribati, New Guinea, Niue, Mexico, Palau, Samoa, Solomon	<i>Citrus</i> spp., <i>Colocasia esculenta</i> , <i>Dioscorea</i> spp., <i>Ipomoea batatas</i> , <i>Manihot esculenta</i> , <i>Momordica charantia</i> , <i>Musa</i>	(Bridge 1988, Campos et al. 1990, Inserra et al. 1990, CABI/EPP0 2000, Kavitha et al. 2008)

	Islands, Southern Europe, Southeast Asia, Tonga, United States, Vanuatu	spp., <i>Theobroma cacao</i> , <i>Zingiber officinale</i>	
<i>Zygotylenchus guevarai</i> (Tobar Jiménez) Braun & Loof	Europe, Pakistan, South Africa, Tunisia, United States Uzbekistan	<i>Apium graveolens</i> , <i>Capsicum annuum</i> , <i>Cucumis melo</i> , <i>Daucus carota</i> , <i>Gossypium hirsutum</i> , <i>Lactuca scariola</i> , <i>Phaseolus vulgaris</i> , <i>Pisum sativum</i> , <i>Solanum</i> spp., <i>Vicia</i> spp., <i>Zea mays</i>	(SON 2003b, Stinner et al. 2010)

FUNGI and STRAMENOPILES

More than 10,000 species of fungi and stramenopiles (fungal-like organisms) cause plant diseases (Agrios 2005), often resulting in lesions, cankers, stunting, necrosis, rots, deformation, dieback, reduced yields, and plant death. Some fungi also produce mycotoxins, which make plants toxic to people and animals (Agrios 2005). Fungi can be moved to new areas on infected plant materials, and with contaminating soil (McCullough et al. 2006).

<i>Armillaria fuscipes</i> Petch	Africa, India	<i>Acacia</i> spp., <i>Cordia</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Armillaria gallica</i> Marxm. & Romagn.	Europe, Japan, South Africa, United States	<i>Diospyros</i> spp., <i>Galeola</i> spp., <i>Prunus</i> spp., <i>Umbellularia</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Armillaria sinapina</i> Bérubé & Dessur.	Canada, Hawai'i, Japan, United States	<i>Acacia</i> spp., <i>Corynocarpus</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Armillaria tabescens</i> (Scop.) Emel	Europe, Fiji, India, Japan, United States	<i>Acacia</i> spp., <i>Aleurites</i> spp., <i>Casuarina</i> spp.,	(USDA-APHIS and USDA-FS 2000, Ramsden et al. 2002, Farr and Rossman 2010)

<i>Apiospora montagnei</i> Sacc. [Anamorph: <i>Arthrinium arundinis</i> (Corda) Dyko & B. Sutton]	Central America, China, New Guinea, Philippines, United States	<i>Citrus</i> spp., <i>Cycas</i> spp., <i>Ixora</i> spp., <i>Musa</i> spp., <i>Persea</i> spp. Poaceae, <i>Bambusa</i> spp., <i>Elaeis</i> spp.	(Khan 1961, Farr and Rossman 2010)
<i>Ceratocystis albifundus</i> M.J. Wingf., De Beer & M.J. Morris	South Africa, Tanzania, Uganda	<i>Acacia</i> spp., <i>Protea</i> spp., <i>Terminalia</i> spp.	(Farr and Rossman 2010)
<i>Ceratocystis fimbriata</i> Ellis & Halst <i>Ceratocystis moniliformis</i> (Hedgc.) C. Moreau	Asia, Africa, Central and South America, United States Australia, Canada, Chile, China, Japan, Philippines, South Africa, United States	<i>Acacia</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Hevea</i> spp., <i>Mangifera</i> spp. <i>Calamus</i> spp., <i>Erythrina</i> spp., <i>Hevea</i> spp.	(CMI 1983, Wingfield et al. 1993) (Wingfield et al. 1993, Farr and Rossman 2010)
<i>Colletotrichum lindemuthianum</i> (Sacc. & Magn.) Scribn. (= <i>Gloeosporium lindemuthianum</i> Sacc. & Magnus)	Africa, Asia, Australia, Canada, Caribbean, Central and South America, Europe, Mexico, New Zealand, United States	<i>Allium cepa</i> , <i>Cucumis melo</i> , <i>Glycine</i> spp., <i>Oryza sativa</i> , <i>Phaseolus</i> spp., <i>Philodendron bipinnatifidum</i> , <i>Vigna</i> spp.	(Vasey and Galloway 1889, Bancroft 1910, Lloyd 1918, Mordue 1971, Farr and Rossman 2010)
<i>Daedaleopsis flavida</i> (Lev.) Roy and Mitra	India	<i>Bambusa</i> spp., <i>Cocos</i> spp., <i>Diospyros</i> spp., <i>Mangifera</i> spp., and other	(De 1994)

		hardwoods	
<i>Ganoderma applanatum</i> (Pers.) Pat.	Africa, Australia, Chile, Europe, Japan, United States	<i>Acacia</i> spp., <i>Casuarina</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Diospyros</i> spp., <i>Persea</i> spp., <i>Tamarindus</i> spp.	(USDA-FS 1993, Schwarze and Ferner 2003, Farr and Rossman 2010)
<i>Ganoderma boninense</i> Pat.	Japan	<i>Cocos</i> spp., <i>Elaeis</i> spp., <i>Livistona</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Ganoderma resinaceum</i> Boud.	Canada, Europe, Pakistan, Russia, West Indies	<i>Dalbergia</i> spp., <i>Mangifera</i> spp.	(Schwarze and Ferner 2003, Farr and Rossman 2010)
<i>Ganoderma zonatum</i> Murrill.	Caribbean, Congo, Tanzania, United States	<i>Acacia</i> spp., <i>Citrus</i> spp., <i>Cocos</i> spp., <i>Grevillea</i> spp., <i>Persea</i> spp., <i>Phoenix</i> spp., <i>Saba</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Gibberella subglutinans</i> (E. Edwards) P.E. Nelson, Toussoun & Marasas] [Anamorph: <i>Fusarium subglutinans</i> (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas]	China, India, Mexico, Philippines, South Africa, South America, United States	<i>Acacia</i> spp., <i>Ananas</i> spp., <i>Cocos</i> spp., <i>Dracaena</i> spp., <i>Musa</i> spp.	(Farr and Rossman 2010)
<i>Heterobasidium annosum</i> (Fr. : Fr.) Bref [Anamorph: <i>Spiniger meineckellus</i> (A. Olson) Stalpers]	Africa, Europe, Fiji, Japan, Pakistan, United States	<i>Chamaecyparis</i> spp., <i>Citrus</i> spp., <i>Diospyros</i> spp.	(Ramsden et al. 2002, Kohl 2007, Farr and Rossman 2010)

<i>Inonotus hispidus</i> (Bull.: Fr.) P. Karst.	China, Europe, Japan, Mexico, United States	<i>Albizia</i> spp., <i>Citrus</i> spp., <i>Rosa</i> spp., <i>Sophora</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Inonotus rheades</i> (Pers.) Bondartsev & Singer.	Australia, Brazil, China, New Zealand, United States	<i>Acacia</i> spp.	(USDA-FS FPL 2003, Farr and Rossman 2010)
<i>Lasiodiplodia crassispora</i> Burgess & Barber	Australia, South Africa, Venezuela	<i>Santalum</i> spp., <i>Syzygium</i> spp., and other hardwoods	(Burgess et al. 2006, Farr and Rossman 2010)
<i>Nectria cinnabarina</i> (Tode: Fr.) Fr. [Anamorph: <i>Tubercularia vulgaris</i> Tode : Fr.]	China, Europe, Japan, Russia, United States	<i>Acacia</i> spp., <i>Citrus</i> spp., <i>Sambucus</i> spp., <i>Sophora</i> spp.	(Farr and Rossman 2010)
<i>Neonectria coccinea</i> (Pers.: Fr.) Rossman & Samuels [Anamorph: <i>Cylindrocarpon candidum</i> (Link) Wollenw.]	Malaysia, Japan, Europe, South Africa, United States	<i>Acacia</i> spp., <i>Cocos</i> spp., <i>Sambucus</i> spp.	(Spaulding 1961, Farr and Rossman 2010)
<i>Neonectria ditissima</i> (Tul. & C. Tul.) Samuels & Rossman [Anamorph: <i>Cylindrocarpon heteronemum</i> (Berk. & Broome) Wollenw.]	Brazil, Canada, Japan, Mexico, New Zealand, South Africa, South America, United States	<i>Acacia</i> spp., <i>Citrus</i> spp., <i>Persea</i> spp., <i>Swietenia</i> spp.	(Spaulding 1961, Farr and Rossman 2010)
<i>Didium caricae</i> Noack	Africa, Australia, Bermuda, Central and South America, China,	<i>Carica</i> spp.	(Ploetz et al. 1994, Farr and Rossman 2010)

	Cuba, Europe, Hawai'i, India, Mexico, New Caledonia, Taiwan, United States		
<i>Ophiostoma quercus</i> (Georgev.) Nannf. [Anamorph: <i>Pesotum roboris</i> (Georgescu, Teodoru & Badea) Grobbelaar, Z.W. de Beer & M.J. Wingf.]	China, Europe, Japan, Russia, South Africa, United States	<i>Acacia</i> spp.	(Farr and Rossman 2010)
<i>Ophiostoma stenoceras</i> (Robak) Melin & Nannf.	Europe, Indonesia, New Zealand, South Africa, South America, United States	<i>Acacia</i> spp.	(Farr and Rossman 2010)
<i>Perenniporia medulla-panis</i> (Jacq.) Donk	Chile, Japan, New Zealand, United States	<i>Acacia</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Pestalotiopsis versicolor</i> (Speg.) Steyaert	Africa, China, Mexico, South America, Virgin Islands	<i>Achras</i> spp., <i>Ananas</i> spp., <i>Artocarpus</i> spp., <i>Coccoloba</i> spp., <i>Cocos</i> spp., <i>Elaeis</i> spp., <i>Pandanus</i> spp., <i>Persea</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Phellinus conchatus</i> (Pers. Fr.) Quél.	Canada, China, Japan, New Zealand, South Africa, United States	<i>Acacia</i> spp., <i>Casuarina</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Phellinus lamaensis</i> (Murrill) R. Heim	China, New Zealand, New	<i>Agathis</i> spp., <i>Araucaria</i> spp.,	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)

<i>Phellinus linteus</i> (Berk. & M.A. Curtis) S. Teng.	Caledonia, Palau, New Guinea China, Japan, Pakistan, United States, West Indies	<i>Hevea</i> spp. <i>Cinnamomum</i> spp., <i>Cordia</i> spp., <i>Diospyros</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Phellinus pachyphloeus</i> (Pat.) Pat.	Africa, Australia, New Zealand, Philippines, Southern Asia	<i>Metrosideros</i> spp., <i>Podocarpus</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Phellinus rimosus</i> (Berk.) Pilát	Australia, China, India, Japan, Mexico, Puerto Rico, South Africa	<i>Acacia</i> spp., <i>Casuarina</i> spp., <i>Vatica</i> spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
<i>Phytophthora heveae</i> Thompson	Australia, Brazil, China, Côte d'Ivoire, Guatemala, India, Malaysia, Philippines, Taiwan, United States	<i>Areca catechu</i> , <i>Bertholletia excelsa</i> , <i>Caesalpinia pulcherrina</i> , <i>Cocos nucifera</i> , <i>Hevea</i> spp., <i>Mangifera indica</i> , <i>Persea americana</i> , <i>Psidium guajava</i> , <i>Theobroma cacao</i>	(Stamps 1978, Chang and Shu 1988, Zhang et al. 1995, Zeng et al. 2009, Farr and Rossman 2010)
<i>Phytophthora megakarya</i> Brasier & Griffin	Africa	<i>Irvingia</i> spp., <i>Theobroma cacao</i>	(Stamps 1984, Guest 2007, Paulin et al. 2008, Farr and Rossman 2010)
<i>Seiridium cardinale</i> (W. Wagener) B. Sutton & I. Gibson	Europe, New Zealand, South Africa, South America, United States	<i>Chamaecyparis</i> spp., <i>Protea</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
<i>Seiridium unicorne</i> (Cooke & Ellis) B. Sutton [Teleomorph:	Africa, India, Japan, United States	<i>Chamaecyparis</i> spp., <i>Ixora</i> spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)

<i>Lepteutypa cupressi</i> (Natrass, C. Booth & B. Sutton) H.J. Swart]			
BACTERIA and PHYTOPLASMAS			
Bacteria and phytoplasmas are microscopic organisms that may infect plants, causing leaf spots, blights, cankers, soft rots, reduced crop yield, and plant death (Agrios 2005). Bacterial plant diseases are often severe in tropical climates. As infected plants may be asymptomatic for a long time, it is often impossible to detect the presence of bacteria or phytoplasmas by visual inspection. Bacteria and phytoplasmas are most likely to be spread to new areas on infected plant material and in soil contaminations.			
<i>Acidovorax avenae</i> subsp. <i>citrulli</i> (Schaad et al.) Willems et al.	Australia, Indonesia, United States	<i>Citrullus lanatus</i> , <i>Cucumis melo</i>	(Saddler 1994, Hopkins et al. 2000)
<i>Erwinia papayae</i> Gardan et al.	Caribbean, Malaysia	<i>Carica papaya</i>	(Gardan et al. 2004, Maktar et al. 2008)
<i>Ralstonia solanacearum</i> race 1 (Smith) Yabuuchi et al.	Africa, Australia, Europe, Canada, Caribbean, Central and South America, FSM, Guam, Hawai'i, Mexico, New Zealand, Southeast Asia, United States	<i>Nicotiana</i> spp., <i>Solanum</i> spp.	(CABI/EPPO 1997h, Cerkauskas 2004, Elphinstone 2005, Hacisalihoglu et al. 2007, Vanitha et al. 2009)
<i>Ralstonia solanacearum</i> race 2, biovar 1 (Smith) Yabuuchi et al.	Africa, Asia, Caribbean, Central America, Guam, Mexico, South America, United States	<i>Heliconia</i> spp., <i>Musa</i> spp.	(CABI/EPPO 1997h, Eyres et al. 2005)
<i>Xanthomonas campestris</i> (Pammel)	Africa, Asia, Canada, Caribbean, Central and South America, Europe, Hawai'i,	<i>Persea americana</i>	(Hayward and Waterston 1965, CAB 1978, Pegg et al. 2002)

	Mexico, United States		
<i>Xanthomonas campestris</i> pv. <i>celebensis</i> (Gäumann)	India, Indonesia	<i>Heliconia</i> spp., <i>Musa</i> spp.	(Bradbury 1986, Eden-Green 1994, Supriadi 2003, Mackie et al. 2007)
<i>Xanthomonas campestris</i> pv. <i>mangiferaeindicae</i> (Patel et al.)	Australia, Brazil, India, Japan, Kenya, New Caledonia, Pakistan, Réunion, South Africa, Southeast Asia, Sudan, Taiwan, United Arab Emirates	<i>Anacardium occidentale</i> , <i>Mangifera indica</i> , <i>Schinus terebinthifolius</i> , <i>Spondias dulcis</i>	(Bradbury 1986, Gagnevin and Pruvost 2001)
<i>Xanthomonas campestris</i> pv. <i>manihotis</i> (Berthet & Bondar)	Africa, Cuba, India, Panama, Southeast Asia, South America	<i>Manihot esculenta</i>	(Bradbury 1986, Lozano 1986)
' <i>Candidatus Liberibacter asiaticus</i> '	China, Indonesia, Belize, Cuba, Iran, Solomon Islands, South America, United States	<i>Citrus</i> spp.	(Da Graca 1991, Gottwald et al. 2007)
Palm lethal yellowing (proposed name: ' <i>Candidatus Phytoplasma palmae</i> ')	Belize, Benin, Cameroon, Caribbean, Ghana, Guyana, Honduras, Mexico, Nigeria, Togo, United States	Arecaceae	(CABI/EPPO 1997g, Harrison and Elliott 2009)
Sweet potato little leaf	Australia, Japan, New Caledonia, Korea, New Guinea, Niue,	<i>Cucurbita maxima</i> , <i>Ipomoea batatas</i> , <i>Solanum lycopersicum</i> ,	(Jackson et al. 1984, Saqib et al. 2006)

	Palau, Solomon Island, Taiwan, Tonga, Vanuatu	<i>Vigna unguiculata</i>	
VIRUSES and VIROIDS			
Viral diseases of plants are second only to fungal infections in terms of economic significance worldwide (Hadidi et al. 1998). Viruses and viroids are often vectored by insects such as aphids, whiteflies, and thrips, but can also be vectored by nematodes and fungi. Virus and viroid infections in plants lead to discoloration, deformation, stunting, reduced vigor, crop losses, and plant death (Hull 2002). If plants become infected with a virus or viroid, the destruction of infected plants is often the only way to control the outbreak (Agrios 2005). The most likely pathway of introduction is infested plant material or the introduction of vector organisms.			
Avocado sunblotch viroid (ASBV)	Australia, Argentina, Ghana, Israel, Mexico, Peru, South Africa, Spain, United States, Venezuela	<i>Persea americana</i>	(Dale et al. 1982, Ploetz et al. 1994, Darvas et al. 1996, Flores et al. 2000, Pegg et al. 2002, Acheampong et al. 2008, De La Torre et al. 2009)
Banana bract mosaic virus (BBrMV)	Central and South America, India, Philippines, Samoa, Sri Lanka, Vietnam	<i>Musa</i> spp.	(Magnaye and Valmayor 1995, Brunt et al. 1996, Thomas and Magnaye 1996, Rodoni et al. 1997)
Banana bunchy top virus (BBTV)	Guam, Hawai'i, southeast Asia, Philippines, Taiwan, numerous islands in the south Pacific, India, and Africa	<i>Musa</i> spp.	(Ferreira et al. 1997; Per. Comm. Englberger)
Bean pod mottle virus (BPMV)	Canada, United States	<i>Desmodium paniculatum</i> , <i>Glycine max</i> , <i>Phaseolus vulgaris</i>	(Brunt et al. 1996, Glesler et al. 2002, Zhang et al. 2009)
Cadang-cadang viroid (CCCVd)	Philippines, Solomon Islands	<i>Cocos nucifera</i> , <i>Corypha elata</i> , <i>Elaeis guineensis</i>	(CABI/EPPO 1997c, Randles 2003, Agrios 2005)

<i>Cassava green mottle virus</i> (CGMV)	Solomon Islands	<i>Manihot esculenta</i>	(Lennon et al. 1987, Frison and Feliu 1991, Brunt et al. 1996)
<i>Cocoa swollen shoot virus</i> (CSSV)	Côte d'Ivoire, Ghana, Nigeria, Sierra Leone, Sri Lanka, Togo	<i>Adansonia digitata</i> , <i>Ceiba pentandra</i> , <i>Cola chlamydantha</i> , <i>Cola gigantea</i> , <i>Sterculia tragacantha</i> , <i>Theobroma cacao</i>	(Brunt 1970, Brunt et al. 1996, ICTVdB Management 2006)
<i>Colocasia bobone disease virus</i> (CBDV)	New Guinea, Solomon Islands	<i>Colocasia esculenta</i>	(Jackson 1978, Zettler et al. 1989, Onwueme 1999, Yang et al. 2003)
<i>Papaya droopy necrosis virus</i> (PDNV)	United States	<i>Carica papaya</i>	(Ploetz et al. 1994, Aires Ventura et al. 2004)
<i>Papaya mosaic virus</i> (PapMV)	South America, United States, and India	<i>Carica papaya</i>	(Pers. Comm. Englberger)
<i>Papaya yellow crinkle virus</i> (PYCV)	Australia	<i>Carica papaya</i>	(Gibb et al. 1996)
<i>Pepino mosaic virus</i> (PepMV)	Canada, Chile, Europe, Peru, United States	<i>Solanum muricatum</i> , <i>Solanum lycopersicum</i>	(Fakhro et al. 2005, EPPO 2006b, Córdoba-Sellés et al. 2007)
<i>Pepper mild mottle virus</i> (PMMoV)	Argentina, Australia, Europe, Japan, United States	<i>Capsicum</i> spp.	(Brunt et al. 1996, Lamb et al. 2001, Zhang et al. 2006a)
<i>Pepper yellow leaf curl virus</i> (PepYLCIV)	Indonesia	<i>Ageratum conyzoides</i> , <i>Capsicum</i> spp., <i>Glycine max</i> , <i>Helianthus annuus</i> , <i>Nicotiana</i> spp., <i>Solanum</i>	(De Barro et al. 2008, Hidayat et al. 2009)

		spp., <i>Vigna</i> spp.	
<i>Tomato spotted wilt virus</i> (TSWV)	Africa, Asia, Australia, Canada, Central and South America, Europe, Mexico, New Zealand, United States	<i>Ananas comosus</i> , <i>Arachis hypogaea</i> , <i>Bidens pilosa</i> , <i>Capsicum annuum</i> , <i>Datura stramonium</i> , <i>Helianthus annuus</i> , <i>Lactuca sativa</i> , <i>Phaseolus vulgaris</i> , <i>Solanum</i> spp., <i>Zinnia elegans</i>	(Zitter et al. 1989, Brunt et al. 1996)
<i>Tomato yellow leaf curl virus</i> (TYLCV)	Africa, Caribbean, Hawai'i, Middle East, United States	<i>Capsicum annuum</i> , <i>Solanum lycopersicum</i> , <i>Solanum melongena</i>	(Navot et al. 1991, Moriones and Navas-Castillo 2000, Melzer et al. 2010)

WEEDS

Agricultural losses due to weeds surpass those caused by any other class of agricultural pest (Pimentel et al. 2001). Weeds may also have enormous ecological impacts by reducing biodiversity, altering fire regimes and hydrological cycles, changing soil chemistry and biology, and promoting siltation or erosion of stream banks and sand dunes. Weeds may also affect human and animal health when they are toxic or cause allergies. Intentional importation of plants for horticultural purposes has been identified as the most important facilitator in the spread of weeds (invasive plants) (Dehnen-Schmutz et al. 2007).

<i>Antigonon leptopus</i>	American Samoa, Fiji, French Polynesia, Guam, Kiribati, RMI, Nauru, CNMI, Palau, Samoa, United States		http://www.issg.org/database/species/distribution.asp?si=203&fr=1&sts=&lang=EN
<i>Bryophyllum daigremontianum</i> (Raym.-Hamet & Perrier) (Crassulaceae)	Australia, Bangladesh, Fiji, Galápagos Islands, Madagascar, New Caledonia, New Zealand,		(McKenzie and Armstrong 1986, Hannan-Jones et al. 2005, Foxcroft et al. 2008, Nahar et al. 2008, USDA NRCS 2009, PIER 2010)

	Niue, RMI, South Africa, United States		
<i>Callisia repens</i> (Jacq.) L. (Commelinaceae)	Caribbean, Central and South America, China, Hawai'i, Mexico, RMI, South Africa, United States		(Velde 2003, Foxcroft et al. 2008, Weber et al. 2008, USDA ARS 2009, Frohlich and Lau 2010)
<i>Centaurea diffusa</i> Lam. (Asteraceae)	Canada, Europe, Mediterranean, United States, Western Asia		(Zouhar 2001a, USDA NAL 2010)
<i>Cirsium arvense</i> (L.) Scop. (Asteraceae)	Australia, Canada, India, Japan, Mediterranean, Middle East, New Zealand, Southeastern Europe, Southern Africa, South America, United States		(Holm et al. 1977, Zouhar 2001b, Kaufman and Kaufman 2007, USDA NAL 2010)
<i>Clidemia hirta</i>	Palau, American Samoa, Fiji, Indonesia, Samoa, United States		http://www.issg.org/database/species/distribution.asp?si=53&fr=1&sts=
<i>Coccinia grandis</i>	Hawai'i, Fiji, French Polynesia, Guam, RMI, FSM, CNMI, Samoa, Tonga, United States		http://www.ctahr.hawaii.edu/inweed/WeedsHI/W_Coccinia_grandis.pdf ; http://www.issg.org/database/species/distribution.asp?si=348&fr=1&sts=&lang=EN
<i>Elymus repens</i> (L.) Gould (Poaceae)	Canada, United States		(Snyder 1992, USDA NAL 2010)

<i>Epipremnum pinnatum</i>	Southeast Asia, United States, Hawai'i, Australia, Fiji, Guam, FSM, RMI, Palau		http://www.cabi.org/isc/?compid=5&dsid=50410&loadmodule=datasheet&page=481&site=144
<i>Jasminum dichotomum</i> Vahl, <i>J. fluminense</i> Vell. (Oleaceae)	Africa, Hawai'i, United States		(IFAS 2007, Kaufman and Kaufman 2007, USDA NRCS 2009)
<i>Lygodium japonicum</i> (Thunb. ex Murr.) Sw. (Lygodiaceae)	Australia, Caribbean, Hawai'i, India, Southeast Asia, United States		(Wilson 2002, Munger 2005, USDA NAL 2010)
<i>Miconia calvescens</i> De Candolle (Melastomataceae)	Hawai'i, French Polynesia, and South America		(Meyer 1996, Medeiros et al. 1997)
<i>Mikania micrantha</i>	American Samoa, Australia, Fiji, French Polynesia, Guam, FSM, CNM, Palau, Papua New Guinea, New Caledonia, Philippines, Thailand, and numerous other Pacific islands		http://www.issg.org/database/species/distribution.asp?si=42&fr=1&sts=
<i>Mimosa diplotricha</i>	Hawai'i, Australia, Other Pacific Islands		http://www.fao.org/forestry/13377-0977cb34791475aa6a7a360640f09778.pdf
<i>Persicaria perfoliata</i> (L.) Gross (= <i>Polygonum</i>)	Canada, East Asia, India, Japan, Philippines,		(Kaufman and Kaufman 2007, Stone 2010, USDA NAL 2010)

<i>perfoliatum</i> L.) (Polygonaceae)	United States		
<i>Piper auritum</i>	Hawai'i, Samoa, Tonga, Florida		(http://www.hear.org/pier/species/piper_auritum.htm ; SPC 2001)
<i>Solidago canadensis</i> L., <i>S. gigantea</i> Aiton (Asteraceae)	Australia, Canada, China, Europe, New Zealand, United States		(Lu et al. 2007, Moroń et al. 2009)
<i>Spathodea campanulata</i>	Southeast Asia, Africa, United States, Mexico, Hawai'i, the Caribbean, South and Central America, Australia, Fiji, Guam, CNMI, RMI, Palau		http://www.cabi.org/isc/?compid=5&dsid=51139&loadmodule=datasheet&page=481&site=144
<i>Syngonium podophyllum</i> Schott (Araceae)	American Samoa, Australia, Central and South America, FSM, Galápagos Islands, Hawai'i, Solomon Islands, South Africa, United States,		(Morgan et al. 2004, Foxcroft et al. 2008, Brunel 2009, PIER 2010)
<i>Tamarix</i> spp. (Tamaricaceae)	Asia, Canada, Europe, United States		(Zavaleta 2000, Kaufman and Kaufman 2007)
<i>Thunbergia grandiflora</i>	Florida, Hawai'i, Australia, Singapore		(Starr et al. 2003)
<i>Tradescantia pallida</i> Rose (Commelinaceae)	Australia, Central America, South Africa, United		(Lampe 1986, Foxcroft et al. 2008, Chimpan and Şipoş 2009, USDA ARS 2009)

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1 **A8 SPECIES ACCOUNTS**

2 **A8.1 Amphibians**

3 **A8.1.1 *Bufo gargarizans***

4 **Common names:** Asiatic toad, common giant toad

5 **Synonymous scientific names:** *Bufo asiaticus*, *Bufo bufo gargarizans*, *Bufo bufo miyakonis*

6 **Adult description:** 56 to 102 mm (2 to 4 in) in length; females larger; spines on the large dorsal
7 tubercles; dark gray to olive to brown dorsal color; three light longitudinal bands; black band extends
8 from parotid to the flank, turning into spots posteriorly; grayish or yellowish venter

9 **Tadpole description:** no information found in the literature

10 **Reproduction:** reproduces in lakes, ponds, swamps, puddles, riverbeds, ditches, and stagnant to slow-
11 flowing water; lays paired strings of 1,200 to 7,400 eggs; metamorphose in summer; sexually mature in
12 3 to 4 years

13 **Habitat:** vegetative cover, in rock crevices, tree hollows, cultivated areas; common in human-inhabited
14 areas; limited by high temperatures and low humidity

15 **Human health impacts:** secrete toxins that can cause severe illness or death if ingested

16 **Economic impacts:** none found in the literature, but undocumented impacts may exist

17 **Ecological impacts:** predation on native fauna

18 **Pathways:** biocontrol; intentional, for education

19 **Control measures:** no information found in the literature

20 **References:** Brubacher et al. 1999; Lever 2003; Liu et al. 2005; Kraus 2009; AmphibiaWeb 2010; Yu et al.
21 2010

22 **A8.1.2 *Bufo melanostictus***

23 **Common names:** Asian black-spotted toad, Asian common toad, Asian eyebrow-ridge toad, black-lipped
24 toad, black-spined toad, common Indian toad, Indian toad, keeled-nosed toad, South Asian garden toad,
25 southeast Asian common toad, spectacled toad

26 **Synonymous scientific names:** *Ansonia kramlei*, *Bufo scaber*, *Bufo tienhoensis*, *Duttaphrynus*
27 *melanostictus*, *Rana dubia*

28 **Adult description:** females more than 150 mm (6 in) in length; several distinct cranial crests; distinct
29 tympanum; double tubercles under third finger only; elliptical parotid; dark spines on tubercles of

1 flanks; 8 to 9 large tubercles along sides of dorsum; gray dorsum with brown to reddish spots; speckled,
2 whitish ventrum; males have an orange or yellow throat during the breeding season

3 **Tadpole description:** 26 to 27 mm (1 in) in length; dark coloration; bufonid body; broad dorsal fin but
4 narrow ventral fin; finely serrated beak; inhabit side pools or puddles; metamorphosis in approximately
5 25 days

6 **Reproduction:** breeds during the rainy season or throughout the year, depending on location; breeds in
7 any available water; males call from shallow pools; male-male competition; lays paired strings of eggs;
8 metamorphosis occurs in about 25 days

9 **Habitat:** Habitat generalist; ponds, paddy fields, low hills, mountains, coastal plains; under stones, logs,
10 dense vegetation, crevices

11 **Human health impacts:** secrete toxins that can cause severe illness or death if ingested; may be a host
12 for the causative agent of human angiostrongyliasis

13 **Economic impacts:** none found in the literature, but undocumented impacts may exist

14 **Ecological impacts:** consumes agricultural pests

15 **Pathways:** boat, cargo

16 **Control measures:** no information found in the literature

17 **References:** Jorgensen et al. 1986; Ding 1988; Saidapur and Girish 2001; Lever 2003; Keomany et al.
18 2007; Kraus 2009; AmphibiaWeb 2010; Frost 2010

19 **A8.1.3 *Eleutherodactylus coqui*:** established in Hawai'i, individuals have been detected and removed
20 from Guam on multiple occasions.

21 **Common names:** coqui frog, Puerto Rican coqui

22 **Synonymous scientific names:** *Eleutherodactylus martinicensis*, *Eleutherodactylus portoricensis*

23 **Adult description:** males approximately 34 mm (1.3 in) snout to vent length; females approximately 41
24 mm (1.6 in) snout to vent length; well-developed pads at the end of the toes; variable coloration with
25 the upper body usually being a grey or grey-brown uniform color; may also have an "M" shape between
26 the shoulders; two broad, light-colored bars running from the snout through the eye to the axilla of the
27 rear legs that is bordered with black spots; a light bar on top of the head between the eyes; underside is
28 usually light-colored and stippled with brown

29 **Reproduction:** breeds year-round; internal fertilization; lays 1 to 2 dozen eggs; do not need water, may
30 construct nests on the ground or use cavities of birds; males care for the clutches; direct development

1 **Habitat:** Habitat generalist; agricultural areas, natural and planted forests, riparian zones, wetlands,
2 urban areas

3 **Human health impacts:** none found in the literature, but undocumented impacts may exist

4 **Economic impacts:** lowering of property values and tourism due to the high noise level associated with
5 calls

6 **Ecological impacts:** increased nutrient cycling, predation on invertebrates causing declines, prey source
7 to potentially support invasive snake populations

8 **Pathways:** cargo, intentional, nursery trade

9 **Control measures:** bans on importation, hand capture, caffeine, citric acid, cargo restrictions and
10 inspections, citric acid spray for imported plants, public education

11 **References:** Bartlett and Bartlett 1999; Campbell and Kraus 2002; Campbell et al. 2002; Kraus and
12 Campbell III 2002; Beard et al. 2003b; Kaiser and Burnett 2006; Christy et al. 2007a; Christy et al. 2007c;
13 Tuttle et al. 2008; Kraus 2009; AmphibiaWeb 2010; ISSG 2010

14 **A8.1.4 *Eleutherodactylus planirostris*:** established on Guam and in Hawai'i

15 **Common names:** greenhouse frog

16 **Synonymous scientific names:** *Eleutherodactylus ricordii*, *Euhyas planirostris*, *Lithodytes ricordii*

17 **Adult description:** males about 19 mm (0.7 in) in length; females may be greater than 25 mm (1 in) in
18 length; rust, orange, or brown skin, dark, with warts and a whitish or gray venter; either mottled
19 markings or light longitudinal stripes; possible dark triangle between the eyes; enlarged finger pads;
20 elongate toe pads which point toward the tips of the toes

21 **Reproduction:** breeds from late spring to early autumn in Florida; males call from the ground or plants
22 and herbs; reproduces in debris or damp holes; lays 1 to 2 dozen eggs; direct development

23 **Habitat:** Habitat generalist; ubiquitous, diverse habitats; woodlands, scrub, yards, gardens, greenhouses
24 and nurseries; beneath boards or natural objects, in crevices

25 **Human health impacts:** none found in the literature, but undocumented impacts may exist

26 **Economic impacts:** none found in the literature, but undocumented impacts may exist

27 **Ecological impacts:** prey source to potentially support invasive snake populations

28 **Pathways:** cargo, nursery trade

29 **Control measures:** caffeine, hydrated lime (no longer allowed), public education

- 1 **References:** Stevenson 1976; Bartlett and Bartlett 1999; Campbell and Kraus 2002; Kraus and Campbell
2 III 2002; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; ISSG 2010
- 3 **A8.1.5 *Fejervarya cancrivora*:** established on Guam
- 4 **Common names:** Asian brackish frog, crab-eating frog, mangrove frog, rice field frog
- 5 **Synonymous scientific names:** *Limnonectes cancrivora*, *Rana cancrivora*
- 6 **Adult description:** information not found
- 7 **Reproduction:** reproduces in any available water
- 8 **Habitat:** Habitat generalist; mangrove forests, estuarine habitats, swamps, wet coastal areas; swales;
9 human-inhabited areas, including rice fields, gardens, and urban areas; can tolerate some salinity
- 10 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 11 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 12 **Ecological impacts:** prey source to potentially support invasive snake populations
- 13 **Pathways:** aquaculture contaminant, food
- 14 **Control measures:** no information found in the literature
- 15 **References:** Zhigang et al. 2004; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009
- 16 **A8.1.6 *Fejervarya limnocharis***
- 17 **Common names:** alpine cricket frog, field frog, rice frog
- 18 **Synonymous scientific names:** *Limnonectes limnocharis*, *Rana limnocharis*
- 19 **Adult description:** 39 to 43 mm (1.5 to 1.7 in) in length; pointed snout projects beyond the mouth;
20 obtuse canthus; width of upper eyelid is wider than the internarial distance, which is longer than the
21 interorbital width; distinct tympanum; fingers pointed, toes with obtuse or swollen tips and slightly
22 webbed; males with mottled brown, loose upper throat and w-shaped marking; gray brown or olive
23 skin; dark “v” between the eyes; yellow stripe down the dorsal midline; white venter
- 24 **Tadpole description:** 26 to 27 mm (1 in) in length; long, oval body; convex venter; tail about twice the
25 body length and pointed; dorsal fin broader in the middle, while ventral fin follows the line of the tail;
26 dark tip on tail
- 27 **Reproduction:** breeds during the rainy season; males call from edges of flowing water; lays batches of
28 eggs adhered to grass

1 **Habitat:** habitat generalist; wetlands, plains, alpine; dense vegetation bordering canals, streams,
2 torrents, ponds, puddles, and rice fields; can tolerate some salinity

3 **Human health impacts:** none found in the literature, but undocumented impacts may exist

4 **Economic impacts:** none found in the literature, but undocumented impacts may exist

5 **Ecological impacts:** prey source to potentially support invasive snake populations

6 **Pathways:** aquaculture contaminant, biocontrol, research, pet trade

7 **Control measures:** no information found in the literature

8 **References:** Hutchins et al. 2003a; van Dijk et al. 2004a; Lee et al. 2006; Christy et al. 2007a; Christy et
9 al. 2007c; Kraus 2009; Wu and Kam 2009; AmphibiaWeb 2010

10 **A8.1.7 *Hyla cinerea***

11 **Common names:** American green tree frog, Carolina tree frog, green tree frog, marsh tree frog

12 **Synonymous scientific names:** *Calamita cinereus*, *Calamita lateralis*, *Hyla blochii*, *Hyla carolinensis*, *Hyla*
13 *lateralis*, *Hyla semifasciata*, *Rana bilineata*, *Rana lateralis*

14 **Adult description:** 44.5 to 63.5 mm (1.8 to 2.5 in) in length; females larger; slender body; legs one and a
15 half times the head and body length; pointed head, flat between the eyes; large eyes extend laterally;
16 skin fold over the bronze-colored tympanum to the shoulder; slight webbing of toes; large disks on
17 fingers and toes; bold yellow green to gray green on the dorsum with a white or yellow line along the
18 sides of the head and body; similar colored bands on the posterior of the arm and anterior and posterior
19 of the legs; lower jaw dark; whitish venter; pale yellow throat; can change color from light to dark

20 **Tadpole description:** 4.5 to 5.5 mm (0.2 in) in length at hatching; 60 mm (2.4 in) in length at
21 metamorphosis; color changes throughout development; blotches eventually form the lateral bands; in
22 later stages body is green, venter is yellow to buff, and the long tail is mottled yellow; arched dorsal fin;
23 bulging eyes

24 **Reproduction:** reproduces in floating or emergent vegetation; lays eggs in clutches of 478 to 3,946 eggs;
25 metamorphose in 24 to 45 days

26 **Habitat:** habitat generalist; coastal lowlands, ponds, lakes, swamps, marshes, sloughs, dry streambeds,
27 cultivated areas; water margins; perches on broad leaves

28 **Human health impacts:** none found in the literature, but undocumented impacts may exist

29 **Economic impacts:** none found in the literature, but undocumented impacts may exist

30 **Ecological impacts:** vector of a disease of weedy plants

1 **Pathways:** aquaculture contamination, cargo, nursery trade, pet trade

2 **Control measures:** no information found in the literature

3 **References:** Dickerson 1969; Garton and Brandon 1975; Stevenson 1976; Layne Jr. et al. 1989; Wygoda
4 and Williams 1991; Wygoda and Garman 1993; Lever 2003; Gunzburger 2006; Kraus 2009;
5 AmphibiaWeb 2010; Frost 2010

6 **A8.1.8 *Kaloula picta***

7 **Common names:** painted narrow-mouth toad, slender-digit chorus frog

8 **Synonymous scientific names:** *Callula picta*, *Plectropus pictus*

9 **Adult description:** males 32.8 to 51.2 mm (1.3 to 2 in) in length, with an average of 39.6 mm (1.6 in);
10 females 34.7 to 56.1 mm (1.4 to 2.2 in) in length, with an average of 42.2 mm (1.7 in); females larger on
11 average; dorsal tubercles present; prominent, pointed outer metatarsal tubercle; lateral glandular ridge;
12 glandular venter; stratified coloration on flank and posterior thigh; may have spots on the lower back

13 **Reproduction:** breeds May through February, beginning with the rainy season, and peaks July through
14 October; males call from the water; reproduces in ephemeral pools; lays 812 to 4,029 eggs; one clutch
15 per female per year; eggs hatch within 13 to 15 hours; 3.1-3.3 mm (0.1 in) in length at hatching;
16 metamorphose in 18 days

17 **Habitat:** forests, shrublands, grasslands, wetlands, tropics; most common in human-inhabited areas,
18 including agricultural lands, ditches, artificial ponds, gardens, and urban areas; burrows or hides in logs,
19 dropped coconuts, or stones

20 **Human health impacts:** none found in the literature, but undocumented impacts may exist

21 **Economic impacts:** none found in the literature, but undocumented impacts may exist

22 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

23 **Pathways:** boat, cargo

24 **Control measures:** no information found in the literature

25 **References:** Cendaña and Fermin 1940; Diesmos et al. 2002; Diesmos et al. 2004a; Christy et al. 2007a;
26 Christy et al. 2007c; Kraus 2009; Frost 2010

27 **A8.1.9 *Kaloula pulchra***

28 **Common names:** Asian painted frog, banded bullfrog, beautiful kaloula, Malayan narrow-mouthed frog,
29 Malaysian narrow-mouth toad, Malaysian painted frog, ox frog, painted balloon frog, painted bullfrog,
30 painted burrowing frog, painted microhylid frog, piebald digging frog

1 **Synonymous scientific names:** *Callula macrodactyla*, *Callula pulchra*, *Kaloula aureata*, *Kaloula*
2 *macrocephala*

3 **Adult description:** 54 to 75 mm (2.1 to 3 in) in length; females larger; robust body with short, thick hind
4 legs; rounded snout; two spades on feet for digging; lacks a cervical vertebrae; generally smooth skin;
5 dark grey, light brown or pinkish skin with a large brown spot over much of the back; two large, irregular
6 light-colored bands running from the eye to the groin; snout tan; whitish to yellow brown venter with
7 brown spots; males have a black throat; inflates body when threatened

8 **Reproduction:** breeds during the rainy season or year-round, depending on climate; males call while
9 floating in the water; reproduces in small pools or ponds; rapid larval growth

10 **Habitat:** habitat generalist; wetlands, riverbanks, dry forests; burrow or hide in vegetation; human-
11 inhabited areas, including agricultural, residential, and urban areas; commensal, no longer found in
12 undisturbed habitats

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** possible predation on native fauna, due to its generalist habits; potential carrier of
16 chytridiomycosis; possible competition with native anurans

17 **Pathways:** aircraft, boat, cargo, intentional, pet trade

18 **Control measures:** no information found in the literature

19 **References:** Heyer 1973; Hutchins et al. 2003a; Kuangyang et al. 2004b; Hou et al. 2006; Christy et al.
20 2007a; Christy et al. 2007c; Tyler and Chapman 2007; Page et al. 2008; Kraus 2009; AmphibiaWeb 2010;
21 Frost 2010

22 **A8.1.10 *Limnodynastes tasmaniensis***

23 **Common names:** marbled frog, spotted grass frog, spotted marsh frog

24 **Synonymous scientific names:** *Limnodynastes peronii* var. *tasmaniensis*, *Limnodynastes tasmanicus*

25 **Adult description:** maximum 48 mm (1.9 in) in length; generally Rana-like appearance; green to olive-
26 gray back with dark blotches; white venter; dark line from snout to arm; dark spots anteroventral to the
27 eye; light ridge from the upper jaw to the top of the foreleg; usually a white stripe along the midline of
28 the dorsum; smooth to slightly rough skin; very little webbing on toes

29 **Tadpole description:** dark dorsum with gold spots on the ventrum of the tail

1 **Reproduction:** breeds year-round, with peaks August through March; males call from vegetation on
2 edges of shallow water; aquatic; reproduces in grassy ditches, small pools, grassy marshes, and shallow
3 ponds; lays foam nests of 90 to 1,350 eggs adhering to vegetation; metamorphose in 3 to 5 months or
4 less; sexually mature at 80 to 100 days after metamorphosis

5 **Habitat:** habitat generalist; streams, lakesides, marshes, shrublands; under logs, stones, or debris

6 **Human health impacts:** none found in the literature, but undocumented impacts may exist

7 **Economic impacts:** none found in the literature, but undocumented impacts may exist

8 **Ecological impacts:** known to carry chytridiomycosis, a possible threat to native anurans

9 **Pathways:** cargo

10 **Control measures:** no information found in the literature

11 **References:** Moore 1961; Hutchins et al. 2003a; Hero et al. 2004b; Kraus 2009; AmphibiaWeb 2010;
12 Frost 2010

13 **A8.1.11 *Litoria aurea***

14 **Common names:** golden bell frog, golden frog, golden tree frog, green frog, green and golden bell frog,
15 green and golden swamp frog

16 **Synonymous scientific names:** *Auletris jacksoniensis*, *Hyla aurea*, *Hyla jacksoniensis*, *Hyla jacksonii*, *Rana*
17 *aurea*, *Ranoidea aurea*, *Ranoidea jacksoniensis*, *Ranoidea resplendens*, *Ranoidea ulongae*

18 **Adult description:** about 55 to 108 mm (2 to 4.3 in) in length; females larger; glandular stripe from the
19 mouth to the base of the forearm; fleshy webbing on toes and disks on fingers and toes; cream or yellow
20 fold extending from the eye almost to the groin; fold on chest; sides and abdomen have a rough texture;
21 prominent, gold tympanum; smooth, bright green dorsum with brown blotches; white venter; males
22 have a yellowish throat

23 **Tadpole description:** large at metamorphosis; high tail fin; heavily pigmented

24 **Reproduction:** breed in mid-spring to summer, peaking October-March; males call from water; lays a
25 mat of 2,400 to 11,600 eggs; hatch in 2 to 3 days; metamorphose in about 2, but up to 11, months

26 **Habitat:** habitat generalist; ponds, lakes, streams, grassy marshes, swamps, low-lying grasslands, forest
27 clearings, agricultural lands; prefers isolated, still, shallow, and pristine waters; perches in emergent
28 vegetation

29 **Human health impacts:** carries the pathogen which causes eosinophilic meningitis (EM) in humans

30 **Economic impacts:** none found in the literature, but undocumented impacts may exist

1 **Ecological impacts:** predation on native skinks and other vertebrates; known to carry chytridiomycosis, a
2 possible threat to native anurans

3 **Pathways:** biocontrol, cargo, intentional, pet trade, possibly as food for ducks

4 **Control measures:** no information found in the literature

5 **References:** Moore 1961; Pyke and White 1996, 2001; Lever 2003; Hero et al. 2004d; Vörös et al. 2008;
6 Kraus 2009; AmphibiaWeb 2010; Frost 2010; ISSG 2010

7 **A8.1.12 *Litoria caerulea***

8 **Common names:** Australian green tree frog, Australian tree frog, blue frog, great green tree frog, green
9 tree frog, smiling frog, White's tree frog

10 **Synonymous scientific names:** *Calamita cyanea*, *Calamites coreulea*, *Hyla caerulea*, *Hyla coerulea*, *Hyla*
11 *cyaneus*, *Litoria irrorata*, *Pelodyras caeruleus*, *Pelodyras irrorata*, *Rana austrasiae*, *Rana caerulea*, *Rana*
12 *coerulea*

13 **Adult description:** about 72.4 to 97.7 mm (2.8 to 3.8 in) in length; dorsum solid, leaf green to greenish
14 brown; white venter with greenish throat; anterior and posterior of the thigh is tan or yellow-green;
15 occasionally white spots on the dorsum; large glandular ridge of skin between the eye and shoulder;
16 prominent tympanum; fingers slightly webbed, toes heavily webbed

17 **Reproduction:** breeds October to January in Australia; males call from hiding spots near water;
18 reproduces in ponds; lays clusters of 100 to 200 eggs, with 2,000 to 3,000 eggs total; metamorphose in 6
19 weeks

20 **Habitat:** habitat generalist; deserts, woodlands, grasslands, shrublands, rain forests; often in human-
21 inhabited areas, near buildings or objects holding water; perches on or hides in various objects; does not
22 need a water body, can withstand severe droughts

23 **Human health impacts:** none found in the literature, but undocumented impacts may exist

24 **Economic impacts:** none found in the literature, but undocumented impacts may exist

25 **Ecological impacts:** known to carry chytridiomycosis, a possible threat to native anurans

26 **Pathways:** biocontrol, cargo, intentional, pet trade

27 **Control measures:** no information found in the literature

28 **References:** Moore 1961; Main and Bentley 1964; Buttemer 1990; Christian and Parry 1997; Bartlett and
29 Bartlett 1999; Lever 2003; Hero et al. 2004e; Berger et al. 2005; Kraus 2009; AmphibiaWeb 2010; Frost
30 2010

1 **A8.1.13 *Litoria chloris***

2 **Common names:** Australian red-eyed tree frog, north coast green tree frog, red-eyed green tree frog,
3 red-eyed tree frog, southern orange-eyed tree frog

4 **Synonymous scientific names:** *Dryomantis chloris*, *Hyla chloris*

5 **Adult description:** about 52.7 to 65 mm (2 to 2.6 in) in length; distinct tympanum with a ridge from the
6 eye across the dorsal side of the membrane; rounded canthus; webbed fingers and toes with large disks;
7 leaf green dorsum; white to bright yellow venter; purplish or brown posterior of thigh; inner portion of
8 hands is yellow, whereas the outer portion is green; red eyes

9 **Tadpole description:** medium sized; coloration is light grey to dark brown; may have gold along the
10 sides

11 **Reproduction:** breeds during heavy rains in spring and summer, October to February; males call from
12 the ground or shallow pools beside streams; reproduces in flooded spots, mountain streams, and
13 grasslands; lays single egg or clumps of eggs within vegetation; each female lays over 1,000 eggs per
14 year; sexually mature in 2 to 3 years

15 **Habitat:** coastal rain forests, wet sclerophyll forests, and human-inhabited areas, especially in objects
16 holding water; perches high in trees

17 **Human health impacts:** none found in the literature, but undocumented impacts may exist

18 **Economic impacts:** none found in the literature, but undocumented impacts may exist

19 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

20 **Pathways:** cargo, intentional

21 **Control measures:** no information found in the literature

22 **References:** Moore 1961; Hero et al. 2004c; Morrison et al. 2004a; FAN 2006; Kraus 2009; AmphibiaWeb
23 2010; Frost 2010

24 **A8.1.14 *Litoria ewingii***

25 **Common names:** Australian brown tree frog, brown tree frog, Ewing's tree frog, southern brown tree
26 frog, whistling tree frog

27 **Synonymous scientific names:** *Hyla ewingi*, *Hyla inguinalis*, *Rawlinsonia calliscelis*, *Rawlinsonia ewingi*,
28 *Rawlinsonia parvidens*

29 **Adult description:** 26 to 50 mm (1 to 2 in) in length; short legs and a broad head; toes with small disks
30 and very slight webbing; distinct tympanum; grey to dark brown, smooth dorsum; brown to black patch

- 1 on back extending from between the eyes to the cloaca, often with a light stripe down the midline;
2 white stripe extending from the snout, through the eye and tympanum, to the base of the forelegs;
3 whitish venter; ventral side of thighs bright orange
- 4 **Reproduction:** breeds year-round; males call from the ground or short emergent or floating vegetation;
5 reproduces in still water of various water bodies; lays clumps of eggs, with 500 to 700 eggs total,
6 attached to vegetation below the water surface; metamorphosis varies from 7 to 8 weeks to 6 to 7
7 months
- 8 **Habitat:** habitat generalist; moist environments; streams, lakesides, woods, shrublands, rain forests,
9 alpine lakes and meadows, and human-inhabited areas, including gardens, pasturelands, and urban
10 areas
- 11 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 12 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 13 **Ecological impacts:** known to carry chytridiomycosis, a possible threat to native anurans
- 14 **Pathways:** biocontrol, cargo, intentional, pet releases
- 15 **Control measures:** no information found in the literature
- 16 **References:** Moore 1961; Lever 2003; Hero et al. 2004a; Pauza and Driessen 2008; Kraus 2009;
17 AmphibiaWeb 2010; Frost 2010
- 18 **A8.1.15 *Litoria fallax*:** Established on Guam
- 19 **Common names:** dwarf tree frog, Eastern dwarf tree frog, Eastern sedgefrog
- 20 **Synonymous scientific names:** *Dryomantis fallax*, *Dryomantis glauerti*, *Hyla bicolor glauerti*, *Hyla*
21 *glauerti*, *Hylomantis fallax*, *Litoria glauerti*
- 22 **Adult description:** information not found
- 23 **Reproduction:** breeds during heavy rains of summer; lays clumps of eggs attached to vegetation below
24 the water surface
- 25 **Habitat:** vegetation on margins of swamps, streams, lagoons, ponds, and farm dams; dense populations
- 26 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 27 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 28 **Ecological impacts:** prey source to potentially support invasive snake populations

1 **Pathways:** aircraft, cargo, escape

2 **Control measures:** no information found in the literature

3 **References:** Lever 2003; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; AmphibiaWeb 2010; Frost
4 2010

5 **A8.1.16 *Microhyla pulchra*:** Established on Guam

6 **Common names:** beautiful pygmy frog, Guangdong rice frog, marbled pygmy frog, painted chorus frog,
7 painted frog, yellow-legged narrow-mouthed frog, yellow-legged pigmy frog

8 **Synonymous scientific names:** *Diploelma pulchrum*, *Engystoma pulchrum*, *Microhyla hainanensis*,
9 *Microhyla major*, *Microhyla melli*, *Microhyla pulchrum*, *Ranina symmetrica*, *Scaptophryne labyrinthica*

10 **Adult description:** about 32 mm (1.3 in) in length; slender with a prominent snout; distance between
11 the upper eyelids does not exceed the interorbital space; lacks disks on digits but has some webbing on
12 toes; large subarticular tubercles; generally smooth, olive, grey, or pinkish brown dorsum; a thin, dark
13 bar between the eyes; dark band extending from the eye to the flank; nested v-shaped markings on the
14 back, with the arms of the v's often breaking up into spots; barred markings on legs; yellowish white
15 venter, with mottling on the throat and chest

16 **Reproduction:** breeds during the rainy season, April to October; reproduces in ephemeral pools, ponds,
17 and paddy fields; metamorphose in about 23 days

18 **Habitat:** habitat generalist; common in forest edges; ponds, mud, brackish marshes, grasslands, and
19 human-inhabited areas including gardens, fields and plantations

20 **Human health impacts:** none found in the literature, but undocumented impacts may exist

21 **Economic impacts:** none found in the literature, but undocumented impacts may exist

22 **Ecological impacts:** prey source to potentially support invasive snake populations

23 **Pathways:** aquaculture contaminant

24 **Control measures:** no information found in the literature

25 **References:** Boring 1934; van Dijk et al. 2004b; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009;
26 Frost 2010

27 **A8.1.17 *Osteopilus septentrionalis***

28 **Common names:** Cuban tree frog, giant tree frog

29 **Synonymous scientific names:** *Hyla dominicensis*, *Hyla septentrionalis*

1 **Adult description:** males 27 to 89 mm (1 to 3.5 in) , and some up to 100 mm (4 in) in length; females 52
2 to 165 mm (2 to 6.5 in) in length; usually warts on dorsum; rounded snout; prominent tympanum; pale
3 green, gray, light brown, or reddish brown to bronze skin; dark reticulations or elongate markings,
4 possibly with lighter cream or yellow markings on the flanks; venter whitish; gray throat common in
5 males; large finger disks with basal webbing; skin on top of head co-ossified with the skull, forming a
6 casque

7 **Tadpole description:** 32 mm (1.3 in) in length; large; ovoid body; small, anteroventral mouth; caudal fins
8 high with pointed tip; black body with grayish caudal musculature; black or brown spots on fins

9 **Reproduction:** breeds throughout the rainy season although males are reported to breed on only a
10 single day; population increases dramatically post-breeding; males call from elevated sites, such as in
11 bushes or trees; reproduce in ephemeral ponds, flooded areas, ditches, swimming pools, and fountains;
12 lays clusters of 25 to 75 eggs, up to more than 200 eggs total

13 **Habitat:** habitat generalist; low to moderate elevations; humid habitats; under objects or in plants;
14 human-inhabited areas, including urban areas, city parks, swimming pools, and gardens

15 **Human health impacts:** skin secretions may cause irritation to mucous membranes in humans; mating
16 calls may be annoying

17 **Economic impacts:** clogged drains; water contamination; cause of short circuits in transformers

18 **Ecological impacts:** predation of native frogs

19 **Pathways:** boat, cargo, intentional, nursery trade, pet trade, vehicle, on/in construction materials

20 **Control measures:** early detection, exclusion, hand capture with euthanasia, plant fumigation

21 **References:** Allen and Neill 1953; Stevenson 1976; Carmichael and Williams 1991; Bartlett and Bartlett
22 1999; Townsend et al. 2000; Savage 2002; Bomford et al. 2005; Owen 2005; Smith 2005; Platenberg and
23 Boulon Jr. 2006; Vargas Salinas 2006; Varnham 2006; Anguilla National Trust 2007; Campbell 2007;
24 Johnson 2007; Hedges et al. 2008; Kraus 2009; Perry 2009; Frost 2010; ISSG 2010

25 **A8.1.18 Polypedates leucomystax**

26 **Common names:** Asian brown tree frog, banana frog, bamboo tree frog, common tree frog, four-lined
27 tree frog, golden foam-nest frog, golden tree frog, jar tree frog, Java whipping frog, Malayan house frog,
28 perching frog, striped tree frog, white-lipped tree frog

29 **Synonymous scientific names:** *Hyla leucomystax*, *Hyla quadrilineata*, *Hyla sexvirgata*, *Polypedates*
30 *rugosus*, *Polypedates teraiensis*, *Rhacophorus maculatus leucomystax*

- 1 **Adult description:** males 50 mm (2 in) in length; females 80 mm (3 in) in length; dorsum various shades
2 of brown; markings range from spots to longitudinal stripes; is able to change color, from light during
3 the day to darker at night
- 4 **Tadpole description:** about 6 to 14 mm (0.2 to 0.6 in) in length; lateral eyes
- 5 **Reproduction:** can breed year-round, depending on climate, but peaks during the rainy season; aquatic;
6 males call from water margins and/or perches in vegetation; reproduces in ephemeral pools; lays a foam
7 nest of 100 to 400 eggs, attached to vegetation; metamorphose in 28 to 33 days
- 8 **Habitat:** habitat generalist; wetlands, forests, edge habitats, beaches, and human-inhabited areas,
9 including agricultural lands, ditches, urban areas, garden ponds, and buildings; commensal
- 10 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 11 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 12 **Ecological impacts:** possible competition with endemic anuran species
- 13 **Pathways:** aircraft, boat, cargo
- 14 **Control measures:** no information found in the literature
- 15 **References:** Heyer 1973; Diesmos et al. 2004b; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009;
16 Kuraishi et al. 2009; AmphibiaWeb 2010; Frost 2010
- 17 **A8.1.19 *Polypedates megacephalus*:** Established on Guam
- 18 **Common names:** Hong Kong whipping frog, hour-glass-marked tree frog, spot-legged tree frog, white-
19 lipped tree frog
- 20 **Synonymous scientific names:** *Polypedates maculates* var. *unicolor*, *Rhacophorus leucomystax*
21 *megacephalus*
- 22 **Adult description:** 40 to 66 mm (1.6 to 2.6 in) in length; x-shaped markings or 4 longitudinal stripes
- 23 **Reproduction:** breeds March to September (in native range); reproduces in shallow, still water with
24 aquatic vegetation; lays foam nests of 300 to 400 eggs, in vegetation overhanging water
- 25 **Habitat:** habitat generalist; wetlands, ponds, marshes, tropical forests, grasslands, shrublands, bamboo
26 groves, and cultivated fields, orchards; dense vegetation;
- 27 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 28 **Economic impacts:** none found in the literature, but undocumented impacts may exist

- 1 **Ecological impacts:** prey source to potentially support invasive snake populations
- 2 **Pathways:** aquaculture contaminant
- 3 **Control measures:** no information found in the literature
- 4 **References:** Lazell et al. 1999; Lau et al. 2004; Lee et al. 2006; Christy et al. 2007a; Christy et al. 2007c;
5 Wu et al. 2007; Kraus 2009; Frost 2010
- 6 **A8.1.20 *Pseudacris regilla***
- 7 **Common names:** Cascade mountain tree frog, northern pacific tree frog, Oregon wood frog, Pacific
8 chorus frog, Pacific hyla, Pacific tree frog, Pacific tree-toad, western Oregon tree frog
- 9 **Synonymous scientific names:** *Hyla regilla*, *Hyla scapularis*, *Pseudacris pacifica*
- 10 **Adult description:** males 25.5 to 48 mm (1 to 1.9 in) in length; females 25 to 47 mm (1 to 1.9 in) in
11 length; toes with large disks and webbing; gray to green to brown dorsum; black stripe extending from
12 the snout, through the eye, to the shoulder; commonly a triangular mark on the head and dark spots
13 across the back and legs; bands or blotches on legs; able to change colors in different environments;
14 males have a wrinkled throat
- 15 **Tadpole description:** 45 to 55 mm (1.8 to 2.2 in) in length at metamorphosis; deep-bodied with a tail
16 twice the body length; black, yellowish brown, or dark brown coloration with black spots; whitish venter
17 with a bronze tint
- 18 **Reproduction:** breeds January to July; aquatic; males call from ponds; male-male competition;
19 reproduces in still or slow-moving waters, often with vegetation; lays clusters of 9 to 80 eggs, with 400
20 to 750 eggs total, often attached to submerged vegetation; each female may lay more than 3 clutches
21 per year; eggs hatch in 1 to 5 weeks; metamorphose in about 2 to 2.5 months; sexually mature in less
22 than 1 year to 2 years
- 23 **Habitat:** habitat generalist; springs, oases, rivers, ponds, marshes, sloughs, forests, grasslands, deserts,
24 and human-inhabited areas, including ditches, plant nurseries, livestock water tanks, and other
25 agricultural areas; most time spent on the ground under vegetation or other cover
- 26 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 27 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 28 **Ecological impacts:** known to carry chytridiomycosis, a possible threat to native anurans; may compete
29 with California tree frogs
- 30 **Pathways:** agricultural trade, cargo, intentional, nursery trade, pet trade

1 **Control measures:** no information found in the literature

2 **References:** Dickerson 1969; Fellers et al. 2001; Rorabaugh et al. 2004; Christy et al. 2007a; Christy et al.
3 2007c; Kraus 2009; AmphibiaWeb 2010; Frost 2010; Somma 2010b

4 **A8.1.21 *Rana catesbeiana***

5 **Common names:** American bullfrog, bullfrog

6 **Synonymous scientific names:** *Lithobates catesbeianus*, *Rana catesbeana*, *Rana catesbyana*

7 **Adult description:** the largest frog in North America; about 101.6 to 165.1 mm (4 to 6.5 in) in length,
8 with a record of 203.2 mm (8 in); skin is various shades of green to dark black; lighter venter; sides of
9 face and lips bright green; may have dark spots on forelimbs and/or bands on hind limbs; yellow throats
10 common in males, whereas females have white throats; has a ridge from the eye down to the top of the
11 foreleg; the longest toe extends beyond the webbing of the foot

12 **Tadpole description:** up to 76.2 mm (3 in) in length; stippled olive with lateral lines and a lighter venter

13 **Reproduction:** males call from sides of water on floating vegetation; male-male competition during the
14 breeding season; aquatic; reproduces in vegetation-choked shallows; lays rafts of up to 20,000 eggs;
15 hatch in 3 to 5 days; metamorphose in 2 months to 2 years, depending on climate

16 **Habitat:** habitat generalist; ponds, lakes, swamps, large ditches, wetlands, canals, slow rivers and
17 oxbows, rice fields, garden ponds; can withstand high salinity

18 **Human health impacts:** none found in the literature, but undocumented impacts may exist

19 **Economic impacts:** consumes agricultural pest insects; damage to aquaculture;

20 **Ecological impacts:** predation on native fauna, especially other herptiles; competition with native
21 anurans, in both larval and adult stages; possible disease transmission to native fauna

22 **Pathways:** aquaculture contaminant, biocontrol, farming/hunting for human consumption, intentional,
23 lab release, pet trade, natural dispersal

24 **Control measures:** Early detection; shooting; use of spears, bow and arrow, clubs, nets, traps; angling;
25 electrofishing; hand capture; fencing; collection of egg masses; draining ponds and excavating
26 sediments; public education; bans on importation

27 **References:** Bartlett and Bartlett 1999; Lever 2003; Kraus 2009; Santos-Barrera et al. 2009;
28 AmphibiaWeb 2010; ISSG 2010

29 **A8.1.22 *Rana guentheri*:** Established on Guam

30 **Common names:** Guenther's amoy frog, Guenther's frog, Guenther's red-and-black frog, barking frog

1 **Synonymous scientific names:** *Hylarana guentheri*, *Rana elegans*, *Sylvirana guentheri*

2 **Adult description:** males 65 to 74 mm (2.6 to 2.9 in) in length; females 61 to 74 mm (2.4 to 2.9 in) in
3 length; flat head with protruding snout; noticeable maxillary glands at the corners of the mouth; fold
4 extending from the tympanum to the shoulder; flattened dorsolateral folds extending from the eye to
5 the hip; robust limbs, with hind limbs up to 1.5 times the total body length; lacks disks on fingers and
6 toes; smooth skin, excepting the posterior; dark mustard to olive or red brown dorsum; yellowish brown
7 to brown dorsum; black marks along the longitudinal folds; lateral black spots; stripes on outside of legs
8 and dark spots on posterior of legs; white venter; metallic platinum to gold upper lip

9 **Tadpole description:** dorsolateral eyes; narrow mouth; relatively high tail fin; speckled grayish green
10 coloration; pointed, speckled brown tail

11 **Reproduction:** breeds May to June; reproduces in still water bodies; lays clutches of 2,000 to 3,000 eggs;
12 females lay once per year; metamorphose in 45 to 60 days

13 **Habitat:** habitat generalist; lowlands, shrublands, grasslands, riverbanks, ponds, marshes, pools, ditches,
14 and paddy fields; disturbed habitats; hides in aquatic vegetation

15 **Human health impacts:** carries the pathogen which causes eosinophilic meningitis (EM) in humans

16 **Economic impacts:** none found in the literature, but undocumented impacts may exist

17 **Ecological impacts:** prey source to potentially support invasive snake populations

18 **Pathways:** aquaculture contaminant

19 **Control measures:** no information found in the literature

20 **References:** Alicata 1991; Lazell et al. 1999; Kuangyang et al. 2004a; Christy et al. 2007a; Christy et al.
21 2007c; Lv et al. 2008; Kraus 2009; AmphibiaWeb 2010; Frost 2010

22 **A8.1.23 *Rana nigromaculata***

23 **Common names:** dark-spotted frog, black-spotted pond frog

24 **Synonymous scientific names:** *Pelophylax nigromaculatus*, *Pelophylax nigromaculata*, *Rana esculenta*

25 **Adult description:** vomerine teeth; posterior part of tongue free and forked; toes webbed; horizontal
26 pupil; dorsal coloration grey, grayish-olive, olive to green with large dark spots which are sometimes
27 absent; numerous longitudinal wrinkles between the dorso-lateral folds; light middorsal line and two
28 lines on dorso-lateral folds usually present; no temporal spot; belly white, sometimes with small amount
29 of dark spots on throat; males differ from females by having white vocal sacs behind the mouth angles
30 and nuptial pads on the first finger

- 1 **Tadpole description:** no information found in the literature
- 2 **Reproduction:** occurs soon after emerging from hibernation; axillary amplexus; 600 to 5,000
3 eggs/clutch; metamorphosis depends on latitude and altitude but occurs between May and August;
4 sexually mature at 2 years
- 5 **Habitat:** habitat generalist; meadows; deserts; forests; shrublands; grasslands; wetlands; pastures;
6 gardens; urban areas; artificial ponds; prefers stagnant water; hibernate in winter
- 7 **Human health impacts:** carrier of the *Spirometra* tapeworm that causes human sparganosis
- 8 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 9 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 10 **Pathways:** food, aquaculture, pet trade
- 11 **Control measures:** no information found in the literature
- 12 **References:** Kuzmin et al. 2004; Li et al. 2009; AmphibiaWeb 2010; Frost 2010
- 13 **A8.1.24 *Rana sylvatica***
- 14 **Common names:** wood frog
- 15 **Synonymous scientific names:** *Lithobates sylvaticus*, *Rana maslini*, *Rana pennsylvanica*, *Rana*
16 *temporaria*
- 17 **Adult description:** 37 to 83 mm (1.5 to 3.3 in) in length; females larger; large dorsolateral folds
18 extending from the eye to the cloaca, with the lateral edge darker than the medial edge; additional,
19 shorter folds along the back; webbed toes; gray to tan to bright reddish brown or golden dorsum; dark
20 marking possible on back and sides; some populations have a white line down the dorsal midline; wide,
21 dark marking from the snout to the tympanum; white, sometimes mottled, venter with a dark pectoral
22 mark
- 23 **Tadpole description:** 50 to 60 mm (2 to 2.4 in) in length at metamorphosis; larger individuals are
24 cannibalistic
- 25 **Reproduction:** breeds after first rains of late winter to early spring, varies from January to June by
26 latitude; aquatic; reproduces in ephemeral pools or ponds; eggs deposited communally; lays clutches of
27 500 to 1,500 eggs each; metamorphose in 65 to 130 days; males sexually mature at 1 to 2 years, females
28 at 2 to 3 years
- 29 **Habitat:** habitat generalist; forests, tundra, subalpine woodlands, willow stands, moist meadows,
30 swamps, and human-inhabited areas; can be far from water sources; terrestrial hibernator

- 1 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 2 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Ecological impacts:** may be a carrier for ranavirus and *Batrachochytrium dendrobatidis* that can infect
4 and kill other amphibians
- 5 **Pathways:** biocontrol, cargo, research
- 6 **Control measures:** no information found in the literature
- 7 **References:** Light 1991; Ouellet et al. 2005; Harp and Petranka 2006; Muir et al. 2007; Kraus 2009;
8 AmphibiaWeb 2010; Frost 2010
- 9 **A8.1.25 *Rhinella marina***
- 10 **Common names:** cane toad, giant toad, marine toad
- 11 **Synonymous scientific names:** *Bufo aqua*, *Bufo marinus*, *Bufo strumosus*, *Chaunus marinus*, *Rana*
12 *marina*
- 13 **Adult description:** heavy body with short legs; up to 150 mm (6 in) in length; weight of females up to 1.5
14 kg (3.3 pounds); females larger; toes are webbed but fingers are not; large cranial crests; has tarsal
15 folds; tan, brown, dark brown, dull green, or black skin with warts; mottled coloration in females; venter
16 mottled whitish color; large parotid glands
- 17 **Tadpole description:** 10 to 25 mm (0.4 to 1 in) in length; ovoid body; subterminal mouth; short tail with
18 pointed caudal fin; dark brown or black body and tail
- 19 **Reproduction:** breeds throughout the rainy season (April to November in Costa Rica); males call from
20 edges of water bodies; strong male-male competition in populations with high densities; reproduce in
21 shallow water with little cover; lays paired strings of 2,500 to 12,500 eggs; hatch in 36 hours to 4 days;
22 metamorphose in 14 to 80 days
- 23 **Habitat:** all lowland and premontane zones, particularly disturbed areas; subtropical forests close to
24 fresh water, rainforests, man-made ponds, gardens, drain pipes, debris, under cement piles and boards,
25 houses, and disturbed areas; able to withstand a high level of salinity; can withstand a broad
26 temperature range
- 27 **Human health impacts:** secrete toxins (bufotenine toxin) from parotid glands that can cause serious
28 illness or death and human fatalities have occurred; reservoirs for *Leptospira interrogans* that causes
29 Weil's disease (infectious jaundice) in humans; calls may disturb sleep
- 30 **Economic impacts:** toxify livestock water sources where they breed and die

- 1 **Ecological impacts:** will eat most anything; competition with native species
- 2 **Pathways:** biocontrol, cargo, seafreight (container/bulk), intentional, natural dispersal, pet trade,
3 vehicles, water currents, zoo trade
- 4 **Control measures:** public education, exclusion; research being conducted: use of parasites and viral
5 vectors, pheromones
- 6 **References:** Hinckley 1963; Pernetta and Watling 1979; Brandt and Mazzotti 1990; Catling et al. 1999;
7 Crossland 2000; Lever 2001; Christy et al. 2007a; Kraus 2009; ISSG 2010
- 8 **A8.2 Birds:** an important species for Micronesia which is not included in this list is the Eurasian
9 Tree Sparrow which is established on various islands within Micronesia including Guam.
10 Various other species could readily be added to this list.
- 11 **A8.2.1 *Columba livia*:** established on numerous islands in the region and the broader Pacific
- 12 **Common names:** common pigeon, domestic pigeon, feral pigeon, rock dove
- 13 **Synonymous scientific names:** no information found in the literature
- 14 **Adult description:** 29 to 36 cm (11.6 to 14.4 in), 194 to 398 g (6.84 to 14.04 oz); variable species,
15 generally blue-grey with green and purple sheen on neck; wings with two black bars; white rump; cere
16 whitish; bill black; the description above refers to the wild form; are many patterns among feral birds
17 from white, red, and black.
- 18 **Reproduction:** most of the year; as many as five broods per year; two eggs per brood; eggs are smooth,
19 white, and glossy; nests on ledges and flat surfaces; new nests are built on top of old nests; nests consist
20 of twigs, roots, pine needles, straw, and grass stems; incubation length is 18 days; hatchlings are
21 altricial; fledging occurs in 25 to 45 days
- 22 **Habitat:** Cities, towns, villages, farms, and cliffs.
- 23 **Human health impacts:** carry up to 60 human pathogens including viruses, bacteria, fungi, and
24 protozoans; reasonable evidence that they are responsible for the spread of several noxious diseases
25 including: psittacosis or ornithosis, cryptococcal meningitis, histoplasmosis, toxoplasmosis, encephalitis,
26 Q fever, chlamydia, campylobacter, diarrheagenic *E. coli*, WNV, *Enterocytozoon bieneusi*, fleas that cause
27 allergies
- 28 **Economic impacts:** nuisance in most of the larger cities in the world because of their fouling of
29 buildings, statues, etc. with droppings; contaminate grain for human consumption; nests clog
30 drainpipes; occasionally interfere with crops; compete with domestic fowl for food.
- 31 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 32 **Pathways:** escaped or run wild, intentional.

1 **Control measures:** exclusion, habitat modification, hazing, repellents, toxicants, fumigants, trapping,
2 shooting, contraception

3 **References:** Long 1981; Lever 1987; Johnston 1992; Williams and Corrigan 1994; To et al. 1998; Stein
4 and Raoult 1999; Trávniček et al. 2002; Haag-Wackernagel and Moch 2004; Haag-Wackernagel and
5 Śpiewak 2004; Gibbs et al. 2006; Graczyk et al. 2007; Avery et al. 2008; Magnino et al. 2009; Salant et al.
6 2009; Silva et al. 2009; Haag-Wackernagel and Bircher 2010; Rosario et al. 2010

7 **A8.2.2 *Dicrurus macrocercus*:** Established on Guam and Rota

8 **Common names:** black drongo, drongo, king crow

9 **Synonymous scientific names:** no information found in the literature

10 **Adult description:** 22.5 to 31 cm (11 to 12.4 in); 38 to 59 g (1.34 to 2.08 oz); black with a bluish gloss;
11 red eyes; usually white spot on nape; prominent rectal bristles; tail deeply forked; bill black.

12 **Reproduction:** breed mainly February to August; amount of eggs variable; 2 to 5 eggs.

13 **Habitat:** open country, marshes, roadsides, cultivated areas, cities, and towns

14 **Human health impacts:** none found in the literature, but undocumented impacts may exist

15 **Economic impacts:** none found in the literature, but undocumented impacts may exist

16 **Ecological impacts:** thought to be responsible for decline of some small passerines in the Marianas

17 **Pathways:** intentional, natural spread

18 **Control measures:** no information found in the literature

19 **References:** Long 1981

20 **A8.2.3 *Francolinus francolinus***

21 **Common names:** black francolin, black partridge, Indian black francolin

22 **Synonymous scientific names:** none

23 **Adult description:** females lighter than males; mostly black below and rufous brown above; crown to
24 nape rufous brown; eye region is black; cheeks and ear-coverts are white; prominent broad chestnut
25 collar on dorsal surface of neck surrounded by white-spotted black feathers; feathers of nape distinctly
26 mottled black and white; back is brown; lower back, rump, chin, throat, and area below the ear-coverts
27 are black; breast is black with oval white spots on sides and flanks; lower breast and thighs are black to
28 reddish brown with large white spots or bars; center of abdomen and vent are lighter chestnut with
29 whitish bars.

1 **Reproduction:** may produce two clutches in India; generally nests in well-concealed areas; ground-
2 nesting; nest consists of a shallow scrape or depression on the bare ground which may or may not be
3 lined sparingly with grass, stems, twigs, leaves, or feathers; eggs are short-subelliptical to short oval and
4 are smooth and glossy; egg coloration dependent on habitat but are pale olive brown to chocolate
5 brown and often have white specks of calcareous deposits; clutch size is usually 6 to 8 eggs; incubation
6 lasts approximately 18 days; hatchlings are precocial.

7 **Habitat:** habitat generalist; dry grasslands, open pasturelands, dry scrubland and savanna, well-
8 vegetated habitats, and areas adjacent to fields

9 **Human health impacts:** none found in the literature, but undocumented impacts may exist

10 **Economic impacts:** none found in the literature, but undocumented impacts may exist

11 **Ecological impacts:** alternative prey source for BTS

12 **Pathways:** introduced as a game bird, natural spread

13 **Control measures:** no information found in the literature

14 **References:** Long 1981; Conry 1988b; Islam 1999; Birdlife International 2009a

15 **A8.2.4 *Lonchura malacca***

16 **Common names:** tricolored munia, black-headed munia, chestnut-breasted munia, chestnut mannikin,
17 black-headed mannikin

18 **Synonymous scientific names:** none

19 **Adult description:** upper parts brown; rump reddish brown; head, neck, and breast black, underparts
20 brown with a black or white patch in the center of the abdomen; vent, thighs, and under tail-coverts
21 black; upper tail-coverts and tail yellow to orange-red; bill silver-grey or slaty blue

22 **Reproduction:** nest is a ball of coarse grass lined with finer grass and contains a lateral entrance hole at
23 the end of a short spout; nest in low bushes, trees, or grass tussocks; clutch size is 4 to 8 eggs

24 **Habitat:** forests, shrublands, wetlands, arable lands, plantations.

25 **Human health impacts:** none found in the literature, but undocumented impacts may exist

26 **Economic impacts:** damage rice

27 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

28 **Pathways:** pet trade, natural spread

1 **Control measures:** hazing, glue-coated perches

2 **References:** Reidinger and Libay 1979; Long 1981; Birdlife International 2009b

3 **A8.2.5 *Padda oryzivora*:** established in Hawai'i and an incipient population on Guam

4 **Common names:** Javan finch, Java sparrow, rice or paddy bird

5 **Synonymous scientific names:** no information found in the literature

6 **Adult description:** 14.5 to 16 cm (5.8 to 6.4 in); head, chin, upper throat, band behind ear-coverts;
7 upper tail-coverts and tail black; sides of face to ear-coverts and under tail-coverts white; remainder
8 grey; belly and lower flanks vinous; bill pink; pure-white form can occur.

9 **Reproduction:** may breed seasonally or year-round depending on location; colonial; nests are bell-
10 shaped or domed with a side entrance and are located 1 to 18 m (3.3 to 60 feet) above ground in natural
11 and artificial crannies; eggs are white, oval, and matte; clutch size: 3 to 8 eggs; may produce a second
12 brood; both sexes incubate; incubation lasts 13 to 15 days; hatchlings are altricial; fledging occurs in 15
13 to 17 days

14 **Habitat:** rice fields, villages, cities, mangroves, open country, and scrub; largely in association with man.

15 **Human health impacts:** none found in the literature, but undocumented impacts may exist

16 **Economic impacts:** destroy agricultural crops, especially rice fields.

17 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

18 **Pathways:** intentional, escaped, imported, religious, ship

19 **Control measures:** no information found in the literature

20 **References:** Long 1981; Lever 1987; Islam 1997

21 **A8.2.6 *Passer domesticus*:** established in Hawai'i

22 **Common names:** English sparrow, European sparrow, house sparrow

23 **Synonymous scientific names:** no information found in the literature

24 **Adult description:** 14.3 to 15.5 cm (5.72 to .2 in). 25 to 37 g (0.88 to 1.3 oz); crown, nape, and lower
25 back dark grey; lores black; nape through eye brown; white stripe over eye; back brown streaked black;
26 wings brown with a single white bar on middle coverts; throat and breast black; cheeks and sides of
27 neck white; belly whitish or grayish; tail dull brown; bill black. Female: generally lacks as much black on
28 throat; upper parts dusky brown; bill brown.

1 **Reproduction:** breed all year; 2 to 3 or more broods per year; breeding times depend on area; clutch
2 size usually 2 to 7 eggs; eggs are glossy and smooth and are oval to long-oval in shape; the eggs are
3 white to greenish white or bluish white with dots or spots of grays or browns particularly around the
4 larger end; nests consist of dried vegetation and are often found in enclosed spaces; incubation lasts 10
5 to 14 days; hatchlings are altricial; fledging occurs at 14 days.

6 **Habitat:** open forest, wooded country, grasslands, cultivated areas, parks, gardens, cities, towns, and
7 everywhere there is human settlement.

8 **Human health impacts:** cause contamination with droppings, and help spread human disease, such as
9 toxoplasmosis, WNV, chlamydiosis, coccidiosis, salmonellosis, transmissible gastroenteritis,
10 shistosomiasis, and trichomoniasis.

11 **Economic impacts:** does harm in arable areas and lands adjacent to these areas, damage wheat and
12 other cereals, damage vegetable crops, dig up newly sown seeds, eat fruit crops, block drain and water
13 pipes with nesting materials, distribute poultry cestodes and nematodes

14 **Ecological impacts:** displace some indigenous insectivorous birds

15 **Pathways:** biocontrol, intentional, ships, cargo vessels, grain boats, followed horses and their food,
16 natural spread

17 **Control measures:** exclusion, removal of roosting sites, hazing, repellents, toxicants, trapping, shooting,
18 and changes in agricultural practices.

19 **References:** Long 1981; Pascual et al. 1999; Komar et al. 2005; Lowther and Cink 2006; Une et al. 2008;
20 Gondim et al. 2010

21 **A8.2.7 *Passer montanus***

22 **Common names:** tree sparrow

23 **Synonymous scientific names:** no information found in the literature

24 **Adult description:** 11.6 to 15 cm (4.64 to 6 in.); 17 to 27 g (0.6 to 0.95 oz); crown and back of head
25 chestnut; lores, line beneath eye to above ear-coverts, chin and throat black; ear-coverts white, with
26 black patch; neck almost surrounded by white collar; upper parts brown, streaked black; underparts
27 whitish or ashy; rump, upper tail-coverts and tail buffish brown, wing with two white bars; bill brown or
28 grayish.

29 **Reproduction:** Breed December to June (September to January in Australia); often colonial; 2 to 3
30 clutches per year; nests are domed and consist of loosely intertwined stems of grass, straw, and roots
31 surrounding a cup lined with soft material (feathers, fur, flower parts, waste paper, cloth, string, green
32 leaves); nest has a side entrance; nests in cavities or dense foliage; clutch size is 4 to 7 eggs; eggs are
33 subelliptical, slightly glossy, and smooth; eggs are white to pale gray and are heavily marked with spots,

- 1 blotches, or speckling of dark brown, purple, or gray (usually heavier on broad end); incubation is
2 approximately 12 days; hatchlings are altricial; fledging occurs around 14 days.
- 3 **Habitat:** wooded regions, open fields, grasslands, parks, gardens, orchards, villages, and towns.
- 4 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 5 **Economic impacts:** damage crop fields; cause damage when grain is drying, being threshed, fed to
6 domestic animals and stored in open grain bins; spoil grain with their manure; cause damage to fruit
7 crops; damage young vegetable seedlings and leaves; cause damage to houses by nesting in them;
8 compete for food with domestic poultry
- 9 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 10 **Pathways:** intentional, ship, boat, steamboat
- 11 **Control measures:** no information found in the literature
- 12 **References:** Long 1981; Lever 1987; Barlow and Leckie 2000
- 13 **A8.2.8 *Pycnonotus jocosus*:** Established in Hawai'i, Fiji, and Majuro
- 14 **Common names:** Red-eared Bulbul, Red-whiskered Bulbul
- 15 **Synonymous scientific names:** no information found in the literature
- 16 **Adult description:** 17.3 to 22 cm (6.92 to 8.8 in); 23 to 42 grams (0.81 to 1.48 ounces); upper parts
17 brown, with crested blackish crown a red patch behind eye; cheeks and throat white; a broken blackish
18 or dark brown band from breast around sides of neck; underparts grayish white; under tail-coverts red;
19 tail brown, tipped white; bill black.
- 20 **Reproduction:** variable, January to August; 2 to 3 broods per season; nests are cup-shaped and consist
21 of rootlets, twigs, dead leaves, and grasses bound by cobwebs on the outside; the nest cup is lined with
22 hair, soft fibers, rootlets, and fine materials; clutch is 2 to 5 eggs; eggs are short oval in shape, and are
23 smooth with little or no gloss; eggs are pale pink to reddish white marked with numerous reddish-brown
24 blotches, spots, and streaks with secondary markings of pale, inky purple; spots on the eggs may form a
25 ring or cap around the broad end; incubation lasts 10 to 14 days; hatchlings are altricial; fledging occurs
26 in approximately 12 days.
- 27 **Habitat:** forest edges, secondary growth, woodland, cultivation, parklands, gardens, and villages.
- 28 **Human health impacts:** none found in the literature, but undocumented impacts may exist

- 1 **Economic impacts:** Not great pests in native range; in non-native range reported damage fruits,
2 vegetables, and flowers; may spread seeds of invasive plants and facilitate germination of those seeds
3 by passage through the gut
- 4 **Ecological impacts:** compete with mockingbirds for berries in Florida
- 5 **Pathways:** Natural spread, escaped, intentional, unauthorized release, ship
- 6 **Control measures:** repellents
- 7 **References:** Long 1981; Lever 1987; Cummings et al. 1994; Islam and Williams 2000; Mandon-Dalger et
8 al. 2004; Linnebjerg et al. 2009
- 9 **A8.2.9 *Streptopelia bitorquata dusimieri***
- 10 **Common names:** Java ring dove, Javan collared dove, Javan turtledove, Javanese collared dove,
11 Philippine turtle-dove
- 12 **Synonymous scientific names:** *Streptopelia bitorquata*
- 13 **Adult description:** 30 cm (12 in); forehead, crown, and nape grey; broad black, white-edged, half collar
14 on hindneck; remainder of neck and upper mantle pinkish, often with rusty tinge; breast mauvish pink;
15 belly and under tail-coverts white or grayish-white; flanks grayish; back brown; primaries and
16 secondaries blackish, remainder of wing blue-grey; rump dark grey-brown; central tail-feathers brown,
17 outer feathers pale grey with basal third dark grey, under tail grayish white with basal third black; bill
18 blackish or dark grey, red at nape.
- 19 **Reproduction:** April to August (eastern Java); Eggs: 2
- 20 **Habitat:** habitat generalist; forest edges, open country with trees, villages, fields, and cultivation.
- 21 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 22 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 23 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 24 **Pathways:** intentional
- 25 **Control measures:** no information found in the literature
- 26 **References:** Long 1981; USGS 2005b

1 **A8.3 Mammals**

2 **A8.3.1 *Clethrionomys rutilus***

3 **Common names:** red-backed vole, red-backed mouse, northern red-backed vole, northern red-backed
4 mouse

5 **Synonymous scientific names:** *Myodes rutilus*

6 **Adult description:** head and body 80 to 110 mm (3.2 to 4.3 in) in length; tail 23 to 44 mm (0.9 to 1.7 in)
7 in length; weight 14.2 to 42.6 g (0.5 to 1.5 oz); sides of body yellow; upper parts bright reddish to rufous;
8 ear brown; dorsum red, or dark brown to blackish; tail densely furred; under tail yellow; feet whitish or
9 buff.

10 **Reproduction:** breed from April to October; gestation is 17 to 20 days; litter size is 1 to 8 pups; produce
11 3 to 4 litters per year; young are born naked and helpless; young weaned at 3 to 4 weeks; mature at 3 to
12 4 months

13 **Habitat:** habitat generalist; forest and taiga, grassland, tundra, woodland, forest, buildings, around
14 decaying stumps.

15 **Human health impacts:** reservoir for tularemia, Lyme disease

16 **Economic impacts:** none found in the literature, but undocumented impacts may exist

17 **Ecological impacts:** may damage trees

18 **Pathways:** plants and nursery trade, with firewood

19 **Control measures:** exclusion, habitat modification, zinc phosphide, anticoagulants, trapping

20 **References:** Nakao et al. 1994: O'Brien 1994: Berdal et al. 1996: Long 2003: Tobin and Fall 2004: Linzey
21 et al. 2008

22 **A8.3.2 *Didelphis marsupialis***

23 **Common names:** American opossum, black-eared opossum, southern opossum, Virginia opossum

24 **Synonymous scientific names:** *Didelphis virginiana*

25 **Adult description:** head and body 300 to 584 mm (11.8 to 23 in) in length; tail 255 to 535 mm (10 to 21
26 in) in length; weight 136 to 504 g (4.8 to 17.8 oz); females smaller than males; fairly heavy-bodied;
27 pointed muzzle with pink nose pad; face is white with black patches around eyes; short, black legs with
28 white toes; coloration varies regionally, ranging between grey, black, brown, reddish, and rarely white;
29 prehensile tail; fur-lined pouch on abdomen of females

1 **Reproduction:** breeds year-round with peaks in January to March and May to July; 1 to 2 litters per year;
2 gestation 8 to 13 days; 4, 8 to 18, or 25 young per litter, but must find mammae to survive; young
3 develop in pouch for 2 months; weaned at 90 to 100 days; males sexually mature at 8 months, females
4 at 6 months

5 **Habitat:** habitat generalist; forest, brush areas, woods near streams, cultivated areas with trees; prefers
6 areas with hollow trees; common in suburban and agricultural areas

7 **Human health impacts:** carriers of parasites that affect public health and poultry; reservoir for
8 leishmaniasis, toxoplasmosis, tularemia, relapsing fever, leptospirosis, and Rocky Mountain spotted
9 fever

10 **Economic impacts:** predation on poultry, eat vegetable and corn crops

11 **Ecological impacts:** predation on birds, such as the ground dove, possibly causing local extinctions;

12 **Pathways:** cargo, boat, escape, intentional, natural spread

13 **Control measures:** exclusion, habitat modification, trapping, shooting

14 **References:** Barr 1963; Henry 1969; McManus 1974; Lins and Lopes 1984; Jackson 1994; Carme et al.
15 2002; Long 2003; Yai et al. 2003; Schallig et al. 2007

16 **A8.3.3 *Herpestes javanicus*:** Established in Hawai'i and Fiji

17 **Common names:** Indian mongoose, small Indian mongoose

18 **Synonymous scientific names:** *Herpestes auropunctatus*

19 **Adult description:** head and body of males 250 to 350 mm (10 to 13.8 in) in length; tail 200 to 310 mm
20 (8 to 12 in) in length; tail shorter than head and body length; weight 312 to 1,300 g (11 to 46 oz);
21 females smaller than males; body slender with short legs; elongated head with a pointed muzzle; tail has
22 a muscular base; coloration ranges from buff to dark gray-brown; coat has a speckled or grizzled
23 appearance

24 **Reproduction:** 2 litters per year; gestation 42 to 43 days; 1 to 5 young per litter, with an average of just
25 over 2; altricial; weaned at 4 to 5 weeks; sexually mature in first year

26 **Habitat:** open dry bush and savannah; cultivated and disturbed areas; near villages; lives in burrows and
27 crevices but climbs well

28 **Human health impacts:** carries diseases transmissible to humans and pets, including rabies,
29 leptospirosis, canine distemper, canine hepatitis, toxoplasma, salmonella, feline panleukopenia,
30 streptococcus, and pulmonary virus

- 1 **Economic impacts:** predation on poultry, eggs, and small livestock
- 2 **Ecological impacts:** predation on native wildlife, causing the near extinction of many ground-dwelling
3 species of frogs, reptiles, mammals and ground-nesting birds
- 4 **Pathways:** biocontrol, intentional, natural spread
- 5 **Control measures:** trapping, poisoning (diphacinone), and bounties
- 6 **References:** Baker and Russell 1979; Nellis and Small 1983; Coblenz and Coblenz 1985; Nellis 1989;
7 Smith et al. 2000; Krebs et al. 2003; Long 2003; Morley 2004; Blanton et al. 2006; Hays and Conant 2007;
8 Watari et al. 2008; Leighton et al. 2009; ISSG 2010

9 **A8.3.4 *Macaca fascicularis***

10 **Common names:** Crab-eating Macaque. Long-tailed Macaque, Cynomolgus Monkey, Kera

11 **Synonymous scientific names:** *M. cynomolgus* or *M. irus*

12 **Adult description:** Body length in adult 38-55 cm with comparable short arms and legs. Tail is longer
13 than body, 40-60 cm. Females weight 3-6 kg, while males range from 5-9 kg. "In addition to being taller
14 and heavier, males have much larger canine teeth than females. Macaques have cheek pouches in which
15 they can store food as they forage, and transport it away from the foraging site to eat." (Cawthon Lang
16 K.A., 2006). Life span 31 years.

17 **Reproduction:** Gestation ranges from 167 to 193 days. Females give birth to one infant.

18 **Habitat:** "Long-tailed macaques live in primary, secondary, coastal, mangrove, swamp, and riverine
19 forests from sea level up to elevations of 2000 m (6561 ft). They prefer forested areas near water and
20 are found in higher densities near riverbanks, lakeshores, or along the seacoast. They preferentially
21 utilize secondary forest, especially if it borders human settlement, where they have access to gardens
22 and farms to crop-raid. Long-tailed macaques are widespread throughout the islands of Southeast Asia
23 into mainland Asia." (Cawthon Lang K.A., 2006)

24 **Human health impacts:** Carrier of B-virus (Cercopethecine herpesvirus 1), which can be transmitted to
25 humans, and is estimated to be lethal in 70-80% of untreated human cases (Cohen et al. 2002). Most
26 macaques carry B virus without any overt signs of disease (Huff & Barry 2003). Macaques bite and
27 scratch humans, which can result in traumatic injury, and can lead to serious infections. They can also
28 carry a number of other human and zoonotic diseases, and, "in addition to viruses that have been
29 identified, there is the potential for previously unknown diseases to transfer from the monkeys to
30 humans posing a serious health risk to nearby communities and beyond." (Cawthon Lang K.A., 2006)

31 **Economic impacts:** In their native range, they are known as crop raiders, having impacts on agriculture,
32 including fruit crops, root crops such as cassava and sweet potato, and many others. These macaques
33 also enter houses when people are not at home and raid food and damage clothing, etc. On the island
34 of Angaur, where they are introduced, these macaques have made crop production virtually impossible,

1 except for small gardens next to people’s homes, and even these are damaged when the residents are
2 away from home.

3 **Ecological impacts:** Known predator of bird nests; populations of several native birds on the island of
4 Angaur in Palau have been severely impacted – either severely reduced in population or completely
5 absent. These macaques also prey on insects and small reptiles, as well as small crustaceans, but their
6 impact on these species is unknown. Since they are largely frugivorous, they contribute to the spread of
7 seeds of some tree species, and can perhaps alter forest composition and structure. “Where they forage
8 in mangroves, long-tailed macaques spend time consuming crabs and have also been seen eating frogs,
9 shrimp and octopus.” (Cawthon Lang K.A., 2006)

10 **A8.3.5 *Microtus californicus***

11 **Common names:** California vole, California meadow vole, Amargosa vole

12 **Synonymous scientific names:** none

13 **Adult description:** 139 to 207 mm (5.5 to 8 in) total length; tawny olive to cinnamon brown with brown
14 to black overhairs; grayish underparts; bicolored tail; pale feet

15 **Reproduction:** can breed every 3 weeks in good conditions; breeding season varies depending on
16 region; year-round breeders in coastal populations; nests are located under logs, boards, or a few
17 centimeters under the earth’s surface; nests are made with dried grasses and forbs; produce 1 to 11
18 offspring; gestation lasts approximately 22 days; young are altricial at birth; young weaned in
19 approximately 2 weeks; young generally independent at 2 weeks; sexual maturity at approximately 3
20 weeks for females and 5 weeks for males.

21 **Habitat:** broad-leafed chaparral, oak woodlands, grasslands, marshy ground, wet meadows, coastal
22 wetlands, agricultural areas, and dry, grassy hillsides.

23 **Human health impacts:** vectors of plague, tularemia, hantavirus, and Lyme disease

24 **Economic impacts:** girdle seedlings and mature trees; damage or destroy crops such as alfalfa, clover,
25 grain, potatoes, and sugar beets; damage irrigation systems; damage lawns, golf courses, and ground
26 covers

27 **Ecological impacts:** girdle seedlings and mature trees; may compete with other rodents

28 **Pathways:** nursery trade

29 **Control measures:** exclusion, habitat modification, repellents, zinc phosphide, anticoagulants, trapping

30 **References:** Greenwald 1956; Jameson Jr. 1958; Stark 1963; Kartman and Hudson 1971; Hudson et al.
31 1972; Heske et al. 1984; O'Brien 1994; Song et al. 1995; Bennett et al. 1999; Peronne 2002; Long 2003;
32 Vredevoe et al. 2004; Álvarez-Castañeda et al. 2008

1 **A8.3.6 *Mus musculus***

2 **Common names:** common mouse, house mouse

3 **Synonymous scientific names:** *Mus domesticus*

4 **Adult description:** head and body 70 to 102 mm (2.8 to 4 in) in length; tail 65 to 95 mm (2.6 to 3.7 in) in
5 length; weight 8.5 to 41.5 g (0.3 to 1.5 oz); body brownish grey with a paler venter; coloration ranges
6 from light brown to dark grey; ears and muzzle pointed; large eyes; the semi-naked tail is as long as the
7 head and body

8 **Reproduction:** r-selected with high reproductive capacity; often continuous breeding; generally 6 to 8
9 litters per year, but can be as high as 11; gestation 13 to 31 days; 4 to 12 young per litter; altricial;
10 weaned at 21 days; sexually mature in 3 to 8 weeks

11 **Habitat:** habitat generalist; found in every habitat type and on every continent, including Antarctica;
12 found especially in human-inhabited places; can maintain populations in extreme conditions; island
13 populations often thrive even more than those on the mainland

14 **Human health impacts:** reservoir for various disease organisms and parasites that can affect humans
15 such as plague, salmonella, leptospirosis, toxoplasmosis, and rickettsial pox

16 **Economic impacts:** agricultural damage, especially to grains and legumes; consumption and
17 contamination of stored foods and livestock feed; nuisance noise, odors, and droppings; economic costs
18 due to damage to insulation, wiring, and farm machinery

19 **Ecological impacts:** predation on native plants and wildlife, including seabird chicks and eggs,
20 invertebrates, and reptiles; extinction of native island vertebrates

21 **Pathways:** aircraft, boat, cargo, escape, natural spread, vehicle

22 **Control measures:** anticoagulants, fumigants, traps, repellents, exclusion

23 **References:** Timm 1994a: Long 2003: Witmer and Jojola 2006: Meerburg et al. 2009: ISSG 2010

24 **A8.3.7 *Myotis lucifugis***

25 **Common names:** little brown bat, little brown myotis

26 **Synonymous scientific names:** *Myotis lucifugus*

27 **Adult description:** 60 to 102 mm (2.4 to 4 in) in length; 222 to 269 mm (8.7 to 10.6 in) wingspan; weight
28 5 to 14 g (0.2 to 0.5 oz); pale tan through reddish brown to dark brown depending on geographic
29 location; ventral side is lighter in color; fur is glossy and sleek

- 1 **Reproduction:** produce 1 to 2 offspring; gestation lasts 50 to 60 days; young are weaned at 3 to 4
2 weeks; young are independent at 4 weeks; sexual maturity at approximately 7 months
- 3 **Habitat:** habitat generalist; buildings, trees, under rocks, in piles of wood, abandoned mines or caves,
4 forested lands near water
- 5 **Human health impacts:** reservoirs for coronavirus, polyomavirus, rabies; guano is associated with
6 histoplasmosis, associated with bat-aircraft strikes
- 7 **Economic impacts:** may roost in dwellings associated with humans leaving rub marks, guano, and urine;
8 noise may be bothersome to some people; associated with bat-aircraft strikes
- 9 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 10 **Pathways:** cargo, ships, aircraft, natural dispersal
- 11 **Control measures:** exclusion, repellents, trapping
- 12 **References:** Fenton and Barclay 1980; Burnett 1989; Greenhall and Frantz 1994; Constantine 2003;
13 Havens and Myers 2006; Arroyo-Cabrales and Castaneda 2008; Misra et al. 2009; Peurach et al. 2009
- 14 **A8.3.8 *Pipistrellus javanicus***
- 15 **Common names:** Javan pipistrelle
- 16 **Synonymous scientific names:** *Pipistrellus babu* Thomas, 1915; *Pipistrellus camortae* Miller, 1902;
17 *Pipistrellus peguensis* Sinha, 1969; *Scotophilus javanicus* Gray, 1838
- 18 **Adult description:** 75 to 90 mm (3 to 3.5 in) total length; weighs 4 to 7 g (0.1 to 0.2 oz); dark brown fur
19 that is darker at the base; fur is lighter ventrally; flat head with a broad muzzle that appears swollen;
20 short ears
- 21 **Reproduction:** have 3 breeding seasons; produce 2 offspring/breeding season
- 22 **Habitat:** habitat generalist; common in urban and agricultural areas; primary and secondary lowland
23 montane forest, caves
- 24 **Human health impacts:** associated with bat-aircraft strikes
- 25 **Economic impacts:** associated with bat-aircraft strikes
- 26 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 27 **Pathways:** cargo, ships
- 28 **Control measures:** no information found in the literature

1 **References:** Daniel and Yoshiyuki 1982; Constantine 2003; Bates et al. 2005; Francis et al. 2008; Peurach
2 et al. 2009

3 **A8.3.9 *Rattus exulans***

4 **Common names:** kiore, little rat, Maori rat, Pacific rat, Polynesian rat

5 **Synonymous scientific names:** *Mus exulans*, *Mus maorium*

6 **Adult description:** head and body 80 to 140 mm (3.2 to 4.1 in) in length; tail 108 to 147 mm (4.3 to 5 in)
7 in length; weight 30 to 180 g (1 to 6 oz); dorsum brown or grey brown, venter whitish; pointed muzzle
8 and large ears; tail dark with fine scales; smaller than the black and Norway rats

9 **Reproduction:** breeds year-round, peaks in spring to late summer; 1 to 6 or more litters per year;
10 gestation 19 to 30 days; altricial; weaned at 4 weeks; mature in 8 to 12 months

11 **Habitat:** habitat generalist; bush, scrub, grassland, forest; under logs and rocks; houses, clearings,
12 gardens, paddy fields

13 **Human health impacts:** carries zoonotic diseases including leptospirosis, plague, lungworm, and others;
14 create breeding sites for mosquitoes by knocking coconuts to the ground

15 **Economic impacts:** damages rice, maize, sugarcane, coconut, cacao, pineapple, mangoes, passion fruit,
16 paw paw, cassava, kumarans, and root crops

17 **Ecological impacts:** preys on native birds, lizards, and turtle eggs; consumption of native flora

18 **Pathways:** boat, cargo, food

19 **Control measures:** habitat alteration, snap traps, zinc phosphide, anticoagulants, compound 1080 not
20 effective

21 **References:** Kepler 1967; Tobin 1994; Vickery 1994; Spennemann 1997; Robinet et al. 1998; Campbell
22 and Atkinson 1999; SPREP 2000; Atkinson and Towns 2001; Worthy and Holdaway 2002; Long 2003;
23 Meerburg et al. 2009; ISSG 2010

24 **A8.3.10 *Rattus norvegicus***

25 **Common names:** brown rat, common rat, Norway rat

26 **Synonymous scientific names:** none

27 **Adult description:** head and body 165 to 280 mm (6.5 to 11 in) in length; tail 122 to 230 mm (4.8 to 9 in)
28 in length; weight 120 to 580 g (4.2 to 20.4 oz), up to 909 g (32 oz); robust body; coloration grey to
29 grayish brown on dorsum, with a white venter; ears, feet and tail flesh-colored; blunt muzzle and small
30 ears and eyes

- 1 **Reproduction:** breeds year-round; 6 litters per year; gestation 20 to 26 days; 5 to 10, and up to 22,
2 young per litter; altricial; weaned at 28 days; mature in 3 to 4 months
- 3 **Habitat:** habitat generalist; found everywhere except deserts and polar regions
- 4 **Human health impacts:** consumption and contamination of stored foods; chew through power cables;
5 fleas are vectors of plague; vector of hantavirus
- 6 **Economic impacts:** damage to sugarcane;
- 7 **Ecological impacts:** reduced Canada goose populations in the Aleutian Islands; decimation and
8 extinction of native plant, mammal, reptile, bird and invertebrate populations
- 9 **Pathways:** boat, natural spread, seafreight (container/bulk)
- 10 **Control measures:** exclusion, habitat modification, toxicants, fumigants, traps
- 11 **References:** Timm 1994b; Long 2003; Meerburg et al. 2009; ISSG 2010
- 12 **A8.3.11 *Rattus rattus***
- 13 **Common names:** black rat, house rat, roof rat, ship rat
- 14 **Synonymous scientific names:** none
- 15 **Adult description:** head and body of males 165 to 254 mm (6.5 to 10 in) in length; tail 140 to 252 mm
16 (5.5 to 10 in) in length; weight 85 to 350 g (3 to 8.8 oz); sleek body; coloration blue-black, black or brown
17 on dorsum and grey, buff, or whitish on venter; pointed muzzle with black snout; large eyes and ears;
18 black or brown tail, mostly naked with fine scales; feet with five toes; similar to the Asian house rat
19 (*Rattus tanezumi*)
- 20 **Reproduction:** breeds year-round; 5 to 6 litters per year; gestation 21 to 30 days; 1, 5 to 8, or 12 young
21 per litter; weaned at 21 to 28 days; sexually mature in 3 to 4 months; polygamous; makes a spherical
22 nest of loose vegetation and other material
- 23 **Habitat:** habitat generalist; not found in deserts; prefers rivers, streamsides, and human-inhabited
24 areas, such as orchards and gardens
- 25 **Human health impacts:** reservoir of zoonotic diseases, including leptospirosis and trichinosis; rat fleas
26 are vectors for pasteurella, murine typhus, and plague
- 27 **Economic impacts:** agricultural damage to poultry operations and crops such as rice, sugarcane, coconut
28 and macadamia orchards; consumption and contamination of stored foods; economic costs from
29 damage to structures and materials
- 30 **Ecological impacts:** predation on and extinction of native rats, bats, turtles, tortoises, and endemic birds

1 **Pathways:** cargo, natural dispersal, seafreight (container/bulk), road vehicles

2 **Control measures:** Exclusion, habitat modification, toxicants, fumigants, traps

3 **References:** Marsh 1994; Vanderwerf 2001; Long 2003; Meerburg et al. 2009; ISSG 2010

4 **A8.3.12 *Rattus tanezumi***

5 **Common names:** Asian house rat, Oriental house rat, tanezumi rat

6 **Synonymous scientific names:** *Rattus rattus mindanensis*

7 **Adult description:** males about 191 mm (7.5 in) in length; females about 182 mm (7 in) in length; weight
8 150 to 280g (5.3 to 10 oz); males larger; reddish to grayish brown or darker dorsum; lighter venter;
9 morphologically similar to the black rat; *R. tanezumi* females have 5 pairs of teats in a different
10 configuration than the 6 pairs found on *R. rattus* females; the two species are separated based on
11 genetic analysis

12 **Reproduction:** breeds during growth of rice crops; gestation 21 to 29 days; 4 to 10, with an average of 7
13 young per litter; polyestrous, possibly up to 6 litters per year; females sexually mature at 2 to 4 months

14 **Habitat:** habitat generalist; disturbed lowlands, grasslands, shrublands, various forests; especially found
15 in human-inhabited areas, including agricultural lands, villages, gardens, and urban areas

16 **Human health impacts:** reservoir for hanta virus, Bartonella, scrub typhus, leptospirosis, and
17 Cryptosporidium

18 **Economic impacts:** damage to rice, sugarcane, and coconut crops; consumption and contamination of
19 stored foods; consumption of livestock feed

20 **Ecological impacts:** likely preys on birds and bird eggs

21 **Pathways:** unknown

22 **Control measures:** removal; zinc phosphide, racumin; clearing vegetation; scrub burning; fencing;
23 research being conducted: timing of application (just prior to the breeding season), cost-benefit analysis
24 (Control measures beneficial when crop losses exceed 5%), trap-barrier systems

25 **References:** Coleman et al. 2003; Long 2003; Singleton et al. 2003; Tobin and Fall 2004; Wilson and
26 Reeder 2005; Li et al. 2007; Miller 2007; Stuart et al. 2007; Heaney and Molur 2008; Jittapalapong et al.
27 2009; Lv et al. 2009; Meerburg et al. 2009; Plyusnina et al. 2009; Johansson et al. 2010

28 **A8.3.13 *Suncus murinus*:** Established on Guam and in the CNMI

29 **Common names:** Asian musk shrew, brown musk shrew, house shrew, Indian musk shrew, large musk
30 shrew, money shrew, musk shrew

1 **Synonymous scientific names:** *Crocidura murina*, *Sorex murinus*, *Suncus caeruleus*

2 **Adult description:** head and body 50 to 150 mm (2 to 6 in) in length; tail 46 to 100 mm (1.8 to 4 in) in
3 length; weight of males 30 to 147 g (1 to 5 oz), females 20 to 82 g (0.7 to 2.9 oz); females smaller;
4 coloration pale grey to brown or black with lighter venter; long, pointed nose; prominent, round,
5 human-like ears; mostly naked tail with thick base and thin tip; musky odor from sweat glands on throat
6 and behind ears

7 **Reproduction:** breeding varies from seasonal to year-round, depending on location; gestation 29.6 to
8 30.3 days; 1 to 6 or 8 young per litter; altricial; sexually mature at 36 days

9 **Habitat:** habitat generalist; open grassy areas, swamps, pond margins, grassland, deserts, and human-
10 inhabited areas, such as houses, warehouses, drains, croplands, and gardens

11 **Human health impacts:** reservoir for plague, hantavirus, Q fever, and probably salmonella; nuisance
12 odors

13 **Economic impacts:** consumption of stored foods; possible predation on poultry; damage to seeds, young
14 plants, and grass

15 **Ecological impacts:** competition and predation on invertebrates and vertebrates (particularly lizards);
16 damage to seeds, young plants, and grass

17 **Pathways:** biocontrol, boat, cargo, seafreight (container/bulk), vehicle

18 **Control measures:** exclusion, habitat alteration, traps, anticoagulants

19 **References:** Cavanaugh et al. 1969; Yadav et al. 1979; Rodda and Fritts 1992; Fritts and Rodda 1998;
20 SPREP 2000; Varnham et al. 2002; Long 2003 Duplantier et al. 2005; Seymour et al. 2005; Henttonen et
21 al. 2008; Meerburg et al. 2009; ISSG 2010

22 **A8.4 Reptiles:** Some species missing from the follow list of possible reptile invaders include
23 Iguana iguana (a known invader in Puerto Rico, Florida, Fiji and other locations with at least one
24 individual having been found on Guam) and *Varanus indicus* (which is known from some islands
25 of Micronesia but not all suggesting that it might be able to travel and establish on current
26 monitor free islands if permitted). There are probably other species which should also be
27 added to this list.

28 **A8.4.1 Agama agama**

29 **Common names:** African red-headed Agama, Agama lizard, common agama, rainbow lizard

30 **Synonymous scientific names:** *Agama boensis*, *Agama colonorum*, *Agama picticauda*, *Agama smithii*,
31 *Lacerta agama*, *Oreodeira gracilipes*, *Tropidolepis africanus*

1 **Adult description:** whitish underside; buff brown back limbs and tail with a slightly lighter stripe down
2 the middle and six to seven dark patches to the side of this stripe. There is some sexual dimorphism. The
3 subordinate males, females, and adolescents possess an olive green head. A blue body and yellow tail
4 and head characterize the dominant male. Has a large head separated from the body, a long tail, well-
5 developed external ear openings and eyelids. The maximum size for male lizards is 25 cm (9.8 in); female
6 lizards are 20 cm (7.9 in) in length.

7 **Reproduction:** Females reach sexual maturity at age fourteen to eighteen months, males at two years;
8 reproduce during wet season although are capable of reproducing nearly year round in areas of
9 consistent rainfall; female lays her eggs in a hole she digs with her snout and claws; hole is five
10 centimeters deep and is found in sandy, wet, damp soil that is exposed to sunlight nearly all day and
11 covered by herbage or grasses; eggs are usually laid in clutches ranging from five to seven ellipsoidal
12 eggs; thermoregulated embryo species resulting in all males at 29° C and all females at 26 to 27° C eggs
13 hatch within 8 to 10 weeks. Hatchlings will be between 3.7 and 3.8 cm (1.5 in) snout-vent plus their 7.5
14 cm (3 in) tail. They will almost immediately start eating rocks, sand, plants, and insects.

15 **Habitat:** habitat generalist; any area with enough vegetation for reproduction (including human
16 inhabited areas).

17 **Human health impacts:** none found in the literature, but undocumented impacts may exist

18 **Economic impacts:** none found in the literature, but undocumented impacts may exist

19 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

20 **Pathways:** cargo, pet trade

21 **Control measures:** no information found in the literature

22 **References:** Hilgris 2000; Lever 2003; Kraus 2009; Uetz 2010

23 **A8.4.2 *Anolis carolinensis*:** already established in parts of the region

24 **Common names:** Green anole

25 **Synonymous scientific names:** *Anolis bullaris*, *Anolis porcatus*, *Anolis principalis*, *Dactyloa (Ctenocercus)*
26 *carolinensis*, *Lacerta principalis*

27 **Adult description:** between 127 to 203 mm (5 to 8 in) in length; females are smaller than males; ability
28 to change color; color depends on mood, temperature, humidity and health; resting or content anoles
29 are brown or bright green; they are darker in color when cold, and pasty gray when overly warm.
30 Females have a light vertebral line; displaying males can erect a low vertebral crest on the nape and
31 anterior trunk. They have adhesive lamellae on their foot pads; tails and bodies are long and slender,
32 and their heads have pointed snouts; keeled scales; rounded tail that is longer than snout-vent length
33 (75 mm).

- 1 **Reproduction:** One egg is laid at 14 to 17-day intervals throughout the warm months of the year; eggs
2 need moist soil and foliage; incubation varies between just over a month and 2 months. Breeds from
3 March to October.
- 4 **Habitat:** habitat generalist; arboreal; favors tall native grasses, shrubs, and trees. Requires greenery,
5 some shade and a moist environment; also can be found on walls and fences.
- 6 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 7 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 8 **Ecological impacts:** decline of native insects such as buprestid, cerambycid, cucurliionid, and melandryid
9 beetles; lycaenid and papilionid butterflies; bees; and odonates.
- 10 **Pathways:** nursery trade, pet trade, biocontrol
- 11 **Control measures:** no information found in the literature
- 12 **References:** Stevenson 1976; Jenssen et al. 1996; Bartlett and Bartlett 1999; Smith 1999; Abe et al.
13 2008; Kraus 2009; Uetz 2010
- 14 **A8.4.3 *Anolis cristatellus***
- 15 **Common names:** crested anole, Puerto Rican crested anole, greater Antillian anole
- 16 **Synonymous scientific names:** *Anolis cozumelae*, *Anolis lindeni*, *Ctenonotus cristatellus*, *Ptychonotus*
17 *(Istiocercus) cristatellus*, *Xiphosurus cristatellus*
- 18 **Adult description:** medium-sized anole; trunk-ground ecomorph. Females can reach 50 mm (2 in) in
19 snout to vent length. Males may reach 74 mm (3 in) in length and have dark-bordered dewlaps that
20 range in color from olive-green to yellow or orange. Males typically have a wavy tail crest, and the
21 vertebral and nape crests can be erected by muscular contraction. The dorsal color ranges from olive-
22 tan to almost black, with lighter colored anoles exhibiting dark bars or blotches on the trunk and tail.
- 23 **Reproduction:** reproductive seasonality observed; seasons depend on elevation, photo thermal period
24 and temperature; ample rainfall is not an indicator of successful clutch survival.
- 25 **Habitat:** habitat generalist; native to dry forests but can adapt to any habitat; montane habitats, shrubs,
26 fence posts, building walls, brush piles, and rock piles; open areas in higher elevations; Low density
27 suburban development, areas peripheral to core urban areas; small towns, agricultural habitat, and
28 recently disturbed, early successional community; ability to shift and modify structural habitats in
29 response to competitive interactions thus displacing less adaptable anoles
- 30 **Human health impacts:** none found in the literature, but undocumented impacts may exist

- 1 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 2 **Ecological impacts:** possible displacement of native Anolis species
- 3 **Pathways:** cargo, intentional, pet trade escapees
- 4 **Control measures:** no information found in the literature
- 5 **References:** Gorman and Licht 1974; Light 1974; Genet 2002; Malhotra et al. 2007; Kraus 2009; FLWCC
6 2010b; Uetz 2010

7 **A8.4.4 *Anolis distichus***

8 **Common names:** Bahaman Bark Anole, bark anole, Hispaniolan gracile anole

9 **Synonymous scientific names:** *Anolis distichoides*, *Anolis dominicensis*

10 **Adult description:** smaller scales than other lizards; granular, double row of unkeeled scales on the
11 back; blunter head; protruding eyes; dark crossbar between the eyes and four dark Vs on the back;
12 yellowish dewlap; snout-vent length about 40 mm (1.6 in); tail somewhat longer.

13 **Reproduction:** no information found in the literature

14 **Habitat:** shaded, covered areas; forests; trunk ecomorph (middle of tree trunks); uses steep, long
15 perches

16 **Human health impacts:** none found in the literature, but undocumented impacts may exist

17 **Economic impacts:** none found in the literature, but undocumented impacts may exist

18 **Ecological impacts:** competition with native anoles

19 **Pathways:** cargo, intentional, nursery

20 **Control measures:** no information found in the literature

21 **References:** Stevenson 1976; Williams and Case 1986; Lever 2003; Mattingly and Jayne 2004; Kraus
22 2009; Uetz 2010

23 **A8.4.5 *Anolis extremus***

24 **Common names:** Barbados anole

25 **Synonymous scientific names:** *Anolis roquet*

26 **Adult description:** males can reach 83 mm (3.3 in) snout-vent length and females can reach 60 mm (2.4
27 in) snout-vent length. females are smaller and less colorful than males. Olive-brown to olive-green in

1 color, and patterned with dark blotches and light spots; greenest on the sides and posterior dorsum. The
2 venter is a sunny yellow, and the head is gray to gray-brown.

3 **Reproduction:** no information found in the literature

4 **Habitat:** closed areas; edges; inhabits darker, more shaded places in patchy habitats. Trunk-ground
5 species; residential areas with plant cover (such as ornamental palms and citrus trees)

6 **Human health impacts:** none found in the literature, but undocumented impacts may exist

7 **Economic impacts:** none found in the literature, but undocumented impacts may exist

8 **Ecological impacts:** may displace native anoles

9 **Pathways:** cargo, pet trade, research

10 **Control measures:** no information found in the literature

11 **References:** Schoener 1970; Bartlett and Bartlett 1999; Kraus 2009; Uetz 2010

12 **A8.4.6 *Anolis porcatius***

13 **Common names:** Cuban green anole

14 **Synonymous scientific names:** *Anolis principalis*

15 **Adult description:** not found

16 **Reproduction:** reproductive seasonality; reproduce during rainy season; oviductal eggs form in April;
17 ovulation occurs April to October; clutch size of one egg;

18 **Habitat:** uses the trunk and canopy of trees from 1 to 6 m (3.3 to 19.7 feet) above the ground; Low
19 density suburban development, areas peripheral to core urban areas, and small towns

20 **Human health impacts:** none found in the literature, but undocumented impacts may exist

21 **Economic impacts:** none found in the literature, but undocumented impacts may exist

22 **Ecological impacts:** possible competition with other anoles

23 **Pathways:** cargo

24 **Control measures:** no information found in the literature

25 **References:** Ochotorena et al. 2005; Kraus 2009; FFWCC 2010a; Uetz 2010

26 **A8.4.7 *Anolis sagrei*:** established in Hawai'i

27 **Common names:** brown anole, Cuban brown anole

1 **Synonymous scientific names:** *Norops sagrei*

2 **Adult description:** males can reach up to 64 mm (2.5 in) weighing 6 to 8g (0.2 to 0.3 oz); females only
3 reach up to 48 mm (1.9 in) weighing 3 to 4g (0.1 oz). Brown in color; males have bands of light yellow
4 spots and are dorsally dark. Males erect a nuchal, vertebral, and anterior caudal ridge. Females and
5 juveniles have a dark, scalloped-edged, light vertebral stripe; laterally compressed, keeled tail; orange
6 dewlap; snout-vent length 50 mm (2 in), but tail longer.

7 **Reproduction:** breed during the summer; becomes sexually active and establishes territories in March
8 or April, and defends territories through August or September. Females lay eggs singly on an
9 approximately weekly basis for the entire summer by alternating the use of their left and right ovaries.

10 **Habitat:** habitat generalist—likes disturbed habitats; forms territory among shrubs, vines, fences and
11 trees; terrestrial inhabiting open vegetation as well as moist forested areas; can also occupy the higher
12 niches in trees. Prefers semi-tropical environment

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** reduction of spider populations, competition with native anoles, predation of native
16 anoles and lizards

17 **Pathways:** cargo, intentional, nursery trade, pet trade, ship, vehicle

18 **Control measures:** no information found in the literature

19 **References:** Stevenson 1976; Spiller and Schoener 1988; Lee et al. 1989; Spiller and Schoener 1990,
20 1994; Bartlett and Bartlett 1999; Gerber and Echternacht 2000; Campbell 2001; Greene et al. 2002;
21 Wardle 2002; Lever 2003; Varnham 2006; Masterson 2007; Huang et al. 2008; Huang et al. 2009a; Kraus
22 2009; ISSG 2010

23 **A8.4.8 *Boa constrictor***

24 **Common names:** boa, boa constrictor

25 **Synonymous scientific names:** *Boa constrictor constrictor*, *Boa diviniloqua*, *Boa diviniloquax*, *Boa*
26 *orophias*, *Boa ortonii*, *Constrictor auspex*, *Constrictor diviniloquus*, *Constrictor formosissimus*, *Constrictor*
27 *occidentalis*, *Constrictor rex serpentum*, *Epicrates sabogae*, *Euncetes murinus*

28 **Adult description:** no labial pits, a dark brown middorsal stripe running from the snout onto the neck,
29 head surface covered by small smooth scales, the dorsal scales small and smooth, and the subcaudals
30 single. Can reach 4.5 m (14.8 feet) in length with females being larger than males; head distinct from
31 neck; body somewhat compressed, stout; tail short and prehensile; eye small, with vertically elliptical
32 pupil; 2 or 3 nasal scales; no distinct loreal; no enlarged chin shields, distinct mental groove bordered by
33 small scales; pelvic spurs visible. Ground color light brown to gray; head usually with a median elongate
34 dark mark, sometimes bifurcate posteriorly or forming cross between eyes; side of head usually with a

1 distinct downward-slanting dark postorbital stripe that is continuous through eye with a distinct broad
2 dark brown blotch that extends from lip nearly to nostril; usually a narrow vertical dark brown bar below
3 eye; dorsum with 22 to 35 dark brown or black dorsal blotches and similarly colored smaller lateral
4 blotches; dorsal blotches usually with an elongate cream or yellow spot laterally and frequently
5 vertebrally; lateral blotches usually with light centers; dorsal blotches frequently fusing to create a chain
6 of dark figures surrounding a series of oval light areas on middle of back at least anteriorly; tail usually
7 banded with black, yellowish, and red; venter gray with paired lateral dark spots; subcaudal area with a
8 series of median black spots; iris beige, transected by a narrow dark brown horizontal bar.

9 **Reproduction:** boas at higher latitudes tend to breed in the cool season and give birth in the warm
10 season, but seasonality in precipitation may be more important in low-latitude areas; reproductive
11 seasonality is incredibly variable; extended gestational durations mean that an entire reproductive cycle
12 may take at least a year for females, considering follicular growth, mating, ovulation, gestation, and
13 parturition. Copulation is rarely observed in the field, and it is difficult to tell whether groups of boas
14 constitute mating aggregations; Reproduction occurs in winter and is synchronized, resulting in mid-
15 spring ovulation. Although based on a small number of neonates, parturition is inferred to be at the end
16 of the wet season (February to March) extends this period through April. Litter sizes vary from 20 to 64.

17 **Habitat:** habitat generalist; occurs in agricultural areas, desert, natural forests, planted forests,
18 range/grasslands, ruderal/disturbed, scrub/shrublands, urban areas

19 **Human health impacts:** may attack small children

20 **Economic impacts:** predation of pets and small animals; carriers of ticks that may impact livestock

21 **Ecological impacts:** predation of native fauna; competition with native reptiles; non-native boas may
22 transmit foreign pathogens to U.S. populations of squamate reptiles

23 **Pathways:** cargo, escape, intentional, pet trade

24 **Control measures:** Capture and euthanasia

25 **References:** Martínez-Morales and Cuarón 1999; BurrIDGE et al. 2000; Savage 2002; BurrIDGE and
26 Simmons 2003; Cuarón et al. 2004; Quick et al. 2005; Reed 2005; Romero-Nájera et al. 2007; Kraus 2009;
27 Reed and Rodda 2009; ISSG 2010; Uetz 2010

28 **A8.4.9 *Boiga irregularis*:** established on Guam

29 **Common names:** brown catsnake, brown treesnake, catsnake, mangrove snake

30 **Synonymous scientific names:** *Boiga flavescens*, *Coluber irregularis*, *Dendrophis (Ahetula) fusca*,
31 *Dipsadomorphus irregularis*, *Dipsas boydii*, *Dipsas irregularis*, *Dipsas ornate*, *Hurria pseudoboiga*,
32 *Pappophis flavigastra*, *Pappophis laticeps*, *Triglyphodon flavescens*, *Triglyphodon irregular*

33 **Adult description:** nocturnal, opisthoglyphic, euryphagic; slender; vertical elliptical pupils; set in large
34 eyes; short, blunt heads that are noticeably larger than their necks; arboreal; markings range from vague

1 to distinct dark blotches on a background of brown to yellow. Slender tail that average 21% of their total
2 length; slightly venomous

3 **Reproduction:** Oviparous; Reproduction occurs during the wetter, warmer months which could be any
4 time of year in Guam. Gravid females are less active or more secretive; courtship includes male
5 mounting female, rubbing her body with his chin, and progressing in a jerky motion toward her head
6 while attempting to lift her tail with his tail. Females have ability to store sperm over extended periods
7 of time. Females lay eggs in holes and crevices or underground; clutch sizes are 4 to 12 eggs

8 **Habitat:** habitat generalist; habitat includes: agricultural areas, coastland, natural forests, planted
9 forests, range/grasslands, riparian zones, ruderal/disturbed, scrub/shrublands, urban areas, and
10 wetlands.

11 **Human health impacts:** envenomation of humans; increased insect populations carrying diseases

12 **Economic impacts:** power outages; loss of tourism; preys on poultry

13 **Ecological impacts:** reduction in native biodiversity

14 **Pathways:** aircraft stowaway, cargo, military exercises, natural dispersal, pet trade, seafreight
15 (container/bulk), translocation of machinery, vehicles

16 **Control measures:** fence barriers, electric barriers, fence line searches, traps, detector dogs, methyl
17 bromide, acetaminophen, reduction of prey base

18 **References:** Savidge 1987; Fritts et al. 1990; Fritts and McCoid 1991; Rodda and Fritts 1992; Rodda et al.
19 1992; Fritts et al. 1994; Wiles et al. 1995; Engeman and Linnell 1998; Engeman et al. 1998a; Engeman et
20 al. 1998b; Engeman et al. 1998c; Fritts and Rodda 1998; Rodda et al. 1998; Perry and Morton 1999;
21 Rodda et al. 1999a; Fritts and Leasman-Tanner 2001; Perry et al. 2001; Savarie et al. 2001; Aguon et al.
22 2002; Engeman et al. 2002; Fritts 2002; Rodda et al. 2002 Wiles et al. 2003; Avery et al. 2004; Haynes
23 and Marler 2005 Savarie et al. 2005; Vice et al. 2005; Westbrook et al. 2005; Esselstyn et al. 2006; Gragg
24 et al. 2007; Rodda and Savidge 2007; D'Evelyn et al. 2008; DoD 2008c; Mortensen et al. 2008; Kraus
25 2009; Tyrrell et al. 2009; ISSG 2010; Mauldin and Savarie 2010; Shwiff et al. 2010; Uetz 2010

26 **A8.4.10 *Calotes versicolor*:** a single individual has been removed from the wild on Saipan in the CNMI
27 (Stanford, personal communication) and it is established in multiple locations with SE Asia and on the
28 island of Diego Garcia.

29 **Common names:** bloodsucker lizard, changeable lizard, crested tree lizard, Eastern garden lizard, garden
30 lizard, Indian tree lizard, Oriental garden lizard

31 **Synonymous scientific names:** *Agama tiedemanni*, *Agama versicolor*, *Agama vultuosa*, *Calotes cristatus*,
32 *Calotes gigas*, *Calotes viridis*

33 **Adult description:** about 284 to 378 mm (11 to 15 in) in total length, snout-vent length 81 to 140 mm
34 (3.2 to 5.5 in), tail length 203 to 295 mm (8 to 11.6 in); large and shoulder, expandable dewlaps, and a

1 slender tail; body compressed laterally; males have a conspicuous dorsal crest; 35 to 52 scales over the
2 body; lateral scales point backwards and upwards; two spines above the tympanum; lacks an oblique
3 fold; lacks a pit anterior to the shoulder; coloration dull brown, gray, or olive with various brown spots
4 or bars; males have a pale yellow body with black throat patches and crimson areas on the anterior
5 during breeding

6 **Reproduction:** oviparous; lays eggs late May to October; 1 to 23 eggs per clutch, may have multiple
7 clutches per year; elliptical, white eggs; eggs average 10-13 x 4-10 mm (0.4-0.5 x 0.2-0.4 in) and increase
8 in size after being laid; hatch in 40 to 47 days; lacks an egg-tooth; precocial; hatchlings 22 to 27 mm (0.9
9 to 1 in) in length; under unfavorable conditions, females are able to retain eggs over 6 months by
10 arresting embryo development

11 **Habitat:** common in human-inhabited areas, including parks, gardens, agricultural areas, waste lands,
12 open forests; near water sources; bask on vegetation and roost in shrubs or trees

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** displaces native lizard and skink species

16 **Pathways:** biocontrol, cargo, intentional, nursery trade, pet trade

17 **Control measures:** no information found in the literature

18 **References:** Pandha and Thapliyal 1967; Erdelen 1984; Lever 2003; Enge and Krysko 2004; Kraus 2009;
19 Uetz 2010

20 **A8.4.11 *Carlia ailanpalai*:** established on Guam, Rota, and several islands in the FSM

21 **Common names:** curious skink

22 **Synonymous scientific names:** *Carlia fusca*, *Carlia fuscum*

23 **Adult description:** 32 to 66 mm (1.3 to 2.6 in) snout vent length; dorsum and sides mostly brown, but
24 occasionally have a few white, single-scaled spots or narrow brown lines; dorsolateral white stripe, if
25 present, is faded and confined largely to the neck and axilla; lateral brown band similarly uncommon,
26 faded, and darkest on neck to axilla; midlateral stripe absent; venter cream to ivory

27 **Reproduction:** no information found on wild populations

28 **Habitat:** open, grassy ruderal habitats

29 **Human health impacts:** none found in the literature, but undocumented impacts may exist

30 **Economic impacts:** none found in the literature, but undocumented impacts may exist

31 **Ecological impacts:** serves as a prey source for BTS; competes with native lizards

1 **Pathways:** ecosystem disturbance

2 **Control measures:**

3 **References:** Case and Bolger 1991; Rodda et al. 1991; Rodda and Fritts 1992; Fritts and Rodda 1998;
4 Rodda et al. 1999a; Rodda et al. 1999b; Lever 2003; Zug 2004; Bomford et al. 2005; Pitt et al. 2005;
5 Buden 2009; Kraus 2009

6 **A8.4.12 *Chondrodactylus bibronii***

7 **Common names:** Bibron's gecko, Bibron's thick-toed gecko, cape button-scaled gecko

8 **Synonymous scientific names:** *Pachydactylus bibronii*, *Tarentola bibronii*

9 **Adult description:** 140 to 200 mm (5.5 to 7.9 in) in total length, snout-vent length 75 to 100 mm (3 to 4
10 in), tail roughly the same length as the body; large head and stout body; covered with tough tubercles;
11 segmented body with even, keeled scales; enlarged toe pads with 10 to 12 transverse lamellae under
12 the middle toes; ventral scales do not overlap; lacks loose skin flaps; coloration tan to brown to gray
13 with irregular dark bars and white spots; 8 to 10 white bands on the tail of juveniles; white venter

14 **Reproduction:** breeds in spring; lays pairs of eggs; two clutches per female per year; hatch in late
15 summer; hatchlings 63 mm in length

16 **Habitat:** arid climates, agricultural areas; terrestrial, among rocks, vertical surfaces

17 **Human health impacts:** none found in the literature, but undocumented impacts may exist

18 **Economic impacts:** urine and feces in structures

19 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

20 **Pathways:** cargo, intentional, pet trade

21 **Control measures:** no information found in the literature

22 **References:** Griffin 2002; Cape Nature 2007; Kraus 2009; GeckoWeb 2010; Uetz 2010

23 **A8.4.13 *Cnemidophorus lemniscatus***

24 **Common names:** rainbow lizard, rainbow whiptail, tropical racerunner

25 **Synonymous scientific names:** *Cnemidophorus cryptus*, *Cnemidophorus gramivagus*, *Cnemidophorus*
26 *picturatus*, *Cnemidophorus pseudolemniscatus*, *Cnemidophorus sctitata*, *Lacerta lemniscata*

27 **Adult description:** snout-vent length 35 to 90 mm (1.4 to 3.5 in), tail length 136 to 175 mm (5.4 to 6.9
28 in), weight 4 to 10 g (0.1 to 0.4 oz); males larger; females with 9 dorsal stripes which may diffuse into
29 spots; males with 3 dorsal stripes, rows of dorsolateral white and yellow spots, sides with areas of
30 green, yellow, and gray, sides and bottom of head blue with white spots, and venter a combination of
31 ivory, blue, and green with spots

1 **Reproduction:** bisexual and parthenogenetic populations; breeds during the wet season, August-
2 September in Amazonia; possibly multiple clutches per female; lays 1 to 4 eggs per clutch; snout-vent
3 length 26 to 45 mm (1 to 1.7 in), and weight 0.9 g (0.03 oz) at hatching; white to pale yellowish dorsal
4 stripes on a dark background; light brown venter; stripe down the dorsal midline; dark hind legs with
5 spots

6 **Habitat:** coastal scrub, beach strand, savannah, grasslands, forest edges, and human-inhabited areas,
7 including suburban/urban areas; near water; on the ground or in perches

8 **Human health impacts:** none found in the literature, but undocumented impacts may exist

9 **Economic impacts:** none found in the literature, but undocumented impacts may exist

10 **Ecological impacts:** competition with native lizards

11 **Pathways:** cargo, pet trade, intentional

12 **Control measures:** no information found in the literature

13 **References:** Serena 1984; Vitt et al. 1997; Lever 2003 Mesquita and Colli 2003; van Buurt 2006;
14 Montgomery et al. 2007; Kraus 2009; Uetz 2010

15 **A8.4.14 *Cryptoblepharus carnabyi***

16 **Common names:** Carnaby's wallskink, spiny-palmed snake-eyed skink

17 **Synonymous scientific names:** *Cryptoblepharus plagiocephalus*

18 **Adult description:** information not found

19 **Reproduction:** information not found

20 **Habitat:** open forests with or without a dense understory, rocky outcrops; utilizes tree hollows; avoids
21 grazed areas; will utilize restored habitats

22 **Human health impacts:** none found in the literature, but undocumented impacts may exist

23 **Economic impacts:** none found in the literature, but undocumented impacts may exist

24 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

25 **Pathways:** cargo

26 **Control measures:** no information found in the literature

27 **References:** Asher and Bell 1998; Gibbons and Lindenmayer 2002; Cunningham et al. 2007; Kraus 2009;
28 Michael et al. 2010; UniProt 2010b

1 **A8.4.15 *Cryptoblepharus poecilopleurus***

2 **Common names:** mottled snake-eyed skink, snake-eyed skink

3 **Synonymous scientific names:** *Ablepharus boutonii poecilopleurus*, *Ablepharus heterurus*, *Ablepharus*
4 *poecilopleurus*, *Cryptoblepharus boutoni*

5 **Adult description:** 46 to 48 mm (1.8 in) in length, weight 1.2 to 1.5 g (0.05 oz); stationary, transparent
6 scale over the eye and lower eyelid unable to close; small eye surrounded by small scales; front- and
7 interparietal shields usually fused into diamond shape; large, shiny scales; coloration olive; indistinct
8 white stripe along each side of the back bordered with brown splotches; all dorsal surfaces with small
9 brown and white spots; whitish venter

10 **Reproduction:** information not found

11 **Habitat:** open, disturbed, grassy woodlands, rocky areas; near coasts

12 **Human health impacts:** none found in the literature, but undocumented impacts may exist

13 **Economic impacts:** none found in the literature, but undocumented impacts may exist

14 **Ecological impacts:** significant prey source for BTS

15 **Pathways:** boat, cargo, possibly natural colonization

16 **Control measures:** no information found in the literature

17 **References:** Garman 1901; Crombie and Steadman 1986; Gill 1993; Fritts and Rodda 1998; Lever 2003;
18 USGS 2005c; McCoy 2006; Kraus 2009; Uetz 2010

19 **A8.4.16 *Cryptoblepharus plagiocephalus***

20 **Common names:** Callose-palmed shinning-skink, Peron's snake-eyed skink

21 **Synonymous scientific names:** *Ablepharus boutonii punctatus*, *Ablepharus boutonii plagiocephalus*,
22 *Ablepharus peronii*, *Cryptoblepharus burtonii*, *Cryptoblepharus carnabyi*, *Scincus plagiocephalus*

23 **Adult description:** snout-vent length 30 to 55 mm (1.1 to 2.2 in); shallow head and short legs;
24 stationary, transparent scale over the eye; ear opening present; pale, acute plantar scales; coloration
25 grayish to dark brown with irregular stripes

26 **Reproduction:** reproduces year-round with a peak September-January; eggs 13 x 5 mm (0.5 x 0.2 in); 2
27 eggs per clutch

28 **Habitat:** open woodlands; arboreal, utilizes tree hollows; inhabit diverse environments

29 **Human health impacts:** none found in the literature, but undocumented impacts may exist

30 **Economic impacts:** none found in the literature, but undocumented impacts may exist

1 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

2 **Pathways:** cargo

3 **Control measures:** no information found in the literature

4 **References:** Davidge 1980; James and Shine 1985; Gibbons and Lindenmayer 2002; Sullivan 2005; Kraus
5 2009 JCU 2010a Uetz 2010)

6 **A8.4.17 *Cryptoblepharus virgatus***

7 **Common names:** cream-striped shinning-skink, fence skink, wall skink

8 **Synonymous scientific names:** *Ablepharus boutoni pulcher*, *Ablepharus boutoni virgatus*, *Ablepharus*
9 *boutonii clarus*, *Ablepharus virgatus*

10 **Adult description:** snout-vent length less than 40 mm (1.6 in), tail equally long; blunt snout; granules
11 partially surround the eye; small ear opening; rounded, pale plantar scales; smooth lamellae beneath
12 the digits; 22 rows of smooth or slightly keeled scales on the body; coloration gray to yellowish brown;
13 sides of head brown; brown marking down the dorsal midline; smooth, narrow brown longitudinal
14 stripes; small brown and white spots on flanks and toes; white venter

15 **Reproduction:** breeds August-January or year-round, depending on latitude

16 **Habitat:** woodland, saltmarshes, shrublands, habitat edges, and human inhabited areas, including
17 agricultural and urban areas; arboreal, utilizes tree hollows

18 **Human health impacts:** none found in the literature, but undocumented impacts may exist

19 **Economic impacts:** none found in the literature, but undocumented impacts may exist

20 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

21 **Pathways:** cargo, railways

22 **Control measures:** no information found in the literature

23 **References:** Garman 1901; Clerke and Alford 1993; Gill et al. 2001; Anderson and Burgin 2002; Gibbons
24 and Lindenmayer 2002; Garden et al. 2007 JCU 2007; Kraus 2009; Spencer et al. 2009; Macdonald 2010;
25 Uetz 2010

26 **A8.4.18 *Cyrtopodion scabrum***

27 **Common names:** rougtail gecko, rough-tailed gecko

28 **Synonymous scientific names:** *Cyrtodactylus basoglui*, *Cyrtodactylus scaber*, *Cyrtopodion scaber*,
29 *Gymnodactylus scaber*, *Stenodactylus scaber*, *Tenuidactylus scaber*

1 **Adult description:** rather prickly looking lizard. Rows of prominent pointed keeled scales covering the
2 tail, along with enlarged warty tubercles on the body. A medium-sized gecko, 7.5 to 11.7 cm (3 to 4.6 in)
3 with enlarged toe pads and immovable eyelids, it is sand colored above with small dark brown spots.
4 The tail has dark rings. Nocturnal.

5 **Reproduction:** no information found in the literature

6 **Habitat:** in and around buildings, where it feeds on insects and other arthropods

7 **Human health impacts:** none found in the literature, but undocumented impacts may exist

8 **Economic impacts:** none found in the literature, but undocumented impacts may exist

9 **Ecological impacts:** displaces Mediterranean gecko (another invasive)

10 **Pathways:** cargo

11 **Control measures:** no information found in the literature

12 **References:** Kraus 2009; GeckoWeb 2010; Uetz 2010

13 **A8.4.19 *Diadophis punctatus***

14 **Common names:** ring-necked snake, southern ring-necked snake

15 **Synonymous scientific names:** *Ablabes punctatus*, *Calamaria punctata*, *Coluber punctatus*, *Homalosoma*
16 *punctata*, *Natrix punctatus*

17 **Adult description:** small; greenish-gray or blackish dorsal coloration, yellow to reddish ventrally, yellow
18 color extending dorsally to form a ring around the neck, sometimes interrupted middorsally; maximum
19 length about 38 cm (15 in). Some may have spots on venter; 13 to 17 anterior rows of body scales, 14 to
20 17 rows at mid-body and 13 to 15 rows anterior to anal vent; scales are smooth but with an apical pit;
21 anal plate is divided. Each maxillary has 12 to 21 teeth; those anterior are slender and erect, the 2 most
22 posterior teeth are longer, thicker and directed backward, and separated from the anterior teeth by a
23 diastema. Males have ridges on the body scales near anal vent.

24 **Reproduction:** females mature by 2nd spring; ovulation occurs in June; reproduce annually; oviparous;
25 embryos are somewhat more advanced than other oviparous snakes; aggregations occur in the spring
26 and fall and mating may occur during these times also; egg laying occurs in June or July; nesting sites are
27 under rocks, leafpiles, or fallen bark, in rotting logs and stumps, sawdust piles, or in the walls of animal
28 burrows. 2 to 10 eggs are laid in one clutch (average 3 to 4); larger females lay more eggs; eggs are
29 white, rough, leathery and elongate; hatching occurs in late August or September after an incubation
30 period of 46 to 60 days; hatching process takes several hours.

31 **Habitat:** woodlands; shrublands; meadows; prairies; hides in rocks, logs, stumps, fallen bark or human
32 debris; moist habitats

- 1 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 2 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 4 **Pathways:** cargo, nursery trade
- 5 **Control measures:** no information found in the literature
- 6 **References:** Stevenson 1976; Ernst and Barbour 1989; Kraus 2009; FMNH 2010b
- 7 **A8.4.20 *Dinodon rufozonatum***
- 8 **Common names:** red banded snake
- 9 **Synonymous scientific names:** *Coronella striata*, *Dinodon cancellatum*, *Dinodon rufozonatus*,
10 *Eumesodon striatus*, *Lycodon rufo*, *Lycodon rufozonatus*
- 11 **Adult description:** 800 mm (31 in) in length; nocturnal
- 12 **Reproduction:** no information found in the literature
- 13 **Habitat:** widely distributed from the periphery of croplands to forest
- 14 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 15 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 16 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 17 **Pathways:** unknown
- 18 **Control measures:** no information found in the literature
- 19 **References:** Atsuo 2004; Uetz 2010
- 20 **A8.4.21 *Elaphe carinata***
- 21 **Common names:** Chinese king ratsnake, keeled ratsnake, king ratsnake, Taiwan stink snake, stinking
22 goddess
- 23 **Synonymous scientific names:** *Coluber camillo*, *Coluber phyllophis*, *Elaphe osborni*, *Phyllophis carinata*,
24 *Spaniopholis kreyenbergi*, *Spaniopholis Souliei*
- 25 **Adult description:** large, impressive, heavy-bodied constrictor; habit of eating other snakes; heavily
26 keeled scales that give the skin a rough texture; distinctive habit of releasing a strong, offensive odor
27 from post-anal glands when handled or otherwise threatened; undergoes a rather radical color
28 transformation from relatively non-descript tan-colored juveniles into dark brown or black adults with a
29 striking pattern of bright yellow highlights; tear-drop shaped pupil; can reach 240 cm (94 in) in length.

1 **Reproduction:** Mating usually occurs in spring, with 6 to 12 eggs being laid in early to mid-summer; 40
2 to 60 days incubation before hatching

3 **Habitat:** terrestrial; known to inhabit open forests, fields, meadows and bamboo thickets, although it
4 has also been collected near houses

5 **Human health impacts:** none found in the literature, but undocumented impacts may exist

6 **Economic impacts:** none found in the literature, but undocumented impacts may exist

7 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

8 **Pathways:** pet trade

9 **Control measures:** no information found in the literature

10 **References:** Arkive 2010; Uetz 2010

11 **A8.4.22 *Elaphe guttata***

12 **Common names:** chicken snake, corn snake, red corn snake, red rat snake

13 **Synonymous scientific names:** *Collopeltis guttatus*, *Coluber carolinianus*, *Coluber compressus*, *Coluber*
14 *floridanus*, *Coluber guttatus*, *Coluber guttatus guttatus*, *Coluber guttatus sellatus*, *Coluber laetus*,
15 *Coluber maculates*, *Coluber molossus*, *Coluber pantherinus*, *Coluber rosaceus*, *Coryphodon pantherinus*,
16 *Elaphe emoryi intermontana*, *Elaphe guttata guttata*, *Elaphe guttata rosacea*, *Elaphe laeta*, *Elaphe*
17 *rosacea*, *Elaphe rosaliae*, *Elaphis alleghanensis*, *Elaphis guttatus*, *Natrix guttatus*, *Natrix maculatus*,
18 *Natrix pantherinus*, *Pantherophis guttata*, *Pantherophis guttatus*, *Pituophis guttatus*, *Scotophis guttatus*,
19 *Scotophis laetus*

20 **Adult description:** gray with black-bordered orange or red dorsal blotches and spots, black spots on the
21 lips, and large black squared-blotches on a white venter. A prominent black-bordered, spear-shaped
22 blotch extends forward from neck between eyes, and another black-bordered stripe extends back-ward
23 from the eye past the corner of the mouth and onto the neck. Underside of tail is dark striped; pitted
24 body scales are keeled and occur in 25 rows anteriorly, 27 at mid-body, and 19 at the anal vent; divided
25 anal plate; no sexual dimorphism; 9 to 12 smooth, equal-sized teeth on each maxilla; nocturnal.

26 **Reproduction:** females reach sexual maturity at 16 to 18 months, males at 18 months; mating occurs
27 from March to May; ovulation occurs in late May; gestation period between copulation and oviposition
28 is 35 to 68 days; eggs are laid in late May or June; nest sites are in mammal burrows, sawdust piles, and
29 rotting stumps and logs; eggs are white and elongated and tough; clutch size ranges from 3 to 30 eggs
30 (average of 10 to 15 eggs). Incubation is 51 to 58 days; hatching occurs July to early September. Females
31 can lay one or two clutches per year.

32 **Habitat:** brush fields, pine barrens, open deciduous woodlands, canyons, rocky ledges, caves, around
33 trash dumps and old buildings; often in trees or bushes; occasionally swimming across small streams;

1 swamps; agricultural fields; residential areas; pinelands; hardwood hammocks; man-made structures
2 such as erosion control rocks

3 **Human health impacts:** none found in the literature, but undocumented impacts may exist

4 **Economic impacts:** none found in the literature, but undocumented impacts may exist

5 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

6 **Pathways:** cargo, nursery trade (such as in the root ball of plants), pet trade

7 **Control measures:** no information found in the literature

8 **References:** Ernst and Barbour 1989; Lever 2003; Henderson 2004; Sperry and Taylor 2008; Kraus 2009;
9 FMNH 2010a

10 **A8.4.23 *Elaphe taeniura friesi***

11 **Common names:** beauty snake, Taiwan beauty snake

12 **Synonymous scientific names:** *Coluber taeniurus*, *Coluber taeniurus var. friesei*, *Coluber schmackeri*,
13 *Elaphe schmackeri*, *Elaphe taeniura*, *Elaphe taeniura friesi*, *Elaphe taeniura grabowskyi*, *Elaphe taeniura*
14 *mocquardi*, *Elaphe taeniura ridleyi*, *Elaphe taeniura schmackeri*, *Elaphe taeniura yunnanensis*, *Elaphe*
15 *taeniura vaillanti*, *Elaphe taeniurus*, *Elaphis grabowskyi*, *Elaphis taeniurus*, *Elaphis yunnanensis*,
16 *Orthriophis taeniurus*, *Orthriophis taeniurus friesi*, *Orthriophis taeniurus ridleyi*, *Orthriophis taeniurus*
17 *yunnanensis*

18 **Adult description:** variable in color, but usually has light and dark shades of brown and yellow; the
19 anterior part of the snake has a pattern of splotches and banding; the tail is just striped.

20 **Reproduction:** oviparous; Eggs: 4 to 5

21 **Habitat:** forests

22 **Human health impacts:** none found in the literature, but undocumented impacts may exist

23 **Economic impacts:** none found in the literature, but undocumented impacts may exist

24 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

25 **Pathways:** cargo, pet trade

26 **Control measures:** no information found in the literature

27 **References:** Kraus 2009; Oakland Zoo 2010; Uetz 2010

28 **A8.4.24 *Elgaria multicarinata***

29 **Common names:** southern alligator lizard

1 **Synonymous scientific names:** *Gerrhonotus multicoloratus*

2 **Adult description:** Adult length up to 53 cm (21 in); half of total length is its long, slim tail; small legs
3 when compared to body size; light or medium brown to yellow ochre in color with variable cross-bars on
4 the back and some black and white spots along the sides; have a fold of skin along the lower sides where
5 the scales of the belly meet the scales of the back; faint, thin black stripes on belly that run through the
6 middle of each scale row; scales on the back are large with very distinct keeling; skin texture appears
7 rough; have large, triangular-shaped heads (more pronounced in males).

8 **Reproduction:** oviparous; mate in May; up to 20 eggs laid in June or July.

9 **Habitat:** habitat generalist, dry, open woodlands of ponderosa pine and oak; often found among rocks,
10 and the leaf litter of oaks, wild grapes, other vines, and poison oak; frequently found in coastal plains as
11 well as in mountainous regions up to 2,286 m (7,500 feet) in elevation; adapted to living in urban
12 habitat; often seen in yards, gardens, in garages, and under piles of wood, rocks, and debris

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

16 **Pathways:** cargo, possibly in aircraft

17 **Control measures:** no information found in the literature

18 **References:** Mahoney et al. 2003; BMNHC 2006; Kraus 2009

19 **A8.4.25 *Emoia cyanura***

20 **Common names:** azure-tailed skink, bluetail emo skink, copper-tailed skink, white-bellied skink

21 **Synonymous scientific names:** *Emoia pheonura*, *Eumeces lessonii*, *Eusoma lessonii*, *Lygosoma arundelii*,
22 *Lygosoma cyanurum*, *Lygosoma cyanurum schauinslandi*, *Lygosoma impar*, *Scincus cyanurus*, *Tiliqua*
23 *kienerii*, *Tiliqua lessonii*

24 **Adult description:** small, striped skink; has 65 to 70 scales on the underside of the fourth toe. When
25 compared to *Emoia caeruleocauda*, the bluetail emo skink has a vertebral stripe that is wider on the
26 head and the stripes are whiter. Also, there is a pineal eye spot that is visible in the middle of the head
27 behind the eyes. The scales of the vertebral stripe are unfused which means that median scales are not
28 present. The belly and underside of the thighs are white. The tail will never be a bright blue color;
29 instead it is a pale blue-green. The belly will also never be bright green.

30 **Reproduction:** no information found

31 **Habitat:** forest, grassy and rocky areas near seashore, and gardens. In areas where it exists with *Emoia*
32 *caeruleocauda*, the bluetail emo skink can usually be found living at the forest edge and not in the

1 interior. On the islands in American Samoa it occurs in most habitats, but is less abundant in dense
2 forest at higher elevations

3 **Human health impacts:** none found in the literature, but undocumented impacts may exist

4 **Economic impacts:** none found in the literature, but undocumented impacts may exist

5 **Ecological impacts:** may be contributing to the naturalization of species that prey on it

6 **Pathways:** cargo, personal effects

7 **Control measures:** no information found in the literature

8 **References:** Gill 1993; Schwaner and Ineich 1998; Lever 2003; USGS 2005c Kraus 2009; Uetz 2010;
9 UniProt 2010a

10 **A8.4.26 *Eulamprus tenuis***

11 **Common names:** bar-sided forest skink, bar-sided skink, barred-sided skink

12 **Synonymous scientific names:** *Lygosoma erucata*, *Lygosoma (Sphenomorphus) tenue*, *Lygosoma tenue*,
13 *Sphenomorphus tenuis*, *Tiliqua tenuis*

14 **Adult description:** no information found

15 **Reproduction:** no information found

16 **Habitat:** open habitat, disturbed areas, areas with open canopies, and wet habitats like rainforests and
17 wet sclerophyll forests. They are arboreal.

18 **Human health impacts:** none found in the literature, but undocumented impacts may exist

19 **Economic impacts:** none found in the literature, but undocumented impacts may exist

20 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

21 **Pathways:** cargo

22 **Control measures:** no information found in the literature

23 **References:** Kraus 2009; Uetz 2010

24 **A8.4.27 *Gehyra mutilata*:** established on numerous islands within Micronesia and the broader Pacific
25 region

26 **Common names:** common four-clawed gecko, mutilating gecko, stump-toed gecko

27 **Synonymous scientific names:** *Dactyloperus insulensis*, *Gecko pardus*, *Gehyra beebei*, *Gehyra harrieti*,
28 *Gehyra insulanus*, *Gehyra insulensis*, *Gehyra mugtilata (sic)*, *Gehyra mutilate*, *Gehyra packardii*,
29 *Hemidactylus mutilates*, *Hemidactylus navarii*, *Hemidactylus navarri*, *Hemidactylus Peronii*, *Hemidactylus*

1 (*Peropus*) *mutilates*, *Hemidactylus platurus*, *Hemidactylus pristiurus*, *Peripia mutilate*, *Peripia Peronii*,
2 *Peropus (Dactyloperus) Peronii*, *Peropus mutilates*, *Peropus multilatus (sic)*, *Peropus packardii*

3 **Adult description:** Total adult length is between 8.5 to 11.5 cm (3.4 to 4.5 in); absence or near-absence
4 of a claw on the inner digit of its fore and hind feet; stout body; row of enlarged scales running along the
5 underside of tail; during day they are gray to grayish brown in color, but fade to whitish when active at
6 night; head and body speckled with light and dark spots; very thin light lines ring the tail; dark-edged
7 light line runs through eyes; has a flattened tail that is constricted at the base so that it has a carrot-like
8 shape; skin is somewhat translucent.

9 **Reproduction:** females lay two round eggs that are adherent to each other and to the substrate.

10 **Habitat:** habitat generalist; may occur in natural forests, disturbed garden areas, and urban areas. They
11 are arboreal.

12 **Human health impacts:** none found in the literature, but undocumented impacts may exist

13 **Economic impacts:** none found in the literature, but undocumented impacts may exist

14 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

15 **Pathways:** cargo, pet trade, zoo trade

16 **Control measures:** no information found in the literature

17 **References:** Fisher 1997; Kraus 2009; Rocha et al. 2009; GeckoWeb 2010; Uetz 2010

18 **A8.4.28 Gekko gekko:** established in Hawai'i

19 **Common names:** Tokay gecko

20 **Synonymous scientific names:** *Gekko reevesii*, *Gekko verticillatus*, *Gekko aculeatus*, *Gekko annulatus*,
21 *Gekko guttatus*, *Gekko indicus*, *Gekko perlatus*, *Gekko tenuis*, *Gekko teres*, *Gekko verticillatus*, *Gekko*
22 *verus*, *Gymnodactylus tenuis*, *Lacerta gekko*, *Platydactylus guttatus*

23 **Adult description:** one of the largest gecko species in the world reaching nearly 305 mm (12 in) in
24 length. Orange and white markings against a gray or blue-gray ground color; upperparts ultramarine
25 with numerous spots of rusty red or orange; the protuberant eyes may vary from yellow-green to
26 orange. The pupils are complex and vertically elliptical; no eyelids; toe pads are large and easily visible.
27 Nocturnal; head relatively large and triangular; tail banded with dark pigment; total length up to 350
28 mm (13.8 in).

29 **Reproduction:** may lay several clutches annually; the young exceed 76 mm (3 in) at hatching; communal
30 nesting occurs; the hard-shelled, paired, adhesive-shelled eggs are deposited in secluded areas of
31 buildings, tree hollows, or other like spots; females lay pairs of eggs communally; as many as 140 eggs
32 have been found in one nest

- 1 **Habitat:** urban
- 2 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 4 **Ecological impacts:** preys upon native lizard and frog species
- 5 **Pathways:** biocontrol, cargo, intentional, pet trade
- 6 **Control measures:** no information found in the literature
- 7 **References:** Stevenson 1976; Meshaka Jr. et al. 1997; Bartlett and Bartlett 1999 Kraus 2009; GeckoWeb
8 2010; Uetz 2010
- 9 **A8.4.29 *Gekko hokouensis***
- 10 **Common names:** Kwangsi gecko
- 11 **Synonymous scientific names:** *Gekko japonicas*, *Gekko liboensis*, *Luperosaurus amissus*
- 12 **Adult description:** small; arboreal; insectivorous; nocturnal; possessing a single process in each side of
13 the base of tail, and limbs covered only with granular scales; has a single spur on each side of the base of
14 the tail; tubercles are absent on the four limbs, and relatively few around the middle of the body.
- 15 **Reproduction:** females have oviductal eggs in April and may have multiple clutches until the end of July,
16 when egg production ceases. This pattern of Reproduction differs from the continuous Reproduction
17 seen in tropical geckos, and is common to other subtropical and temperate geckos. Cessation of
18 ovulation during the late summer when temperature is still high may result from selection caused by the
19 low tolerance of developing embryos against lower temperature in autumn, as in a few other East Asian
20 geckos.
- 21 **Habitat:** montane environments
- 22 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 23 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 24 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 25 **Pathways:** nursery trade, cargo
- 26 **Control measures:** no information found in the literature
- 27 **References:** Zhou et al. 1982; Okada et al. 2002; Bauer and Baker 2008; Kraus 2009; Uetz 2010
- 28 **A8.4.30 *Gonatodes albogularis***
- 29 **Common names:** yellow-headed gecko

1 **Synonymous scientific names:** *Gonatodes fuscus*

2 **Adult description:** Has round pupils and lacks toe pads; very dimorphic, it is only the dark bodied males
3 (with a bluish sheen, especially at night) that have the yellow head and a dark shoulder spot sometimes
4 outlined with blue. The male's tail is yellow and if not regenerated, will have white tip. Coloration is
5 brightened during breeding season. Females are gray with a lighter collar; markings on body may have a
6 light crossbanded effect. Belly is usually light. Diurnal; snout-vent length is 38 mm (1.5 in) with tail about
7 the same length; head and body slightly depressed and limbs well developed; hind legs noticeably
8 stouter than the forelegs; very large eyes that lack lids.

9 **Reproduction:** lays a single egg at a time; each female can produce several eggs annually; incubation
10 lasts a little more than 2 months; eggs are large compared to the size of the animal; are white and
11 brittle; hatchlings are about 15 mm (0.6 in) long from snout to vent; may reproduce year-round, but
12 Reproduction decreases during the dry season

13 **Habitat:** inhabiting large-diameter, rough-barked, horizontal limbs; rock and rubble piles and behind
14 exfoliating tree bark; found inside and outside dwellings or other buildings; prefers dry microhabitats

15 **Human health impacts:** none found in the literature, but undocumented impacts may exist

16 **Economic impacts:** none found in the literature, but undocumented impacts may exist

17 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

18 **Pathways:** cargo, pet trade

19 **Control measures:** no information found in the literature

20 **References:** Smith 1946; Stevenson 1976; Bartlett and Bartlett 1999; Krysko 2005 Kraus 2009

21 **A8.4.31 *Hemidactylus frenatus*:** established on numerous islands in Micronesia as well as the broader
22 Pacific region

23 **Common names:** Common house gecko

24 **Synonymous scientific names:** *Hemidactylus mabouia*

25 **Adult description:** average length is 76 to 102 mm (3 to 4 in) and can reach 114 mm (4.5 in). Ashy gray
26 dorsal color with an irregular pattern of obscure darker pigment; lighter color at night; ventral surface is
27 nearly white; a gray lateral line may be present; scales are mostly smooth, and six rows of pronounced
28 spinous scales on tail.

29 **Reproduction:** eggs are only weakly adhesive and are usually placed in crevices or beneath loose ground
30 debris. Females produce several clutches are produced annually; communal nesting; 48-day incubation
31 period; 51 mm (2 in) long hatchlings.

32 **Habitat:** habitat generalist

- 1 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 2 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Ecological impacts:** competition with native geckos; has displaced to some extent the gecko species
- 4 *Nactus coindemirensis*; predation on native geckos; host of the pentasome parasites *Raillietiella frenatus*
- 5 and *Waddycephalus* species; carries the red gecko mite *Geckobia bataviensis*
- 6 **Pathways:** boat, cargo, intentional, natural dispersal, nursery trade, pet trade, seafreight
- 7 (container/bulk)
- 8 **Control Methods:** exclusion, euthanasia
- 9 **References:** Case and Bolger 1991; Case et al. 1994; Hanley et al. 1995 Petren and Case 1996 Canyon
- 10 and Hii 1997; Hanley et al. 1998; Bartlett and Bartlett 1999; Brown et al. 2002; Jones and Cole 2004;
- 11 Barquero and Hilje 2005; Cole et al. 2005; Cogger et al. 2006; Dame and Petren 2006; Varnham 2006;
- 12 Barton 2007; Couper et al. 2007; Newbery and Jones 2007; Conroy et al. 2009; Csurhes and Markula
- 13 2009; Kraus 2009; Hoskin 2010; ISSG 2010
- 14 **A8.4.32 Hemidactylus garnotii**
- 15 **Common names:** fox gecko, Garnot's house gecko, Indo-Pacific gecko
- 16 **Synonymous scientific names:** *Doryura garnotii*, *Doryura gaudama*, *Doryura vulpecula*, *Hemidactylus*
- 17 *blanfordii*, *Hemidactylus (Doryura) mandellianus*, *Hemidactylus garnetii*, *Hemidactylus guadama*,
- 18 *Hemidactylus ludekingii*, *Hemidactylus mortoni*, *Hemidactylus peruvianus*, *Hoplopodion (Microdactylus)*
- 19 *peruvianum*, *Hoplopodion (Onychopus) garnotii*, *Lepidodactylus garnotii*, *Nycteridium gaudama*
- 20 **Adult description:** small with a sharply denticulate lateral fringe on the strongly depressed tail and claws
- 21 on the inner fingers and toes; large divided digital pads and no retractile claws. All are females. 65 mm
- 22 (2.6 in); dorsum with small flat granular scales except along sides, where small tubercles present; two or
- 23 three pairs of large chin shields. Dorsum uniform grayish tan or marbled with darker brown, usually with
- 24 small whitish spots of various sizes and shapes; venter yellow, underside of tail pale red.
- 25 **Reproduction:** Parthenogenetic; motions of courtship are still indulged and may be necessary to
- 26 stimulate egg development. Several sets of two eggs are produced annually; breeds year-round in warm
- 27 areas; eggs are placed in crevices; incubation lasts for 7 weeks; hatchlings are 51 mm (2 in) long.
- 28 **Habitat:** buildings, trees, fences and similar structures
- 29 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 30 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 31 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 32 **Pathways:** cargo, intentional, nursery trade, zoo trade

1 **Control methods:** no information found in the literature

2 **References:** Stevenson 1976; Lazell Jr. 1989; Bartlett and Bartlett 1999; Savage 2002; Kraus 2009 Uetz
3 2010

4 **A8.4.33 *Hemidactylus platyurus***

5 **Common names:** flat-tailed house gecko

6 **Synonymous scientific names:** *Cosymbotus platyurus*, *Gecko marginatus*, *Hemidactylus marginatus*,
7 *Hemidactylus platyurus*, *Lomatodactylus platyurus*, *Platyurus marginatus*, *Stellio platyurus*

8 **Adult description:** nocturnal; snout longer than the distance between the eye and the ear-opening, one
9 time and a half the diameter of the orbit; forehead concave; ear-opening small, oval, oblique. Rostral
10 four-sided, not twice as broad as high, with median cleft above; nostril bordered by the rostral, the first
11 labial and three nasals. Tail depressed, flat inferiorly, with sharp denticulated lateral edge, covered
12 above with uniform small granules, below with a median series of transversely dilated plates. Body
13 depressed; limbs moderate, depressed; digits strongly dilated, about half-webbed, inner well developed;
14 3 to 6 lamellae under the inner, 7 to 9 under the median digits. Grey above, marbled with darker grey;
15 generally a dark streak from eye to shoulder; lower parts white; length of head and body 61 mm (2.4 in);
16 tail 66 mm (2.6 in); lateral skin flaps on the body.

17 **Reproduction:** mating does not take place seasonally, and copulation occurs when the ovarian eggs are
18 small, indicating that viable spermatozoa may be retained by the females for considerable periods of
19 time. Reproduce at any time of the year without undergoing a definite seasonal cycle; lay pairs of eggs in
20 crevices above ground.

21 **Habitat:** bright commercial areas such as walls of warehouses

22 **Human health impacts:** none found in the literature, but undocumented impacts may exist

23 **Economic impacts:** none found in the literature, but undocumented impacts may exist

24 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

25 **Pathways:** cargo, pet trade

26 **Control methods:** no information found in the literature

27 **References:** de Rooij 1915; Church 1962; Kraus 2009; Biolib 2010 GeckoWeb 2010

28 **A8.4.34 *Hemidactylus turcicus***

29 **Common names:** Mediterranean gecko, Mediterranean house gecko

30 **Synonymous scientific names:** *Gecko meridionalis*, *Gecko verrucosus*, *Gecko verruculatus*, *Gecus*
31 *cyanodactylus*, *Hemidactylus exsul*, *Hemidactylus granosus*, *Hemidactylus karachiensis*, *Hemidactylus*
32 *robustus*, *Hemidactylus verruculatus*, *Lacerta turcica*

1 **Adult description:** large eyes, toe pads, and size (maximum snout-vent length is 60 mm, tail about the
2 same); transverse lamellae divided medially. This is the most warty species of the four species of house
3 geckos, its head, body, legs and tail covered with prominent tubercles. Adults may reach 13 cm (5 in).
4 Like all house geckos they are rather flattened, with large heads, bulging eyes with vertical pupils and
5 covered with an immovable clear spectacle. It is usually darker brown or gray with darker spots by day
6 than at night, when it may appear a ghostly white. Irregular dark markings across the head and back
7 may disappear at night. The tail has dark bands, which are especially prominent in juveniles. The belly is
8 white and somewhat translucent.

9 **Reproduction:** Females lay pairs of oval white hard shelled eggs above ground, under loose bark, palm
10 fronds or other protected location. They are a communal nesting species. A female's clutch of two eggs
11 may amount to 25% or more of her body weight.

12 **Habitat:** often found lurking on walls or ceilings near lights, waiting to ambush moths and other insects

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** outcompetes native nocturnal climbing geckos

16 **Pathways:** biocontrol, cargo, intentional, pet trade, vehicle

17 Control methods: no information found in the literature

18 **References:** Stevenson 1976; Kraus 2009; GeckoWeb 2010; Uetz 2010

19 **A8.4.35 *Hemiphyllodactylus typus***

20 **Common names:** common dwarf gecko, Indo-pacific tree gecko

21 **Synonymous scientific names:** *Hemiphyllodactylus albostictus*, *Hemiphyllodactylus ceylonensis*,
22 *Hemiphyllodactylus crepuscularis*, *Hemiphyllodactylus insularis*, *Hemiphyllodactylus leucostictus*,
23 *Hemiphyllodactylus margarethae*, *Lepidodactylus auranticus*, *Lepidodactylus ceylonensis*, *Lepidodactylus*
24 *crepuscularis*, *Platydactylus crepuscularis*, *Ptyodactylus gracilis*, *Spathodactylus mutilates*,
25 *Spathoscalabotes mutilates*

26 **Adult description:** tiny; secretive; nocturnal; slender, translucent body covered in tiny granular scales;
27 lacks the warty tubercles and spines found on many other geckos; relatively long thin body and
28 proportionately short legs, but only reaches 6 to 9 cm (2.4 to 3.5 in); rudimentary, clawless inner toe on
29 the forefoot; color varies from almost white at night to light or dark gray or brown; tiny white flecks and
30 irregular black smudges are scattered along the back; there is a thin black line running from the snout
31 through the eye and across the neck and shoulder; underside of the tail is orange.

32 **Reproduction:** all are females; lay fertile eggs without copulating with a male. Each gecko lays pairs of
33 adherent eggs under bark or other protected location.

- 1 **Habitat:** forested areas and valleys, not around urban areas
- 2 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 4 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 5 **Pathways:** cargo, nursery trade, zoo trade
- 6 **Control methods:** no information found in the literature
- 7 **References:** Kraus 2009; GeckoWeb 2010 Uetz 2010
- 8 **A8.4.36 *Lampropholis delicata***
- 9 **Common names:** dark-flecked garden sun skink, delicate skink, garden skink, penny skink, rainbow skink
- 10 **Synonymous scientific names:** *Leiolopisma delicata*
- 11 **Adult description:** snout-vent is 4 to 5 cm (1.6 to 2 in); tail is 6 cm (2.4 in); active during the day as well
12 as the night; upper portion of the body is darker than the underside, and there is often a white line
13 present on the flank; lower eyelid is movable; plain-looking with short limbs, a small head and a small
14 ear. Usually rich brown above, sometimes bordered on the edges of the back by a narrow, often broken,
15 narrow line of paler color; no vertebral stripe; narrow black stripe runs back from the tip of the snout,
16 through the eye, often breaking up above the ear before reforming into a dark band on the upper sides;
17 sides dark dorsally, becoming paler toward the belly. Uniform coloration on side of neck; head is
18 generally not distinct from the neck; cream colored below, without any trace of orange or pink.
- 19 **Reproduction:** share an egg-laying site; clutch sizes range from 3 to 6 eggs.
- 20 **Habitat:** generalist; widespread; often seen foraging in gardens for small insects in gardens where there
21 is moisture; occur most commonly in dry areas amongst open grassy woodland at low altitudes
- 22 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 23 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 24 **Ecological impacts:** possible competition with native reptiles
- 25 **Pathways:** cargo, nursery trade
- 26 **Control methods:** no information found in the literature
- 27 **References:** Baker 1979; Howard et al. 2003; Lever 2003; Peace 2004 NZHS 2008; TPWS 2008; Kraus
28 2009 JCU 2010b

- 1 **A8.4.37 *Lepidodactylus aureolineatus***
- 2 **Common names:** golden scaly-toed gecko
- 3 **Synonymous scientific names:** no information found in the literature
- 4 **Adult description:** no information found in the literature
- 5 **Reproduction:** no information found in the literature
- 6 **Habitat:** coconut palms and aerial ferns
- 7 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 8 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 9 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 10 **Pathways:** cargo; nursery trade
- 11 **Control methods:** no information found in the literature
- 12 **References:** Zug 2006; Kraus 2009
- 13 **A8.4.38 *Lepidodactylus lugubris*:** Established on numerous islands of Micronesia as well as the broader
- 14 Pacific
- 15 **Common names:** common smooth-scaled gecko, mourning gecko
- 16 **Synonymous scientific names:** *Amydosaurus lugubris*, *Dactyloperus Pomareae*, *Gecko harrieti*, *Gecko*
- 17 *lugubris*, *Gehyra neglecta*, *Gehyra ogasawarasimae*, *Gehyra variegata ogasawarasimae*, *Gymnodactylus*
- 18 *candeloti* (sic), *Gymnodactylus caudeloti*, *Hemidactylus meijeri*, *Lepidodactylus candeloti*, *Lepidodactylus*
- 19 *ceylonensis*, *Lepidodactylus crepuscularis*, *Lepidodactylus divergens*, *Lepidodactylus lugubris*,
- 20 *Lepidodactylus mysorensis*, *Lepidodactylus roseus*, *Lepidodactylus woodfordi*, *Peripia cantoris*, *Peripia*
- 21 *lugubris*, *Peripia meyeri*, *Peripia mysorensis*, *Peripia ornate*, *Peropus neglectus*, *Peropus roseus*, *Peropus*
- 22 *variegatus ogasawarasimae*, *Platydactylus (Lepidodactylus) crepuscularis*, *Platydactylus lugubris*
- 23 **Adult description:** nocturnal; large digital pads, non retractile claws on the outer digits, the first digit
- 24 clawless, and basally webbed digits. Males are 35 to 39 mm (1.5 in) in standard length and females are
- 25 31 to 45 mm (1.2 to 1.8 in) in length. Digits webbed basally; dorsal scales homogeneous, granular; chin
- 26 shields small, several in contact with infralabials; ventral scales flat, rounded, imbricate; tail flattened
- 27 beneath with some-what serrate margin, covered with small flat scales; subcaudal scales somewhat
- 28 enlarged. Skin on back is satiny and lacks tubercles. Dorsum pale light pinkish gray to light brown,
- 29 sometimes uniform but usually with prominent pair of brown spots just anterior to forelimbs; often with
- 30 scattered small dark spots and/or irregular lines or chevrons; a wide dark band from snout through eye
- 31 to forelimb; tail usually with dark markings; venter creamy white.

1 **Reproduction:** an all-female species, the uni-sexual mourning geckos are communal nesters, laying pairs
2 of eggs in favored locations such as tree cavities, in leaf axils or under loose bark. Some females seem to
3 take on a dominant role, even showing courtship-like behavior. Eggs are saltwater tolerant.

4 **Habitat:** arboreal and found in and around residences

5 **Human health impacts:** none found in the literature, but undocumented impacts may exist

6 **Economic impacts:** none found in the literature, but undocumented impacts may exist

7 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

8 **Pathways:** cargo, pet trade, zoo trade

9 **Control methods:** no information found in the literature

10 **References:** Savage 2002; Kraus 2009; GeckoWeb 2010; Uetz 2010

11 **A8.4.39 *Lipinia noctua*:** Native to parts of Micronesia

12 **Common names:** moth skink

13 **Synonymous scientific names:** *Euprepes novarae*, *Leiolopisma noctua*, *Lygosoma (Leiolopisma) miotis*,
14 *Lygosoma (Leiolopisma) noctua*, *Lygosoma (Leiolopisma) subnitens*, *Lygosoma (Lipinia) aurea*, *Lygosoma*
15 *miotis*, *Lygosoma noctua*, *Lygosoma vertebrale*, *Scincus noctua*

16 **Adult description:** small, 55 mm (2.2 in); has paired scales; yellow spot on the top of the head, which
17 may be contiguous with a narrower yellow mid-dorsal stripe continuing onto the body but fading before
18 reaching the base of the tail. It also has an interparietal scale and lacks supranasal scales, small scales
19 between the scale containing the nostril and the internasals on the top of the snout. Overall, the
20 coloration is brown or tan flecked with lighter and darker marks. A thick black line runs from the snout
21 to the eye and onto the lateral body, fragmenting before reaching the base of the hindlimb. The lips are
22 marked with alternating black and white bars. The belly is yellow to orange under the body and legs,
23 fading to a pale bluish green under the tail and chin. This lizard will break its toes as well as its tail to
24 escape the grasp of a potential predator.

25 **Reproduction:** gives birth to live young; ovoviparous; both oviducts are functional

26 **Habitat:** habitat generalist; found on the ground or low in trees; walls of buildings; has terrestrial and
27 arboreal habits

28 **Human health impacts:** none found in the literature, but undocumented impacts may exist

29 **Economic impacts:** none found in the literature, but undocumented impacts may exist

30 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

31 **Pathways:** cargo

1 **Control methods:** no information found in the literature

2 **References:** Zweifel 1979; USGS 2005c; Kraus 2009; Uetz 2010

3 **A8.4.40 *Lycodon aulicus*:** This species has been captured several times including a probable record from
4 Yap (Stanford, personal communication)

5 **Common names:** common wolf snake, Indian wolf snake, wolf snake

6 **Synonymous scientific names:** *Lycodon aulicus capucinus*

7 **Adult description:** nocturnal; large front teeth; enlarged, non-grooved rear maxillary teeth. The
8 common wolf snake is a relatively slender-bodied snake with a ventrolateral keel along the body
9 commonly associated with arboreal snakes. It also has a head that is distinctly wider than the neck, a
10 vertically elliptical pupil, 17 longitudinal rows of smooth dorsal scales at midbody, dorsal scales with
11 apical scale pits, 181 to 211 ventral scales, 56 to 70 subcaudals, a divided anal scale, a weak
12 ventrolateral keel on lateral margins of ventrals, a preocular scale, a loreal scale in broad contact with
13 divided internasal scales, and a snout somewhat flattened and protruding beyond lower jaw. The dorsal
14 coloration is variable, usually brown with a reticulation of fine white lines, and occasionally with white
15 crossbars. The reported maximum size is variable and may be related to the abundance and diversity of
16 prey. Females may attain larger sizes than males with a maximum length of 50 to 84 cm (19.7 to 30 in)
17 (depending on the location).

18 **Reproduction:** oviparous with up to a dozen eggs laid at one time up to twice per year. Clutch size is
19 correlated to female body size. Females have been discovered curled around eggs and males are known
20 to stay in close association with females after mating.

21 **Habitat:** habitat generalist; in and around rock walls, stone piles, and trash piles; in drier areas where
22 lizards are abundant. Usually found around urban areas and human-made structures. They occupy
23 terrestrial and arboreal habitats as well as almost any kind of disturbed habitat

24 **Human health impacts:** none found in the literature, but undocumented impacts may exist

25 **Economic impacts:** none found in the literature, but undocumented impacts may exist

26 **Ecological impacts:** possible detrimental effect on gecko, mouse, skink, and frog populations

27 **Pathways:** cargo, natural dispersal

28 **Control methods:** no information found in the literature

29 **References:** Mehrtens 1987; Fritts 1993; Kraus 2009

30 **A8.4.41 *Mabuya multifasciata***

31 **Common names:** common sun skink, East Indian brown mabuya, many-lined sun skink, rough mabuya

1 **Synonymous scientific names:** *Euprepes sebae*, *Eutropis multifasciata*, *Eutropis multifasciatus*, *Mabuia*
2 *monticola*, *Mabuia multifasciata*, *Plestiodon sikkimensis*, *Scincus multifasciatus*, *Tropidolepisma*
3 *macrurus*

4 **Adult description:** 30 to 34 mid-body scale rows; 43 to 45 paravertebral scale count; 3 dorsal keels;
5 reduced size of the first supraocular, not in contact with the frontal; upper secondary temporal overlaps
6 the parietal. Relatively large; slight sexual dimorphism occurs where males are generally larger than
7 females; males can reach 117 mm (4.6 in) and females can reach 116 mm (4.6) in length.

8 **Reproduction:** viviparous; parturition begins in early May and females can produce up to 2 litters each
9 breeding season; litter size ranges from 2 to 7;

10 **Habitat:** terrestrial; open sunny space; prefers disturbed habitats such as forest edges and riverbeds;
11 gardens; rice fields

12 **Human health impacts:** none found in the literature, but undocumented impacts may exist

13 **Economic impacts:** none found in the literature, but undocumented impacts may exist

14 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

15 **Pathways:** cargo, pet trade

16 **Control methods:** no information found in the literature

17 **References:** Pauwels et al. 2003; Ji et al. 2006; Howard et al. 2007; Kraus 2009 Uetz 2010

18 **A8.4.42 *Naja kaouthia***

19 **Common names:** Bengal Cobra, Monocellate Cobra, Monocled cobra, Thailand Cobra

20 **Synonymous scientific names:** *Naja naja sputatrix*, *Naja tripudians* var. *fasciata*

21 **Adult description:** have a single circular mark on dorsal hood; relatively placid; has spitter fangs but
22 rarely spits. Throat pale, with scarcely any dark mottling, often followed by a single dark band. Vento-
23 lateral throat spots distinct and remainder of venter is pale or increasingly cloudy with darker
24 pigmentation towards rear. Hood markings are usually distinct and is usually a pale, oval, or circular
25 marking with a dark center and occasionally a narrow dark outer border. Medium to large in length,
26 heavy bodied snake with long cervical ribs capable of expansion to form a hood when threatened. Body
27 is compressed dorsoventrally and sub-cylindrical posteriorly. Can grow to a maximum of about 2 m (6.6
28 feet) but rarely exceeds 1.6 m (5.2 feet). Head is elliptical, depressed, slightly distinct from neck with a
29 short, rounded snout and large nostrils. Eyes are medium in size with round pupils. Dorsal scales are
30 smooth and strongly oblique. Underside of tail is usually light, but often suffused with dark pigment.
31 Nocturnal.

32 **Reproduction:** the female will lay about 25 to 45 eggs and she usually stays with them until they hatch.
33 The offspring are independent as soon as they are born.

1 **Habitat:** adaptable to a wide range of terrain including grassland plains, jungle, open fields and even
2 heavy populated regions. Usually found at elevations below about 700 m (2,296 feet). Often found in
3 tree holes and areas where rodents are plentiful.

4 **Human health impacts:** venomous; bites are potentially fatal

5 **Economic impacts:** none found in the literature, but undocumented impacts may exist

6 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

7 **Pathways:** cargo

8 **Control methods:** no information found in the literature

9 **References:** Looareesuwan et al. 1988; Greene 1997; Wüster 1998 Khandelwal et al. 2007; Amin et al.
10 2008; Kraus 2009; Kulkeaw et al. 2009; UAA 2010; Uetz 2010

11 **A8.4.43 *Pelodiscus sinensis***

12 **Common names:** Chinese soft-shell turtle, Chinese softshell

13 **Synonymous scientific names:** *Trionyx spiniferus*

14 **Adult description:** carapace length averages 112 to 250 mm (4.4 to 10 in); carapace is oval with a
15 marginal ridge; carapace smooth except for a few enlarged blunt knobs on the anterior rim above the
16 neck; head and limbs olive to yellowish-white; head and neck may have fine black lines; throat is either
17 light with vermiculations or dark with yellow spots; often fine black lines radiating from the eye; tubular
18 snout with a lateral ridge projecting from each side of the nasal septum; fleshy lips; ventral surface pale
19 or white; cluster of wattles between neck and carapace lacking or underdeveloped

20 **Reproduction:** males produce mature sperm in October to November; female may retain viable sperm
21 for up to one year; females ovulate 2 to 5 times a year; mating May to August depending on region; nest
22 squarish hole with corners rounded out; clutch size 7 to 30 eggs; eggs are white and spherical to oval;
23 eggs weighing 3.3-6.2 g (0.1 to 0.2 oz) and 17.6-22.2 mm (0.7 to 0.9 in) in diameter; incubation lasts 23
24 to 89 days depending on soil temperature; sexually mature in 4 to 6 years

25 **Habitat:** habitat generalist; lowland aquatic habitats; rivers; lakes, ponds, canals, and creeks with slow
26 currents; marshes; drainage ditches

27 **Human health impacts:** potential reservoir for cholera

28 **Economic impacts:** none found in the literature, but undocumented impacts may exist

29 **Ecological impacts:** may negatively impact native freshwater fish; carriers of iridovirus

30 **Pathways:** pet trade, food, religious, ecosystem disturbance

31 **Control methods:** no information found in the literature

1 **References:** ATWG 2000; Tokita and Kuratani 2001; Wong et al. 2002; Ji et al. 2003; Lever 2003; Zhang
2 et al. 2008; Huang et al. 2009b; Kraus 2009; Chen and Lue 2010; Somma 2010a

3 **A8.4.44 *Python molurus bivittatus***

4 **Common names:** Asian rock python, Burmese python, Indian python, Indian rock python, rock python

5 **Synonymous scientific names:** *Boa albicans*, *Boa castanea*, *Boa cinerea*, *Boa orbiculata*, *Boa ordinata*,
6 *Coluber boaeformis*, *Coluber molurus*, *Python bivittatus*, *Python bivittatus bivittatus*, *Python bora*,
7 *Python jamesonii*, *Python molurus*, *Python tigris*, *Python trivittatus*

8 **Adult description:** have light-colored skin with a characteristic pattern of many dark brown patches
9 bordered in black. A non-venomous constrictor having short prehensile tail; heavy body; large, angular
10 but supple skull with high counts of small, severely recurved teeth; vertical pupils; temperature-sensing
11 thermal pits in their lips; narrow belly scales; bodies circular in cross section; flanks with many rows of
12 tiny scales; males are 2.0 to 4.5 m (6.6 to 14.8 feet) in length and between 5 and 50 kg (11 to 110
13 pounds); females are 2.6 to 8.2 m (8.5 to 27 feet) in length and between 10 and 182 kg (22 to 401
14 pounds); Females usually larger than males.

15 **Reproduction:** hatchlings are independent, grow rapidly, mature in a few years and reproduce. Females
16 brood their eggs, enclosing the eggs in their coils for incubation, raising their body temperature if
17 necessary by shivering thermogenesis. Courtship occurs as temperatures warm (March/April). Females
18 shed their skin, males rub on female, if receptive, female opens cloaca and intromission occurs. Females
19 have ability to fertilize own eggs. Female fasts prior to oviposition and brooding. Clutch size varies
20 between 8 and 107, however, average clutch size is towards the low end of that range; females produce
21 one clutch per year; 60 to 90 day gestation period.

22 **Habitat:** habitat generalist

23 **Human health impacts:** could attack humans

24 **Economic impacts:** predation on livestock; attacks on livestock; carrier of ticks that could harm livestock

25 **Ecological impacts:** predation and competition with native fauna; reduction in native biodiversity;
26 transmission of Inclusion Body Disease to native reptiles

27 **Pathways:** cargo, escape, natural dispersal, pet trade, intentional release by pet owners

28 **Control Methods:** radio telemetry, pheromones, traps, detector dogs, hand capture, acetaminophen

29 **References:** Burrige and Simmons 2003; Lovgren 2005; Reed 2005 Schumacher 2006; Pitt and Witmer
30 2007; Beck et al. 2008; Kraus 2009; Reed and Rodda 2009; ISSG 2010; Mauldin and Savarie 2010; Uetz
31 2010

32 **A8.4.45 *Ramphotyphlops braminus*:** widespread throughout the Pacific region including Micronesia

33 **Common names:** blind snake, Brahminy blindsnake, flower pot snake

1 **Synonymous scientific names:** *Argyrophis bramicus*, *Argyrophis truncatus*, *Eryx braminus*, *Glauconia*
2 *braueri*, *Onychocephalus capensis*, *Ophthalmidium tenue*, *Tortrix russelii*, *Typhlina braminus*, *Typhlops*
3 *braminus*, *Typhlops limbrickii*, *Typhlops russeli*, *Typhlops (Typhlops) euproctus*, *Typhlops (Typhlops)*
4 *inconspicuus*, *Typhlops pseudosaurus*

5 **Adult description:** 6.35 to 16.5 cm (2.5 to 6.5 in); small, thin, and shiny silver gray, charcoal gray, or
6 purple; head and tail-tip indistinct; neck not narrow; eyes are small dot-like remnants under the scales;
7 tail is tipped with a tiny pointed spur; head scales are small and similar to body scales; grayish to brown
8 belly; scales smooth and shiny; 14 dorsal scale rows along entire body.

9 **Reproduction:** lays eggs or may be live-bearing; individuals are all female and reproduce unisexually;
10 parthenogenic and up to eight genetically identical female offspring are produced; species is a complex
11 of unisexual and bisexual species

12 **Habitat:** habitat generalist; urban and agricultural areas. Lives in soil and leaf litter, and found under
13 rotting logs, leaves, and trash. Also found in gardens.

14 **Human health impacts:** none found in the literature, but undocumented impacts may exist

15 **Economic impacts:** none found in the literature, but undocumented impacts may exist

16 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

17 **Pathways:** cargo, nursery trade

18 **Control measures:** no information found in the literature

19 **References:** Nussbaum 1980; Kamosawa and Ota 1996; Kraus 2009; FLMNH 2010

20 **A8.4.46 *Saprosincus mustelina***

21 **Common names:** southern weasel skink, weasel shadeskink, weasel skink

22 **Synonymous scientific names:** *Lampropholis mustelina*, *Lygosoma (Leiolopisma) mustelinum*, *Lygosoma*
23 *(Liolepisma) pseudotropis*, *Lygosoma (Mocoo) lacrymansm*, *Lygosoma (Mocoo) orichalceum*, *Lygosoma*
24 *(Mocoo) sonderi*, *Lygosoma paraeneum*, *Mocoo mustelina*, *Saprosincus mustelinus*

25 **Adult description:** snout to vent length from 45 to 160 mm (1.8 to 2.3 in); body is coppery brown with
26 darker flecks on the back; ventral surface is cream colored; has a prominent white spot below and
27 immediately behind the eye; has a dark streak through the eye; the color of the tail is similar to the
28 back, but with a short, paler, dark edged streak starting immediately in front of the hind limb and
29 continuing onto the upper section of the tail.

30 **Reproduction:** females lay eggs in a communal nest that contains the eggs of many females; up to four
31 eggs per clutch.

1 **Habitat:** Prefers habitat with fallen timber or rotting vegetation; found among leaf litter in wet
2 sclerophyll forests

3 **Human health impacts:** none found in the literature, but undocumented impacts may exist

4 **Economic impacts:** none found in the literature, but undocumented impacts may exist

5 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

6 **Pathways:** cargo, nursery trade

7 **Control measures:** no information found in the literature

8 **References:** MNP 1999; Gill et al. 2001; Kraus 2009; Uetz 2010

9 **A8.4.47 *Sceloporous occidentalis***

10 **Common names:** coast range fence lizard, Great Basin fence lizard, Island fence lizard, northwestern
11 fence lizard, Pacific blue-bellied lizard, San Joaquin fence lizard, Sierra fence lizard, western fence lizard

12 **Synonymous scientific names:** *Sceloporus becki*, *Sceloporus biseriatus nigro-ventris*, *Sceloporus*
13 *biseriatus* var. *A*, *azureus*, *Sceloporus frontalis*, *Sceloporus longipes*, *Sceloporus occidentalis*, *Sceloporus*
14 *occidentalis becki*, *Sceloporus occidentalis biseriatus*, *Sceloporus occidentalis bocourtii*, *Sceloporus*
15 *occidentalis longipes*, *Sceloporus occidentalis occidentalis*, *Sceloporus occidentalis taylori*, *Sceloporus*
16 *occidentalis* var. *b*, *variegates*, *Sceloporus smaragdinus*, *Sceloporus undulatus biseriatus*, *Sceloporus*
17 *undulatus occidentalis*

18 **Adult description:** snout-vent length is 89 cm (3.5 in); 15 to 25 cm (6 to 10 in) in total length; scales are
19 keeled and somewhat spiny; color ranges from light gray to black with dark blotches on the back that
20 continue down the tail; males have bright blue, sometimes greenish, bellies and the underside of their
21 legs are yellow; females lack this decorative coloring.

22 **Reproduction:** breed in May or June; up to 10 eggs per clutch that can be laid as early as July, producing
23 hatchlings as early as mid-August.

24 **Habitat:** habitat generalist; found from the coast to the highest mountain areas at over 1,829 m (6,000
25 feet); ranging from coastal sage scrub and chaparral on the coast and foothills, to the forests of higher
26 elevations; found near ground in rock and wood piles, tree trunks, and lower branches of shrubs; urban
27 areas; desert landscapes

28 **Human health impacts:** none found in the literature, but undocumented impacts may exist

29 **Economic impacts:** none found in the literature, but undocumented impacts may exist

30 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

31 **Pathways:** cargo, research

1 **Control measures:** no information found in the literature

2 **References:** Kraus 2009; NVDoW 2010; Uetz 2010

3 **A8.4.48 *Sphaerodactylus argus***

4 **Common names:** common ocellated gecko, ocellated gecko

5 **Synonymous scientific names:** *Sphaerodactylus argus argus*, *Sphaerodactylus henriquesi*

6 **Adult description:** 5 to 6 cm (2 to 2.5 in) in length; have small toe pads and eyelash-like scales projecting
7 above each eye; Adults and juveniles have similar coloration. They are brownish in color with light dorsal
8 and lateral spots from head to tail. The ocelli on head and neck tend to form a lineate pattern. Have a
9 coral red tail and has small, keeled and slightly overlapping dorsal scales. Occasionally individuals are
10 almost patternless.

11 **Reproduction:** females lay single eggs at intervals (in the Caribbean).

12 **Habitat:** is found around buildings, in vacant lots, and stands of Australian pine

13 **Human health impacts:** none found in the literature, but undocumented impacts may exist

14 **Economic impacts:** none found in the literature, but undocumented impacts may exist

15 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

16 **Pathways:** cargo

17 **Control measures:** no information found in the literature

18 **References:** Krysko and King 2002; Kraus 2009; GeckoWeb 2010; Uetz 2010

19 **A8.4.49 *Sphaerodactylus elegans***

20 **Common names:** ashy gecko, Cuban ashy gecko

21 **Synonymous scientific names:** *Sphaerodactylus alopex*, *Sphaerodactylus cinereus*, *Sphaerodactylus*
22 *elegans elegans*, *Sphaerodactylus elegans punctatissimus*, *Sphaerodactylus punctatissimus*,
23 *Sphaerodactylus [sic] elegans*, *Sphaerodactylus [sic] punctatissimus*

24 **Adult description:** total length is 7 cm (2.75 in); are dark gray-brown in color with head, body, tail, and
25 legs covered with a network of tiny salt and pepper spots; can be paler at night; smooth granular scales
26 along the back, with a small spine-like scale over each eye. Are distinguished by having a vertical pupil,
27 digits without widened subdigital lamellae, and dorsal scales relatively small, smooth, granular, and
28 juxtaposed. They also have numerous light dorsal and lateral ocelli each comprised of only one scale.

29 **Reproduction:** females lay single eggs under loose bark or other cover objects; eggs are sometimes laid
30 communally; have been found together with those of common and Amerafrican house geckos.

- 1 **Habitat:** trees, buildings, vacant lots, and stands of Australian pine
- 2 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 3 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 4 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 5 **Pathways:** cargo
- 6 **Control measures:** no information found in the literature
- 7 **References:** Krysko and Daniels 2005; Kraus 2009; GeckoWeb 2010; Uetz 2010
- 8 **A8.4.50 Tarentola mauritanica**
- 9 **Common names:** common wall gecko, Moorish gecko
- 10 **Synonymous scientific names:** *Gecko fascicularis*, *Gecko muricatus*, *Gecko stellio*, *Lacerta mauritanica*,
11 *Platydactylus facetanus*, *Platydactylus mauritanicus*, *Platydactylus muralis*, *Tarentola mauritanica*
12 *mauritanica*, *Tarentola mauritanica subvar. Atlantica*, *Tarentola mauritanica subvar. Lissoide*, *Tarentola*
13 *saharae*, *Tarentola (Tarentola) mauritanica*, *Tarentola tuberculata*
- 14 **Adult description:** up to 15 cm (6 in) in total length; has golden, vertically slit eyes with red veins;
15 distinct rows of large tubercles shingle the back, pointed tubercles cover the neck and legs, and whorls
16 of tubercles on the tail give it a spiny, armored appearance; is sandy gray in color; paler at night; belly is
17 white with overlapping ventral scales; males are larger and have broader heads; have enlarged,
18 undivided toe pads; large, bulging eyes with a fixed transparent covering.
- 19 **Reproduction:** Females lay pairs of eggs.
- 20 **Habitat:** habitat generalist; In the United States it is confined to the walls of buildings; It is found in
21 warm, dry coastal regions around the Mediterranean, in stone walls, boulders, and wood piles
- 22 **Human health impacts:** none found in the literature, but undocumented impacts may exist
- 23 **Economic impacts:** none found in the literature, but undocumented impacts may exist
- 24 **Ecological impacts:** none found in the literature, but undocumented impacts may exist
- 25 **Pathways:** cargo, intentional, nursery trade, pet trade
- 26 **Control measures:** no information found in the literature
- 27 **References:** Mahrtdt 1998; Vogrin et al. 2008; Kraus 2009; GeckoWeb 2010; Uetz 2010

1 **A8.4.51 *Tiliqua scincoides***

2 **Common names:** common bluetongue, eastern bluetongue, eastern blue-tongued lizard, northern
3 bluetongue

4 **Synonymous scientific names:** *Cyclodus boddaertii*, *Lacerta scincoides*, *Scincus crotaphomelas*, *Scincus*
5 *tuberculatus*, *Tiliqua scincoides chimaerea*, *Tiliqua scincoides intermedia*, *Tiliqua whitii*

6 **Adult description:** Is a large, flattened, terrestrial lizard with small limbs; snout to vent length is
7 approximately 400 mm (15.7 in); weight up to 700 g (25 oz); blue colored tongue; color patterns can
8 vary between individuals where some have banded markings while others have blotchy markings;
9 typical color pattern is a white ventrolateral region, stopping at the dorsoventral scales, and a brown
10 dorsolateral surface; head pale brown to gray and this color decreases in intensity posteriorly; also has
11 dorsal transverse pale markings and oblique dorsolateral black markings that interrupt this coloration;
12 body has wide yellow-orange large bands or blotches as well; limbs are tertiary gray.

13 **Reproduction:** viviparous; 10 to 20 individuals per litter; a female will produce a litter every 1 to 2 years;
14 individuals are born precocious; breeding occurs in the spring; males exhibit mate guarding.

15 **Habitat:** suburban gardens, urban areas, seasonally wet and dry savannah woodlands, coastal
16 heathlands, montane wet sclerophyll woodlands, and fringes of rainforests. Common in highly disturbed
17 areas

18 **Human health impacts:** none found in the literature, but undocumented impacts may exist

19 **Economic impacts:** none found in the literature, but undocumented impacts may exist

20 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

21 **Pathways:** cargo, intentional

22 **Control measures:** no information found in the literature

23 **References:** Carpenter and Murphy 1978; Lissone 1999; Koenig et al. 2001; Kraus 2009; Uetz 2010

24 **A8.4.52 *Trachemys scripta***

25 **Common names:** red-eared slider, common slider, Cumberland slider turtle, slider, yellow-bellied slider

26 **Synonymous scientific names:** *Chrysemys scripta*, *Chrysemys scripta elegans*, *Chrysemys picta*, *Emys*
27 *cumberlandensis*, *Emys elegans*, *Emys troostii*, *Pseudemys ornate*, *Pseudemys scripta*, *Testudo scripta*,
28 *Trachemys scripta elegans*

29 **Adult description:** carapace length is 125 to 289 mm (5 to 11 in); prominent yellow to red patches on
30 each side of the head; carapace and skin are olive to brown with yellow stripes or spots; males smaller
31 than females with a longer, thicker tail

1 **Reproduction:** mating may occur in both spring and fall; nesting April to July in temperate zones,
2 December to May in the tropics; females may store sperm up to 79 days; nests are flask-shaped with a
3 chamber 11 to 21 cm (4 to 8 in) deep; may have up to 6 clutches; 2 to 30 eggs per clutch depending on
4 size of female; incubation 59 to 112 days; timing of sexual maturity highly variable

5 **Habitat:** habitat generalist; lakes, riparian zones, water courses, wetlands; prefers large, quiet bodies of
6 water with soft bottoms; can tolerate brackish water

7 **Human health impacts:** carrier of *Salmonella enterica*; host to *Gnathostoma binucleatum*, the causative
8 agent of gnathostomosis

9 **Economic impacts:** none found in the literature, but undocumented impacts may exist

10 **Ecological impacts:** competes with and may displace native turtles

11 **Pathways:** pet trade, intentional release, religious, zoo trade, natural dispersal

12 **Control measures:** trapping; use of detector dogs to locate turtles and nests; egg removal

13 **References:** TFTSP 1996; Cadi and Joly 2003; Lever 2003; Cadi and Joly 2004; Nagano et al. 2006; Scalera
14 2006; Guerrero and Alba-Hurtado 2007; Gaertner et al. 2008; Polo-Cavia et al. 2008; Kraus 2009; ISSG
15 2010; Polo-Cavia et al. 2010

16 **A8.4.53 *Trimeresurus elegans***

17 **Common names:** elegant pit viper, Sakishima habu

18 **Synonymous scientific names:** *Craspedocephalus elegans*, *Lachesis lutea*, *Lachesis luteus*, *Lachesis*
19 *mucrosquamatus*, *Protobothrops elegans*, *Trimeresurus luteus*

20 **Adult description:** resembles the Okinawan Habu (*Trimeresurus flavoviridis*) in color and pattern, but is
21 smaller in size (usually 91 cm [3 feet] long).

22 **Habitat:** found on Irimote, Ishigaki, and Miyako Islands; found in several types of terrain and active
23 mainly at night

24 **Human health impacts:** venomous (have a hemorrhagic toxin)

25 **Economic impacts:** none found in the literature, but undocumented impacts may exist

26 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

27 **Pathways:** exhibit, as food, in medicinal drinks

28 **Control measures:** no information found in the literature

29 **References:** Keegan and Yoshino 1959; Mehrtens 1987; Nikai et al. 1991; Rodda et al. 1999b; Chijiwa et
30 al. 2006; Kraus 2009; Uetz 2010

1 **A8.4.54 *Trimeresurus flavoviridis***

2 **Common names:** Habu, Okinawan habu

3 **Synonymous scientific names:** *Lachesis flavoviridis*, *Protobothrops flavoviridis*, *Trimeresurus flavoviridis*
4 *flavoviridis*, *Trimeresurus riukiuanus*

5 **Adult description:** average length is 122 to 152 cm (4 to 5 feet), but they have been known to exceed
6 213 cm (7 feet) in length. They are the largest of the Asian terrestrial pit vipers; usually pale or dark
7 brown, greenish-brown, or olive in color; has a pattern of irregular blotches that vary in shades of green
8 or brown and bordered with yellow or grayish-yellow (this pattern can represent a marbled effect);
9 large, triangular head attached to a slim neck.

10 **Reproduction:** mate in early spring and a female may lay up to 18 eggs in mid-summer. The eggs hatch
11 after 5 to 6 weeks of incubation. The hatchlings are ten inches in length and are identical to the adults.

12 **Habitat:** sparsely wooded plains and fields adjacent to forests; brushy, rocky hillsides

13 **Human health impacts:** venomous; bites cause permanent physical damage or impairment; bites may
14 sometimes be fatal

15 **Economic impacts:** none found in the literature, but undocumented impacts may exist

16 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

17 **Pathways:** cargo

18 **Control measures:** electric fencing, traps

19 **References:** Hayashi et al. 1980; Hayashi et al. 1983; Mehrtens 1987; Ford and Seigel 1989; Shiroma and
20 Akamine 1992; Yokoyama and Yoshida 1994; Sawai et al. 1996; Rodda et al. 1999b; Yamamoto et al.
21 2001; Yamamoto et al. 2002; Kitano et al. 2003; Kraus 2009; Uetz 2010

22 **A8.4.55 *Trimeresurus mucrosquamatus***

23 **Common names:** brown-spotted pit viper, pointed-scaled pit viper, Taiwan habu

24 **Synonymous scientific names:** *Lachesis mucrosquamatus*, *Protobothrops mucrosquamatus*,
25 *Trionocephalus mucrosquamatus*, *Trimeresurus mucrosquamatus*

26 **Adult description:** adult length: males 1122 mm (44 in) and females 1160 mm (46 in); tail length: males
27 195 mm (7.7 in) and females 205 mm (8 in); sharp, triangular head with a thick black-brown lateral band
28 behind eyes; mottled top of head, below is whitish; body is yellow-brown with large black patches on
29 back; patches on dorsal side of body usually form a wave-like pattern that serve as camouflage; belly is
30 white in color, but heavily powdered with light brown; tail is brownish in color with dark dorsal spots
31 (but the tail can possibly be pink during their life). The scales are in 25 longitudinal rows at midbody; the
32 scales on the upper surface of head are small and each scale is keeled posteriorly; internasals are 5 to 10
33 times the size of adjacent scales and are separated by 3 to 4 scales; supraoculars are long, narrow, and

1 undivided and there are 14 to 16 small interocular scales in line between them; are two scales in line
2 between upper preocular and nasal; has 9 to 11 upper labials and the first upper labial is separated from
3 the nasal by a suture; are 2 to 3 small scales between upper labials and subocular; 2 to 3 smooth rows of
4 temporal scales above the upper labials, but above those the scales are keeled.

5 **Reproduction:** eggs: 3 to 15 per nest; laid in summer; females show egg protecting behavior.

6 **Habitat:** mountainous habitat, cultivated land, houses, farms, bushes, barns

7 **Human health impacts:** venomous; bites may cause death without the proper antivenom

8 **Economic impacts:** none found in the literature, but undocumented impacts may exist

9 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

10 **Pathways:** unknown

11 **Control measures:** no information found in the literature

12 **References:** Smith 1943; Leviton et al. 2003; Hung 2004; Kraus 2009; Uetz 2010

13 **A8.4.56 *Uta stansburiana***

14 **Common names:** northern ground uta, northern side-blotched lizard, side-blotched lizard, western
15 ground uta

16 **Synonymous scientific names:** *Uta antique*, *Uta mannophorus*, *Uta stellata*

17 **Adult description:** mostly brown, with five, light-colored, dorsal stripes running from the head at least to
18 the beginning of the tail (these stripes are sometimes indistinct); during the breeding season, males
19 often take on a distinctly bluish hue on the head, tail, top of the back, and sides.

20 **Reproduction:** breeding begins early in spring. Females typically lay 1 to 2 clutches from spring to
21 midsummer; 3 to 4 eggs per clutch; females in warmer climates may lay up to 7 clutches in one year;
22 most eggs hatch from June to August and the offspring mature quickly.

23 **Habitat:** lives in flat desert habitat, rocky outcrops, hills, and mountainous regions. Prefer sites with
24 some vegetation

25 **Human health impacts:** none found in the literature, but undocumented impacts may exist

26 **Economic impacts:** none found in the literature, but undocumented impacts may exist

27 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

28 **Pathways:** cargo, possibly in aircraft, possibly in construction materials

29 **Control measures:** no information found in the literature

1 **References:** Nussbaum 1981; Ferguson et al. 1990; Hutchins et al. 2003b; Mahoney et al. 2003; Kraus
2 2009; Uetz 2010

3 **A8.4.57 *Xenochrophis piscator***

4 **Common names:** Asiatic water snake, checkered keelback

5 **Synonymous scientific names:** *Amphiesma flavipunctatum*, *Col. Quincunciatus*, *Hydrus piscator*, *Natrix*
6 *piscator*, *Nerodia (Tropidonotus) piscator*, *Tropidonotus piscator*, *Tropidonotus quincunciatus*

7 **Adult description:** Total length: males up to 947 mm (37 in) and females up to 1,020 mm (40 in); chess-
8 like pattern on the body, sometimes with broad blotches and very conspicuous and sometimes with
9 smaller blotches; large, cloudy cream or pale gray dorsolateral blotches; nuchal marking often absent (if
10 not absent then present as an inverted V); subocular streaks are faint, reduced to a blotch or absent; a
11 venter uniform, with the ventrals darker only on the outermost edges; a high number of ventral and
12 subcaudal scales in males.

13 **Reproduction:** clutch size ranges from 9 to 74; clutch size increases with increasing body size

14 **Habitat:** lowland habitat; mangroves; occurs close to water quite often, although they are not strongly
15 aquatic

16 **Human health impacts:** none found in the literature, but undocumented impacts may exist

17 **Economic impacts:** none found in the literature, but undocumented impacts may exist

18 **Ecological impacts:** none found in the literature, but undocumented impacts may exist

19 **Pathways:** unknown

20 **Control measures:** no information found in the literature

21 **References:** IUCN 2009, Vogel and David 2006; Brooks et al. 2009; Uetz 2010

22 **A9 CRITERIA QUESTIONS USED TO EVALUATE RISK OF TRANSPORTING**
23 **VERTEBRATE INVASIVE SPECIES**

24 A risk level was assigned to each pathway based on 16 criteria questions pertaining to probability of
25 species transport, invasive potential of species, the pathway's conduciveness to transport species, and
26 control-interdiction-eradication methods. These 16 evaluated criteria questions are as follows:

27 **3. Introducing invasive species on a frequent basis?**

28 Extremely high frequency ranking is defined, in relative terms, as introducing numerous invasives (i.e.,
29 10 or more) that have had either human health pandemic implications resulting in deaths; moderate is 5
30 or more that have caused serious **Economic impacts** on (i.e., failure of) major industries; low is 2 or
31 more introduced invasives that negatively impacted 2 or more ecological niches).

- 1 **4. Transmitting a large number of different viable species?**
- 2 Extremely High (i.e., ranking of 10) infers a pathway capable of transferring 100 or more viable invasives
3 species in a single event.
- 4 **5. Transmitting a large number of viable individuals per invasive species?**
- 5 Extremely High infers the pathway transmits numerous (i.e., 100 plus) viable populations that can
6 readily be established. Extremely low infers that only 1 to 2 specimens capable of
7 establishment/**Reproduction** are transmitted. Zero is 'no risk'; infers no specimen survival.
- 8 **6. Introducing invasive species into hospitable ecosystems or Habitats?**
- 9 Level 10 infers exact ecosystem match with invasive species' natural **Habitat**; plentiful food sources, no
10 predators or ecosystem controls. Zero (0) risk is when environmental factors preclude invasive species
11 establishment.
- 12 **7. Introducing invasive species at multiple entry points?**
- 13 Level 10 equals 100% likelihood of invasive species survival due to hospitable pathway ecosystem. Level
14 1 equates to pathway that by nature (i.e., travel through arctic climes) will result in invasive mitigation.
- 15 **8. For transmitting invasive species, based on standard treatment measures?**
- 16 Level 10 infers multiple entry points (4 or more) that expand across the continental United States; Level
17 1 infers single, localized entry point.
- 18 **9. To assist spread of invasive species to uncontaminated shipments during transport or storage?**
- 19 Zero (0) level indicates all IS are dead upon arrival; 3 indicates most (60%) of the invasive species are still
20 reproductively viable; 5 indicates 100% of invasive species are alive, and have expanded populations,
21 colonies or enhanced invasiveness capabilities).
- 22 **10. For transmitting invasive species based on current screening techniques?**
- 23 High reflects a pathway that commingles multi-source vectoring agents with multiple dissemination
24 points i.e., multi-source, commingled WPM in a cargo hold with multiple dissemination points. Low
25 equates to no cross-contamination or spread.
- 26 **11. Transporting an invasive species that is difficult to detect once in the destination ecosystem?**
- 27 A rating of zero (0) indicates that virtually all invasives are detected prior to or during transit. A rating of
28 5 indicates that there are no detection methods for the invasives prior to or during transit.
- 29 **12. Transmitting invasive species that are capable of surviving in multiple Habitats?**

1 Zero (0) indicates that all invasives are detected immediately at the pathway endpoint. A rating of 5
2 indicates the species is/are so difficult to detect, there is a 100% likelihood they will be disseminated
3 without detection.

4 **13. Transmitting invasive species into ecosystems conducive to natural spread?**

5 An assessment of zero (0) indicates the pathway does not transmit any generalists. An assessment of 5
6 indicates the majority of invasives transmitted by this pathway are generalists with at least 3 or more
7 populations capable of surviving in any of the pathway endpoints.

8 **14. Transmitting invasive species that are further spread by human activities?**

9 A rating of zero (0) indicates the pathway transmits invasives with low reproductive rates or ones that
10 are fragile in any ecosystem other than that of origination. A ranking of 5 indicates the pathway
11 transmits multiple (i.e., 10 or more) invasives that are highly mobile; spread by wind, water; have/high
12 reproductive rates in multiple ecosystems.

13 **15. Introducing invasive species that are known to be invasive in similar ecosystems but are not
14 yet in the endpoint ecosystem?**

15 A rating of zero (0) indicates that humans or human activities do not spread the invasive species. A
16 rating of 5 indicates humans or human activities are the primary agent for the rapid spread of pandemic
17 invasive species.

18 **16. Transmitting invasive species that are novel and have limited scientific data upon which to
19 develop control methods?**

20 Zero (0) indicates the pathway transmits no compatible IS; 3 rating indicates the pathway transmits
21 invasives that are in some, not all, U.S. ecoregions, but are not yet present in the pathway endpoint
22 ecosystem. Level 5 infers the pathway transmits viable invasive species into pristine ecosystems.

23 **17. Transmitting an invasive species for which existing control options are too expensive to
24 implement?**

25 Zero (0) indicates there are comprehensive control options to mitigate all invasives transmitted. Level 5
26 indicates there are no existing control options.

27 **18. To what degree does the pathway's own ecosystem enhance the viability of opportunity for
28 transmission of invasive species?**

29 Level 0 equates to a pathway that by nature results in mitigation (i.e., no movement of invasive species).
30 Level 5 equals 50% likelihood in invasive species survival. In other words, some species may be able to
31 survive in the pathway ecosystem whereas others cannot. Level 10 equals 100% likelihood of invasive
32 species survival due to a hospitable pathway ecosystem.

1 **A10 UMBRELLA CATEGORY PATHWAY OUTLINE**

2 Major **Pathways** were organized under three umbrella categories: Transportation, Living Industry, and
3 Miscellaneous, and further divided into sub- and nested **Pathways** identified as being pertinent to the
4 military mission.

5 **(T) TRANSPORTATION Pathways and Sub-pathways**

6 T. 1. Modes of Transportation

7 T.1.1 Air Transportation

8 T.1.1.1 Commercial Air Traffic

9 T.1.1.2 Military Air Traffic

10 T.1.2 Water Transportation

11 T.1.2.1 Commercial Maritime Traffic

12 T.1.2.2 Military Maritime Traffic

13 T.2 Military Travel and Transportation of Military Vehicles

14 T.2.1 Military Cargo and Vehicles Used in Training Exercises

15 T.3. Items Used in the Shipping Process

16 T.3.1 Cargo Containers

17 T.3.2 Wood Packaging Materials

18 T.4. Travel/Tourism/Relocation

19 T.4.1 Household Goods and Personal Vehicles

20 T.5. Transportation of Construction Materials, Equipment, and Vehicles

21 **(L) LIVING INDUSTRY Pathways and Sub-pathways**

22 L.1 Plant **Pathways**

23 L.1.1 Plant Materials and Plant and Nursery Trade

24 L.2 Food **Pathways**

25 L.2.1 Aquaculture

26 L.2.2 Plants and Plant Parts as Food

27 **(M) MISCELLANEOUS Pathways and Sub-pathways**

28 M.1 Ecosystem Disturbance

29 M.1.1 Natural Spread of Established Populations

30 M.1.2 Man-made and Natural Disturbances

1 M.2 Garbage

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1 **A12 PRELUDE TO THE DRAFT PATHWAY ANALYSIS FOR HAWAI'I**

2 **A12.1 WHAT IS THE PATHWAY ANALYSIS OF INVASIVE SPECIES INTRODUCTION INTO THE**
3 **STATE OF HAWAII?**

4 The Pathway Analysis of Invasive Species Introduction into the State of Hawai'i is a working document
5 that was created by the United States Department of Agriculture (USDA), Animal Plant Health Inspection
6 Service (APHIS), Plant Protection Quarantine (PPQ) to assist in identifying terrestrial biological risks to
7 Hawai'i. It is important to note that this document is a "Pathway Analysis" and not a "Pest Risk
8 Assessment" (PRA or "risk analysis" in Intergovernmental Panel on Climate Change terms). A Pathway
9 Analysis uses available science, information, and technology to determine appropriate measures to
10 mitigate risks of sometimes multiple pests and commodities moving via a specific pathway. A pathway is
11 any means that allows the entry or spread of a pest. This includes travelers, conveyances, commodities,
12 cargo, military movements, and others. A PRA uses available science, information, and technology to
13 determine appropriate measures to address specific risks associated with specific pests or commodities.

14 Hawai'i is unique in that it has different ecosystems and vulnerabilities than the rest of the United
15 States. For example, although Hawai'i is one of the smallest states in the United States, comprising just
16 0.2% of its total land mass, more than 25% of the endangered species in the United States occur there
17 (OTA 1993). Hawai'i is infamous not only as "the extinction capital of the United States," with 72% of the
18 country's recorded extinctions (Gagné 1988; OTA 1993) but also as the location with the greatest
19 species extinction rate per square mile of anywhere in the world
20 (<http://hbs.bishopmuseum.org/endangered/>).

21 Hawai'i imports the majority of agriculture products consumed. Commodities have been imported into
22 Hawai'i before PRAs were completed on individual commodities. Because of Hawai'i's location,
23 commercial and private conveyances arrive there from a variety of locations. Many of the originating
24 locations are without sound quarantine and export practices. Other originating locations are without a
25 complete understanding of the pests present in their countries or of the pest pressures on their
26 countries.

27 APHIS developed this Pathway Analysis to assist PPQ in developing approaches and strategies to
28 minimize all risks within its authority, and to further develop effective actions to prevent the
29 introduction and spread of pests and to promote appropriate measures for their control.

30 **A12.2 WHY RELEASE IN DRAFT FORM?**

31 With the exception of Chapter B5, the quantitative data sufficient for statistical analysis were not
32 available, especially for domestic arrivals (and the suspected foreign origin commodities arriving through
33 domestic trade). Despite these shortcomings (that kept the analysis in draft form), APHIS has enhanced
34 and implemented actions and fortified partnerships to address key elements in the pathway analysis.
35 Entities outside of APHIS believe their activities may benefit, as APHIS has benefited, from the draft
36 information. Thus, APHIS is releasing the draft. APHIS believes the release of this information is timely to
37 the completion of the Micronesian Biosecurity Plan and fits well with the information in that document.

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

1 In understanding the information and risks, it is beneficial for the reader to understand that preventing
2 pest and invasive species from entering Hawai'i falls mainly on two agencies. There are many agencies
3 within Hawai'i that work on protecting resources from invasive species; USDA-APHIS and HDOA are the
4 two agencies that specifically handle prevention through import inspections. USDA-APHIS-PPQ holds
5 authority and by a Memorandum of Agreement, holds joint responsibility with Customs and Border
6 Protection for quarantine activities and actions as they relate to foreign arrivals of people, commodities,
7 and conveyances. Because the State of Hawai'i is under official quarantine for a variety of pests, APHIS
8 also holds authority and responsibility for reducing the risks of pests moving from Hawai'i to the U.S.
9 mainland. The State of Hawai'i holds the authority and responsibility for reducing the risks of pests
10 entering Hawai'i from other U.S. states. While USDA and the Hawai'i Department of Agriculture (HDOA)
11 have different authorities and responsibilities, both agencies have entered in to a Memorandum of
12 Understanding (MOU) that generally describes shared roles, responsibilities, resources, and enabling
13 authorities, and facilitates cooperation in phytosanitary issues and risk mitigation activities.

14 **A12.3 ACTIONS BASED ON THE PATHWAY ANALYSIS**

15 While additional, yet unavailable, information could be used to gain a more complete understanding of
16 the pest pressures on Hawai'i, PPQ has used the available information presented in this document to
17 strengthen and create programs that reduce the risks and close pathways for pests entering Hawai'i
18 regardless of what the pests are or their origin. PPQ is present on the islands of Hawai'i, Kauai, Lanai,
19 Maui, Molokai, and Oahu with an outlying work unit in Guam where it works closely with state, private
20 and federal partners to achieve the reduction of risks. PPQ–Hawai'i also supports operations in the
21 Commonwealth of Northern Mariana Islands (CNMI) and American Samoa. Together many agency
22 programs serve as a safety net to reduce risks from entering Hawai'i. Some of the activities PPQ has
23 undertaken to address the risks identified in this document are outlined below.

24 **A12.3.1 Cooperative Agriculture Pest Survey Program**

25 PPQ funds the Cooperative Agriculture Pest Survey (CAPS) program and works with the HDOA, the
26 University of Hawai'i, the Guam Department of Agriculture, the University of Guam, the CNMI
27 Department of Land and Natural Resources, the Northern Mariana College, the American Samoa
28 Department of Agriculture, and the Samoa Community College to determine if pests of concern have
29 entered the island ecosystems. In fiscal year (FY) 2011, PPQ entered into 24 agreements (including Farm
30 Bill and CAPS agreements), totaling \$1.2 million. This included working with six agencies from Hawai'i,
31 Guam, the CNMI, and American Samoa. These agreements covered surveys for various pests including
32 citrus greening and imported fire ants. These cooperative surveys allow for early detection of invasive
33 species and quick response to reduce pest risk to the State of Hawai'i. For FY 12, there are 29
34 agreements, totaling \$1.6 million. Actions of PPQ and other agencies may be based on the information
35 that is produced by the CAPS program.

36 **A12.3.2 Smuggling Interdiction and Trade Compliance**

37 PPQ's Smuggling Interdiction and Trade Compliance (SITC) program is very active in Hawai'i and the
38 American Pacific with the purpose of detecting and closing pathways in which restricted or prohibited

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

1 agricultural commodities make illegal entry into the United States and its territories. More funding and
2 capacity is needed for similar programs in the non-US jurisdictions covered by this plan if the FSM, Palau
3 and the RMI are to establish similar standards. SITC partners with various agencies including other USDA
4 agencies, the Department of Homeland Security's (DHS) Customs and Border Protection (CBP), the U.S.
5 Fish and Wildlife Service (USFWS), the U.S. Department of Health and Human Services, Food and Drug
6 Administration (FDA), various Hawai'i state agencies, and the University of Hawai'i at Manoa to achieve
7 its goal of closing pathways. PPQ strengthened the Hawai'i SITC team by shifting employees to the
8 program and allowing employees from other operations to assist when needed. Hawai'i SITC also
9 conducted PPQ officer and safeguarding training in American Samoa, Guam, and the CNMI Departments
10 of Agriculture for local quarantine officers. SITC established a network of informants, importers,
11 retailers, and joint federal/state/county agency contacts that allows for the quick acquisition of
12 intelligence, making APHIS' mission objectives more easily achieved. SITC and the cooperating agencies
13 provide outreach to industry and market owners about pest risk concerns. SITC works to identify and
14 close pathways. This work assists to mitigate pests that are not detected during the entry process. SITC
15 Hawai'i created a searchable and user-friendly database (PPQ287), used specifically for mail
16 interceptions that has become a module in the national Agricultural Quarantine Activity System (AQAS)
17 system. The PPQ287 Mail Interception Database provides a means to do the following in the event of a
18 mail interception:

- 19 • Electronically generate a notification (Form 287) to be provided to the intended recipient
20 and the sender. These notifications indicate that an unauthorized material—animal
21 products, animal byproducts, plants, plant products, plant pests, or soil—was removed from
22 the mail package, and why.
- 23 • Record the regulatory action that CBP took when intercepting the mail.
- 24 • Provide a means to prepare monthly and quarterly reports.
- 25 • Centralize the management of all mail interceptions into a single database. This greatly
26 improved the accessibility and quality of data gathered for intercepted mail.

27 While the database is now used nationally, the Honolulu Post Office became the postal location where
28 most pests and pest risks are intercepted. Hawai'i SITC also conducts joint activities with the HDOA to
29 mitigate pest risk concerns and to support HDOA-led operations such as the Maritime Agriculture Risk
30 Survey in which red imported fire ants (RIFA) (*Solenopsis invicta* Buren) were targeted in cargo
31 containers that are not traditionally inspected. Again, while this appears to be a very worthwhile
32 program, the non-US jurisdictions of Micronesia are not covered by it and would be greatly assisted in
33 helping to protect the entire region if they could develop similar initiatives.

34 **A12.3.3 Funding and Grants**

35 USDA provides funding through the Farm Bill to develop Pest Management Practices for non-native
36 pests on nursery plants. In addition, Hawai'i is applying for new funds to develop similar strategies for
37 cut flower and foliage production. Hawai'i will be applying for future USDA funding for these
38 management programs.

1 **A12.3.4 Emergency Response**

2 PPQ-Hawai'i takes a lead role in emergency response exercises in cooperation with HDOA, the University
3 of Hawai'i at Manoa, and Hawai'i industry representatives. These exercises, which practice the use of
4 the Incident Command System, are designed to enable quick and effective responses from all regulatory
5 agencies to effectively and swiftly address ecological, agrosecurity emergencies.

6 **A12.3.5 Containment Facilities**

7 As the lead regulatory agency, APHIS has many programs to ensure the safe trade and movement of
8 commodities, people, and conveyances to Hawai'i. Regulated containment facilities are used so
9 commodities with restricted market access may enter prior to being cleared for movement to
10 consumers. Some commodities are stored in containment facilities until they are transferred from
11 Hawai'i under safeguarded conditions. In addition to increasing the number of inspections of existing
12 containment facilities to verify compliance with permit conditions, PPQ-Hawai'i has trained additional
13 containment facility inspectors to oversee new and existing facilities that house imported plant pests
14 and diseases not known to occur in Hawai'i. Increased interaction with HDOA has been achieved to
15 assist stakeholders by streamlining the containment facility inspection process.

16 **A12.3.6 Post-entry Quarantine and Inspections**

17 At HDOA's request PPQ maintains a strong post-entry program. APHIS also regulates all post-entry
18 activities where plants and plant cuttings that have the potential to harbor unseen diseases, viruses,
19 plasmas, etc. are brought into Hawai'i under quarantine conditions to be grown out until the plants are
20 at a stage where symptoms occur and contaminated plants can be identified. PPQ-Hawai'i conducts joint
21 inspections with HDOA that allow for more thorough inspections and also strengthen state and federal
22 roles in the program. The quarantined products are only released from quarantine after both APHIS and
23 HDOA are confident that the product is pest-free. PPQ-Hawai'i regularly conducts Field Plant Pathology
24 Training to improve inspecting capabilities of inspecting officers.

25 **A12.3.7 Biotechnology**

26 PPQ strictly regulates biotechnology activities in Hawai'i. APHIS' Biotechnology Regulatory Service (BRS)
27 reviews all potential risk of biotech materials being spread and/or released in Hawai'i. Strict guidelines,
28 regulations, and protocols are considered and developed jointly by BRS and HDOA. Only materials
29 approved by both Hawai'i and BRS are considered for approved for growing in Hawai'i. PPQ-Hawai'i
30 developed a tracking system that allows monitoring biotech activities at a local level. HDOA is invited to
31 jointly conduct inspections with PPQ. Biotech training is held in Hawai'i every 3 years to certify that
32 inspecting officers are current in all laws, regulations, and protocols.

33 **A12.3.8 Convention on International Trade in Endangered Species of Wild Fauna and Flora**
34 **Materials**

35 PPQ facilitates legal and safe trade of Convention on International Trade in Endangered Species of Wild
36 Fauna and Flora (CITES) materials by maintaining CITES protocols and abilities at the USDA Honolulu
37 Plant Inspection Station. All CITES shipments entering Hawai'i are inspected for proper documentation

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

1 and all materials are inspected for quarantine pests to ensure protection of Hawai'i's agricultural and
2 nursery industries. Over the last year 393,242 plants have been inspected with 47 plants refused entry.
3 All CITES plants seized due to lack of CITES documentation are sent to authorized Plant Resource Rescue
4 Centers.

5 **A12.3.9 Import Permits**

6 To further close pathways, PPQ and HDOA require permits to be obtained for the importation, transit,
7 domestic movement, and environmental release of foreign organisms that could impact the ecosystem
8 and agriculture if permitting requirements are not established. Permits are issued in consultation with
9 HDOA and in accordance with federal regulation and under the authority of the Plant Protection and
10 Honeybee Acts. Other actions taken in responses to the information gained from the analysis include
11 adding additional information in import permits for palm seeds entering Hawai'i, training CBP
12 Agriculture Inspectors on the requirements and inspection of seeds entering Hawai'i under special
13 Import Permits, and working closely with CBP Agriculture Inspectors at the U.S. Postal Service (USPS)
14 facility identifying plants and plant products that are admissible or prohibited into Hawai'i. All of these
15 achievements further contribute to the reduction of the movement of pests into Hawai'i.

16 **A12.3.10 Fruit Fly Detection Program**

17 PPQ maintains a Fruit Fly Detection Program (FFDP) in Hawai'i that is designed to detect exotic fruit fly
18 species in high-risk areas and to provide a "first alert" trigger for swift emergency actions in cooperation
19 with HDOA. This program collaborates with groups like the HDOA, USDA's Agricultural Research Service,
20 and PPQ's Center for Plant Health Science and Technology (CPHST) to develop and implement new
21 control technologies for invasive fruit fly pests. Examples include developing traps and lures for
22 surveillance and detection, as well as methods for the mass rearing of sterile insects to be released in
23 combat against invasive fruit fly species. PPQ maintains the USDA Fruit Fly Facility in Waimanalo, Hawai'i
24 and collaborates with the California Department of Food and Agriculture Fruit Fly Facility, the University
25 of Hawai'i, and CPHST to sterilize fruit fly pupae for programs that use the Sterile Insect Technique to
26 rear larvae for USDA sterilized fruit fly release programs. Furthermore, since the analysis was conducted,
27 PPQ's FFDP has participated in the evaluation of Oahu to determine which areas are at the highest risk
28 for possible introduction of new fruit fly species. The FFDP focuses on these areas with year-round fruit
29 fly trap monitoring. With its expertise, the Hawai'i FFDP also assists with other pest detection/trapping
30 programs as needed including the Nettle Caterpillar (*Darna pallivitta* Moore) Survey, European Pepper
31 Moth (*Duponchelia fovealis*) Survey, Coconut Pest Survey (Coconut Rhinoceros beetle *Oryctes*
32 *rhinoceros*), and Red Palm Weevil (*Rhynchophorus ferrugineus*) Survey.

33 **A12.3.11 Key Partnerships**

34 PPQ works to identify high-risk commodities and associated pathways, adapt targeting and compliance
35 methodologies, utilize risk analysis in determining inspectional processes, and provide cross-training at
36 the port level. This work is carried out in partnership with a number of organizations in APHIS and
37 federal and state agencies discussed below. PPQ takes a lead role in the Hawai'i Risk Assessment
38 Committee meetings, where federal and state regulatory agencies meet to discuss new and emerging

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

1 risks and collaborate to develop mitigations. In this venue, PPQ partners with Veterinary Services,
2 Wildlife Services (WS), DHS CBP, FDA, USFWS, and HDOA to identify high-risk commodities and
3 associated pathways, adapt targeting and compliance methodologies, utilize risk analysis in determining
4 inspectional processes, and in providing cross-training at the port level. For example; PPQ developed
5 and delivered pest detection and pest identification training to CBP Agricultural Specialists working in
6 foreign passenger baggage, air cargo, maritime, and the mail branch. Included in the training were
7 modules addressing pests of concern that are seen at ports of entry, most common pests of concern
8 intercepted at the Port of Honolulu, insect and federal noxious weed identification, and disease
9 symptom recognition. By offering continual training opportunities, PPQ is strengthening working
10 relationships with CBP and improving the ability to effectively exclude exotic pests.

11 PPQ is a steering committee member in the Coordinating Group on Alien Pest Species (CGAPS), where
12 management-level staff from every major agency and organization in Hawai'i, including federal, state,
13 county, and private entities influence policy and funding decisions, improve communications, increase
14 collaboration, and promote public awareness as it relates to quarantine and in invasive species work.
15 CGAPS provides policymakers with information for decision making, and works closely with legislators to
16 write and introduce new legislation to address safeguarding, quarantine, eradication, and preventative
17 actions and abilities. CGAPS successfully secured a new funding mechanism from the legislature in 2007
18 and 2008 to pay for cargo inspection and associated infrastructure. It plays a key role in facilitating
19 communication and cooperation among federal and state agencies, and developed the Silent Invasion
20 public education campaign, which includes television, print media, and direct community outreach by
21 staff. CGAPS has reduced the risk of the brown treesnake (BTS) (*Boiga irregularis* [Merrem]) becoming
22 established in Hawai'i by training state-wide rapid-response search teams and supporting interdiction
23 measures. As a proactive measure, CGAPS has developed a rapid-response plan to eradicate incursions
24 by the RIFA. CGAPS also worked to create the Hawai'i Invasive Species Council (HISC) for the special
25 purpose of engaging cabinet-level leadership to provide policy direction, coordination, and planning
26 among state departments, federal agencies, and international and local initiatives. The HISC approves an
27 annual budget to support invasive species prevention, control, research and technology, and public
28 outreach projects across the state. Funded projects include the county-based Invasive Species
29 Committees, Aquatic Invasive Species team and hull fouling/ballast water coordinator, the Weed Risk
30 Assessment program, and the Hawai'i Ant Lab. For FY 13, HISC funded a project in conjunction with the
31 Hawai'i Biodiversity Information Network to create an interagency pest notification system and link
32 online reporting to the pest hotline.

33 PPQ is working with HDOA to address its concern for improved notification procedures of the possible
34 importation of federal non-actionable pests that may not have significant impacts to the nation's
35 agriculture industry, but may have significant impacts to Hawai'i's agriculture and natural resources.
36 These non-actionable pests are imported into Hawai'i, either accidentally or intentionally through the air
37 and maritime pathways.

38 Key partners in Hawai'i should be more connected with regional entities involved with IAS such as RISC,
39 SPREP, SPC, PIP and others.

1 **A12.3.12 Pacific Safeguarding Initiative**

2 Recognizing the uniqueness of Hawai'i and the pest pressures from the Pacific and Asia Regions, PPQ
3 established the Pacific Safeguarding Initiative (PSI), which is designed to reduce or eliminate risks before
4 they approach the shores of the United States. The PSI accomplishes this by building a coordinated
5 framework and partnership network with national plant protection organizations, regional plant
6 protection organizations, universities, non-government organizations (domestic and foreign), U.S.
7 Embassy staffs, and other organizations. Its goal is to strengthen regional and national pest exclusion
8 activities within the Asia and Pacific Region, enhance pest detection activities within the region,
9 strengthen pest mitigation and suppression activities, and enhance communication and reporting of
10 pest detection and mitigation activities within the region. Further, PSI works to build the capacity of
11 national and regional plant protection organizations as well as key stakeholders to effectively manage
12 current and future pest risks, and to negotiate with other U.S. agencies to elevate invasive species issues
13 within their departments.

14 In the past year the PSI has:

- 15 • Co-drafted a resolution for the Micronesian Chief Executives in which the Chief Executives of
16 Guam, the CNMI, Palau, the Federated States of Micronesia and the Republic of the
17 Marshall Islands resolve that they shall, among other things, integrate invasive species
18 concerns into national and regional efforts and provide dedicated staff to work on
19 Micronesia Regional Invasive Species Council initiatives to reduce the movement of pests
20 into and out of their respective countries and the region. This resolution was signed by all
21 Presidents and Governors in the region.
- 22 • Led discussions and actions with HDOA, the National Invasive Species Council (NISC), The
23 Nature Conservancy, and the Coordinated Group on Invasive Species to develop a more
24 efficient method of evaluating plant pests that are not known to occur in Hawai'i for
25 potential federal action and to harmonize actionable pest lists.
- 26 • Worked with airlines to reduce risk in international passenger flights in the region.
- 27 • Met with members of the Pacific Plant Protection Organization (PPPO) to help draft the
28 PPPO 2012-2018 Strategic Framework (adopted), and to develop a 3-year implementation
29 plan (adopted).
- 30 • Assumed the USDA lead role in the Micronesia Biosecurity Plan.

31 All these activities and programs are accomplished to reduce risk to Hawai'i while maintaining
32 transparency. Not only do these activities result in increased safe trade, they also result in the
33 protection of American agriculture and natural resources in Hawai'i, the Pacific, and the U.S. mainland
34 from threats posed by foreign invasive and agricultural pests.

1 **A13 PATHWAY ANALYSIS OF INVASIVE SPECIES INTRODUCTION INTO THE STATE** 2 **OF HAWAI'I**

3 **A13.1 INTRODUCTION**

4 **A13.1.1 Rationale for Pathway Analysis of Invasive Species Introduction into Hawai'i**

5 Three characteristics contribute to the uniqueness of the Hawai'ian Archipelago: 1) the islands are
6 arranged linearly in chronological order; 2) there is a large number of endemic species, many of which
7 are numerically dominant and display traits distinct from related taxa; and 3) evolutionary phenomena
8 characteristic of island environments in general, such as adaptive shifts, loss of dispersal ability, and
9 arborescence, are developed to an extraordinary degree (Simon 1987). The features of island life—
10 isolation, specialization, limited mobility, and lack of defenses (e.g., toxins, thorns)—have rendered it
11 vulnerable to various kinds of disturbance. For example, unlike the organisms that have originated on
12 continents, most species endemic to Hawai'i and other oceanic islands have evolved in isolation from
13 certain evolutionary pressures, such as grazing and trampling by ungulate mammals; predation by
14 rodents, ants, amphibians, reptiles, and carnivorous mammals; virulent diseases; and frequent and
15 intense fires (Westbrooks 1998). Because of this, the biota of oceanic islands is thought to be
16 comparatively fragile—lacking defenses against introduced predators, parasites, pathogens, and grazers,
17 and adaptations to allow coexistence with introduced competitors (Simberloff 1995). Thus, like other
18 oceanic islands, Hawai'i is particularly vulnerable to biological invasions. For example, although Hawai'i
19 is one of the smallest states in the United States, comprising just 0.2% of its total land mass, more than
20 25% of the endangered species in the United States occur there (OTA 1993). Hawai'i is infamous as “the
21 extinction capital of the United States,” with 72% of the country's recorded extinctions (Gagné 1988;
22 OTA 1993).

23 A growing recognition of Hawai'i's unique status and the vulnerability of its agriculture and other
24 economic sectors, as well as its natural environment, to biological invasion has prompted legislative
25 action. On July 27, 2005, former Congressman Ed Case (2nd District, Hawai'i) introduced the Hawai'i
26 Invasive Species Prevention Act (H.R. 3468) to the U.S. House of Representatives. The purpose of this bill
27 was “to recognize the unique ecosystems of the Hawai'ian Islands and the threat to these ecosystems
28 posed by non-native plants, animals, and plant and animal diseases, to require the Secretary of
29 Agriculture and the Secretary of the Interior to expand federal efforts to prevent the introduction in
30 Hawai'i of non-native plants, animals, and plant and animal disease, and for other purposes.” The bill
31 concluded that “the current Federal statutory and regulatory regime is not sufficient to minimize the
32 introduction of invasive species into Hawai'i and the environmental, economic, and social harm that
33 would result from the introduction of additional invasive species.” Among other things, the bill proposed
34 “rules regarding the establishment of a system of post-arrival quarantine protocols for all persons,
35 baggage, cargo, containers, packing materials, and other items traveling or being shipped to Hawai'i
36 from domestic and foreign locations” and the establishment of “an expedited process for the State of
37 Hawai'i and its political subdivisions to seek the approval of the Secretaries to impose general or specific
38 prohibitions or restrictions upon the introduction or movement of invasive species or diseases from
39 domestic or foreign locations to Hawai'i....”

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1 In order to address the invasive species problem in Hawai'i, the origins of alien species, and the means
2 or "pathways" by which they are introduced into the state, must be examined. To date, no pathway
3 analysis has been conducted by the USDA to assess and quantify the risks posed by invasive species to
4 Hawai'i's agriculture and natural environment, and to provide a sound basis for science-based decision
5 making. The objectives of this study, requested by the Deputy Administrator of the USDA-APHIS-PPQ
6 branch, were several. The study sought to answer the following questions:

- 7 • What are the major pathways by which invasive species are introduced into Hawai'i?
- 8 • What is the present risk to Hawai'i of introduction and establishment of invasive species
9 from foreign countries and from the U.S. mainland and its overseas territories?
- 10 • What are the current sanitary and phytosanitary regulations, practices, and resources in
11 Hawai'i?

12 The present report is divided into two broad sections. In the first section, providing background
13 information, invasive species already established in Hawai'i and their consequences are discussed
14 (Chapter B3). Next, an outline of state and federal programs for alien species interdiction in Hawai'i is
15 presented (Chapter B4). Chapters B5 through B9 in the second section present results of analyses of the
16 risks of quarantine material and invasive pests entering the State of Hawai'i via the airline passenger,
17 cargo, "hitchhikers," wood packaging material, and military pathways, respectively. Lastly, a discussion
18 of some species with potential to invade Hawai'i, including potential consequences, is presented
19 (Chapter B10).

1 **A14 INVASIVE SPECIES IN HAWAI'I AND THEIR CONSEQUENCES**

2 As a tourist destination and center for commerce at the “crossroads of the Pacific,” Hawai'i has always
3 been vulnerable to the introduction and establishment of exotic organisms. Based on current estimates,
4 the total number of plant species present in the Hawai'ian Islands exceeds 11,000, of which
5 approximately 8,000 to 10,000 (72 to 90%) have been introduced (Staples et al. 2000; Staples and Cowie
6 2001; Eldredge 2006). This amounts to an average of more than 40 new plant introductions per year
7 over the past two centuries (Loope 1998). Of the more than 2,100 introduced species that constitute the
8 more commonly cultivated plants in Hawai'i, at least 470, or 22%, are considered invasive or potentially
9 invasive (Staples et al. 2000). At least 79 of the exotics have been officially designated as noxious weeds
10 by the HDOA (Hawai'i Administrative Rules § 4-68).

11 An estimated 9,277 terrestrial arthropod species are known from Hawai'i, of which 3,432 (37%) are
12 nonindigenous (Eldredge 2006). The first alien insects undoubtedly were brought with the early
13 Hawai'ians, who introduced fleas and the head louse (*Pediculus humanus capitis* De Geer) to the islands;
14 later, European explorers and whalers introduced other noxious arthropod pests, such as mosquitoes
15 (probably *Culex quinquefasciatus* Say), first recorded in 1826 from Lahaina on the island of Maui
16 (Pemberton 1964). Immigrants comprise 6% (133 species) of the estimated total of 2,171 mollusc
17 species. In all, some 500 species of arthropods and molluscs in Hawai'i can be classified as pests
18 (Beardsley 1991). Of these, 98% have been introduced. In recent years, the rate of new pest arthropods
19 and molluscs establishing in Hawai'i has averaged 3.5 species annually (Beardsley 1991). Over 1,100
20 plant parasitic and pathogenic species (nematodes, bacteria, fungi, and other microorganisms) are
21 known to occur in Hawai'i (Raabe et al. 1981). Most of these are non-indigenous.

22 **A14.1 IMPACT ON THE ENVIRONMENT**

23 At least one half of the wild species in Hawai'i today are non-indigenous (OTA 1993). No other area in
24 the United States has as great a proportion of established non-indigenous species (OTA 1993). They
25 have had a profoundly negative effect on natural environments in Hawai'i; natural areas that still
26 support indigenous species in relatively intact habitats make up only about 25% of Hawai'i (OTA 1993).
27 For all natural areas, the control and management of invasive species consumes the vast bulk of
28 resource management budgets (OTA 1993).

29 Introduced arthropods have been implicated in the decline or extinction of rare native plant and animal
30 species through direct feeding, predation, or parasitization; disruption of pollination; transmission of
31 pathogens; and competition (e.g., Warner 1968; Howarth 1985; van Riper et al. 1986; Gambino et al.
32 1987; Gambino 1992; Howarth et al. 2001; Oboyski et al. 2004; Johnson and Denslow 2005). Some of
33 the greatest harm visited upon native species and ecosystems, directly or indirectly, has resulted from
34 invasion by ants (Krushelnycky et al. 2005), no species of which occurred in Hawai'i before the arrival of
35 humans (Wilson 1996). Similarly, the introduction of alien snails has led to drastic declines or extinctions
36 in endemic snail species (Hadfield and Mountain 1980; Cowie 1998).

37 Invasive plants, many of which were intentionally introduced, are systematically altering the basic
38 properties of some of Hawai'i's ecosystems, such as light availability, soil water-holding capacity,

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1 nutrient uptake, and other microclimatic variables (Vitousek 1992; Cordell et al. 2002). Non-native
2 grasses have played a major role in altering the natural fire regime in Hawai'i (Staples 2001; Benton
3 2006). Smith (1985) discussed the characteristics of 86 alien plant species that have become significant
4 pests of native ecosystems in Hawai'i, many displacing populations of less competitive native plants.
5 Additional plant species with the potential to become invasive continue to be introduced into the state
6 (e.g., Staples et al. 2006), a major route being the trade in horticultural plants (Staples and Cowie 2001).

7 Plant invasions in Hawai'i often have been facilitated by the grazing and other disturbances to native
8 habitat caused by introduced ungulate mammals (Stone 1985). Although single-species invasions in
9 Hawai'i, such as those involving plants, in themselves may be devastating to native biota or ecosystems
10 (e.g., Vitousek et al. 1987; Hughes and Denslow 2005), invasive species (e.g., alien grasses and vines,
11 mammals, predatory and parasitic Hymenoptera) also may act in concert to threaten native species,
12 such as birds, drastically restricting their foraging ranges (e.g., Banko et al. 2002).

13 The precarious state of the endemic Hawai'ian biota has been summarized thusly (OTA 1993): "By many
14 measures, the Hawai'ian Islands represent the worst-case example of the Nation's [nonindigenous
15 species] problem. No other area in the United States receives as many new species annually, nor has as
16 great a proportion of [nonindigenous species] established in the wild. At the same time, Hawai'i, the
17 Nation's so-called extinction capital, has the greatest concentration of threatened and endangered
18 species in the United States and the greatest number of extinct species as well. While habitat
19 destruction has been and continues to be a main factor in the demise of the indigenous biota,
20 [nonindigenous species] have been identified as an important, if not the most important, current
21 threat."

22 **A14.1.1 Impact on Agriculture**

23 All of the crops cultivated and livestock raised in Hawai'i are introduced species, and virtually all of the
24 agricultural pests in Hawai'i have been introduced as well (OTA 1993). Invasive pests impact agriculture
25 directly by destroying crops and increasing costs of production, and by limiting markets in mainland and
26 foreign areas that have imposed quarantines on produce from Hawai'i because of the threat of new
27 pests (OTA 1993). For example, because of a federal quarantine, fruit fly host products can only be sold
28 in the rest of the United States if they have undergone some type of quarantine treatment (e.g.,
29 fumigation, irradiation). Quarantine treatments are generally required even for commodities, to which
30 the damage caused by pests of concern is insignificant or rare. Quarantine treatments add significant
31 costs to these commodities, which reduce their competitiveness in the global marketplace (McGregor
32 2004).

33 Although the full economic impact of invasive species on Hawai'i's agriculture is unknown, the presence
34 of non-indigenous quarantine pests in Hawai'i was estimated to result in a \$300-million annual loss of
35 agricultural export revenue from the closure of U.S. mainland and foreign markets alone (USDA 2006b).

36 Additionally, invasive pests have had a profound impact on shaping Hawai'i's agriculture as a whole. For
37 example, McGregor (2004) noted that, although the agronomic conditions are favorable in Hawai'i for a

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1 variety of fruit crops, these crops are never seriously considered for commercial development in Hawai'i
2 because of the imposing nature of fruit fly damage, quarantine restrictions, and costly post-harvest
3 treatments. In particular, the loss of export markets, resulting from quarantine restrictions in the U.S.
4 mainland and some foreign countries, is often cited as the main barrier to the expansion of Hawai'i's
5 diversified agriculture (OTA 1993).

6 **A14.1.2 Case Studies**

7 **A14.1.2.1 Plants**

8 **A14.1.2.1.1 *Miconia calvescens* DC (Melastomataceae) (miconia, velvet tree)**

9 **Origin:** Tropical America: Mexico, Central and South America

10 **Mode of introduction:** Introduced intentionally as an ornamental plant in the 1950s or 1960s.

11 **Environmental impacts.** *Miconia* has been spreading aggressively in both native and disturbed forests
12 since its introduction, threatening many of Hawai'i's remaining native plants (Staples and Cowie 2001;
13 Kaiser 2006). This invasive weed has the potential of completely dominating all of Hawai'i's native wet
14 forests, as it has in Tahiti, where dense, monotypic stands of the tree now cover 65% or more of the
15 main island after the introduction of just a single specimen in 1937 (Kaiser 2006). *Miconia*'s ability to
16 out-compete native plants is well documented: it forms dense thickets that block sunlight and crowds
17 out other plants, and it produces an enormous number of seeds that are spread by birds and rats, and
18 remain viable in soil for many years (Staples 2001). Additionally, it promotes erosion because its shallow
19 root system does not hold soil on steep slopes, particularly in heavy rains (Reaser et al. 2007).

20 **Economic impacts.** *Miconia* is not an agricultural pest per se, and it is difficult to measure its economic
21 impact because damages are indirect, impacting ecosystem services and non-market goods, such as
22 biodiversity (Kaiser et al. 2006; Kaiser 2006). Kaiser (2006) attempted to quantify such damages, and
23 estimated that if *miconia* were to become established throughout its potential range in Hawai'i, total
24 damages could reach an average of \$377.4 million per year.

25 *Miconia* was targeted for eradication in the Hawai'ian Islands in 1991, and there is an active campaign to
26 remove it from all islands where it occurs and to prevent its spread. While the budget for the program
27 on all islands is unknown, Kaiser et al. (2006) reported that the Oahu Invasive Species Committee
28 allocated \$321,000 to *miconia* control in 2005 and that Maui expends approximately \$1 million per year
29 on *miconia*-related activities. Tavares (1998) reported that, between 1995 and 1997, approximately
30 \$500,000 was spent on *miconia* control and research programs on the Big Island of Hawai'i. Currently
31 *Miconia* is not considered eradicable from Hawai'i Island and not likely eradicable from Maui. If a
32 successful biocontrol could be developed then eradication might become a more feasible option.

33 **A14.1.2.1.2 *Psidium cattleianum* Sabine (Myrtaceae) (strawberry guava)**

34 **Origin:** Brazil

35 **Mode of introduction:** Originally introduced for cultivation in the 1800s.

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1 **Environmental impacts.** Strawberry guava was introduced intentionally as a fruit tree, but since has
2 become one of the islands' worst pests (Smith 1998; Staples 2001), especially in native rain forests
3 where it infests thousands of hectares (Johnson and Denslow 2005). Its dense thickets suppress native
4 species, and the plant is adapted to disturbance (Jacobi and Warshauer 1992). Strawberry guava may
5 build up an enormous seed bank in the soil, and seeds tend to germinate at higher rates in areas subject
6 to disturbance, such as that caused by feral pigs. In areas where strawberry guava is established, the
7 ground may be carpeted with highly shade-tolerant seedlings, which release compounds into the soil
8 that prevent other species from germinating (Staples 2001; Johnson and Denslow 2005), an adaptation
9 termed allelopathy. Additionally, strawberry guava plants produce an enormous number of fruit, which
10 are eaten by birds and other animals, and which, in turn, spread the seeds (Staples 2001).

11 The displacement of native trees is also facilitated by the interaction of strawberry guava with two
12 invasive species of ginger: *Hedychium gardnerianum* Shepard ex Ker-Gawl. (kahili ginger) and *Hedychium*
13 *coronarium* Koenig (white ginger). These species tend to cover and strangle the seedlings of both native
14 trees and strawberry guava, but guavas are more tolerant of the cover, and are better able to survive
15 than are native trees (Cox 1999).

16 **Economic impacts.** As with miconia, it is difficult to measure the economic impacts of strawberry guava.
17 In addition to the damages caused to ecosystem services and biodiversity, the numerous fruit produced
18 by a single plant provide a major food resource to fruit fly pests of Hawai'ian agriculture, which
19 increases the difficulty and cost of controlling these species (Johnson and Denslow 2005). Unfortunately,
20 strawberry guava, and its congener, *Psidium guajava*, the common guava, are still planted as
21 ornamentals and fruit trees (Staples and Cowie 2001).

22 **A14.1.2.1.3 *Pennisetum setaceum* (Forssk.) Chiov (Poaceae) (fountain grass)**

23 **Origin:** Northern Africa

24 **Mode of introduction:** Introduced as an ornamental grass around 1914.

25 **Environmental impacts.** Fountain grass is one of several non-native grasses that have played a major
26 role in altering the natural fire regime in Hawai'i. Lightning is uncommon on oceanic islands; therefore,
27 in contrast to many other terrestrial environments, fire has not played much of an evolutionary role in
28 the native ecosystems of Hawai'i (Westbrooks 1998). Thus, few Hawai'ian endemic plant species possess
29 adaptations to fire. Humans are the cause of most fires in Hawai'i, and these fires are fueled primarily by
30 non-native grasses (Brooks et al. 2004).

31 Like other invasive grasses in Hawai'i, fountain grass is a highly aggressive, fire-adapted colonizer of
32 pastures and grasslands that readily out-competes and replaces native plants and rapidly re-establishes
33 after burning. In the summer, when the grass dries out, it becomes a fire hazard. The grass burns quickly
34 with intense heat, resulting in severe damage to native forest species, which are not adapted to such
35 extreme fire regimes (Staples 2001; Benton 2006). Fountain grass out-competes other grasses by
36 regenerating quickly after burning; native grasses and many forage grasses do not have this capacity
37 (Staples 2001).

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1 In addition to increasing the frequency and intensity of fires, there is some evidence that fountain grass
2 also alters basic ecosystem properties, such as light availability, soil water holding capacity, nutrient
3 uptake, and other microclimatic variables (Cordell et al. 2002). Fountain grass is also an aggressive
4 invader of bare lava flows, where it reportedly interferes with normal plant succession (Tunison 1992;
5 Staples and Cowie 2001). Its seeds are dispersed by wind, water, humans, vehicles, and birds (Tunison
6 1992), but because of an active control program to prevent it from spreading to other islands, so far,
7 extensive damage has been limited to the Big Island (HDLNR 2007).

8 **Economic impacts.** Control of fountain grass is difficult and expensive, often costing more than \$12,000
9 per hectare (Cordell et al, 2002).

10 **A14.1.2.2 Arthropods**

11 It has been estimated that since European contact with the Hawai'ian Islands in the 18th century,
12 approximately 15 to 20 new species of insect immigrate to Hawai'i each year (Beardsley 1962; 1979).

13 **A14.1.2.2.1 *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) (oriental fruit fly)**

14 **Origin:** Southern Asia

15 **Mode of introduction:** Military air transport from Saipan (Jang and Harris 2005).

16 **Environmental impacts.** The oriental fruit fly is widespread in native forests, and feeds on both native
17 and introduced fruits. Efforts to control fruit fly populations, particularly with organophosphate
18 pesticides, may severely impact native species.

19 **Economic impacts.** The oriental fruit fly was introduced into Hawai'i around 1945, and quickly displaced
20 the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (introduced around 1910 [Clausen et al.
21 1965]), throughout most of its range (Vargas et al. 2001; Jang and Harris 2005). Along with the melon fly,
22 *B. cucurbitae* (Coquillett), the oriental fruit fly is the most damaging of Hawai'i's exotic fruit flies. It has a
23 wide host range, and is a major pest of almost every variety of fruit grown commercially in Hawai'i
24 (Harris 1989). Guava, mango, papaya, carambola, passion fruit, citrus, tomato and breadfruit are
25 particularly susceptible, and, left uncontrolled, oriental fruit flies can damage up to 100% of fruit in a
26 production area (CABI 2006).

27 In Hawai'i, producers suffer significant direct and indirect economic losses from fruit fly damage
28 (Hendrichs 1996). Even with control, annual losses in fruit crops resulting from infestations by the
29 oriental fruit fly may exceed 13% (Culliney 2002), undoubtedly an underestimate. Globally, *B. dorsalis*
30 causes millions of dollars worth of damage each year (SPC 2002b). Additionally, fruit flies can have a
31 significant impact on crop values, even when they do not actually infest the fruit. Fruit quality can be
32 reduced due to fruit fly oviposition punctures ("stings"), which affect the appearance of fruit, even in
33 fruits unfavorable for larval survival (Harri 1989). Moreover, many fruits, including papayas and
34 tomatoes, are harvested before they are ripe, in part to avoid fruit fly stings and infestations. Harvesting
35 these fruits early affects their taste. Papayas, for example, increase in sugars and sweetness as they
36 mature on the tree. McGregor (2004) estimated that growers could expect about \$.11 more per

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1 kilogram (kg) for tree-ripened papaya than papaya picked green, which would translate into approximately \$750,000 per year for the industry.

3 Strict quarantine regulations are necessary to prevent the movement of fruit flies from the Hawai'ian Islands to fruit fly-free areas, and fruit producers have had to invest in expensive post-harvest treatments and facilities to disinfest fruit cargoes before or during shipment (Hendrichs 1996; Howarth et al. 2001). Costs of post-harvest treatments can be significant. Additionally, millions of dollars continue to be spent on fruit fly-related research, including research on various control techniques (e.g., area-wide pest management, sterile insect technology) and alternative post-harvest treatments.

9 In addition to these direct costs, there are immeasurable indirect costs associated with lost markets and industries. McGregor (2004) speculated that these costs are likely to be much greater than the direct costs mentioned above. A study conducted by the Nature Conservancy of Hawai'i (Miller and Holt 1992) postulated, based on industry estimates, that oriental and melon flies cost Hawai'i \$300 million per year in lost markets. While there are few data available to confirm this estimate, it is clear that the presence of exotic fruit flies is a significant deterrent to the research and development of crop industries that are significant hosts of fruit flies. For example, in Hawai'i, practically all guavas are processed—none is sold for fresh consumption—due to high oriental fruit fly infestations (McGregor 2004).

17 ***A14.1.2.2 Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae) (spiral whitefly)***

18 **Origin:** Central America and the Caribbean

19 **Mode of introduction:** Accidentally introduced about 1978, probably on flowers or produce (Howarth et al. 2001).

21 **Environmental impacts.** The spiraling whitefly has a broad host range. It is generally found in coastal areas (Howarth et al. 2001), but environmental impacts due to the introduction of this pest seem to have been minimal.

24 **Economic impacts.** The spiraling whitefly has been recorded on more than 100 species of plant, belonging to 38 genera and 27 families, and commonly attacks many vegetable, ornamental, fruit, and shade tree crops in Hawai'i (Kessing and Mau 1993; CABI 2006), including annona, avocado, banana, bird-of-paradise, breadfruit, citrus, coconut, eggplant, guava, kamani, Indian banyan, macadamia, mango, palm, paperbark, papaya, pepper, poinsettia, rose, sea grape, and tropical almond (Kessing and Mau 1993).

30 Following its introduction into Hawai'i, *A. dispersus* became a major economic pest, and the HDOA and its cooperators conducted extensive searches for biological control agents that could be introduced to reduce its populations. Several natural enemies were introduced into Hawai'i from the Caribbean in the early 1980s. The biological control program seems to have been successful, and at least one agent was documented to reduce populations by as much as 79% at lower elevations and 99% at higher elevations. At present, the spiraling whitefly is generally considered only a minor pest (Kessing and Mau 1993). Infestations can have serious economic impacts in at least three ways:

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- 1 • Direct damage to the plant caused by feeding: *A. dispersus* larvae (and to a lesser degree, adults) cause damage by sucking sap from leaves. Direct feeding can cause premature leaf drop, which may reduce plant vigor and yields, but rarely kills plants outright (CABI 2006).
- 4 • Indirect damage to the plant caused by excreted honeydew: Damage is caused when sooty molds develop on honeydew excreted by the insects. Sooty molds covering leaves can hinder photosynthesis and reduce yields (CABI 2006).
- 7 • Cosmetic damage to the fruit: Damage is caused by both sooty molds and the white flocculent wax secreted by immature stages. Although cosmetic damage does not affect the plant itself, it can significantly reduce the market-value of crops (CABI 2006).

10 *Aleurodicus dispersus* is a quarantine pest for other countries, and is listed as a reportable/actionable pest for the contiguous United States (despite its presence in Florida) (USDA 2007a). Crop exports are sometimes rejected at a mainland port due to the presence of this pest (Staples and Cowie 2001), meaning lost income for Hawai'i growers.

14 **A14.1.2.2.3 *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) (Formosan**
15 **subterranean termite)**

16 **Origin:** Taiwan or South China

17 **Mode of introduction:** Accidentally introduced via shipping (Staples and Cowie 2001).

18 **Environmental impacts.** There are seven species of termite in Hawai'i, all of them introduced (Woodrow et al. 1999). Although, in general, *C. formosanus* is an urban pest, it has also been found attacking living plants (especially trees), resulting in damage to all parts of the plant, but in particular the heartwood, roots and branches (Lai et al. 1983). In New Orleans, an estimated 30 to 50% of the historic live oak trees are infested with *C. formosanus* (Anonymous 2007). Similar estimates for Hawai'i were not available, but Lai et al. (1983) reported several instances in Hawai'i in which apparently healthy trees were hollowed out by termites, causing them to fall.

25 Additionally, increased use of pesticides to control termite populations has led to negative effects on the environment, including contamination of water supplies caused by runoff (Anonymous 2007).

27 **Economic impacts.** *Coptotermes formosanus* commonly attacks structural timbers, books, and other finished wood or paper products. The termite is considered the single most costly economic pest in Hawai'i, causing over \$150 million worth of damage each year to buildings, furnishings, and trees (Woodrow et al. 1999; Staples and Cowie 2001). Moreover, this species is not believed to have reached its full distribution in Hawai'i, and it is believed that costs will probably increase in the future as 1) the termite moves into areas in Hawai'i where it does not yet occur; 2) the colony density increases in areas where the termite does occur; 3) the values of existing buildings increase; and 4) additional buildings are constructed, putting more buildings at risk (Yates 1992).

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1 One of the reasons for the high costs associated with this insect stems from the fact that *C. formosanus*
2 is an aggressive pest that leaves little evidence of attack until considerable damage has been done.
3 According to Yates (1992), “often the first indication of an infestation is a sagging floor or door, leaking
4 roof, warping of walls, hollow sounding beams, short circuits, telecommunication blackouts, etc.”
5 Colonies of *C. formosanus* are large: in Hawai’i, an average colony contains over 2 million individuals,
6 and some may have as many as 10 million individuals. Because of their numbers, a great deal of damage
7 can occur in a short amount of time. In some cases, unprotected homes built over strong existing
8 colonies have been almost completely destroyed in 2 years (Yates 1992).

9 **A14.1.2.2.4 Ants (Hymenoptera: Formicidae)**

10 There are 43 species of ant in Hawai’i, all of them introduced. In terms of environmental impact, they
11 are arguably the most harmful invasive insect species in Hawai’i. After being introduced into a new area,
12 many species of ant are able to establish colonies quickly in a variety of habitats. They prey on other
13 invertebrates or feed on the seeds of plants, and often out-compete native species for food and space.
14 In Hawai’i, they have been directly associated with the destruction of many native insect species
15 (Staples and Cowie 2001).

16 **A14.1.2.2.5 *Pheidole megacephala* (Fabricius) (bigheaded ant)**

17 **Origin:** Tropical Africa

18 **Mode of introduction:** Accidentally

19 **Environmental impacts.** This ant is widely considered a serious threat to biodiversity and one of the
20 “world’s worst invaders” (Hoffman 2006). In the environment, it is a major predator implicated in the
21 extermination of many lowland insects (Staples and Cowie 2001). Evidence also exists of reductions in
22 vertebrate populations in areas where this ant is extremely abundant. Additionally, it is known to
23 facilitate the invasion of introduced plant species (Hoffman 2006).

24 **Economic impacts.** The bigheaded ant is often a household pest, with large, inter-connected colonies
25 that are difficult and expensive to control (Staples and Cowie 2001). It is also known to chew on
26 irrigation lines, telephone cabling, and electrical wires (Hoffman 2006).

27 In agriculture and horticulture, bigheaded ants can be serious pests, either directly, by collecting and
28 harvesting seeds, or indirectly, by protecting and tending phytophagous Homoptera, such as the pink
29 pineapple mealybug, resulting in population increases of these pests and consequent reductions in plant
30 productivity (Staples and Cowie 2001; Hoffman 2006).

31 **A14.1.2.2.6 *Linepithema humile* (Mayr) (Argentine ant)**

32 **Origin:** Brazil and Argentina

33 **Mode of introduction:** Accidentally

1 **Environmental impacts.** The Argentine ant was introduced into Hawai'i about 1940 (Staples and Cowie
2 2001). Although it is generally associated with disturbed habitats throughout its introduced range, it has
3 also invaded native habitats that have experienced little human disturbance (Krushelnycky 2006).

4 Native arthropods are greatly threatened by Argentine ants. They compete aggressively with native
5 arthropods for limited food resources and nesting sites. For example, in South Africa, the Argentine ant
6 can collect up to 42% of available nectar before bees can forage (Krushelnycky 2006). In Hawai'i, the
7 Argentine ant is believed to be responsible for declines in populations of many native arthropods,
8 including moths and bees, which are essential pollinators of native plants (Cole et al. 1992; Staples and
9 Cowie 2001; Krushelnycky 2006). In addition to out-competing native arthropods, Argentine ants
10 actively prey on a number of native arthropod species, and have even been reported attacking the eggs
11 of the native Hawai'ian goose, or nene, *Branta sandvicensis* (Vigors) (Cole et al. 1992; Krushelnycky
12 2006). The pest has not yet reached its full potential distribution in the islands (Staples and Cowie 2001).

13 **Economic impacts.** Argentine ants do not appear to be important agricultural pests. However, they may
14 have an indirect, negative impact on agriculture and horticulture because they attack the predators and
15 parasitoids of scale insects, causing the scales to multiply and become more serious pests of crops and
16 horticultural plants (Staples and Cowie 2001).

17 **A14.1.2.2.7 *Varroa destructor* Anderson & Trueman (Parasitiformes: Varroidae) (varroa mite)**

18 **Origin:** Far East

19 **Mode of introduction:** Unknown; smuggling, honey bee swarms aboard ships, and shipments of bees
20 transiting Hawai'i are possible sources

21 **Environmental impacts.** The varroa mite is recognized as the most serious pest of the western honey
22 bee, *Apis mellifera* L., worldwide (Anderson and Trueman 2000; Sammataro et al. 2000). Australia and
23 Hawai'i were among the last few areas known to be free of infestation (Culliney 2003). However, in April
24 2007, varroa mites were detected in three abandoned hives on Oahu (Hao 2007).

25 In parasitizing the immature stages of the honey bee, *V. destructor* often kills its host outright (De Jong
26 et al. 1982). If the host survives, the resulting adult bee usually is deformed in some way and incapable
27 of contributing to colony welfare. Colony population size dwindles over time, and, left untreated, a
28 heavy infestation can kill a colony within 3 to 4 years. The mite is known to be a vector for at least four
29 honey bee viruses: sacbrood, acute paralysis, black queen cell, and deformed wing (the latter three not
30 known to occur in Hawai'i), some of which may cause severe mortality in colonies (Bailey and Ball 1991).
31 To combat the parasite, beekeepers must resort to the use of expensive pesticides, although there now
32 are clear indications that the mite is developing resistance to these (Sanford 1998). Wild bee colonies
33 have no defense; they have been reported to be dying out in the continental United States, where *V.*
34 *destructor* is well-established (Kraus and Page 1995).

35 Varroa disperses locally through phoresy, attaching itself to worker and drone honey bees, as well as to
36 a variety of other flower-frequenting insects, including other species of bee, flies, and beetles; flowers

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1 may thusly be used by the mite as way stations to transfer to new insect vehicles (Kevan et al. 1990).
2 Spread of the mite over wide areas within countries results from migratory beekeeping (De Jong 1990).
3 The post-World War II increase in international travel and commerce has facilitated the spread of *V.*
4 *destructor* globally (Sammataro et al. 2000). First recorded on *A. mellifera* in Asia around 1960 (De Jong
5 1990), at present, the species is almost cosmopolitan in distribution (Anderson and Trueman 2000). That
6 this pernicious parasite has dispersed so widely and quickly attests to the ease with which it surmounts
7 geographic barriers and thwarts international quarantines.

8 **Economic impacts.** As agriculture in Hawai'i depends heavily on the pollination services provided by the
9 large feral honey bee population, it could be severely impacted should *V. destructor* become
10 established. For example, since its first detection in 2000, the total economic impact of *V. destructor* on
11 agriculture in New Zealand has been estimated at \$251 to \$566 million (Canyon et al. 2002).

12 The Hawai'i legislature recently passed legislation appropriating \$650,000 to be spent on training and
13 pesticides, and to reimburse beekeepers for mite control costs among other measures (Hao 2007).

14 **A14.1.2.3 Molluscs**

15 **A14.1.2.3.1 *Achatina fulica* Bowdich (*Achatinidae*) (*giant African snail*)**

16 **Origin:** East Africa, but introduced from Japan

17 **Mode of introduction:** Intentionally introduced on more than one occasion as a human food item and as
18 a pet species (Staples and Cowie 2001).

19 **Environmental impacts.** The giant African snail was first introduced into Hawai'i in the 1930s. Since that
20 time, it has become widespread (CABI 2006). Although *A. fulica* is primarily found in disturbed low- to
21 mid-elevation sites in Hawai'i, it has also been observed as an invader of primary or secondary forests
22 (Raut and Barker 2002). Large numbers in native ecosystems pose a threat to native plants, and it may
23 compete with native snails for food and space (Staples and Cowie 2001).

24 **Economic impacts.** The giant African snail is a generalist feeder and is a major crop and garden pest,
25 requiring frequent use of snail bait for control. As Raut and Barker (2002) noted, there are three main
26 costs associated with this pest in tropical agriculture. First, there is a loss of productivity caused by direct
27 feeding on crop plants or on other plants that provide shade or soil enrichment. The snails may also
28 transmit plant pathogens. Secondly, there are costs associated with management of this pest both in
29 terms of labor and in materials. Finally, there are opportunity costs associated with changes in
30 agricultural practices, such as planting only crop species resistant to *A. fulica* (Raut and Barker 2002).
31 The extent to which Hawai'i has incurred such costs is unknown.

32 Additionally, the snail is an intermediate host of the parasitic nematode, *Angiostrongylus cantonensis*
33 (Chen), or rat lungworm, which causes the disease eosinophilic meningoencephalitis in humans (Staples
34 and Cowie 2001).

1 **A14.1.2.3.2 *Euglandina rosea* Ferussac (*Spiraxidae*) (rosy wolf snail)**

2 **Origin:** Latin America, southeastern United States

3 **Mode of introduction:** Intentionally introduced to control African snails.

4 **Environmental impacts.** This snail was introduced into Hawai'i in 1955 as a potential biological control
5 agent against the giant African snail (Cox 1999; Staples and Cowie 2001). It is found in damp places in
6 both disturbed areas and native forests. Instead of controlling African snails, the rosy wolf snail has
7 devastated native snails, eliminating up to half of the 800 snail species endemic to Hawai'i, and is the
8 most serious predator of *Achatinella* spp. (Cox 1999), listed as endangered in Title 50, Part 17, Section
9 11 of the United States Code of Federal Regulations (50 CFR § 17.11).

10 **A14.1.2.3.3 *Pomacea canaliculata* (Lamarck) (*Ampullariidae*) (channeled or golden apple snail)**

11 **Origin:** South America, but probably introduced to Hawai'i from Southeast Asia (Staples and Cowie
12 2001)

13 **Mode of introduction:** Intentionally as a potential human food item for home consumption and as an
14 exotic escargot for the restaurant trade (Staples and Cowie 2001).

15 **Environmental impacts.** The channeled apple snail was introduced into Hawai'i about 1989. Since that
16 time, it has become increasingly widespread in taro growing areas, ponds, streams, and wetlands
17 (Staples and Cowie 2001). It has reached most wet areas on the islands of Kauai, Oahu, Maui, Lanai, and
18 Hawai'i (Levin 2006). According to Levin, almost 4,400 hectares of wetlands, ponds, streams, taro-
19 growing systems, and other habitats are at risk or have already been invaded by this pest. There is little
20 information available on the impact of this snail on freshwater wetland ecosystems and watersheds.
21 However, one recent study suggested that, in Thailand, high densities of *P. canaliculata* were associated
22 with the almost complete absence of aquatic plants, high nutrient concentrations, and subsequent
23 phytoplankton blooms (Carlsson et al. 2004; Levin 2006).

24 **Economic impacts.** *Pomacea canaliculata* is a general feeder that has been recorded on various aquatic
25 weeds, ong choi, and watercress (Levin 2006). It is a major pest of rice throughout much of Japan and
26 Southeast Asia (Staples and Cowie 2001; Cowie 2002). In Hawai'i, it is a serious pest of taro, feeding on
27 the stem, corms, and other plant parts (Staples and Cowie 2001), and accounts for yield losses ranging
28 from 18 to 25% annually (Levin 2006). Mitigation of the impact of this pest has increased labor, time,
29 and cash inputs by as much as 50% above traditional production costs (Levin 2006). Additionally, taro is
30 a crop of considerable cultural importance to Hawai'i (Ooka and Brennan 2000).

1 **A14.1.2.4 Vertebrates**

2 **A14.1.2.4.1 *Eleutherodactylus coqui* Thomas (coqui frog)**

3 **Origin:** Caribbean

4 **Mode of introduction:** Believed to have entered Hawai'i on uninspected potted plant material from
5 Puerto Rico about 1988 (HDOA 2007a).

6 **Environmental impacts.** *Eleutherodactylus coqui* is a small frog (less than 2.5 cm [about 1 inch] in
7 length) with a loud call (Staples and Cowie 2001). Aside from being a major nuisance pest, coqui frogs
8 pose a major threat to Hawai'i's native biota. For example, the population established in Hawai'i is
9 estimated to consume as many as 125,000 insects per hectare per night (CTAHR 2006; HDOA 2007a).
10 Additionally, the frogs compete with Hawai'i's native birds and other fauna that rely on insects for food
11 (Staples and Cowie 2001; CTAHR 2006). Thus, large frog populations could have adverse effects on these
12 species—many of them already threatened or endangered. The frogs also are known to increase soil
13 fertility by converting arthropod biomass into nutrients more readily available to plants, thus potentially
14 altering plant species composition and providing conditions favorable to weed invasion (Beard and Pitt
15 2005).

16 Coqui frogs are quite adaptable to the varied ecological zones and topography in Hawai'i. Whereas, in
17 Puerto Rico, frog populations are kept in check by predators, such as owls, snakes, tarantulas, and
18 scorpions, in Hawai'i, the coqui frog has no natural enemies (CTAHR 2006; HDOA 2007a). Populations
19 have exploded in the last 15 years; there are now over 200 infestations on the Big Island alone, and
20 Maui has over 40 infestations. The Coqui has been found on Oahu in at least five locations (CTAHR
21 2006), but currently there are no established populations. Coqui have been declared eradicated from
22 Kauai as of mid-2012. was recently discovered on Kauai In some areas where Coqui have been able to
23 establish, populations exceed 25,000 frogs per hectare (HDOA 2007a).

24 **Economic impacts.** There is little information on the actual economic consequences of the introduction
25 of this species. However, there is some speculation that, as populations of the frog increase, tourism
26 may be negatively impacted due to the extremely loud noise levels produced by this frog: calls can be as
27 loud as 80 to 90 decibels, about the same as a lawn mower (Staples and Cowie 2001; HDOA 2007a).
28 Since this frog is active at night, many residents and visitors in coqui-infested areas have complained
29 that they are unable to sleep due to the noise produced by the frogs (HDOA 2007a). Beyond potential
30 impacts on tourism, there is a possibility that Hawai'i's nursery industry could be negatively impacted by
31 the presence of this frog if exports are banned because of quarantine restrictions (Staples and Cowie
32 2001). An impact which has not been fully examined is the requirement of property owners to disclose
33 the existence of this species on their property.

1 **A14.1.2.4.2 *Sus scrofa* Linnaeus (feral pig)**

2 **Origin:** East Indies

3 **Mode of introduction:** Intentionally by the Polynesians for food.

4 **Environmental impacts.** Feral pigs represent one of the major threats to forests and other natural areas
5 (OTA 1993). In the process of rooting for food, they damage ground-level plant cover and greatly assist
6 in germination and spread of invasive plants, including strawberry guava. They also topple and eat
7 native tree ferns (Kishinami 2001).

8 **Economic impacts.** Pigs are considered the number one economic and environmental threat to
9 watersheds in Hawai'i, reducing the extent of plant cover, which impacts freshwater resources
10 (Kishinami 2001). Estimated damages from feral pigs range from \$1 million to almost \$24 million per
11 year (Kaiser et al. 1999). A further \$450,000 per year is spent to control pigs in national parks in Hawai'i
12 (Pimentel et al. 2000).

13 **A14.1.2.5 Conclusions**

14 Invasive species have caused hundreds of millions of dollars worth of damage in Hawai'i in terms of crop
15 losses, increased production costs, and lost markets. The sheer number of invasive species makes it
16 nearly impossible to evaluate the full impact of past biological invasions on the Hawai'ian economy.
17 From the few studies that have been conducted, it is clear that the impact must be considerable. For
18 example, fruit flies alone have been estimated to result in a \$300-million annual loss of agricultural
19 export revenue from the closure of U.S. mainland and foreign markets (Miller and Holt 1992). Potential
20 damages to the Hawai'i economy associated with the invasive weed, *Miconia calvescens* DC., have been
21 projected to exceed \$377 million per year (Kaiser 2006). Exotic termites cause more than \$150 million in
22 damage annually to structures throughout the state (Howarth et al. 2001). Estimated damages from
23 feral pigs range from \$1 million to almost \$24 million per year (Kaiser et al. 1999).

24 Perhaps more serious, invasive species have been responsible for endangering and causing the
25 extinction of native species—many of which are not found anywhere else in the world—and for the
26 destruction of native forests and other natural areas.

27 A summary of the impacts associated with the selected non-indigenous species reviewed in this chapter
28 is presented in Table B3-1. The introduction and establishment of other invasive pests, such as RIFA,
29 West Nile virus, and BTS, likely would have a similar or greater impact on Hawai'i's economy, and
30 further endanger the archipelago's endemic biota as well (Choo 2004) (see also Chapter 10).

31

1 **Table B3-1: Summary of Some of the Impacts Associated with Selected Non-indigenous**
 2 **Species in Hawai'i**

Name	Origin	Mode of Introduction	Economic impact	Environmental impact
<i>Miconia calvescens</i> (miconia, velvet tree)	Tropical America	Intentionally, as an ornamental	Almost \$2 million was allocated for control programs in 2005	Forms dense thickets that block sunlight and crowd out other plants; promotes erosion
<i>Psidium cattleianum</i> (strawberry guava)	Brazil	Intentionally, for cultivation	Costly to control	Dense thickets suppress native species; adapted to disturbance
<i>Pennisetum setaceum</i> (fountain grass)	Northern Africa	Intentionally, as an ornamental	Costly to control	Changes the fire regime; out-competes native plants
<i>Bactrocera dorsalis</i> (oriental fruit fly)	Southern Asia	Accidentally on military transports	An estimated \$300 million per year in lost market access; significant crop losses; significant costs of control	Attacks native fruits; large quantities of insecticide are used to control this pest
<i>Aleurodicus dispersus</i> (spiraling whitefly)	Central America and the Caribbean	Accidentally, probably on cut flowers or fresh produce	Considered a major economic pest until biological control agents were introduced	Probably unimportant
<i>Coptotermes formosanus</i> (Formosan subterranean termite)	Taiwan or South China	Accidentally, probably via shipping material	An estimated \$150 million worth of damage every year to wooden structures and other products	May attack living trees; large quantities of insecticide are used to control this pest
Ants (<i>Pheidole megacephala</i> and <i>Linepithema humile</i>)	Africa (<i>P. megacephala</i>); Brazil and Argentina (<i>L. humile</i>)	Accidentally	Household pests that are costly and difficult to control; have indirect impacts on agriculture	Responsible for the extinction or endangerment of several species of endemic insects
<i>Varroa destructor</i> (varroa mite)	Far East	Unknown; smuggling, swarms aboard ships, and shipments of bees transiting Hawai'i are possible sources	New introduction; total economic impact in New Zealand was estimated at \$251 to \$566 million; potential threat to Hawai'i agriculture	Could devastate wild bee populations; plants that depend on pollination for reproduction may be negatively impacted

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Name	Origin	Mode of Introduction	Economic impact	Environmental impact
<i>Achatina fulica</i> (giant African snail)	Africa; probably introduced into Hawai'i from Japan	Intentionally, for food and as a pet species	Can be a major crop and horticultural pest	Competes with native snails for food and space
<i>Euglandina rosea</i> (rosy wolf snail)	Latin America	Intentionally, as a biological control agent for the giant African snail	Probably unimportant	Has devastated Hawai'i's native snails, eliminating up to half of the 800 species endemic to Hawai'i
<i>Pomacea canaliculata</i> (channeled or golden apple snail)	South America, but probably introduced into Hawai'i from Southeast Asia	Intentionally, for food	Has a major effect on taro production in Hawai'i; increases costs of production as much as 50%	May be devastating to communities of aquatic plants
<i>Eleutherodactylus coqui</i> (coqui frog)	Caribbean	Accidentally, probably on plants imported from Puerto Rico	Potential impact on nursery trade if quarantines are put in place; potential impact on tourism	Poses a threat to native Hawai'ian insect populations, including plant pollinators; may compete with native birds for food
<i>Sus scrofa</i> (feral pig)	East Indies	Intentionally, for food by Polynesians	Costly to control	Damaging to indigenous plants; in altering plant cover, indirectly may affect watersheds

1

1 **A15 PROGRAMS FOR ALIEN SPECIES INTERDICTION IN HAWAI'I**

2 **A15.1 HAWAI'I DEPARTMENT OF AGRICULTURE, PLANT INDUSTRY DIVISION, PLANT** 3 **QUARANTINE BRANCH**

4 Among its many responsibilities, the HDOA is charged with preventing the introduction and
5 establishment of alien species in the state. Because of Hawai'i's geography and diverse climatic zones
6 (tropical to temperate), the state is vulnerable to the entry and establishment of more foreign pests
7 than are mainland states. HDOA collaborates with federal agencies to prevent introduction of regulated
8 invasive pests. Similarly, HDOA inspectors involve federal agencies if a detected organism is an
9 endangered species and subject to provisions of the CITES or other federal restrictions.

10 The Plant Quarantine Branch (PQ) of HDOA regulates the importation and movement within the state of
11 all plants and exotic animals (vertebrate and invertebrate). Its primary goal is to prevent the
12 introduction of harmful insects, plant pathogens, illegal animals, and other pests into Hawai'i. HDOA PQ
13 also provides clearance for exporting horticultural products from the state (e.g., rooted plants), and may
14 inspect cut flowers and foliage under cooperative agreement with the USDA.

15 **A15.1.1 Overview of Regulatory Authority**

16 Hawai'i Revised Statutes (HRS) §§ 141 and 150A define the regulatory authority of HDOA. HRS § 141
17 authorizes HDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude commodities infested
18 with pests or any article which is, in itself, a pest, which may be injurious to the agricultural industries
19 and forest resources of the state. Further, HRS § 141 authorizes HDOA to enforce applicable regulations
20 governing the importation into Hawai'i of any agricultural commodities from anywhere outside of the
21 state, at any time or place within the state.

22 HRS § 150A authorizes HDOA to regulate plant, animal, and micro-organism importation into the state,
23 including conditions of importation; the listing of prohibited, restricted, and conditionally approved
24 plants, non-domestic animals, and microorganisms; as well as issuance of permits, collection of user
25 fees, application of interim rules, and imposition of penalties.

26 **A15.1.2 Plant Quarantine Duties and Operations**

27 For imported commodities moving domestically via incoming cargo from the U.S. mainland, HDOA has
28 oversight of all rules and regulations pertaining to airport and sea operations. With regard to export or
29 movement of agricultural commodities from Hawai'i to the U.S. mainland, HDOA complies with federal
30 regulations as stipulated in 7 CFR § 318.13.

31 Shippers of domestic cargo bound for Hawai'i by air or sea must notify HDOA of incoming goods
32 requiring inspection (Miller and Holt 1992). If such freight arrives during nonworking hours, the shipping
33 company must hold the cargo until the next business day to provide PQ inspectors adequate
34 opportunity to examine it. Low staffing levels relative to the large volume of goods entering the state do
35 not allow for inspection of all cargo. Instead, inspectors separate incoming goods into one of three risk
36 categories: high, medium, and low risk, and systematically inspect the items in decreasing order of risk.

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1 The record of past interceptions also influences the selection of items for inspection. For high-risk
2 goods, such as all animals (including fish) and all propagated plants, PQ will inspect 100% of the declared
3 items. For items considered to be of medium or low risk, the inspectors will randomly inspect two or
4 three boxes from a particular cargo lot. Medium-risk goods include cut flowers and foliage, whereas
5 produce is considered to be low risk. Commodities, such as livestock feed, coffee beans, organic
6 fertilizer, and planting media, fall along a continuum between medium and low risk. Lacking any
7 prescribed method or basis for a statistical sampling process, the level of inspection devoted to these
8 spot checks depends on the availability of inspectors.

9 In recent years, PQ also has initiated an Agricultural Quarantine Inspection Monitoring (AQIM) program,
10 in which statistically valid, random sampling techniques are employed to estimate pest incidence in
11 maritime containerized cargo from the mainland. Sampling and data collection follow protocols
12 specified in the USDA-APHIS-PPQ AQIM manual (USDA 2006a).

13 ***A15.1.2.1 Airport Inspection***

14 Currently, PQ inspectors are assigned to inspect domestic incoming articles at various facilities in or
15 around the airport, including airline cargo stations, baggage claim areas, the USDA mail cargo inspection
16 station at the USPS facility, Federal Express (FedEx) and United Parcel Service (UPS) facilities, and the
17 HDOA airport animal quarantine holding facility. All articles regulated by the state must be inspected by
18 a PQ inspector before they can be released to the importer. Requests for inspection are called in to the
19 PQ airport office, and inspectors are dispatched to each inspection site in the order in which the calls are
20 received.

21 PQ inspectors screen packing lists and cargo manifests for commodities that might be hosts of specific
22 pests, based on previous interceptions or interception records. Labels specifying the identity of
23 commodities and their origins are also factors in determining if the commodities in cargo require
24 increased scrutiny. All restricted items are inspected for pests, and the required documents, such as
25 permits, phytosanitary certificates, and certificates of treatment, are verified before the shipment is
26 released.

27 ***A15.1.2.2 Maritime Inspection***

28 Maritime inspections usually involve plant-related commodities only (e.g., produce with longer shelf
29 lives, such as bananas, and materials, such as planting media and organic fertilizer), whereas airport
30 inspections include items of both plant and animal origin, as most fish and other seafood, animals and
31 perishable produce, and plants are air-shipped. PQ inspects containerized freight (other than dry goods)
32 and vehicles upon arrival; dry goods inspection was discontinued years ago because of staff shortages.

33 Through an agreement between HDOA and certain ocean carriers, fully loaded, refrigerated maritime
34 containers that may contain perishable items are allowed to be taken out of the container yard for
35 inspection at a separate, authorized facility, which may be a warehouse, packing and distribution facility,
36 or a repacking facility. Similarly, containers only partially loaded with agricultural commodities may be

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1 delivered to a freight forwarding company where the individual shipments are broken down and set
2 aside for inspection.

3 ***A15.1.2.3 Inter-island Inspection***

4 As required by statute (Hawai'i Administrative Rules § 4-72), all plants and propagative plant parts, and
5 non-domestic animals, including mammals, birds, fish, reptiles, amphibians, and insects, require
6 inspection and certification prior to shipping from Oahu to the outer islands. No inspection is required
7 for seeds, cut greens (including Christmas trees), flowers, and leis, or for pigeons, domestic rabbits,
8 poultry, horses, cattle, cats, and dogs.

9 Private, non-commercial shipments are transported to either the airport or maritime offices for
10 inspection and certification. Large commercial shipments may be inspected at their point of origin
11 before being loaded into containers for inter-island barge transport.

12 ***A15.1.2.4. Military Inspection***

13 Military maritime and airport facilities are subject to PQ inspection, but such inspections are limited due
14 to staff shortages. The branch has established cooperative agreements with military bases clarifying
15 each agency's inspection and interception responsibilities. In addition, PQ has assigned one supervisor
16 full-time responsibility for coordination with military bases.

17 Since 1992, PQ has conducted inspections for detection of BTS in commercial aircraft and ships arriving
18 from Guam. For the purpose of snake detection, PQ attempts to meet and inspect all flights from Guam,
19 with the result that 97 to 98% of arriving flights are inspected. PQ also inspects all military aircraft and
20 ships arriving from Guam. Snake inspection is conducted through visual inspection and sometimes with
21 the help of the BTS canine unit. Aircraft wheel wells are inspected with dogs. For military flights, PQ
22 inspectors do a walk-through of the cargo hold without dogs, and use dogs to check cargo when it is off-
23 loaded. Commercial flights are handled similarly, with cargo checked by dogs when it is off-loaded.
24 During the 6-month period prior to April 25, 2004, PQ inspected 267 commercial flights, 323 military
25 flights, and seven private flights for BTS (Loope and VanGelder 2005).

26 The funding for BTS inspection and interdiction had been subsidized by the Department of the Interior
27 and USDA-APHIS-WS until the current fiscal year. Due to the loss of WS funding, the State of Hawai'i will
28 provide or obtain the necessary funds to continue the operations.

29 ***A15.1.2.5 Passenger Inspection***

30 All passengers, officers, and crew members arriving in Hawai'i via commercial aircraft or vessels, and
31 carrying plants, animals, microbial cultures, or soil must complete an HDOA declaration form and submit
32 the imported items for inspection. This and an in-flight informational film are the only means the state
33 currently has to make travelers from the U.S. mainland aware of restrictions on what can be brought
34 into the state, enabling PQ to inspect and, if necessary, seize prohibited items. Passengers arriving from
35 the mainland by private aircraft or boat also must complete the declaration forms. Private boat owners

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1 arriving at any of the harbors must report to the harbormaster, who, in turn, directs them to PQ for
2 inspection.

3 Airline passenger declaration forms were the sole basis for inspection of incoming passenger baggage
4 until late 1989, when HDOA initiated a citation program and retained a small cadre of trained beagle
5 dogs to inspect checked baggage and express parcels (Miller and Holt 1992). The citation of airlines that
6 were derelict in passing out and collecting declaration forms, in combination with the use of the beagles,
7 resulted in a substantial increase in the number of passengers declaring agricultural items when
8 entering the state.

9 Persons importing illegal species into Hawai'i have been subject to penalties, such as fines or
10 imprisonment, since 1927. Currently, fines range from \$100 to \$25,000 and prison sentences from 30
11 days to 1 year. An amnesty provision exempts from penalties persons who voluntarily surrender, prior
12 to the beginning of any seizure action, a prohibited animal or a restricted animal, for which they have no
13 permit.

14 ***A15.1.2.6 Species Importation Permitting***

15 The Hawai'i Board of Agriculture (BOA) is responsible for establishing the broad operating policies of
16 HDOA, including the species permit application process (Miller and Holt 1992). By law (Hawai'i
17 Administrative Rules § 4-71), the ten-member, governor-appointed board maintains three lists
18 pertaining to the importation of animals and micro-organisms. Listed species are: 1) those conditionally
19 approved (permit required for importation); 2) those restricted (permit required for both importation
20 and possession); and 3) those prohibited. The law makes clear that any animal or micro-organism not on
21 the first two lists also is prohibited. Any violation of permits issued for restricted or conditionally
22 approved organisms is a violation of law. BOA also is responsible for determining additional micro-
23 organism and animal species that are prohibited or approved entry into the state. Under existing rule-
24 making procedures prescribed by the Hawai'i Administrative Practices Act, whenever the lists are
25 revised, they must go through public notice, hearings, and comment.

26 In addition to the animal and micro-organism lists, state law provides for two lists for exotic plants: one
27 for species that may be imported with a permit and one for those that are prohibited. However, unlike
28 the regulation of imported animals and micro-organisms, there is no statutory language that states that
29 plants not appearing on the approved list cannot be imported.

30 ***A15.1.2.6.1 Species Permit Application Process***

31 To prevent introductions of pest species, HDOA has developed a permitting process involving technical
32 review and BOA approval. All individuals requesting to import a plant, animal, or microbial species must
33 file an application with PQ. If an applicant is requesting to import an animal or micro-organism that is
34 not on the conditionally approved or restricted list, a revision must be made to the appropriate list
35 before the species may be imported. All revisions to the animal and micro-organism list must go through
36 the administrative rule-making process. Plants not on the permitted or prohibited lists are not required
37 to go through this process, and may be imported.

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1 If the request is for a species that is on an animal or micro-organism list and has received prior approval
2 by BOA, or is a plant that has received such approval, PQ can issue the permit. If, however, an applicant
3 is requesting a permit for a species that has not received prior BOA approval, PQ will conduct a three-
4 tiered review process to bring the request before the Board.

5 First, the application is submitted to BOA's Technical Advisory Subcommittees. The five subcommittees
6 (Land Vertebrates, Invertebrates and Aquatic Biota, Entomology, Microorganisms, and Plants) are
7 composed of biologists, industry representatives, and government officials. The subcommittees evaluate
8 the application along technical or scientific lines, particularly with regard to the organism's potential
9 impacts. The subcommittees then pass their analyses to the Plant and Animals Advisory Committees,
10 which consider the application and the subcommittee findings, weighing the potential harmful impacts
11 against potential benefits. BOA then reviews the Advisory Committees' recommendation and issues the
12 final decision on the application.

13 BOA may impose permit conditions, such as cage requirements or limitations on breeding or sale of the
14 organism. If an animal is listed in Hawai'i Administrative Rules § 4-71-7 as requiring a bond, it will either
15 be in the amount of \$250, if the importer has a USDA license for the animal under the federal Animal
16 Welfare Act, or \$1,000. PQ also inspects and approves facilities (e.g., laboratories) of applicants before
17 issuing permits for restricted organisms.

18 ***A15.1.2.6.2 Permitted Species Inspection Activities***

19 Once a permit is issued, PQ will inspect and clear a new organism prior to its introduction into the state.
20 This inspection verifies that the species arriving in Hawai'i is in fact the permitted species, and that it
21 does not carry any pests or diseases. PQ conducts port-of-entry inspections at BOA-designated ports.
22 Presently, five harbors (Hilo, Honolulu, Kahului, Kawaihae, and Lihue) and four airports (Honolulu
23 International, Kona, Kahului, and Lihue) are primary port-of-entry inspection sites. Time and manpower
24 permitting, PQ inspectors also may conduct follow-up, post-entry inspections to enforce any permit
25 conditions.

26 ***A15.1.2.6.3 On-Site Inspection Process***

27 In addition to inspecting permitted organisms for compliance with state regulations, PQ conducts on-site
28 inspections of cargo and passengers entering Hawai'i to detect species entering the state without a
29 permit. Inspections are conducted at the nine BOA-designated ports listed above.

30 ***A15.1.2.7 Other Regulatory Programs***

31 **Biotechnology Program:** HDOA participates in the permit review process, subject to federal oversight,
32 while promoting public confidence in the regulatory system. A PQ inspector accompanies the APHIS-PPQ
33 Hawai'i Safeguarding Specialist to perform inspections of genetically modified organism (e.g., GMO
34 corn) field trials.

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1 **Pest Surveys and Control and Eradication Programs:** PQ surveys for new pest introductions, as well as
2 newly detected pests. Information obtained is used to develop aggressive control or eradication
3 strategies.

4 **Rapid Response Programs:** PQ has developed a statewide program aimed at mobilizing a rapid response
5 to snake sightings. PQ and other agency's staffs have attended 3-week early detection and rapid
6 response training on Guam for alien snakes. Rapid response teams are mobilized following credible
7 reported sightings of snakes or other invasive species.

8 **Diagnostics:** PQ provides positive identification of intercepted pests; identification is required before
9 enforcement of any applicable regulatory action.

10 **Compliance and Enforcement:** HDOA compels compliance and enforcement of quarantine laws and
11 regulations through penalties and fines.

12 ***A15.1.2.8 Inspection Procedures During Regularly Scheduled Quality/Efficiency Assessments***

13 HDOA has conducted regularly scheduled, quality/efficiency assessments (so-called risk assessments)
14 throughout the state to evaluate the quality of inspection at ports, determine invasive species
15 pathways, and target commodities that are of the highest pest risk. These operations are performed
16 using a standardized inspection protocol for incoming passengers and cargo. Based on staff availability,
17 multiple teams are dispatched to various inspection targets (e.g., passengers and baggage, cargo, and
18 aircraft), with concentration on higher-risk commodities and other articles.

19 There are several inspection sites. Inspection of air and maritime cargo is performed at the port-of-
20 entry, including, but not limited to, individual airline cargo facilities, express mail stations, or produce
21 distribution sites that meet food safety standards (also known as transitional facilities). The inspection of
22 air cargo, typically arriving in air containers, such as LD3s and LD8s, and ocean cargo, arriving in 20-, 24-
23 and 40-foot-long shipping containers, follows the following general procedures.

24 Inspection teams acquire a packing manifest detailing the exact content and quantity of the
25 commodities in each lot to be inspected. Restricted and prohibited items are refused entry or destroyed.
26 All (100%) commodities deemed high-risk are inspected. Higher-risk commodities include propagative
27 plant materials, various types of cut flowers, leafy vegetables, certain fruits, and organic produce. Upon
28 completing inspection of higher-risk products, 10 to 50% of the volume of lower-risk commodities are
29 inspected.

30 Inspection of aircraft and passengers is conducted as follows: inspectors board the aircraft, obtain and
31 examine the mandated Agricultural Declaration Forms for declared items, walk through the cabin, and
32 check cargo holds and wheel wells. Inspectors monitor passengers and baggage in the baggage claim
33 area. Recorded data include airline and flight number, date of inspection, arrival time, number of
34 passengers and crew, number of collected and completed Agricultural Declaration Forms, number of
35 declared agricultural commodities, and number of intercepted agricultural commodities. Pest
36 interception data are also recorded.

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1 Additional inspection is performed by an inspector and a detector dog. The focus is on monitoring
2 passenger baggage in the baggage claim areas and the small packages arriving via FedEx, UPS, and other
3 package and mail carriers.

4 **A15.1.2.9 Standard Operating Procedures**

5 PQ utilizes a standard operating procedures (SOP) manual that was last revised in November 1989.
6 Several sections in the manual are outdated or no longer apply to PQ’s current facilities, operations, or
7 staff. The branch would benefit greatly from a professional manual writer; however, in lieu of that
8 option, a team made up of program specialists, operations supervisors, and inspectors is collaborating
9 on revising the SOP manual. Based on the current implementation of the HDOA Biosecurity Program,
10 developed in 2005, the existing SOPs are being revised and amended.

11 **A15.1.3 Inspection Facilities**

12 The major ports-of-entry for the State of Hawai’i are located in the major cities on four of the main
13 islands: Hawai’i, Maui, Oahu, and Kauai (Table A15-1). The ports are the major commercial entry points
14 and the foci of inspections in the state for imported and exported goods.

15 **Table A15-1: Major Ports-of-entry in Hawai’i**

Island	Airport	Seaport
Hawai’i	Hilo International Airport (ITO)	Hilo Harbor
	Kona International Airport at Keahole (KOA)	Kawaihae Harbor
Maui	Kahului Airport (OGG)	Kahului Harbor
Oahu	Honolulu International Airport (HNL)	Honolulu Harbor
	Hickam Air Force Base (part of HNL)	Kalaeloa Harbor
Kauai	Lihue Airport (LIH)	Nawiliwili Harbor

16

17 **A15.1.3.1 Minimal Inspection Facility Requirements**

18 HDOA has determined its minimal inspection facility requirements, and the document detailing these
19 requirements is in preparation. The minimal inspection facility requirements include: enclosed cargo
20 inspection areas, including equipment for washing and sterilizing cargo if needed, with adequate lighting
21 and temperature control; computer equipment; refrigerated storage, with adequate volume to hold
22 “pending” items awaiting action; treatment facilities, such as freezers, autoclaves, and garbage
23 disposals; kennels, if dogs teams are at that port; and passenger inspection stations.

24 The size of each port’s inspection facility would need to be based on the expected volume of incoming
25 cargo. Ports receiving high-risk commodities would have provisions for various treatment facilities. For
26 export inspection, large-volume shipments will be inspected and certified at the point of origin, e.g., in
27 packing houses and greenhouses, and not at the port. Inspection of small-volume export cargo will be
28 conducted at the ports; therefore, inspection and consolidation areas are a necessity. Depending on the
29 commodity, the consolidation areas should be properly equipped to maintain quality and quarantine
30 security.

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1 A15.1.3.2 Existing Facilities

2 Not a single port in Hawai'i meets the minimal facility requirements for PQ inspection and quarantine
3 purposes. None of the ports, except Kahului Airport, has adequate facilities to destroy incoming infested
4 commodities. None of the ports has enclosed inspection areas.

5 HDOA does not have fumigation (methyl bromide) chambers or an incineration facility to destroy
6 infested commodities under quarantine supervision. Methyl bromide fumigation is outsourced to a
7 private, certified pesticide applicator based on the applicators' availability. Incineration is provided by a
8 private company without PQ supervision.

9 A15.1.3.3 Facilities Proposed and Under Construction

10 HDOA has begun discussions with various regulatory agencies in Hawai'i on a proposal for a
11 multiagency-use facility at Honolulu International Airport (HNL). HDOA contends that multiagency-use
12 facilities would enhance information sharing and collaboration among federal and state plant
13 quarantine agencies in Hawai'i.

14 New facilities are being constructed at the Kahului Airport to optimize the interdiction of alien species
15 on Maui. These facilities will house two fully-enclosed inspection rooms, a screened inspection area for
16 low-risk commodities, a laboratory, plant and animal holding rooms, kennels, and office space for HDOA,
17 USDA, and DHS CBP personnel.

18 The HNL Master Plan has identified a probable location for a joint inspection facility in the cargo area,
19 which, if realized, would provide space for HDOA, APHIS-PPQ, USFWS, and CBP. This planned multi-
20 agency facility would be co-located with the major international air cargo carriers. A smaller satellite
21 facility is planned for inter-island and domestic cargo inspection. The HNL Master Plan will include an
22 irradiation facility, both for quarantine treatment of fruits and vegetables for export and for imported
23 commodities moving within-state that have insect infestations or diseases.

24 The proposed HNL inspection facility would have a size of about 1 hectare under roof, with enclosed
25 inspection rooms, refrigeration, freezer, autoclave, offices, kennels, and space for other support
26 functions. The master planning process has just begun for the Kona International Airport Master Plan.
27 Kona's is the second busiest international airport in the state, and accommodates a number of overseas
28 domestic and international flights; thus, a joint inspection facility is considered a necessity. Treatment
29 and disposal of garbage are a particular concern at the Kona airport.

30 At Honolulu and Kahului Harbors, the volume of cargo is immense, the ports handling over 10 million
31 and 2 million tonnes, respectively, per year (HDOT 2002; Anonymous 2006). At both ports, space is a
32 primary concern, as there is no room for expansion and immediate solutions are not available.
33 Construction of new cargo facilities has been proposed.

1 **A15.1.4 Staffing**

2 **A15.1.4.1 Existing Personnel**

3 Table A15-2 shows pre-2006 staff and 2007 staffing levels. The 2007 staffing levels indicate increases in
 4 staff resulting from increased funding through the Biosecurity Program Initiative. 2007 staffing levels
 5 are not current levels. In 2009 there was a large reduction in force size by Hawai'i Department of
 6 Agriculture. The discrepancy between 2007 and current numbers is not addressed in this section. The
 7 current number of front line inspectors is lower than that expressed for 2007. Of special notice is that
 8 HDOA currently has no canine program whereas in 2007 there were 6 dog handlers.

9 **Table A15-2: Pre-2006 and 2007 Staff of the Plant Quarantine Branch of the HDOA**

Position	Pay schedule	Pre-2006	2007
Supervisor, Plant Quarantine Inspector V	SR-24	4	4
Master Journeyman, Plant Quarantine Inspector IV	SR-22	9	10
Inspector, Plant Quarantine Inspector III	SR 20	39	62
Dog Handler, Plant Quarantine Inspector III	SR 20	3	6
Technician	SR-11		
Administrative		0	1
Operations		1	14
Dog		0	1
Specialist		1	3
Subject Matter Specialist, Plant Quarantine Inspector V	SR-24	5	7
Accountant		0	1
Management Analyst		0	1
Total		62	110

10
 11 At the 2007 level of staffing, PQ had begun to implement Phase I of its Biosecurity Program, which if and
 12 when completed would result in:

- 13 • Systematic, intense inspection of all high-risk pathways and spot checks of low-risk
 14 pathways
- 15 • Quarterly quality/efficiency assessments (so-called risk assessments or “blitzes”)
- 16 • Compliance agreements
- 17 • Rule changes
- 18 • Control programs for the little fire ant, nettle caterpillar, and coqui frog
- 19 • Military and private jet inspections
- 20 • Inter-island inspections
- 21 • Shared data management with other regulatory agencies
- 22 • Nursery monitoring and assistance

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- 1 • Regular monitoring and surveillance of all air- and seaports for the RIFA

2 **A15.1.4.2 Proposed Levels**

3 Based on the port efficiency and overall staffing evaluations conducted by HDOA, PQ will be seeking an
4 additional 111 positions for administrative, diagnostic, and inspection functions (these are positions
5 above and beyond the 2007 levels, current levels are lower). The additional inspection staff will be
6 servicing the airport and the harbor facilities state-wide. New identifiers and diagnosticians will provide
7 support to the branch’s inspection and monitoring efforts.

8 **A15.1.5 Biosecurity Program**

9 Session Laws of Hawai’i 2006, Act 160, established HDOA’s Biosecurity Program by appropriating \$2.9
10 million to hire new staff and enhance the invasive species program. The 2006 legislative session
11 provided general funds to implement Phase I of the program, i.e., hiring new staff and providing support
12 for statewide pest detection, prevention of spread of incipient infestations, and control programs for
13 incipient and established invasive pest populations. Phase II of the program has the objective of
14 developing strategies to prevent the intentional or unintentional introduction of invasive species at
15 ports-of-entry or, once introduced, to reduce their impacts.

16 The program incorporates HDOA’s mandates, rules, and regulations into a comprehensive program to
17 protect the state’s agriculture and natural resources from invasive pest species and to facilitate trade by
18 providing export compliance as required by Hawai’i’s trading partners.

19 **A15.1.5.1 Components**

20 The program weaves together various components of the traditional aspects of alien species interdiction
21 known as pre-entry, port-of-entry, rapid response, and eradication, with the development of
22 replacement and export crops to facilitate economic growth. The program’s elements are:

- 23 • Prevention
24 • Diagnostics
25 • Detection
26 • Rapid response
27 • Monitoring
28 • Biological sampling
29 • Restoration
30 • Research and development
31 • Educational outreach
32 • Partnerships and cooperative activities

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- 1 • Information management
- 2 • Quality control programs
- 3 • Quarantine treatment facilities
- 4 • Permitting
- 5 • Compliance and enforcement
- 6 • Export programs

7 ***A15.1.5.2 Increasing Capacity for Preventing Intentional Introductions or Reducing their Impacts***

8 Emergency response capability is an integral component of HDOA’s Biosecurity Program. The proposed
9 additional staff, particularly inspectors and diagnosticians, will allow for effective interagency
10 coordination with CBP and APHIS. Incident Command Training is being implemented cooperatively at
11 federal and state levels. HDOA sought the support of Hawai’i’s congressional delegation for the
12 proposed multi-agency use inspection facility at HNL. HDOA has also proposed construction of a
13 treatment and destruction facility for commodities or articles detected at the ports with pest infestation
14 or disease infection, or both. Currently, destruction and treatment of detected pests and pathogens are
15 extremely limited and not easily available to CPB, APHIS, and HDOA.

16 ***A15.1.5.3 Increasing Capacity for Preventing Unintentional Introductions***

17 Preventing invasive species from entering and establishing in Hawai’i is vital to protecting the
18 environment, public health, and economy; invasive species have direct, negative impacts on agricultural
19 industries and tourism.

20 Hawai’i is dependent on imported food, construction materials, medical supplies, and other
21 commodities; this dependency demands essential transportation infrastructure. However, Hawai’i’s
22 ports have not kept pace with current infrastructural demands and those anticipated in the future. To
23 counter the overcapacity at the harbors, steps are being taken to release containers at the ports for
24 immediate inspection at transitional facilities partially to resolve the capacity problem. HDOA is
25 currently working with the carriers and importers to investigate the use of electronic manifests that will
26 allow quick release of commodities and other articles at the docks without compromising the efficacy of
27 pest detection.

28 ***A15.1.5.3.1 Brown Treesnake and Red Imported Fire Ant***

29 During the past few years, HDOA has been attuned to the need to address the heightened risks posed by
30 introduction of certain targeted invasive pest species, such as BTS and RIFA. Intensified military activities
31 in the Pacific have substantially increased BTS risk, challenging the state’s capacity to prevent its entry.
32 Should it become established in Hawai’i, the potential economic impact of BTS has been conservatively
33 estimated at \$485 million annually, resulting from power outages, medical costs, lost tourism revenue,
34 and devastation of native species (HDOA unpublished data). A subsequent detailed study by Swiff et al.
35 (2010) which examined the economic impact of BTS establishing in the State of Hawai’i in regards to

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1 medical treatment, power outages and decreases in tourism placed the total annual damage to Hawai'i
2 at between \$593 million and \$2.14 billion. Accordingly, training specifically for detection of, and rapid
3 response to, BTS introductions should be strengthened. The program for BTS interdiction will be
4 augmented significantly by the proposed additional inspectors and detector dogs in the canine unit.

5 RIFA's geographic distribution has expanded from the Americas to Asia and parts of the Pacific, further
6 increasing its threat to Hawai'i. RIFA is both an agricultural pest and a pest of medical concern. The
7 potential impact to Hawai'i's economy resulting from RIFA establishment has been estimated at \$197
8 million annually (HDOA unpublished data). To counter the threat, HDOA works with CPB and APHIS to
9 intercept ants from foreign and U.S. mainland sources. The proposed increase in staffing will allow
10 increased scrutiny of high-risk commodities and articles from RIFA-infested geographic areas.

11 ***A15.1.5.3.2 Port of Honolulu***

12 The large volume of goods coming into the state cannot be adequately inspected by the present level of
13 port staffing. For maritime cargo, a lack of harbor space also contributes significantly to PQ's inability to
14 perform adequate inspections.

15 With ever-increasing numbers of aircraft and ships arriving, it is envisioned that Honolulu port
16 operations will become a 24-hour, 7-day-a-week activity; currently the airport operates for 20 hours
17 every day. Maritime inspection is currently an 8-hour, 5-day-per-week operation. The future cargo
18 inspection workload will include inspections at approved transitional facilities.

19 The Honolulu staff will be divided into shifts that will work at the airport and maritime offices on a
20 rotational basis. Workload will include meeting aircraft at the gates, which has not been done due to
21 lack of staff, and using detector dogs to interdict undeclared items, including cargo at baggage claim
22 areas; UPS, FedEx, and other express mail carrier inspection stations; and commercial and military flights
23 from the South Pacific and Guam that are considered high-risk for BTS.

24 At seaports, the maritime inspection workload will increase with the required inspection of the
25 Superferry's inter-island cargo. Inspection at transitional facilities should help alleviate problems
26 associated with increasing ship traffic.

27 ***A15.1.5.3.3 Port of Maui***

28 The majority of quarantine inspections are performed at Kahului Airport and Kahului Harbor, which, by
29 volume, are the second busiest airport and third busiest harbor in the state (HDOT 2002). Other ports in
30 the county include Kaulamapau Harbor (Lanai), Lanai Airport, Kalaupapa Harbor (Molokai), Kalaupapa
31 Airport (Molokai), and Kaunakakai Harbor (Molokai). Kahului Airport was the site of a risk assessment,
32 conducted as part of the State Department of Transportation's (DOT) Alien Species Action Plan, which
33 identified cargo as a high-risk pathway (HDOA 2002).

34 Although PQ staffing on Maui has increased with the addition of DOT-funded PQ positions, these
35 positions have been staffed only at the airport.

1 **A15.1.5.3.4 Port of Kona**

2 HDOA is collaborating with DOT in the planning and design of improvements in infrastructure at Kona
3 International Airport and Kawaihae Harbor to enhance both quarantine and export capabilities. The new
4 facilities will include adequate space for offices, inspection stations, and commodity treatment.

5 The number of commercial flights, passengers, and private jets, and the volume of cargo arriving at Kona
6 International Airport have increased steadily over the years (HDOA 2002). The increased traffic at this
7 airport and Kawaihae Harbor have overwhelmed the current staff, preventing effective inspection and
8 monitoring. Ships, aircraft, or cargo may go uninspected, depending on the current inspection priority.
9 The proposed increase in staff should help to mitigate the risks of alien species introduction at the Port
10 of Kona.

11 **A15.1.5.3.5 Port of Hilo**

12 Hilo Port aims to expand export certification capabilities for agricultural commodities, as exports are a
13 major contributor to Hilo's economy. The proposed additional PQ staff will perform the necessary
14 inspections at nurseries prior to movement of propagative and non-propagative plants through the port.

15 **A15.1.5.3.6 Port of Kauai**

16 This port includes Lihue Airport, Nawiliwili Harbor, and Port Allen Harbor. Lihue is the only commercial
17 airport on the island, and receives incoming direct international, domestic, and inter-island flights.
18 Nawiliwili Harbor is the larger of two commercial harbors, and receives the majority of goods shipped
19 into Kauai. Current staffing is inadequate to cover the basic plant quarantine functions, especially as the
20 number of direct overseas flights to the island increases. HDOA has proposed additional staff for the
21 Port of Kauai.

22 **A15.1.6 HDOA Regulations and Federal Pre-emption**

23 USDA-APHIS-PPQ enforces regulations under the authority of the Plant Protection Act of 2000 to
24 safeguard agriculture and natural resources from the risks associated with the entry, establishment, and
25 spread of harmful foreign pests, noxious weeds, and plant diseases. Since March 2003, CBP, under a
26 Memorandum of Agreement between USDA and DHS, has the mandate to inspect and clear foreign
27 passengers and non-propagative agricultural commodities. PPQ continues to perform the inspection and
28 release functions for propagative plant materials. APHIS has the principal responsibility of preserving the
29 marketability of U.S. agricultural products by stopping and controlling the movement of harmful invasive
30 pests that enter the country.

31 HDOA enforces regulations under various plant and non-domestic animal quarantine statutes to prevent
32 the introduction and establishment in Hawai'i of any organism that is harmful to agriculture, animal or
33 public health, or natural resources, including native biota. Hawai'i is quarantined with respect to the U.S.
34 mainland primarily due to the occurrence of pestiferous tephritid fruit fly populations.

35 Under the Plant Protection Act of 2000, 7 USC §7756 subdivision (a), "[no] State or political subdivision
36 of a State may regulate in foreign commerce any article, means of conveyance, plant, biological control

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1 organism, plant pest, noxious weed, or plant product in order (1) to control a plant pest or noxious
2 weed; (2) to eradicate a plant pest or noxious weed; or (3) to prevent the introduction or dissemination
3 of a biological control organism, plant pest, or noxious weed.”

4 HDOA has argued that conflicts in regulation and enforcement exist between it, USDA, and DHS. HDOA
5 further contends that Hawai’i will always be vulnerable to incursions by invasive pests because of
6 inherent safeguarding weaknesses resulting from the federal pre-emption of state quarantine
7 regulations.

8 **A15.2 UNITED STATES DEPARTMENT OF HOMELAND SECURITY, BUREAU OF CUSTOMS AND**
9 **BORDER PROTECTION**

10 **A15.2.1 Overview of Regulatory Authority**

11 Historically, APHIS-PPQ agricultural quarantine inspection (AQI) was responsible for preventing the
12 introduction of harmful, alien agricultural pests and diseases into the United States. With the
13 establishment of DHS, the Homeland Security Act of 2002 transferred the foreign import inspection
14 duties from USDA to DHS. A MOU between USDA and DHS, signed in 2003, articulated the details of
15 responsibilities, operating procedures, working relationships, communication, and framework necessary
16 for APHIS and CBP successfully to perform their agricultural inspection missions (USDA 2003b). Among
17 the agricultural import inspection functions transferred from USDA to DHS are the following:

- 18 • Reviewing passenger declarations and cargo manifests, and, utilizing USDA pest risk data,
19 targeting for inspection high-risk passengers or cargo
- 20 • Inspecting international passengers, luggage, cargo, mail, and means of conveyance
- 21 • Holding cargo and articles of suspected quarantine significance
- 22 • Referring propagative and other designated materials to USDA for inspection, control, and
23 disposition
- 24 • Seizing materials in violation of USDA regulations, safeguarding them to prevent pest
25 escape, and destroying or re-exporting them
- 26 • Collecting and preparing or preserving pest and disease samples for analysis
- 27 • Submitting to USDA intercepted pest and disease specimens for identification
- 28 • Collecting, submitting, and reporting program information
- 29 • Maintaining, monitoring, and enforcing existing compliance agreements
- 30 • Monitoring transit shipments and verifying exit
- 31 • Reviewing import permits and certificates for validity and compliance

32 Among the agricultural inspection and trade functions retained by USDA are:

- 33 • Providing risk analysis guidance and setting inspection protocols

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- 1 • Applying remedial measures other than destruction and re-exportation
- 2 • Providing specialized inspection of propagative plant material and pest identification
- 3 services at plant inspection stations and other facilities
- 4 • Conducting inter- and intra-state inspection of passengers, commodities, and conveyances,
- 5 including pre-clearance of passengers in Hawai'i destined to the U.S. mainland
- 6 • Performing inspection and related activities, such as compliance with requirements of
- 7 agricultural protocols and systems, in connection with the pre-clearance of commodities in
- 8 foreign countries
- 9 • Verifying compliance with trade protocols, including, but not limited to, conducting
- 10 domestic market and transit surveys and outreach to the private sector as part of the APHIS
- 11 SITC programs
- 12 • Investigating and adjudicating AQI violations
- 13 • Issuing phytosanitary (plant health) and animal by-product certificates for U.S. agricultural
- 14 exports
- 15 • Developing regulations, policy, and procedures to establish and enhance coordination
- 16 between USDA and DHS
- 17 • Managing the AQI performance measurement system in consultation with DHS

18 Tables A15-3 and A15-4 show the number of agricultural inspection staff of APHIS-PPQ and CBP,
 19 respectively, in Hawai'i. PPQ has offices at five ports in Hawai'i: Honolulu, Maui, Kauai, Hilo, and Kona.
 20 CBP has Agriculture Specialists in Honolulu and Kona.

21 **Table A15-3: APHIS-PPQ Staff in the Ports of Honolulu, Maui, Kauai, Hilo, and Kona**

Staff	Position	Number of permanent, full time employees ^a
Administrator	State Plant Health Director	1
SOSO	State Operational Support Officer	2
Administrative Assistants		11
Supervisors	Port Directors, Port Supervisors	21
Specialists	Pest Survey Specialist, Pest Identifiers, Export Certification Specialist	6
Inspectors	PPQ Officers and Plant Health Safeguarding Specialists	88
Technicians	Permanent and Temporary ^b	98
SITC	SITC Manager and Officers	3
Total		230

22 ^a As of March 2007.

23 ^b Converted to number of permanent, full-time equivalents.

24
 25

1 **Table A15-4: CBP Agriculture Specialists in the Ports of Honolulu and Kona**

Position	Number of permanent, full time employees ^a
Chief Agriculture Specialist	2
Supervisory Agriculture Specialist	5
Agriculture Specialist (agricultural inspection) ^b	47
Total	54

2 ^a As of May 2007.

3 ^b CBP Officers are cross-trained to perform agricultural inspection to assist Agriculture
4 Specialists on an as-needed basis.
5

6 **A15.2.2 Quarantine and Inspection Activities**

7 At U.S. ports-of-entry (including Honolulu), CBP Agriculture Specialists and cross-trained CBP Officers
8 inspect air and sea cargo, air and sea carriers, and international mail, and clear air and sea passengers,
9 crew, and their luggage arriving from foreign countries to detect prohibited articles (including plant and
10 animal products); ensure that regulated articles comply with federal regulations; treat and dispose of
11 regulated garbage; and intercept regulated pests and diseases. CBP has broader powers of search and
12 seizure than many agencies involved in pest detection and interdiction. For example, the agency does
13 not need a search warrant or to show probable cause to carry out its duties, such as inspection of
14 foreign mail. All packages mailed from outside the United States must have customs declarations that
15 clearly state the nature of the contents. CBP can inspect any mail from foreign points of origin.
16 (Domestic first-class mail may not be inspected without a federal search warrant.) All foreign mail
17 arrives at a central mail facility in Honolulu. CBP conducts inspections at all military installations in
18 Hawai'i when vessels or aircraft arrive from foreign points of origin.

19 A percentage of incoming air passenger baggage, air cargo, maritime cargo, and mail from foreign
20 countries undergoes actual inspection at Hawai'i's international ports-of-entry. The various manuals
21 furnished by USDA determine the percentage of cargo for examination and the risk management
22 principles for use in determining inspections. Items are chosen for inspection based on risks, as
23 determined by risk assessments, past interceptions, and other available information. Articles are
24 inspected for pests and diseases, and may be released, treated based on quarantine requirements prior
25 to release, re-exported, or confiscated and destroyed. The primary aims of quarantine and inspection
26 are to prevent entry of agricultural pests and diseases and to intercept these threats at ports-of-entry
27 while facilitating and promoting worldwide agricultural trade and travel. Any penalties levied are based
28 on the applicable statutes and regulations of USDA, CBP, and USFWS.

29 CBP Agriculture Specialists and cross-trained CBP Officers follow procedures outlined in the Manual for
30 Agricultural Clearance (USDA 2006c) and other applicable USDA manuals. For example, the Fresh Fruits
31 and Vegetables Import Manual (USDA 2007c) lists by country fruits and vegetables that are admissible
32 into the United States, including the required quarantine treatments, if any, and the methods of
33 sampling and inspection intensity. Thus, commercial non-propagative fruits and vegetables arriving at

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1 the ports are inspected and cleared by CBP according to the language and stipulations of the Fresh Fruits
2 and Vegetables Import Manual.

3 CBP makes referrals to the HDOA for pests not covered by quarantines enforced by CBP. These have
4 included ticks, spiders, and reptiles.

5 CBP in Hawai'i collaborates with a Pest Risk Committee (PRC) with two subcommittees covering animal
6 diseases and plant pests. Meetings are attended by both state and federal agencies and departments.
7 Activities of the PRC have included many special operations conducted jointly by CBP, APHIS-PPQ, USDA
8 Food Safety and Inspection Service, FDA, and USFWS involving certain kinds of cargo making entry, with
9 the aim of collecting pest information on particular commodities, interdicting potential smuggling,
10 responding to national alerts, identifying high-risk commodities, and enforcing applicable regulations.
11 The PRC distributes information on pests and diseases known to be of interest to the State of Hawai'i;
12 emerging animal diseases and changing disease status for various countries, state, and federal pest and
13 plant material seizures; and extends outreach to other federal and state agencies. CBP uses this
14 information in its targeting of cargo, and adjusts tactics when new information becomes available.

15 CBP requires a manifest from the shipping agent for all incoming cargo. Cargo entering the United States
16 by way of Honolulu is held by the shipper against a bond. CBP inspects certain types of cargo, such as
17 fresh fruit and vegetables, handicrafts, seeds, animal products and by-products, cut flowers and
18 greenery, heavy equipment and farm machinery for soil, household goods, certain kinds of stone and
19 containers for hitchhiking snails, and other agricultural or food items before granting entry. Other cargo,
20 such as new automobiles, are rarely inspected. When conducting inspections, CBP scrutinizes wood
21 packaging material (WPM) branding and enforces WPM regulations, re-exporting non-compliant
22 materials in accordance with national guidelines. CBP also enforces the CITES, inspecting and seizing
23 non-living CITES-regulated plant shipments and, following safeguarding procedures, delivering living
24 CITES-regulated plants to the APHIS Plant Inspection Station. Through its computerized tracking system,
25 CBP classifies all cargo to determine its rate of duty and to track import quotas and other items of
26 concern. This system stores any special information about an item and identifies those items requiring
27 inspection or approval by any other federal agency. USDA and USFWS have the opportunity to review all
28 incoming plant or animal materials for CBP.

29 CBP uses the Automated Commercial System and the Automated Targeting System for cargo and
30 passengers to identify certain regulated, high-risk agricultural cargo, or passengers with previous
31 violations. Various targeting criteria can identify potential violators, smugglers, and other anomalies that
32 could result in examinations. Holds on cargo can be initiated automatically both nationally and locally.
33 CBP also uses USDA databases for data input and analysis. These include Work Accomplishment Data
34 System (WADS), AQIM, EANs, 280s, and Pest ID. Use of all systems and databases provides CBP detailed
35 information to identify potential cargo, passengers, aircraft, or vessels for examination. CBP has
36 dedicated Agriculture Specialists performing agriculture targeting for the air cargo, sea cargo, and
37 passenger pathways. These efforts are augmented by CBP Officers performing targeting duties at the
38 same locations. In 2006, through such operations, CBP prevented the entry of nearly 50 tonnes of
39 animal products and by-products into Honolulu.

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1 Even before the creation of DHS, the former Customs Service of the U.S. Department of the Treasury, in
2 1991, inaugurated a policy that facilitated minimal inspection of incoming passengers arriving from
3 certain low-risk areas or countries. Passengers who have visited high-risk areas of the world (e.g., those
4 in which highly significant pests or diseases occur, or associated with the smuggling of drugs and other
5 contraband) receive a more careful examination.

6 **A15.2.3 APHIS-PPQ’s Agricultural Quarantine Inspection Monitoring and CBP**

7 The purpose of the AQIM program is to gather data regarding AQI effectiveness (USDA 2006a). The data
8 are used to define and document various pest risk pathways, determine the likelihood for agricultural
9 pests and diseases to enter the United States through various identified routes, and communicate to
10 CBP those agricultural risks that require its attention. At each selected airport (including HNL) and mail
11 facility, CBP officers each year conduct random inspections of passenger baggage and mail. At cargo
12 facilities, various types of cargo shipments are randomly selected each year for complete inspection.
13 Results of passenger baggage inspections are used to estimate the rate of quarantine material arriving
14 at each port. This estimate is used to gauge program effectiveness. For cargo, results are used to
15 estimate the rate of cargo shipments requiring action as they arrive at a port, and the percentage of
16 units approaching with significant pests. Such estimates can be used by ports to gauge their
17 effectiveness in managing pest risk in cargo, and to evaluate the relative risks of various known pest
18 entry pathways.

1 **A16 AIRLINE PASSENGERS**

2 It is worth noting that the information in the section is based on data from prior to 2008.

3 **A16.1 OBJECTIVE**

4 The objective of this chapter is to estimate the likelihood of quarantine plant materials and pests
5 entering Hawai'i with airline passenger baggage, thereby providing a basis for decision making towards
6 phytosanitary improvements, as well as a starting point for discussion and further analysis. It should be
7 noted that data used in this section is not current but comes from a variety of sources, the most recent
8 being a 2007 compilation.

9 **A16.2 ANALYSIS METHODS**

10 AQIM data collected by the DHHS CBP were used to estimate approach rates of quarantine plant and
11 animal materials (QMs) and pests. If sampling procedures are followed correctly, AQIM data are
12 collected through a detailed inspection of randomly selected sampling units. This means that, in contrast
13 to regular, targeted quarantine inspections, AQIM sampling is unbiased and is therefore suitable for risk
14 quantification. Details on AQIM data sets and sampling protocols can be found in the USDA AQIM
15 Handbook (USDA 2006a).

16 AQIM data were available only for HNL, which accounts for the majority of all international airline traffic
17 into Hawai'i. In order to minimize the effects of sampling protocol inconsistencies, we used only the two
18 most recent complete data sets (FY 2005 and FY 2006). The available data set pertains only to
19 international airline passenger baggage; no comparable information was available for visitors from the
20 U.S. mainland.

21 The QM approach rate is defined as the proportion of sampling units in which plant QMs were found.
22 The sampling unit in this case was the group of airline passengers (one to many individuals) traveling
23 together under one U.S. Customs manifest. In order to express the level of uncertainty associated with
24 QM approach rate estimates, they are presented as 95% binomial confidence intervals, i.e., the limits
25 within which the actual approach rates lie with 95% certainty (Steel et al. 1997). For small sample sizes,
26 the uncertainty associated with the approach rate estimate is large (i.e., the binomial confidence
27 intervals become wide). For sample sizes under 20, assumptions regarding statistical distributions may
28 not be accurate (Jones 2007), and uncertainty is so high that these cases are not included in either the
29 discussion of results, or in the figures and tables.

30 We calculated approach rates by country of passenger origin, by travel reason, and by calendar month
31 of travel using the RELIABILITY, MEANS, TABULATE and SQL procedures in SAS® 9.1.3 (SAS Institute
32 2007). The data for FY 2005 and FY 2006 were combined to increase the sample sizes. In order to arrive
33 at an estimate of the total number of QMs that annually enter Hawai'i, we multiplied approach rates by
34 the average number of QMs per interception (source: AQIM data) and the average number of passenger
35 groups entering annually. This last number was calculated by dividing the number of annual visitors by
36 the average passenger group size indicated by AQIM data. The annual number of visitors was obtained
37 from the 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic

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1 Development and Tourism (HDBEDT), referred to as the “DBEDT data set” throughout this document
2 (HDBEDT 2005b).

3 Because the DBEDT data set provided country-specific visitor numbers for only some of the countries in
4 the AQIM data set (those considered major market areas for Hawai’i), we estimated the number of
5 visitor groups for the remaining countries by multiplying the number of passengers sampled during
6 AQIM data collection by 140. This number (with a standard deviation of 97) represents the average ratio
7 of

8
$$\frac{\text{(number of international passenger groups entering Hawai’i)}}{\text{(number of international passenger groups sampled during AQIM)}}$$

9

10 for those countries where visitor numbers were available from the DBEDT data set. As AQIM data are
11 based on a random sampling scheme, this ratio should be approximately constant among countries
12 (though the high standard deviation indicates that this may not be the case). However, for lack of more
13 reliable data, we used this estimate to extrapolate the number of visitor groups for those countries of
14 origin that are not included in the DBEDT data set, and presented the results as point estimates together
15 with their associated standard deviations. The values that are based on this extrapolation are shaded
16 grey in Table B5-1 (below).

17 For the analysis by travel reason, some categories had to be combined, both in the AQIM and in the
18 DBEDT data set in order to make the two data sets match each other. The categories “Business/Work”
19 and “Uniformed crew” of the AQIM data set were combined into one category that was considered
20 equivalent to “MC&I, and Other Business” in the DBEDT data set. The category “Government/Military”
21 in the DBEDT data set was treated as equivalent to “Military” in the AQIM data set. The categories “Visit
22 friends” and “Family visit” of the AQIM data set were combined into one category that was considered
23 equivalent to “Friends and relatives” in the DBEDT data set. The categories “Pleasure” (which includes
24 the sub-categories “Vacation,” “Honeymoon,” and “Wedding”) and “Sports events” of the DBEDT data
25 set were combined into one category that was considered equivalent to the combined categories
26 “Tourism” and “Other” of the AQIM data set.

27 For estimates of pest approach rates, we used a combination of different source data sets, each of
28 which was associated with some uncertainty: AQIM data, USDA-APHIS-PPQ Pest ID, which contains
29 records of all pest interceptions made by PPQ or CBP at U.S. ports-of-entry since 1985 (USDA 2007a),
30 and the DHS CBP WADS, which provides information on the number of certain tasks (e.g., inspections)
31 performed by port inspectors (USDA 2007b). For this analysis, a pest is defined as a species of
32 arthropod, mollusc, weed, nematode, or plant pathogen that is injurious to plants or plant products.

33 **A16.3 RESULTS AND DISCUSSION**

34 **A16.3.1 International Passengers by Country of Origin**

35 QM approach rates for the various countries of origin ranged between zero and approximately 25%
36 (Table B5-1, Figure B5-1). In many cases, the 95% binomial confidence intervals were rather large, due to
37 small sample sizes. For Malaysia, Indonesia, New Zealand, Fiji, and Taiwan, the binomial confidence

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1 intervals included zero (i.e., the approach rates were not significantly different from zero). The lower
2 95% binomial confidence limit (i.e., the estimated minimum approach rate) was highest for Guam,
3 followed by Thailand. Japan, the origin for approximately 70% of all international Hawai'i visitors
4 (HDBEDT 2005b), had a QM approach rate of 1.7%, which was significantly lower than those of Guam,
5 Thailand, and Australia. In spite of its moderate QM approach rate, Japan is the source of the highest
6 number of QMs, due to the large number of visitors from Japan. Approximately 16,000 to 25,000 QMs
7 from Japan, 3,400 to 9,700 QMs from Australia, and 1,200 to 4,000 QMs from Guam are estimated to
8 enter Hawai'i per year; most other countries contribute 2,000 or fewer QMs annually. Most frequent
9 among the plant QMs intercepted from Japan during AQIM data collection (Table B5-5) were species of
10 *Citrus*, which represent a risk of introducing various quarantine pests, especially scales such as *Unaspis*
11 *yanonensis* (Kuwana) (Homoptera: Diaspididae) and the plant bacterial pathogen *Xanthomonas*
12 *axonopodis* *pv.* *citri* (Hasse) Vauterin et al. In fact, during FYs 2005 and 2006, *U. yanonensis* had been
13 intercepted more than 20 times in Japanese air passenger baggage at Hawai'i ports-of-entry (USDA
14 2007a).

15 **A16.3.2 International Passengers by Travel Reason**

16 Due to a relatively small sample size, the category "Military" has a very large confidence interval (2 to
17 18%), which is not extremely informative. It can be said, however, that military travel is associated with
18 QM approach rates that are significantly different from zero. Apart from military travel, the category
19 "Visit friends and family" was associated with the highest QM approach rates (Table B5-2, Figure B5-3).
20 This corroborates the intuitive assumption that international passengers visiting friends and family are
21 more likely than tourists or business travelers to carry QMs because they bring food items as gifts. The
22 QM approach rates for the categories "Tourism" and "Business/Work" were quite similar to each other
23 (though "Tourism" had a narrower 95% binomial confidence interval because of a larger sample size).

24 As tourists represent the majority of all travelers to Hawai'i (i.e., their approach rate is multiplied by the
25 largest number of passengers), they are the group that introduces by far the most QMs into the islands.
26 It must be noted that AQIM and DBEDT data are not in agreement with regard to the numbers of visitors
27 in the various categories. Based on AQIM data, there should be approximately four times as many
28 tourists as there are people visiting friends or family. However, according to DBEDT data, the number of
29 tourists is 18 times higher than the number of people visiting friends or family. We are not sure about
30 the reasons for this discrepancy; our estimates are based on DBEDT data.

31 **A16.3.3 International Passengers by Month**

32 Overall QM approach rates in September were significantly higher than in May (Table A16-3, Figure A16-
33 5). Otherwise, QM approach rates were not significantly different between months. As the number of
34 travelers is more or less constant among months (Table A16-3), the estimated number of QMs entering
35 (Figure B3-5) is proportional to the respective QM approach rates (Figure A16-6).

1 **A16.3.4 All International Passengers**

2 In total, there were 2,114,064 international visitors to Hawai'i in 2005 (HDBEDT 2005b), with an overall
3 QM approach rate of 0.022 to 0.027 (95% binomial confidence interval). This leads to an estimate of
4 40,369 to 54,458 QMs per year being brought into the islands by international airline passengers (Table
5 B5-4). Based on WADS data, an annual average of 17,000 QMs were intercepted by CBP during FYs 2005
6 and 2006 (USDA 2007b), which means that only 31 to 42% of all QMs were intercepted by CBP. This
7 would leave approximately 23,000 to 37,500 QMs entering Hawai'i undetected every year. This estimate
8 of interception efficiency is higher than those from other, similar analyses (e.g., Meissner et al. 2003).

9 **A16.3.5 Pest Approach Rates**

10 In the AQIM data set we analyzed, there were no plant pest interceptions recorded for the over 7,000
11 passenger groups sampled. This means that an estimated 0 to 0.04% (95% binomial confidence limits) of
12 all international air passenger groups brought plant pests into Hawai'i. As 1,360,120 passenger groups
13 visited the state during 2005 and 2006 (Table B5-4), between 0 and 540 plant pests would have arrived
14 with them. We know that, contrary to AQIM sampling guidelines (USDA 2006a), searching for pests is
15 often not performed during AQIM data collection. It may therefore be assumed that the above pest
16 approach rate is a substantial underestimate. From Pest ID data (USDA 2007a), we know that pests are
17 reaching Hawai'ian ports-of-entry; therefore, an estimate of zero for the pest approach rate must be
18 inaccurate. In fact, 426 pests are recorded in the Pest ID database for FYs 2005 and 2006, during which
19 time approximately 4 million international air passengers entered Hawai'i. Based on the calculations
20 above, only about 20% of all QMs are intercepted by CBP. For pests, the interception efficiency likely is
21 considerably lower, since they may not be detected on intercepted QMs, either because they are hidden
22 (e.g., internal feeders) or because the inspector discards the QM without looking for pests. If, therefore,
23 we generously assume that 5% of all pests that are present in air passenger baggage actually are
24 detected and recorded in the Pest ID database, we arrive at an estimate of 8,520 pests entering per 4
25 million passengers (i.e., 4,275 pests per year). This would translate into a pest approach rate of 0.2%
26 (versus the 0 to 0.04% predicted by AQIM data). The probability of establishment after introduction is a
27 function of both the rate of entry and the population size required for persistence (Bartell and Nair
28 2003), and will be different for each pest species. A general and often cited estimate is that about 10%
29 of all non-indigenous insect species introduced into a new range become established (NRC 2002).
30 However, based on Bartell and Nair (2003), this estimate may be too high for some species, so we are
31 here conservatively assuming that between 0.1% and 1% of the arriving pests manage to establish
32 populations in Hawai'i within 25 years of first introduction. Thus, we would expect approximately four 4
33 to 40 pest establishments per year as a result of international air travel alone.

34 In addition to the 2 million international travelers, Hawai'i received about 5.3 million visitors from the
35 U.S. mainland in 2005. It is impossible to quantify the risks associated with the domestic visitors because
36 no randomly collected data are available. However, quarantine inspections by the HDOA have resulted
37 in over 300 pest interceptions in domestic air passenger carry-on baggage between 1995 and 2006
38 (HDOA 2007c) (Table A16-6), demonstrating that visitors entering by air from the U.S. mainland may be
39 a significant pathway for the introduction of exotic pests. One of the more frequently intercepted

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1 species was the Argentine ant, *L. humile*, an extremely invasive tramp species, which has become
2 established and is wreaking ecological havoc in Hawai'i (Cole et al. 1992). Due to a number of biological
3 traits, this and other ant species have a high probability of introduction, so that establishment may
4 easily result from a small number of individuals, provided that a reproductive female (gyne) is among
5 them. Given the low interception efficiency of CBP on international visitors and the relatively small
6 workforce HDOA has available to prevent exotic introductions, it is unlikely that the existing pest risk
7 associated with international and domestic airline passengers can be mitigated effectively under present
8 conditions.

9 **A16.3.6 Summary**

- 10 • For all countries of passenger origin with a sample size of 20 or more, estimated plant QM
11 approach rates were between 0 and 25%. Differences in approach rates between countries
12 of origin were complex, with no country being significantly different from all other
13 countries.
- 14 • For the different travel reasons with a sample size of 20 or more, estimated plant QM
15 approach rates from foreign countries were between 0.4 and 12%. All travel reasons had
16 QM approach rates that were significantly different from zero.
- 17 • For the different months of the year, estimated plant QM approach rates from foreign
18 countries were between 1 and 7%. All months had QM approach rates that were
19 significantly different from zero. December and January were associated with higher
20 approach rates than the summer months.
- 21 • There was not a single pest interception recorded in the AQIM data set. Based on other
22 available information, this seems to be a data quality problem.
- 23 • More than 4,000 plant pest organisms may be entering Hawai'i with foreign airline
24 passengers every year, which may translate into between 4 and 40 pest establishments
25 annually.
- 26 • The percentage of arriving pest species already established in Hawai'i is unknown.
- 27 • The international airline passenger pathway presents a significant pest risk to Hawai'i.
- 28 • Although the pest risk associated with domestic airline passengers cannot be quantified due
29 to a lack of data, it likely is significant.

30 Table A16-1 details AQIM of international air passengers arriving at HNL in FYs 2005 and 2006 by
31 country of passenger origin. The table shows only countries for which the AQIM sample size was at least
32 20. The sampling unit is the group of passengers traveling together under one U.S. Customs manifest.
33 The table shows the country of origin,¹⁰ the number of passenger groups that were found to have
34 quarantine materials (QMs),¹¹ the number of passenger groups inspected,¹² the estimated proportion of

¹⁰ AQIM data for FYs 2005 and 2006.

¹¹ Ibid, p. B-57

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1 passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this
2 estimate. It also lists the total number of QMs detected by country,¹³ the average number of QMs per
3 interception,¹⁴ the total annual number of passengers entering Hawai'i,¹⁵ the average number of
4 passengers per group,¹⁶ and the annual number of groups entering Hawai'i. Finally, it shows the lower
5 and upper confidence limits for the estimated total annual number of QMs entering Hawai'i. Shaded
6 fields indicate that the number of passengers entering was estimated.

¹² Ibid.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic Development, and Tourism (DBEDT data set).

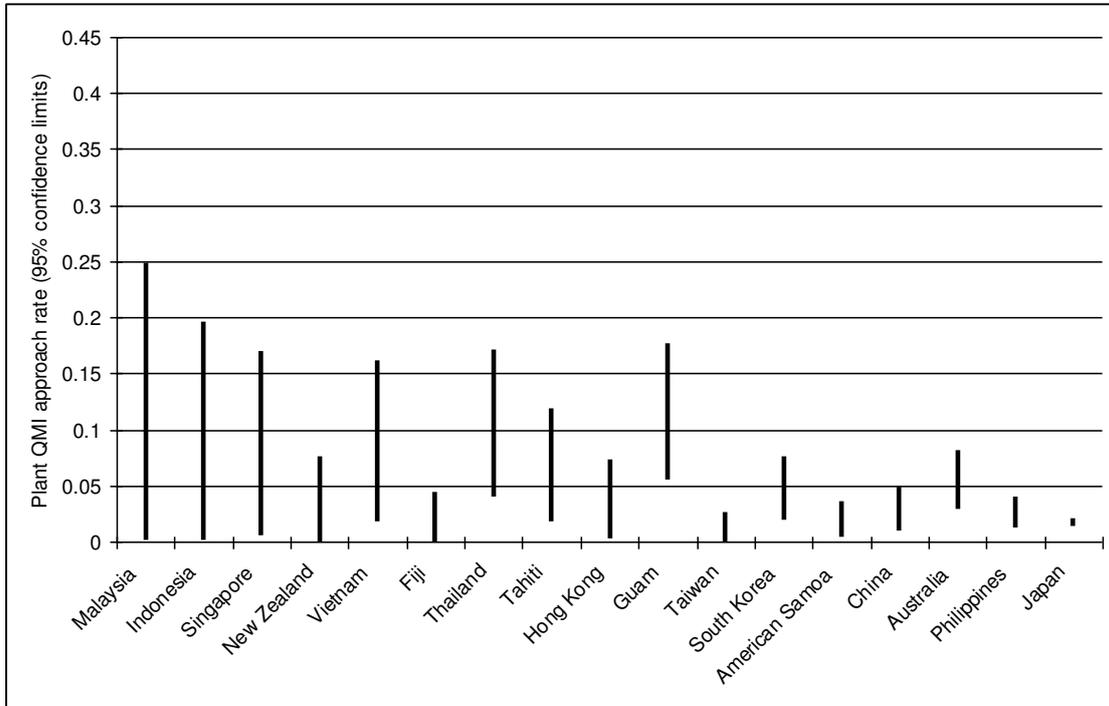
¹⁶ AQIM data for FYs 2005 and 2006.

1 **Table A16-1: Results of Agricultural Quarantine Inspection Monitoring of International Air Passengers Arriving at Honolulu**
 2 **International Airport during FYs 2005 and 2006 by Country of Passenger Origin**

Country of Origin	Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
Malaysia	1	20	0.05	0.0013	0.2487	1	1.00	No data	1.30	2,800	4	696
Indonesia	1	26	0.0385	0.001	0.1964	1	1.00	No data	1.54	3,640	4	715
Singapore	2	40	0.05	0.0061	0.1692	2	1.00	4,050	1.55	2,613	16	442
New Zealand	0	47	0	0	0.0755	0	0	19,451	1.49	13,060	0	986
Vietnam	4	60	0.0667	0.0185	0.162	5	1.25	No data	1.50	8,400	194	1,701
Fiji	0	81	0	0	0.0445	0	0	No data	1.32	11,340	0	505
Thailand	8	88	0.0909	0.0401	0.1713	9	1.13	No data	1.32	12,320	556	2,374
Tahiti	5	95	0.0526	0.0173	0.1186	6	1.20	No data	1.57	13,300	276	1,893
Hong Kong	2	96	0.0208	0.0025	0.0732	2	1.00	5,363	1.43	3,758	9	275
Guam	12	114	0.1053	0.0556	0.1767	17	1.42	No data	1.56	15,960	1,257	3,995
Taiwan	1	215	0.0047	0.0001	0.0256	1	1.00	20,174	1.35	14,905	1	382
South Korea	9	220	0.0409	0.0189	0.0762	12	1.33	35,008	1.60	21,942	553	2,229
American Samoa	4	287	0.0139	0.0038	0.0353	5	1.25	No data	1.69	40,180	191	1,773
China	7	287	0.0244	0.0099	0.0469	7	1.00	42,526	1.48	28,718	284	1,424
Australia	15	299	0.0502	0.0283	0.0814	22	1.47	122,940	1.50	82,051	3,406	9,796
Philippines	13	549	0.0237	0.0127	0.0402	14	1.08	No data	1.73	76,860	1,051	3,327
Japan	76	4509	0.0169	0.0133	0.0211	97	1.28	1,517,439	1.64	925,318	15,707	24,919

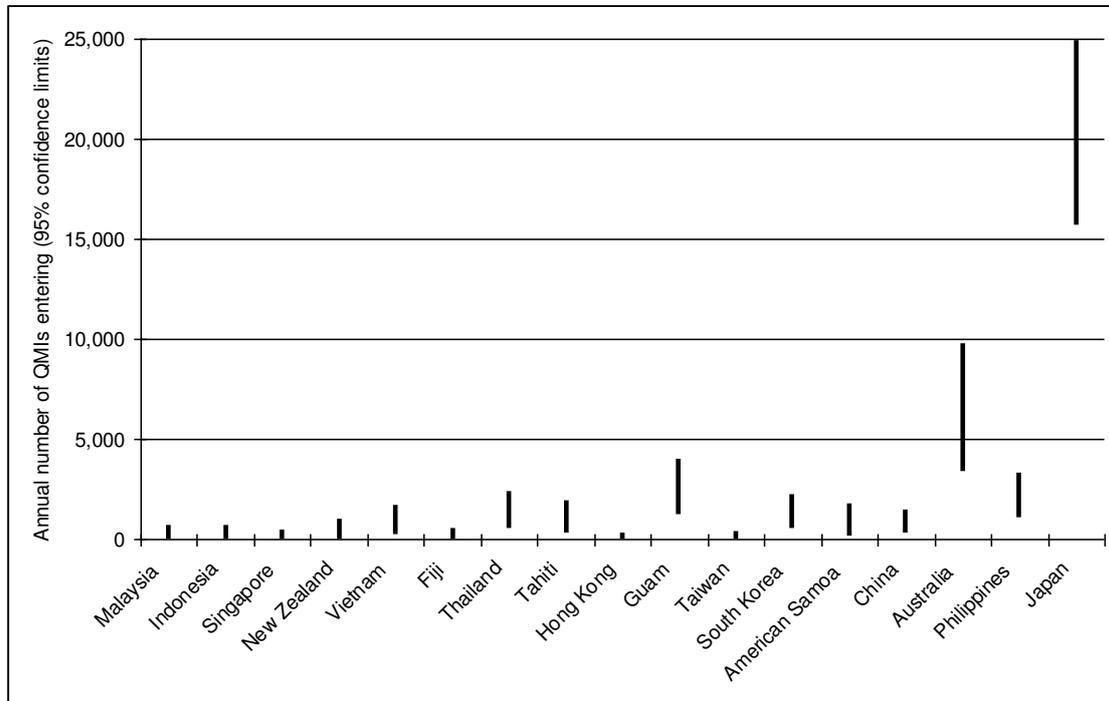
3 Note: Pax=passenger; QM=quarantine plant and animal materials

1 **Figure A16-1: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger**
 2 **Baggage by Country of Passenger Origin**



3
 4 Note: Only countries, for which AQIM sample size was at least 20, are shown.
 5

1 **Figure A16-2: 95% Confidence Intervals of Estimated Annual Number of Plant QMs entering**
 2 **Hawai'i in Airline Passenger Baggage by Country of Passenger Origin**



3
4

5 Table A16-2 shows the results of AQIM of international air passengers arriving at HNL during FYs 2005
 6 and 2006 by travel reason. The sampling unit is the group of passengers traveling together under one
 7 U.S. Customs manifest. The table shows the travel reason,¹⁷ the number of passenger groups that were
 8 found to have QMs, the number of passenger groups inspected,¹⁸ the estimated proportion of
 9 passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this
 10 estimate. It also lists the total number of QMs detected by travel reason,¹⁹ the average number of QMs
 11 per interception,²⁰ the total annual number of passengers entering Hawai'i,²¹ the average number of
 12 passengers per group,²² and the annual number of groups entering Hawai'i. Finally, it shows the lower
 13 and upper confidence limits for the estimated total annual number of QMs entering Hawai'i.

14

¹⁷ AQIM data for FYs 2005 and 2006.

¹⁸ Ibid

¹⁹ Ibid

²⁰ Ibid

²¹ 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic Development, and Tourism (DBEDT data set).

²² AQIM data for FYs 2005 and 2006.

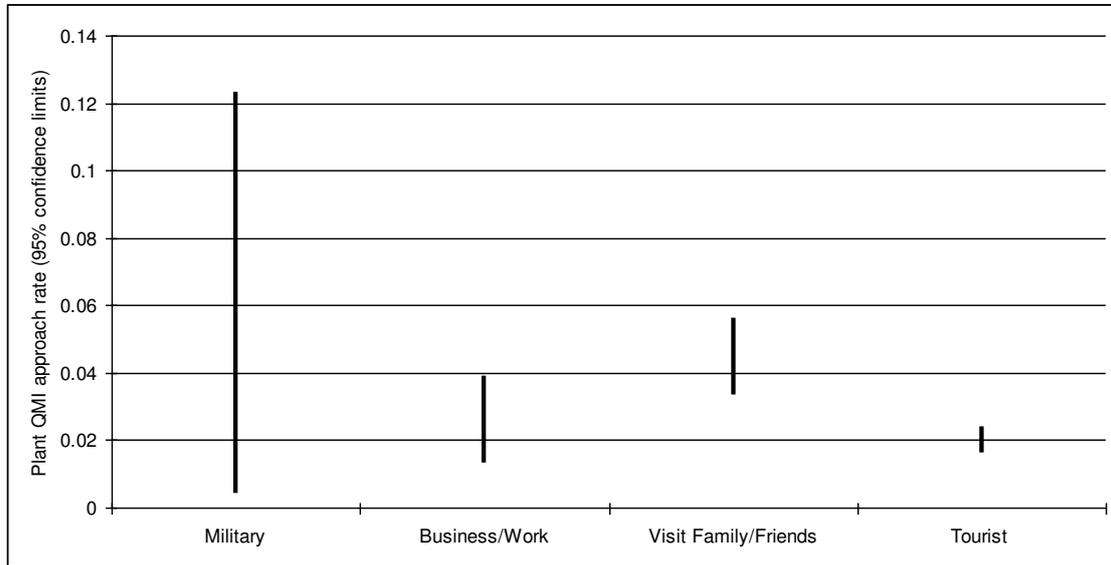
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1 **Table A16-2: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006 by Travel Reason**

Reasons for Travel	School	Military	Business/Work	Visit Family/Friends	Tourism
Pax groups where QMs found	0	2	15	58	102
Pax groups inspected	2	56	630	1,322	5,154
Approach rate (Proportion of groups with QMs)	0	0.0357	0.0238	0.0439	0.0198
Lower 95% confidence limit of approach rate	0	0.0044	0.0134	0.0335	0.0162
Upper 95% confidence limit of approach rate	0.7764	0.1231	0.039	0.0564	0.024
QMs detected	0	4	21	77	123
QMs per interception	0	2.00	1.40	1.33	1.21
Pax entering	7,749	35,019	224,997	109,495	2,165,169
Average Pax per group	1.5	1.25	1	1.64	1.69
Pax groups entering	5,166	28,015	224,997	66,765	1,281,165
Lower 95% confidence limit of QMs entering	.	247	4,221	2,969	25,028
Upper 95% confidence limit of QMs entering	.	6,897	12,285	4,999	37,078

2 Note: Pax=passenger; QM=quarantine plant and animal materials

1 **Figure A16-3: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger**
2 **Baggage by Travel Reason**

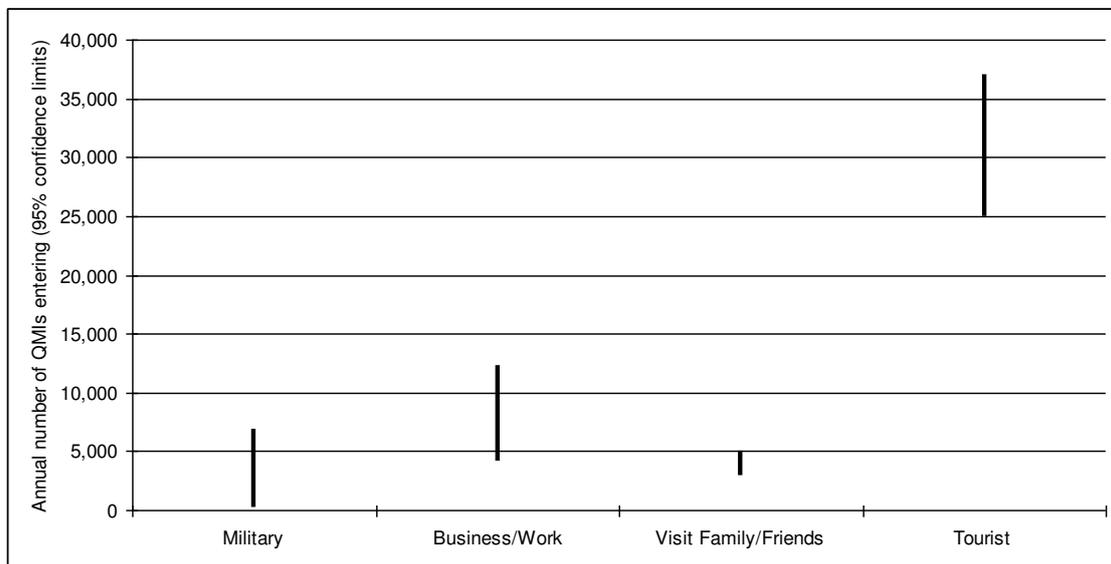


3

4 Note: Only travel reasons, for which AQIM sample size was at least 20, are shown.
5

6

7 **Figure A16-4: 95% Confidence Intervals of Estimated Annual Number of Plant QMs Entering**
8 **Hawai'i in Airline Passenger Baggage by Travel Reason**



8

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1 Table A16-3 shows the results of AQIM of international air passengers arriving at HNL during by calendar month in FYs 2005 and 2006. The
 2 sampling unit is the group of passengers traveling together under one U.S. Customs manifest. The table shows the month of travel, the number
 3 of passenger groups that were found to have QMs, the number of passenger groups inspected, the estimated proportion of passenger groups
 4 that carry QMs, and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total number of QMs detected by
 5 country, the average number of QMs per interception, the total annual number of passengers entering Hawai'i, the average number of
 6 passengers per group, and the annual number of groups entering Hawai'i. Finally, it shows the lower and upper confidence limits for the
 7 estimated total annual number of QMs entering Hawai'i.

8 **Table A16-3: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006 by Calendar Month**

Month	Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
Jan.	23	612	0.0376	0.024	0.0559	27	1.17	215,498	1.7	126,764	3,571	8,318
Feb.	8	522	0.0153	0.0066	0.03	9	1.13	196,209	1.5	130,806	971	4,415
Mar.	15	602	0.0249	0.014	0.0408	18	1.20	212,479	1.6	132,799	2,231	6,502
Apr.	12	601	0.02	0.0104	0.0346	15	1.25	176,396	1.6	110,248	1,433	4,768
May.	12	604	0.0199	0.0103	0.0344	16	1.33	185,965	1.6	116,228	1,596	5,331
Jun.	8	576	0.0139	0.006	0.0272	11	1.38	189,819	1.6	118,637	979	4,437
Jul.	12	603	0.0199	0.0103	0.0345	18	1.50	212,113	1.7	124,772	1,928	6,457
Aug.	11	606	0.0182	0.0091	0.0322	16	1.45	220,421	1.8	122,456	1,621	5,735
Sep.	12	602	0.0199	0.0103	0.0346	15	1.25	207,531	1.5	138,354	1,781	5,984
Oct.	19	603	0.0315	0.0191	0.0488	23	1.21	213,259	1.6	133,287	3,082	7,874
Nov.	16	617	0.0259	0.0149	0.0418	21	1.31	191,555	1.5	127,703	2,497	7,006
Dec.	29	616	0.0471	0.0318	0.0669	36	1.24	233,542	1.7	137,378	5,423	11,409

9 Note Pax=passenger; QM=quarantine plant and animal materials

10

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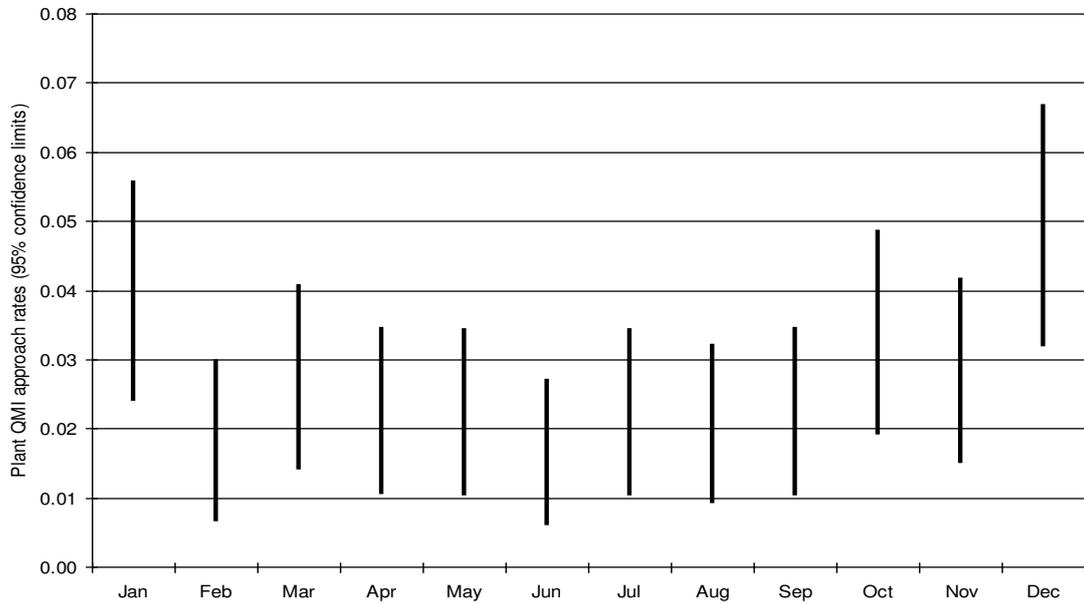
1 Table A16-4 shows the results of AQIM of international air passengers arriving at HNL during FYs 2005 and 2006. The sampling unit is the group
 2 of passengers traveling together under one U.S. Customs manifest. The table shows the number of passenger groups that were found to have
 3 QMs, the number of passenger groups inspected, the estimated proportion of passenger groups that carry QMs, and the lower and upper 95%
 4 binomial confidence limits for this estimate. It also lists the total number of QMs detected, the average number of QMs per interception, the
 5 total annual number of passengers entering Hawai'i, the average number of passengers per group, and the annual number of groups entering
 6 Hawai'i. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering Hawai'i.

7 **Table A16-4: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006**

Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
177	7,164	0.0247	0.0212	0.0286	247	1.40	2,144,064	1.55	1,360,120	40,369	54,459

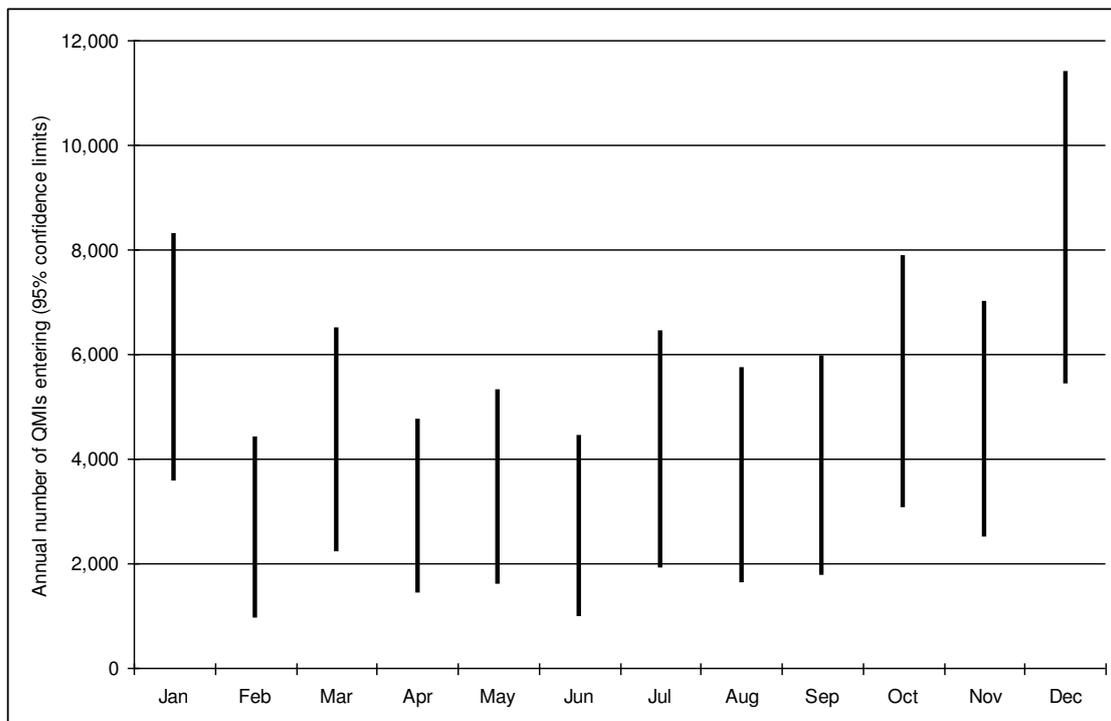
8 Note: Pax=passenger; QM=quarantine plant and animal materials

1 **Figure A16-5: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger**
 2 **Baggage by Calendar Month of Travel**



3
4

5 **Figure A16-6: 95% Confidence Intervals of Estimated Annual Number of Plant QMs Entering**
 6 **Hawai'i in Airline Passenger Baggage by Calendar Month of Travel**



7

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1
2 Table A16-5 lists the country of origin of the inspected airline passengers, the type and number of QM
3 intercepted, and potential (not actually intercepted) pests of the QM that occur in the country of origin,
4 as well as references for the pest information.

5 **Table A16-5: Plant QMs that have been Seized during AQIM Sampling in FY 2005 through**
6 **2006**

Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
American Samoa	Apple	1	<i>Bactrocera kirki</i> (Froggatt) (Diptera: Tephritidae)	Manson 1980; CABI 2006
	Breadfruit	1	<i>Bactrocera distincta</i> (Malloch), <i>B. xanthodes</i> (Broun) (Diptera: Tephritidae)	White and Elson-Harris 1992; CABI 2006
	Citrus, Orange	1	<i>Bactrocera kirki</i> (Froggatt) (Diptera: Tephritidae); <i>Sphaceloma fawcettii</i> var. <i>scabiosa</i> (McAlpine and Tryon) Jenk. (Ascomycetes: Myriangiales)	White and Elson-Harris 1992; Brooks 2006; Farr et al. 2006
	Coconut	1	<i>Aspidiotus pacificus</i> Williams and Watson (Homoptera: Diaspididae)	Ben-Dov et al. 2006
	Grapes	1	<i>Gibberella intricans</i> Wollenw. (Ascomycetes: Hypocreales)	Brooks 2006; CABI 2006
Australia	Apple	10	<i>Bactrocera aquilonis</i> (May) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Banana	3	<i>Bactrocera musae</i> (Tryon) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Citrus, Lemon	1	<i>Bactrocera aquilonis</i> (May); <i>B. neohumeralis</i> (Hardy); <i>B. tryoni</i> (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Citrus, Orange	3	<i>Bactrocera tryoni</i> (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Cucumber	1	<i>Bactrocera cucumis</i> (French) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Pear	3	<i>Bactrocera jarvisi</i> (Tryon); <i>B. neohumeralis</i> (Hardy); <i>B. tryoni</i> (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Tomato	1	<i>Bactrocera aquilonis</i> (May); <i>B. cucumis</i> (French); <i>B. neohumeralis</i> (Hardy); <i>B. tryoni</i> (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
Bangladesh	Seeds	1	NA	NA
Bhutan	Szechuan Peppercorns (<i>Zanthoxylum</i> spp.)	1	NA	NA

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
China	Citrus, Peel	2	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales); <i>Xanthomonas axonopodis</i> pv. <i>citri</i> (Hasse) Vauterin et al. (Xanthomonadales)	CABI/EPPO 1997f Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Citrus, Pomelo	1	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Bactrocera minax</i> (Enderlein); <i>B. tau</i> (Walker) (= <i>Dacus hageni</i> de Meijere) (Diptera: Tephritidae); " <i>Candidatus Liberobacter asiaticum</i> " Jagoueix et al. (Rhizobiales); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales); <i>Xanthomonas axonopodis</i> pv. <i>citri</i> (Hasse) Vauterin et al. (Xanthomonadales)	Kapoor 1989; White and Elson-Harris 1992; CABI/EPPO 1997d; f; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Citrus, Tangerine	1	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Bactrocera minax</i> (Enderlein); <i>B. tsuneonis</i> (Miyake) (Diptera: Tephritidae); " <i>Candidatus Liberobacter asiaticum</i> " Jagoueix et al. (Rhizobiales); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales); <i>Xanthomonas axonopodis</i> pv. <i>citri</i> (Hasse) Vauterin et al. (Xanthomonadales)	White and Elson-Harris 1992; CABI/EPPO 1997d; f; k; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Peach	1	<i>Adoxophyes orana</i> (Fischer von Roeslerstamm) (Lepidoptera: Tortricidae); <i>Aonidiella orientalis</i> (Newstead) (Homoptera: Diaspididae)	Meijerman and Ulenberg 2000; Watson 2005
	Pear	1	<i>Adoxophyes orana</i> (Fischer von Roeslerstamm) (Lepidoptera: Tortricidae); <i>Diaspidiotus ostreaeformis</i> (Curtis) (Homoptera: Diaspididae)	Meijerman and Ulenberg 2000; Watson 2005
China	Szechuan Peppercorns	1	NA	NA
Germany	Apple	1	<i>Adoxophyes orana</i> (Fischer von Roeslerstamm) (Lepidoptera: Tortricidae)	Meijerman and Ulenberg 2000; CABI 2006
	Citrus, Orange	1	None ^b	NA
	Plant, Seedlings	1	NA	NA
Guam	Apple	1	None ^c	NA

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Banana	1	<i>Aonidiella aurantii</i> (Maskell) (Homoptera: Diaspididae); <i>Icerya aegyptiaca</i> (Douglas) (Homoptera: Margarodidae)	Beardsley 1955; Nafus and Schreiner 1999; Watson 2005; CABI 2006
	Eggplant	1	<i>Paracoccus marginatus</i> Williams and Granara de Willink (Homoptera: Pseudococcidae)	Ben-Dov et al. 2006; CABI 2006
	Leaves	1	NA	NA
	Mango	2	<i>Bactrocera frauenfeldi</i> (Schiner) (Diptera: Tephritidae)	White and Elson-Harris 1992; CABI 2006
	Nectarine	1	None ^c	NA
	Nut, Betel w/ Husk (<i>Areca catechu</i>)	6	<i>Colletotrichum arecae</i> Syd. and P. Syd. (Ascomycetes: Phyllachorales)	Farr et al. 2006
	Plant, Seedlings	1	NA	NA
	Plum	1	None ^c	NA
	Santol (<i>Sandoricum koetjape</i>)	1	<i>Bactrocera frauenfeldi</i> (Schiner) (Diptera: Tephritidae)	SPC 2002a; CABI 2006
	Tomato	1	<i>Helicoverpa armigera</i> (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g
Hong Kong	Citrus, Peel	2	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales); <i>Xanthomonas axonopodis</i> pv. <i>citri</i> (Hasse) Vauterin et al. (Xanthomonadales)	CABI/EPPO 1997k; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
India	Apple	1	<i>Bactrocera zonata</i> (Saunders) (= <i>Dacus zonatus</i> [Saunders]) (Diptera: Tephritidae); <i>Dyscerus malignus</i> Mshl., <i>D. fletcheri</i> Mshl. (Coleoptera: Curculionidae); <i>Ulodemis trigrapha</i> Meyrick (Lepidoptera: Tortricidae)	Nair 1975; White and Elson-Harris 1992
Indonesia	Sand Pear	1	<i>Planococcus minor</i> (Maskell), <i>Pseudococcus comstocki</i> (Kuwana) (Homoptera: Pseudococcidae)	Agnello et al. 1992; Ooi et al. 2002; Ben-Dov et al. 2006
Japan	Apple	6	<i>Adoxophyes orana</i> (Fischer von Roeslerstamm), <i>Grapholita molesta</i> (Busck) (Lepidoptera: Tortricidae)	Shiraki 1952; Meijerman and Ulenberg 2000; CABI 2006
	Banana	5	<i>Icerya aegyptiaca</i> (Douglas) (Homoptera: Margarodidae)	Beardsley 1955; Ben-Dov et al. 2006; CABI 2006
	Carrot	1	<i>Alternaria radicina</i> Meier et al. (Ascomycetes: Pleosporales); <i>Pratylenchus thornei</i> Sher and Allen, <i>P. vulnus</i> Allen and Jensen (Pratylenchidae); <i>Psila rosae</i> (F.) (Diptera: Psilidae)	Gotoh and Ohshima 1963; Ellis and Holliday 1972; CABI 2006

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Citrus, Grapefruit	1	<i>Aonidiella citrina</i> (Coquillett), <i>Unaspis yanonensis</i> (Kuwana) (Homoptera: Diaspididae); “ <i>Candidatus Liberobacter asiaticum</i> ” Jagoueix <i>et al.</i> (Rhizobiales); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales)	CABI 1997; CABI/EPPO 1997d; Ben-Dov <i>et al.</i> 2006; CABI 2006; Farr <i>et al.</i> 2006
	Citrus, Orange	19	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Aonidiella citrina</i> (Coquillett) (Homoptera: Diaspididae); <i>Bactrocera tsuneonis</i> (Miyake) (Diptera: Tephritidae); “ <i>Candidatus Liberobacter asiaticum</i> ” Jagoueix <i>et al.</i> (Rhizobiales); <i>Geotrichum candidum</i> Link (Saccharomycetes: Saccharomycetales)	White and Elson-Harris 1992; CABI/EPPO 1997d; Plaza <i>et al.</i> 2004; Ben-Dov <i>et al.</i> 2006; CABI 2006
Japan	Citrus, Peel	1	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Geotrichum candidum</i> Link (Saccharomycetes: Saccharomycetales)	Plaza <i>et al.</i> 2004; CABI 2006
	Citrus, Tangerine	28	<i>Alternaria citri</i> Ellis and N. Pierce (Ascomycetes: Pleosporales); <i>Bactrocera tsuneonis</i> (Miyake) (Diptera: Tephritidae); “ <i>Candidatus Liberobacter asiaticum</i> ” Jagoueix <i>et al.</i> (Rhizobiales); <i>Geotrichum candidum</i> Link (Saccharomycetes: Saccharomycetales); <i>Unaspis yanonensis</i> (Kuwana) (Homoptera: Diaspididae)	White and Elson-Harris 1992; CABI/EPPO 1997d; Plaza <i>et al.</i> 2004; CABI 2006
	Cucumber	3	<i>Phytophthora melonis</i> Katsura, <i>Pythium cucurbitacearum</i> Takimoto (Oomycetes: Pythiales)	Takimoto 1941; Farr <i>et al.</i> 2006
	Fruit, Fresh	4	NA	NA
	Fruit, Salad	1	NA	NA
	Garlic	1	<i>Aceria tulipae</i> (Keifer) (Acari: Eriophyidae); <i>Delia antiqua</i> (Meigen) (Diptera: Anthomyiidae); <i>Urocystis magica</i> Pass. (= <i>U. cepulae</i> Frost) (Ustilaginomycetes: Urocystales)	Schneider <i>et al.</i> 1985; CABI 2006; Farr <i>et al.</i> 2006
	Grapes	1	<i>Brevipalpus lewisi</i> McGregor (Acari: Tenuipalpidae)	James and Whitney 1993; CABI 2006
	Guava	2	<i>Conogethes</i> (= <i>Dichocrocis punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae); <i>Planococcus lilacinus</i> (Cockerell) (Homoptera: Pseudococcidae)	Shiraki 1952; Mani 1995; Kaul and Kesar 2003; Ben-Dov <i>et al.</i> 2006

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Kiwi	2	<i>Lobesia botrana</i> (Denis and Schiffermüller) (Lepidoptera: Tortricidae)	Moleas 1988; Meijerman and Ulenberg 2000
	Lettuce	1	<i>Autographa gamma</i> (L.) (Lepidoptera: Noctuidae); <i>Chromatomyia horticola</i> (Goureau), <i>Liriomyza bryoniae</i> (Kaltenbach) (Diptera: Agromyzidae)	Whittle 1986; CABI/EPPO 1997h; Dempewolf 2004
	Medicine	1	NA	NA
	Melon	1	NA	NA
	Mustard Greens	1	NA	NA
	Onion	1	<i>Aceria tulipae</i> (Keifer) (Acari: Eriophyidae); <i>Delia antiqua</i> (Meigen) (Diptera: Anthomyiidae); <i>Phytophthora porri</i> Foister (Oomycetes: Pythiales); <i>Urocystis magica</i> Pass. (= <i>U. cepulae</i> Frost) (Ustilaginomycetes: Urocystales)	Schneider et al. 1985; CABI 2006; Farr et al. 2006
	Onions, Green	1	<i>Burkholderia cepacia</i> (ex Burkholder) Yabuuchi et al. (Burkholderiales); <i>Stemphylium vesicarium</i> (Wallr.) Simmons (Dothideomycetes: Pleosporales)	Saddler 1994; Cho and Yu 1998; Ozawa et al. 2003; Farr et al. 2006
	Persimmon	3	<i>Conogethes punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae); <i>Eriococcus lagerstroemiae</i> Kuwana (Homoptera: Eriococcidae); <i>Lepidosaphes cupressi</i> Borchsenius (Homoptera: Diaspididae); <i>Pestalotiopsis acaciae</i> (Thümen) Yokoyama and Kaneko (Ascomycetes: Xylariales); <i>Stathmopoda masinissa</i> Meyrick (Lepidoptera: Oecophoridae); <i>Tenuipalpus zhizhilashviliae</i> Reck (Acari: Tenuipalpidae)	Clausen 1931; Tomomatsu et al. 1995; Kim et al. 1997; Umeya and Okada 2003; Yasuda et al. 2003; Ben-Dov et al. 2006
	Plant, Seedlings	1	NA	NA
	Plum	1	<i>Adoxophyes orana</i> (Fischer von Röslerstamm) (Lepidoptera: Tortricidae); <i>Carposina niponensis</i> (Walsingham) (= <i>C. sasakii</i> Matsumura) (Lepidoptera: Carposinidae)	Shiraki 1952; Anonymous 1958; Meijerman and Ulenberg 2000

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
Japan	Potato	1	<i>Globodera rostochiensis</i> (Wollenweber) Behrens (Heteroderidae); <i>Pratylenchus thornei</i> Sher and Allen (Pratylenchidae); <i>Ralstonia solanacearum</i> race 3 (Smith) Yabuuchi <i>et al.</i> (Burkholderiales); <i>Streptomyces scabies</i> (ex Thaxter) Lambert and Loria (Actinomycetales)	Gotoh and Ohshima 1963; Hooker 1988; Brodie 1993; CABI/EPPO 1997e; CABI 2006; Farr <i>et al.</i> 2006
	Potato, Sweet	2	<i>Ralstonia solanacearum</i> race 3 (Smith) Yabuuchi <i>et al.</i> (Burkholderiales)	CABI 2006
	Seeds	2	NA	NA
	Tomato	3	<i>Geotrichum candidum</i> Link (Saccharomycetes: Saccharomycetales); <i>Helicoverpa armigera</i> (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g; Nakamura <i>et al.</i> 2001; Sharma <i>et al.</i> 2006
	Vegetable	2	NA	NA
	Wheat Product	1	NA	NA
South Korea	Apple	2	<i>Carposina sasakii</i> Matsumura (Lepidoptera: Carposinidae); <i>Conogethes punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae); <i>Grapholita molesta</i> (Busck) (Lepidoptera: Tortricidae); <i>Monilinia fructigena</i> Honey ex Whetzel (Ascomycetes: Helotiales); <i>Venturia inaequalis</i> (Cooke) Winter (Ascomycetes: Pleosporales)	Sivanesan and Waller 1974; Honda <i>et al.</i> 1988; Choi <i>et al.</i> 2004; Kang <i>et al.</i> 2004; Farr <i>et al.</i> 2006
	Banana	1	None ^d	NA
	Citrus, Tangerine	2	<i>Aonidiella citrina</i> (Coquillett), <i>Unaspis yanonensis</i> (Kuwana) (Homoptera: Diaspididae); <i>Guignardia citricarpa</i> Kiely (Ascomycetes: Dothideales)	Catling <i>et al.</i> 1977; CABI 1997; CABI/EPPO 1997a; Watson 2005; CABI 2006; Farr <i>et al.</i> 2006
	Fruit, Fresh	1	NA	NA
	Nut, Chestnut	2	<i>Conogethes punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae)	Li <i>et al.</i> 1989; Kang <i>et al.</i> 2004
	Persimmon	1	<i>Asiacornococcus kaki</i> (Kuwana in Kuwana and Muramatsu) (Eriococcidae); <i>Conogethes punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae); <i>Phyllactinia kagicola</i> Sawada (Ascomycetes: Erysiphales); <i>Ponticulothrips diospyrosi</i> Haga and Okajima (Thysanoptera: Phlaeothripidae)	Kim <i>et al.</i> 1997; Lee <i>et al.</i> 2002; Kwon and Han 2003; Farr <i>et al.</i> 2006
	Potato, Sweet	1	<i>Helicobasidium mompa</i> Tanaka (Urediniomycetes: Helicobasidiales)	Clark and Moyer 1988; Farr <i>et al.</i> 2006

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Tomato	2	<i>Bactrocera depressa</i> (Shiraki) (Diptera: Tephritidae); <i>Mamestra brassicae</i> (L.) (Lepidoptera: Noctuidae); <i>Sclerotinia minor</i> Jagger (Ascomycetes: Helotiales)	Okadome 1962; Han et al. 1994; Rojas et al. 2001; CABI 2006; Farr et al. 2006
Malaysia	Citrus, Orange	1	<i>Aonidiella aurantii</i> (Maskell), <i>A. citrina</i> (Coquillett) (Homoptera: Diaspididae); <i>Bactrocera papayae</i> Drew and Hancock (Diptera: Tephritidae); " <i>Candidatus Liberobacter asiaticum</i> " Jagoueix et al. (Rhizobiales)	Yunus and Ho 1980; White and Elson-Harris 1992; CABI/EPPO 1997a; d; Song et al. 2006
Micronesia	Fruit, Fresh	1	NA	NA
	Nut, Betel	1	NA	NA
	Nut, Betel w/ Husk	1	NA	NA
Palau	Leaves	3	NA	NA
	Nut, Betel	2	<i>Bactrocera frauenfeldi</i> (Schiner) (Diptera: Tephritidae)	SPC 2002a
	Nut, Betel w/ Husk	6	<i>Bactrocera frauenfeldi</i> (Schiner) (Diptera: Tephritidae)	SPC 2002a
Philippines	Apple	1	None ^e	NA
	Banana	3	<i>Icerya aegyptiaca</i> (Douglas), <i>I. seychellarum</i> (Westwood) (Homoptera: Margarodidae); <i>Penicillium waksmanii</i> Zaleski (Ascomycetes: Eurotiales); <i>Tiracola plagiata</i> (Walk.) (Lepidoptera: Noctuidae)	Weddell 1930; Beardsley 1955; CAB 1972; Alvindia et al. 2002; Ben-Dov et al. 2006
	Corn	1	<i>Conogethes punctiferalis</i> (Guenée) (Lepidoptera: Pyralidae); <i>Helicoverpa armigera</i> (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g; CABI 2006
Philippines	Fruit, Fresh	1	NA	NA
	Mango	3	<i>Aonidiella citrina</i> (Coquillett) (Homoptera: Diaspididae); <i>Bactrocera occipitalis</i> (Bezzi), <i>B. philippinensis</i> Drew and Hancock (Diptera: Tephritidae); <i>Sternochetus frigidus</i> (F.) (Coleoptera: Curculionidae)	Hill 1983; White and Elson-Harris 1992; Basio et al. 1994; CABI/EPPO 1997a
	Onions, Green	1	<i>Liriomyza huidobrensis</i> (Blanchard) (Diptera: Agromyzidae); ^f <i>Peronospora destructor</i> (Berk.) Casp. (= <i>P. schleideni</i> Unger) (Oomycetes: Peronosporales); <i>Urocystis cepulae</i> Frost (Ustilaginomycetes: Urocystales)	CAB 1978; 1984; CABI/EPPO 1997i; CABI 2002; Farr et al. 2006
	Potato, Sweet	1	<i>Fusarium pallidoroseum</i> (Cooke) Sacc. (Ascomycetes: Hypocreales)	Ray and Ravi 2005; Farr et al. 2006

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Rice Straw	1	<i>Sclerotium oryzae</i> Catt. (Basidiomycetes: Agaricales)	Cintas and Webster 2001; Farr et al. 2006
	Taro	2	<i>Caliothrips striatopterus</i> (Kobus) (Thysanoptera: Thripidae); <i>Phyllosticta colocasiae</i> Höhn. (Ascomycetes: Dothideales); Taro feathery mosaic virus (= taro feathery mottle virus?) (Potyviridae)	Palomar et al. 1983; Reyes and Rillon 1994; CABI 2006; Farr et al. 2006; Hoddle et al. 2006
Russia	Tomato	1	<i>Helicoverpa armigera</i> (Hübner) (Lepidoptera: Noctuidae); <i>Monilinia fructigena</i> Honey ex Whetzel (Ascomycetes: Helotiales)	Schlosser 1975; CABI/EPPO 1997g; CABI 2000; Talekar et al. 2006
Singapore	Apple	1	None ^b	NA
	Banana	1	<i>Bactrocera carambolae</i> Drew and Hancock, <i>B. papayae</i> Drew and Hancock (Diptera: Tephritidae)	White and Elson-Harris 1992; Drew and Hancock 1994
Tahiti	Banana	1	<i>Bactrocera kirki</i> (Froggatt), <i>B. tryoni</i> (Froggatt) (Diptera: Tephritidae); <i>Icerya aegyptiaca</i> (Douglas), <i>I. seychellarum</i> (Westwood) (Homoptera: Margarodidae)	Beardsley 1955; Leblanc and Putoa 2000; Ben-Dov et al. 2006
	Citrus, Tangerine	1	<i>Bactrocera kirki</i> (Froggatt), <i>B. tryoni</i> (Froggatt) (Diptera: Tephritidae)	Leblanc and Putoa 2000
	Kiwi	1	<i>Aonidiella aurantii</i> (Maskell) (Homoptera: Diaspididae)	CAB 1968; Morton 1987
	Lettuce	1	<i>Icerya seychellarum</i> (Westwood) (Homoptera: Margarodidae)	Ben-Dov et al. 2006; CABI 2006
	Plum	1	<i>Bactrocera tryoni</i> (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992; Leblanc and Putoa 2000
	Seeds	1	NA	NA
Taiwan	Plant, w/o Roots	1	NA	NA
Thailand	Banana	3	<i>Bactrocera correcta</i> (Bezzi), <i>B. papayae</i> Drew and Hancock (Diptera: Tephritidae); <i>Icerya aegyptiaca</i> (Douglas), <i>I. seychellarum</i> (Westwood) (Homoptera: Margarodidae)	Beardsley 1955; White and Elson-Harris 1992; Allwood et al. 1999; Ben-Dov et al. 2006
	Bulb, Plant/Flower	1	NA	NA
	Citrus, Orange	1	<i>Aonidiella aurantii</i> (Maskell), <i>A. citrina</i> (Coquillett) (Homoptera: Diaspididae); <i>Bactrocera papayae</i> Drew and Hancock, <i>B. zonata</i> (Saunders) (Diptera: Tephritidae); "Candidatus Liberobacter asiaticum" Jagoueix et al. (Rhizobiales)	White and Elson-Harris 1992; CABI/EPPO 1997d; Ben-Dov et al. 2006

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Country of Origin	QM	Number of QMs	Potential pests of importance ^a	References ^a
	Mangosteen	1	<i>Bactrocera carambolae</i> Drew and Hancock, <i>B. papayae</i> Drew and Hancock (Diptera: Tephritidae); <i>Exallomochlus hispidus</i> (Morrison), <i>Hordeolicoccus nephelii</i> (Takahashi) (= <i>Phenacoccus nephelii</i> Takahashi), <i>Pseudococcus aurantiacus</i> Williams (Homoptera: Pseudococcidae); <i>Pestalotiopsis flagisettula</i> (Guba) Stey. (Ascomycetes: Xylariales)	White and Elson-Harris 1992; Allwood et al. 1999; Lim and Sangchote 2003; Williams 2004; Ben-Dov et al. 2006; PIN 309 ^h
	Mushroom	1	NA	NA
	Plant	1	NA	NA
Thailand	Rice Straw	1	<i>Phoma leveillei</i> Boerema and Bollen (Ascomycetes: Pleosporales)	Kinsey 2002
Tonga	Coconut, Plant	1	<i>Dysmicoccus cocotis</i> (Maskell) (Homoptera: Pseudococcidae); <i>Icerya seychellarum</i> (Westwood) (Homoptera: Margarodidae); <i>Tirathaba rufivena</i> (Walker) (Lepidoptera: Pyralidae)	Zelazny 1985; FAO 1987; Ben-Dov et al. 2006
	Guava	1	<i>Aonidiella aurantii</i> (Maskell) (Homoptera: Diaspididae); <i>Bactrocera facialis</i> (Coquillett), <i>B. kirki</i> (Froggatt), <i>B. passiflorae</i> (Froggatt), <i>B. xanthodes</i> (Broun) (Diptera: Tephritidae)	White and Elson-Harris 1992; Ben-Dov et al. 2006
United Kingdom	Apple	1	<i>Acetobacter pasteurianus</i> (Hansen) Beijerinck and Folpms (= <i>Pseudomonas pomi</i> Cole) (Clostridiales); <i>Cydia pomonella</i> (L.)	Carter 1984; Bradbury 1986
Vietnam	Citrus, Orange	1	<i>Aonidiella aurantii</i> (Maskell) (Homoptera: Diaspididae); <i>Bactrocera tsuneonis</i> (Miyake) (Diptera: Tephritidae); " <i>Candidatus Liberobacter asiaticum</i> " Jagoueix et al. (Rhizobiales); <i>Xanthomonas axonopodis</i> pv. <i>citri</i> (Hasse) Vauterin et al. (Xanthomonadales)	White and Elson-Harris 1992; CABI/EPPO 1997b; d; k; Ben-Dov et al. 2006
	Leaves, Infested	1	NA	NA
	Nut, Betel	1	<i>Pestalotiopsis palmarum</i> (Cooke) Steyaert (Ascomycetes: Xylariales)	Mordue and Holliday 1971; Farr et al. 2006
	Pear	1	<i>Erwinia amylovora</i> (Burrill) Winslow et al. (Enterobacteriales)	CAB 1979; Cao-Van and Chau 1999
	Seeds	1	NA	NA

1 Notes:

2 ^a NA: Information not available or not applicable.

3 ^b There is no citrus production in Germany (Lieberz 2005).

4 ^c There appears to be little or no production of this commodity in Guam (e.g., Morton 1987; NASS 2007).

5 ^d There appears to be little or no banana production in Korea (FAO 2006a).

6 ^e There appears to be little or no apple production in the Philippines (FAO 2006a).

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1 ^f Records for Hawai'i are considered misidentifications of a related species, *L. langei* Frick (Scheffer and Lewis 2001).

2
3 ^g There appears to be little or no apple production in Singapore (FAO 2006b).

4 ^h Records from the APHIS-PPQ Port Information Network (PIN 309) database. Last access: May 2007.

5

6 **Table B5-6 Plant Pests Intercepted by the Hawai'i Department of Agriculture on the Carry-**
7 **on Baggage of Airline Passengers Coming from the U.S. Mainland, 1995-2006**

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
Acaridae	<i>Tyrophagus</i> sp.	1
Agromyzidae	<i>Cerodontha dorsalis</i>	1
Aleyrodidae	<i>Bemisia tabaci</i>	1
	<i>Paraleyrodes minei</i>	1
Anthocoridae	<i>Orius insidiosus</i>	1
Anthomyiidae	<i>Delia radicum</i>	2
Anyphaenidae	<i>Anyphaena</i> sp.	1
Anystidae	Unknown sp.	2
Aphelinidae	<i>Aphelinus asychis</i>	1
	<i>Coccophagus</i> sp.	1
Aphididae	<i>Aphis fabae</i>	1
	<i>Aphis</i> sp.	1
	<i>Brachycaudus cardui</i>	2
	<i>Brevicoryne brassicae</i>	1
	<i>Cerataphis orchidearum</i>	1
	<i>Chaetosiphon fragaefolii</i>	2
	<i>Macrosiphum euphorbiae</i>	1
	<i>Melanaphis sorghi</i>	1
	<i>Myzus</i> sp.	1
	<i>Rhopalosiphum maidis</i>	1
	<i>Rhopalosiphum padi</i>	2
	<i>Schizaphis graminum</i>	1
	<i>Sitobion luteum?</i>	1
	Unknown sp.	1
<i>Utamphorophora humboldti ?</i>	1	
<i>Wahlgreniella nervata</i>	1	
Araneidae	Unknown sp.	2
Arctiidae	Unknown sp.	2
Bedellidae	Unknown sp.	2
Berytidae	<i>Acanthophysa</i> sp.	1
Blatellidae	<i>Blatella germanica</i>	1
	<i>Blattella</i> sp.	1
Blattidae	Unknown sp.	2
Braconidae	Unknown sp.	2
Bradybaenidae	<i>Bradybaena similaris</i>	1
	<i>Bradybaena</i> sp.	1
Carcinophoridae	<i>Euborellia annulipes</i>	1
Cerambycidae	<i>Neoclytus acuminatus</i>	1

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Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	<i>Plectromerus deutipes</i>	1
Chloropidae	Unknown sp.	1
Chrysomelidae	<i>Diabrotica</i> sp.	1
	<i>Diabrotica u. undecimpunctata</i>	1
	<i>Glyptina</i> sp.	1
	<i>Microtheca ochroloma</i>	1
	Unknown sp.	1
Cicadellidae	Unknown sp.	2
Cimicidae	<i>Cimex lectularius</i>	1
Clubionidae	<i>Clubiona</i> sp.?	1
Coccidae	<i>Coccus hesperidum</i>	4
	<i>Milriscutulus</i> sp.	1
	<i>Saisettia oleae</i>	1
	<i>Saisettia coffeae</i>	5
	<i>Saisettia</i> sp.	1
	Unknown sp.	1
Coccinellidae	<i>Coccinella californica</i>	1
	<i>Hippodamia californica</i>	1
	<i>Hippodamia convergens</i>	3
	<i>Mulsantina picta</i>	1
	<i>Scymnus</i> sp.	1
	Unknown sp.	2
Coreidae	<i>Chelinidea vittiger</i>	1
	Unknown sp.	1
Cucujidae	<i>Ahasversus advena</i>	2
Curculionidae	Brachyderinae	1
	Otidocephalinae	1
	<i>Achrastenus griseus</i>	1
	<i>Otiorhynchus</i> sp.	1
	Unknown sp.	3
Dermestidae	<i>Anthrenus verbasci</i>	1
	<i>Trogoderma glabrum</i>	1
Diaspididae	<i>Abgrallaspis cyanophylli</i>	1
	<i>Aondiella aurantii</i>	24
	<i>Aspidiotus nerii</i>	3
	<i>Chionaspis pinifoliae</i>	1
	<i>Chrysomphalus aonidum</i>	3
	<i>Diaspidiotus perniciosus</i>	1
	<i>Diaspis boisduvalii</i>	1
	<i>Lepidosaphes beckii</i>	7
	<i>Selenaspis articulatus</i>	1
	Unknown sp.	1
Diptera	Unknown sp.	1
Drosophilidae	Unknown sp.	3
Dysderiidae	Unknown sp.	1
Elateridae	Agrypninae	1

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Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
Encyrtidae	<i>Anagyrus</i> sp.	1
	Unknown sp.	1
Entomobryidae	Unknown sp.	1
Forficulidae	<i>Forficula auricularia</i>	1
	Unknown sp.	1
Formicidae	<i>Camponotus</i> sp.	2
	<i>Crematogaster</i> sp.	1
	<i>Dolichoderus</i> sp.	1
	<i>Formica</i> sp.	1
	<i>Linepithema humile</i>	25
	<i>Leptogenys falcigera</i>	1
	<i>Leptothorax muscorum</i>	1
	<i>Monomorium destructor</i>	1
	<i>Paratrechina longicornis</i>	1
	<i>Pheidole</i> sp.	2
	<i>Plagiolepis alluaudi</i>	1
	<i>Solenopsis geminata</i>	1
	<i>Solenopsis molesta</i>	1
Gelechiidae	<i>Anarsia lineatella</i>	1
Gracillariidae	<i>Marmara gulosa</i>	15
	<i>Marmara</i> sp.	1
Gryllidae	Nemobiinae	1
	<i>Acheta domestica</i>	2
Helicidae	<i>Helix aspersa</i>	2
Hemerobiidae	Unknown sp.	1
Ichneumonidae	Unknown sp.	1
Ixodidae	<i>Amblyomma</i> sp.	1
	<i>Dermacentor variabilis</i>	1
Labiidae	Unknown sp.	1
Lampyridae	<i>Photinus</i> sp.	2
Largidae	<i>Largus</i> sp.	1
Latridiidae	Unknown sp.	2
Leiodidae	<i>Agathidium</i> sp.	1
Linyphiidae	Unknown sp.	4
Liposcelidae	<i>Liposcelis</i> sp.	1
Lumbicidae	<i>Fiscenia foetida</i>	1
Lygaeidae	<i>Cnemodus</i> sp.?	2
	unknown	1
Miridae	<i>Diplozona collaris</i>	1
	<i>Lygus</i> sp.	1
	Unknown sp.	3
Mordellidae	Unknown sp.	1
Mycetophagidae	<i>Typhaea stercorea</i>	3
Nabidae	<i>Nabis</i> sp.	1
Nitidulidae	<i>Carpophilus</i> sp.	2
	<i>Haptoncus mundus</i>	1

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Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	Unknown sp.	5
Noctuidae	<i>Agrotis ipsilon</i>	1
	<i>Autograph californica</i>	1
	<i>Euxoa auxiliaris</i>	2
	<i>Helicoverpa zea</i>	15
	Unknown sp.	3
None	None	1
Oonopiidae	Unknown sp.	1
Oribatida	Unknown sp.	1
Oxychilidae	<i>Oxychilus alliaris</i>	1
	<i>Oxychilus</i> sp.	1
Pentatomidae	<i>Brochymena arborea</i>	1
	<i>Brochymena cariosa</i>	1
Phalangidae	Unknown sp.	1
Phlaeothripidae	Unknown sp.	1
Phoridae	<i>Megaselia</i> sp.	1
Pseudococcidae	<i>Ferrisia consobrina</i>	1
	<i>Planococcus citri</i>	5
	<i>planococcus</i> sp.	1
	<i>Pseudococcus affinis</i>	10
	<i>Pseudococcus calceolariae</i>	3
	<i>Pseudococcus longispinus</i>	18
	<i>Pseudococcus</i> sp.	1
	<i>Pseudococcus viburni</i>	13
	Unknown sp.	1
	Unknown sp.	1
Psocidae	Unknown sp.	3
Pyralidae	<i>Amyelois transitella</i>	1
	<i>Cactoblastis cactorum</i>	1
	<i>Galleria mellonella</i>	1
	<i>Ostrinia nubilalis</i>	5
	<i>Plodia interpunctella</i>	2
	Unknown sp.	1
Pyrrhocoridae	<i>Dysdercus</i> sp.	1
Reduviidae	<i>Haematoloecha rubescens</i>	1
	Unknown sp.	2
Rhopalidae	<i>Arhyssus</i> sp.	1
	<i>Leptocoris trivittatus</i>	1
Salticidae	<i>Salticus</i> sp.	1
Scarabaeidae	<i>Protaetia orientalis</i>	1
Sciaridae	Unknown sp.	1
Scolytidae	Unknown sp.	1
Staphylinidae	Unknown sp.	3
Succineidae	<i>Succinea</i> sp.	1
Syrphidae	<i>Syrphus</i> sp.	1
Tenebrionidae	<i>Alphitobius diaperinus</i>	1

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Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	<i>Blapstinus histicus</i>	1
	<i>Tenebrio molitor</i>	1
	<i>Zophobas</i> sp.	1
Tenuipalpidae	<i>Tenuipalpus pacificus</i>	1
Tetranychidae	<i>Tetranychus</i> sp.	1
Theridiidae	Unknown sp.	1
Thomisidae	<i>Coriarachne versicolor</i>	1
Thripidae	<i>Chirothrips</i> sp. (poss. <i>manicatus</i>)	1
	<i>Frankliniella occidentalis</i>	3
	<i>Heliothrips haemorrhoidalis</i>	2
	<i>Thrips</i> sp.	1
Thripidae	<i>Thrips tabaci</i>	1
Tineidae	Unknown sp.	1
Tipulidae	Unknown sp.	2
Tortricidae	<i>Cydia deshaisiana</i>	10
	<i>Cydia pomonella</i>	3
	<i>Spilonota ocellana</i>	1
	Unknown sp.	5
Vespidae	<i>Vespula squamosa</i>	1
Zonitidae	<i>Retinella</i> sp.	1

1

1 **A17 CARGO**

2 This chapter summarizes statistics on foreign and domestic imports of fresh agricultural commodities
3 into Hawai'i and discusses them in the context of the associated pest risk. It should be noted that data
4 used to develop this section does not necessarily reflect the current situation. The most recent data
5 sources used for this section are from a 2007 compilation.

6 As Hawai'i is an island state, both international and domestic cargo arrives either by ship or—to a much
7 lesser degree—by aircraft. Approximately 80% of all goods (agricultural and non-agricultural) in Hawai'i
8 have to be imported, and 98% of these arrive in ocean vessels (Figures B6-1 and B6-2) (HDBEDT 2005a;
9 Hawai'iWeb 2007). According to official statistics, Hawai'i received 4.5 million tonnes of sea cargo from
10 domestic trade and 8 million tonnes from foreign trade in 2005 (U.S. Army Corps of Engineers 2005b).
11 However, these numbers do not tell the whole story, as the overwhelming majority of all foreign cargo is
12 not shipped from the exporting country directly to Hawai'i, but makes entry on the U.S. mainland first
13 and is then shipped from there to Hawai'i as domestic cargo (Kosciuk 2007). Information on the true
14 origin of much of this cargo gets lost. Furthermore, on arrival in Hawai'i, it becomes subject to a
15 different set of phytosanitary inspections than directly-shipped foreign cargo. This is because all foreign
16 imports are cleared by the DHS CBP at Honolulu Harbor or HNL on the island of Oahu (Kosciuk 2007),
17 whereas domestic shipments (including shipments of foreign origin arriving from the U.S. mainland) are
18 cleared by the HDOA. HDOA clears cargo at the following locations: Honolulu Harbor and HNL; Hilo
19 Harbor, Kawaihae Harbor, Hilo International Airport, and Kona International Airport at Keahole on the
20 island of Hawai'i; Kahului Harbor and Kahului Airport on the island of Maui; and Nawiliwili Harbor and
21 Lihue Airport on the island of Kauai (HDOA 2007b).

22

Figure B6-1: Honolulu Harbor



23

24
25
26

Source: Hawai'i Department of Transportation,
<http://www.hawaii.gov/dot/publicaffairs/index.htm>

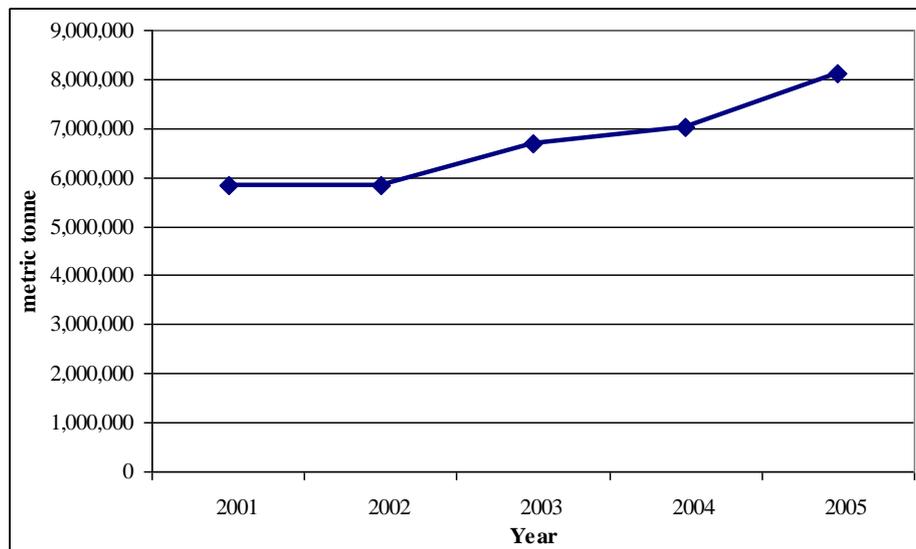
27 The volume of foreign imports to Hawai'i has been increasing over recent years (Figure B6-2) (HDBEDT
28 2005a). The majority of all containerized cargo enters Hawai'i through Honolulu Harbor (Table B6-1)

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1 (HDOT 2006), which, in 2005, received 4,395 inbound vessels ranging in draft²³ and type (e.g., dry cargo,
2 tanker, tow or tug). Of these, only 444 were of foreign origin, whereas 3,951 arrived from the U.S.
3 mainland (Table A17-1) (U.S. Army Corps of Engineers 2005a); not all of them were carrying commercial
4 cargo. One source reported that in 2005 the harbor received 1,121 overseas vessels carrying commercial
5 cargo (HDBEDT 2005a).

6 Most of the commercial cargo arriving by aircraft makes entry at HNL (Table A17-2), which receives the
7 bulk of both foreign and domestic air cargo, as well as foreign and domestic air mail (HDBEDT 2005a;
8 Kosciuk 2007). In 2005, over 9,000 international flights carried freight into the state, 94% of which was
9 received at HNL (Bureau of Transportation Statistics 2006); no statistics were available on the number of
10 domestic flights. Of domestic freight arriving in 2005, 94% entered through HNL (Table B6-2) (Bureau of
11 Transportation Statistics 2007).

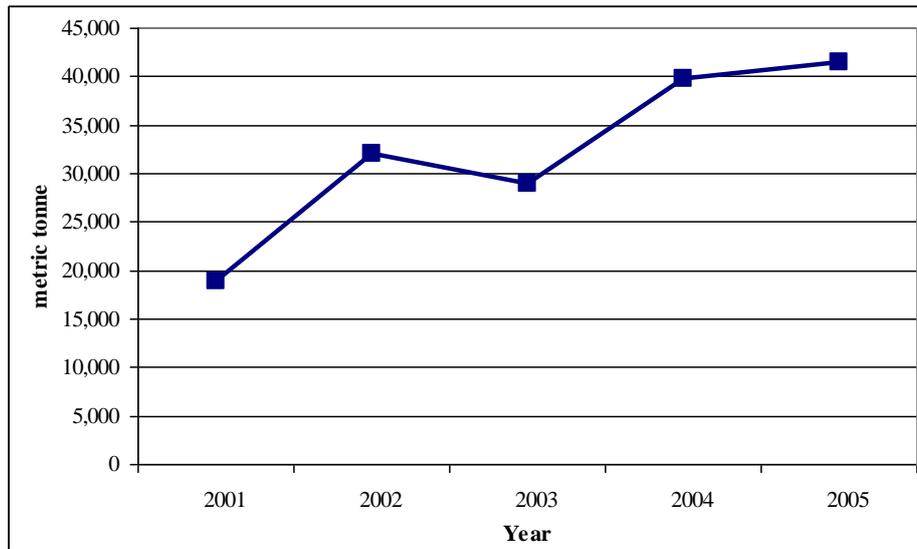
12 **Figure A17-1: Foreign Cargo (in Tonnes) Arriving in Hawai'i between 2000 and 2005 via**
13 **Maritime Vessels (top) and Aircraft (bottom)**



14

²³ Draft is defined as the depth of water necessary to float a vessel, and is usually measured in feet (U.S. Army Corps of Engineers, Navigation Data Center, U.S. Waterway Data, Data Dictionary, available at <http://www.iwr.usace.army.mil/NDC/data/dictionary.htm>. Last accessed 22 June 2007.)

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1

2

3

Source: HDBEDT 2005a

4 **Table A17-1: Foreign and Domestic Commercial Traffic Arriving at Hawai’ian Maritime Ports**
5 **in 2005**

Harbor	Number of Vessels Inbound ^a		Total Vessels Inbound	Cargo (tonnes) ^b		Total Cargo (tonnes)
	Foreign	Domestic		Foreign	Domestic	
Honolulu	444	3,951	4,395	5,625,453	12,440,224	18,065,677
Hilo	92	887	979	23,587	1,787,154	1,810,741
Kawaihae	5	872	877	0	2,010,321	2,010,321
Kahului	30	1,390	1,420	69,853	3,678,634	3,748,487
Barbers Point	73	1,264	1,337	1,956,798	3,601,523	5,558,321
Nawiliwili	79	659	738	1,814	1,791,690	1,793,504
Grand total	723	9,023	9,746	7,677,505	25,309,546	32,987,051

6 Source: U.S. Army Corps of Engineers 2005a

7 ^a Inbound self-propelled and non-self-propelled vessels, which include dry cargo, tanker, and tow or tug vessels
8 ranging in draft.

9 ^b Cargo includes agricultural and non-agricultural freight. Numbers were rounded.

10

11

1 **Table A17-2: Number of Aircraft and Passengers, and Amount of Cargo and Mail Arriving at**
 2 **Hawai’ian Airports in 2005**

Airport	Number of Aircraft		Number of Passengers		Cargo (tonnes) ^f		Mail (tonnes) ^f	
	Foreign Origin ^{a, c}	Domestic Origin	Foreign Origin ^{b, c}	Domestic Origin ^{d, e}	Foreign Origin ^c	Domestic Origin ^{d, e}	Foreign Origin ^c	Domestic Origin ^{d, e}
Honolulu	8,899	NA	2,067,067	781,897	63,736	42,919	354	4,696
Kahului	399	NA	52,741	315,530	4	2,191	0	0.24
Kona	389	NA	84,585	96,353	935	355	0	0.05
Grand Total	9,687	NA	2,204,393	1,193,780	64,675	45,465	354	4,696.29

- 3 NA Information not available.
- 4 ^a Flights into Hickam Air Force Base and Marine Corps Base Hawai’i were excluded. The total number of aircraft
- 5 that carried freight was 9,116, of which 8,912 carried both freight and passengers and 204 carried freight only.
- 6 The number of domestic flights was not available.
- 7 ^b Passengers in transit (100,172 passing through Honolulu International Airport) were excluded.
- 8 ^c Data source: Bureau of Transportation Statistics (2006).
- 9 ^d Data source: Bureau of Transportation Statistics (2007).
- 10 ^e Inter-island aircraft were excluded.
- 11 ^f Cargo includes agricultural and non-agricultural freight. Numbers were rounded.

13 When evaluating the risk of pest introduction through the import of agricultural commodities, it is useful
 14 to know the country of origin and the quantity of arriving commodities, as well as the types of pests
 15 associated with them and the likelihood that these pests are present on them. For this analysis, it was
 16 impossible to obtain much of this information due to a lack of suitable or reliable data.

17 Agricultural commodity imports from foreign origins are recorded by CBP in the USDA-APHIS-PPQ Fruit
 18 and Vegetables database (AQAS 2007). This database contains information on the type of commodity
 19 imported, number of shipments, quantity (with unit of measure), and country of origin. This database
 20 records only imports from foreign countries that have first made entry at a U.S. port; these imports, now
 21 classified as domestic (as mentioned above), fall outside the scope of the database. Beyond its scope are
 22 also all non-agricultural shipments (which nevertheless may present a considerable risk by harboring
 23 hitchhiking pests or pests in WPM; see Chapters B7 and B8). Regarding the quantity of commodity
 24 imports, the unit of measure differs depending on the commodity type. For example, for cut flowers the
 25 unit is usually number of stems, and more rarely kilograms; the unit is also kilograms for fruits and
 26 vegetables, whereas for propagative material, it may be number of plant units, or number of flasks. As
 27 these units are not interconvertible, any quantitative comparison among commodity types becomes
 28 impossible. The situation is even more difficult regarding number, size, and commodity type in domestic
 29 shipments, for which barely any information exists.

30 Although a greater number of shipments of agricultural commodities arrives in Hawai’i by aircraft as
 31 compared to maritime transport, these shipments are typically smaller in volume and weight as
 32 compared to agricultural shipments arriving by sea (discussed in more detail below) (AQAS 2007).
 33 Comparisons among the numbers of shipments from foreign origin entering Hawai’i does not take into
 34 account the size or weight of the shipment. For example, cut flower shipments accounted for about half
 35 of the agricultural shipments entering Hawai’i from foreign origin, yet these shipments are in general

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1 smaller (shipments varied from fewer than 100 stems to over 1,000 stems) than fruit and vegetable and
2 propagative plant shipments.

3 For pest interceptions on foreign shipments, a database, Pest ID, is maintained by APHIS-PPQ (USDA
4 2007a). From this database, it is possible to determine the kinds of pests that have been intercepted.
5 However, the information cannot be used for quantitative analysis because only pest interceptions are
6 recorded, leaving the number of inspected units and the inspection procedures unknown. Once a
7 quarantine pest is found in a commodity, the inspection is usually terminated, so that the severity of the
8 infestation, as well as additional pest species that may be present, remain unknown. Of special
9 relevance to this analysis is the fact that foreign shipments undergo phytosanitary inspection at the U.S.
10 port of first entry; this means that pest interceptions on foreign shipments that make entry at a U.S.
11 mainland port before being shipped to Hawai'i are recorded in the database under the name of that
12 port, making it impossible to identify them as ultimately being destined for Hawai'i.

13 Pest interceptions made by HDOA are recorded in one of two databases maintained by the HDOA Plant
14 Quarantine Branch (HDOA 2007c). These interceptions pertain to domestic shipments almost
15 exclusively; however, on occasion, HDOA inspects shipments of foreign origin, and, if interceptions are
16 made, they are recorded in the same databases. One database contains records for pathogens, the
17 other stores records for arthropods (Oishi 2007).

18 **A17.1 FOREIGN IMPORTS**

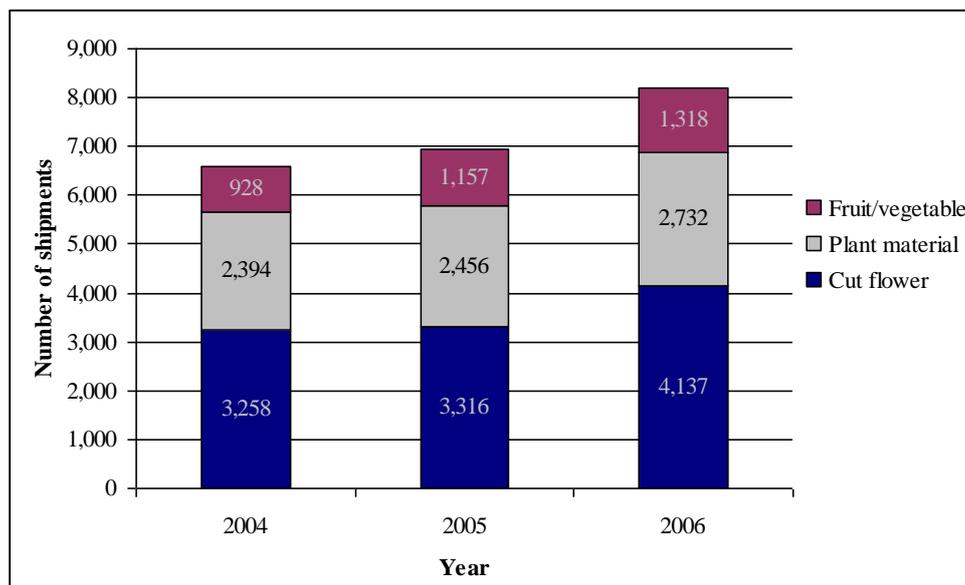
19 This section provides an overview of shipments of fresh agricultural commodities imported into Hawai'i
20 from foreign origins between January 1, 2004 and December 31, 2006. It should be noted that the data
21 presented here are an incomplete reflection of the actual import situation, because foreign imports are
22 commonly cleared at a port-of-entry on the U.S. mainland before proceeding to Hawai'i (Kosciuk 2007).
23 The commodities involved may undergo repackaging, and are often combined with commodities
24 produced in the United States (Kosciuk 2007), making it difficult to determine their true origin.

25 Such practices allow trade to circumvent the commodity risk assessment process (e.g., USDA 2000), the
26 purpose of which is to identify and mitigate pest risks associated with foreign imports. Perhaps for
27 reasons of expedience, Hawai'i is often neglected when risks to the United States associated with
28 importation of foreign commodities are assessed. Any rules or regulations resulting from these
29 assessments are likely not to pertain to Hawai'i, and the commodities are not permitted to be imported
30 directly into the state. However, under current practices, a commodity that was deemed a low pest risk
31 for the U.S. mainland, although representing a high risk for Hawai'i, would be enterable into the
32 mainland without undergoing any phytosanitary treatments, and subsequently could be sent on to
33 Hawai'i as part of a domestic shipment.

34 Between 2004 and 2006, almost 22,000 shipments of fresh agricultural commodities for consumption
35 (an average of approximately 7,000 shipments/year) arrived from 56 different countries at Hawai'ian
36 ports-of-entry (AQAS 2007). During this period, the number of shipments imported increased for each
37 major commodity category (Figure B6-3). Nearly 330 of these consignments were destroyed or re-

1 exported due to the presence of an actionable pest, a contaminant, or a discrepancy with the
2 phytosanitary certificate.

3 **Figure B6-3: Shipments of Fresh Agricultural Commodities Imported into Hawai'i between**
4 **2004 and 2006, by Commodity Type**



5

6 Source: AQAS 2007

7

8 Thailand, Japan, Indonesia, Canada, and Taiwan accounted for 90% of all incoming foreign agricultural
9 shipments (Figure A17-4). In addition to these nations, each of the following countries exported 100 or
10 more agricultural shipments to Hawai'i: Australia, China, the Cook Islands, Fiji, Malaysia, New Zealand,
11 the Philippines, Singapore, and South Korea. This comparison does not take into account the quantities
12 of the commodities received, as an inconsistency of units made a comparison across commodity types
13 impossible (Figure B6-5) (AQAS 2007). Thailand accounted for 54% of the total number of foreign
14 agricultural shipments; Japan, Indonesia, Canada, and Taiwan accounted for approximately 13%, 11%,
15 9%, and 3% of the agricultural shipments, respectively. The other 49 countries or territories exporting to
16 Hawai'i each accounted for less than 1% of the number of agricultural shipments (AQAS 2007).

17 Of the total number of agricultural shipments of foreign origin imported into Hawai'i, about half were
18 cut flowers originating from twelve countries (Figure A17-6). The majority of them (94%) came from
19 Thailand, with Japan and the Cook Islands each accounting for about 2%. The nine other countries, from
20 which cut flowers were imported, each accounted for less than 1% of the shipments. All cut flower
21 shipments arrived by aircraft (AQAS, 2007).

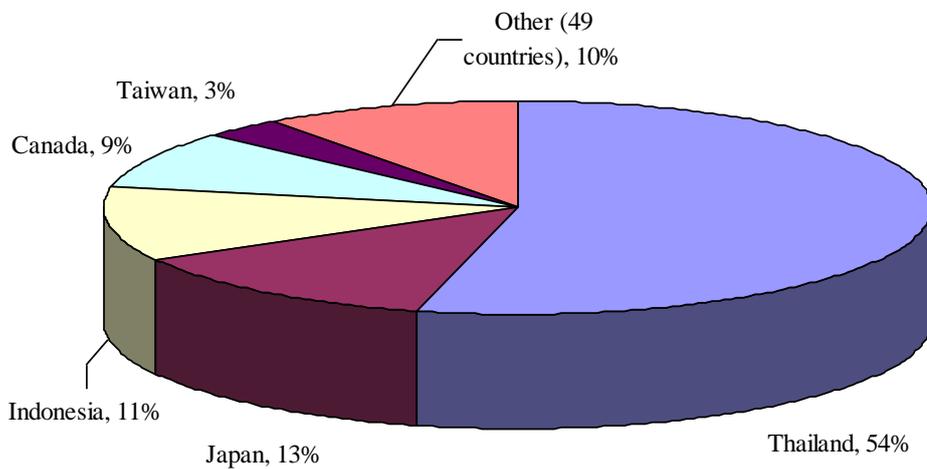
22 Shipments of propagative material, originating in 47 different countries, accounted for 35% of the total
23 number of agricultural shipments imported from foreign origins (Figure A17-6). The majority of these
24 shipments came from Indonesia (about 30%), Canada (about 26%), and Thailand (about 23%), whereas

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1 Taiwan and Singapore accounted for 6% and 3%, respectively. The other 42 countries and territories
2 each accounted for less than 2% of the total number of shipments. The majority of the propagative
3 material shipments (about 90%) entered Hawai'i by aircraft (AQAS 2007).

4 Shipments of fruits and vegetables, originating in 15 different countries, accounted for about 16% of the
5 agricultural shipments imported from foreign areas (Figure A17-5). The majority of these shipments
6 (about 75%) came from Japan. China, Fiji, New Zealand, South Korea, and Taiwan each contributed
7 between 3% and 7% of the imports. The other nine countries, from which fruit and vegetables were
8 imported, each accounted for less than 1% of the shipments. Most of these shipments (about 84%)
9 arrived via aircraft (AQAS 2007).

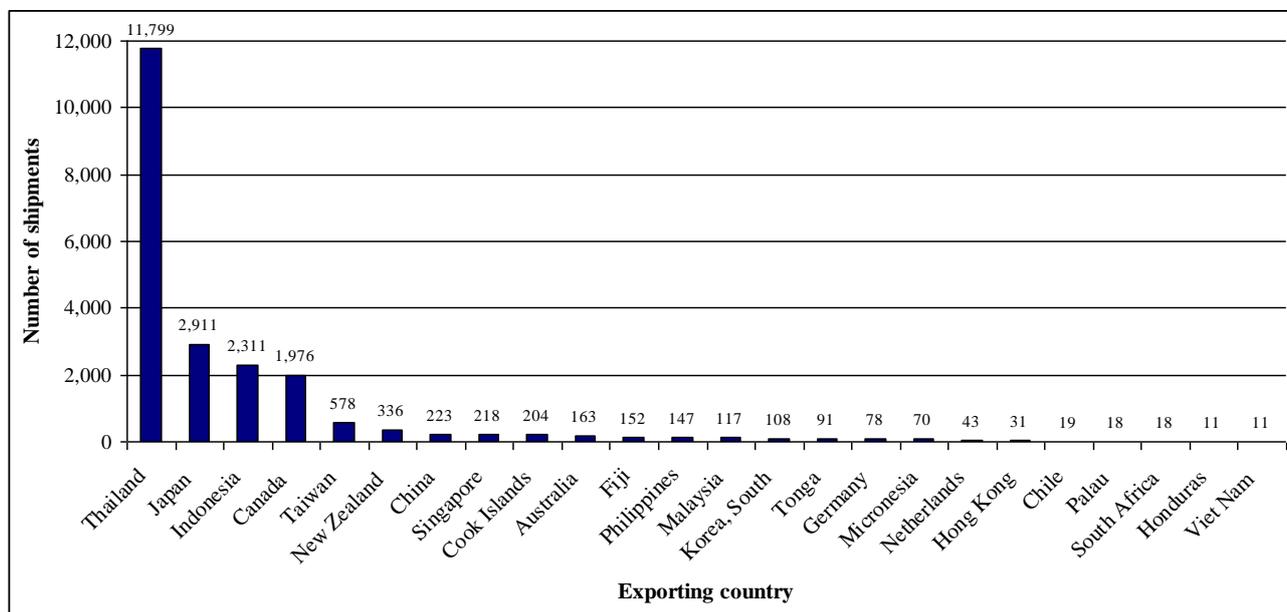
10 **Figure A17-4. Thailand, Japan, Indonesia, Canada, and Taiwan Accounted for 90% of the Fresh**
11 **Agricultural Shipments Entering Hawai'i between 2004 and 2006**



12

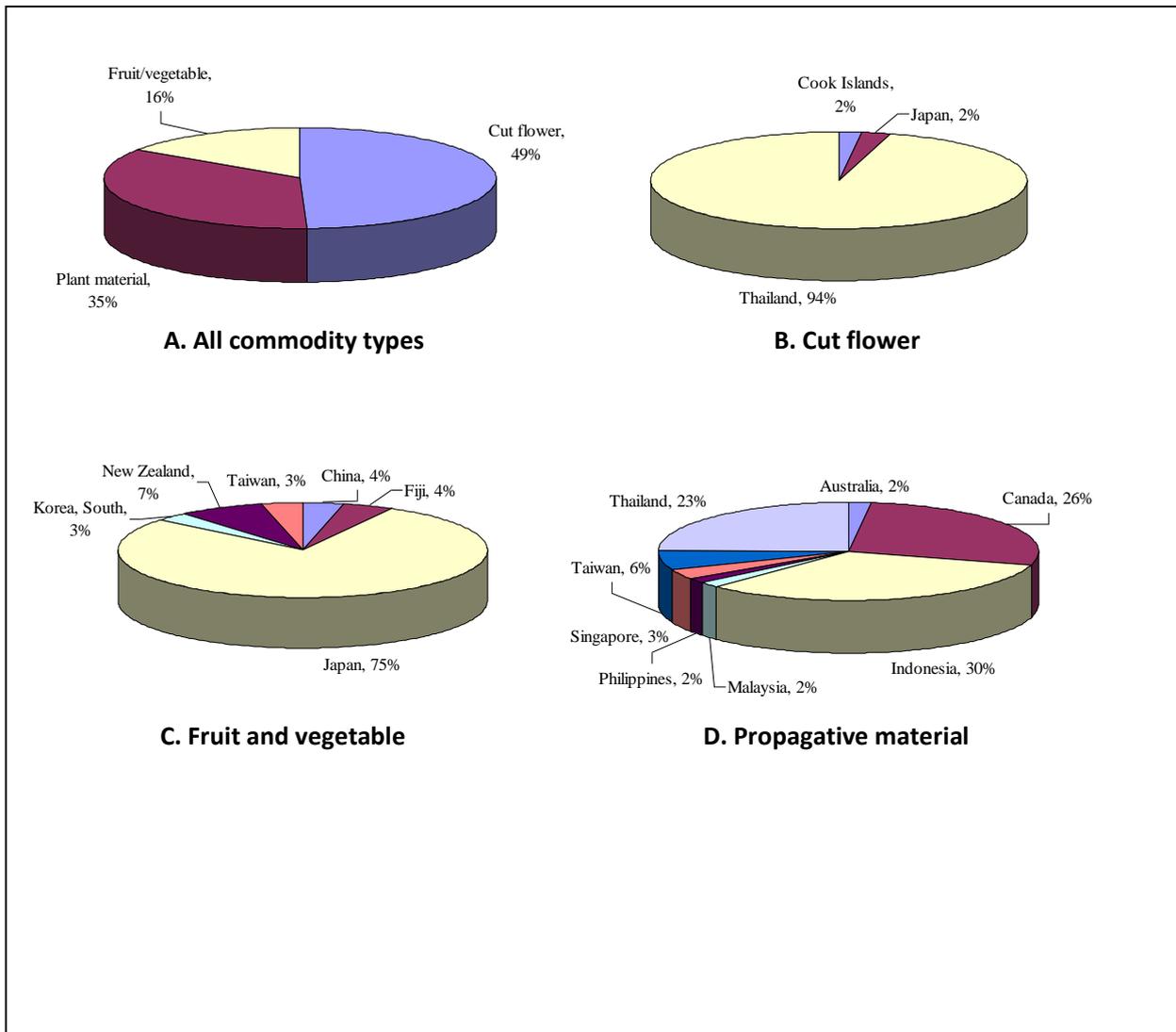
13 Source: AQAS 2007

1 **Figure A17-5: Number of Shipments (Air and Maritime) of Fresh Agricultural Commodities Exported to Hawai'i between January**
 2 **2004 and December 2006**



3
 4 Source: AQAS 2007
 5 Note: Only countries that shipped a total of ten or more shipments during this period are included.

1 **Figure A17-6: Number of Shipments of Fresh Agricultural Commodities of Foreign Origin**



2 **Imported into Hawai'i, January 1, 2004 to December 31, 2006**

3 Source: AQAS 2007

4 A=Percentage of shipments by commodity type.

5 B=Percentage of cut flower shipments by country of origin.

6 C=Percentage of fruit and vegetable shipments by country of origin.

7 D=Percentage of propagative material shipments by country of origin.

8

9 **A17.1.1 Imports from Thailand**

10 Fifty-four percent (54%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006
 11 originated in Thailand (Figure A17-4). All of these shipments arrived by aircraft (AQAS 2007). Cut
 12 flowers, mostly orchids (*Dendrobium* spp.), accounted for 85% of the shipments from Thailand. Most of

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1 the remaining 15% of the shipments contained over 100 different genera of plant propagative material.
2 Fruit and vegetable shipments (mostly fresh mushrooms) accounted for less than 1% of the shipments
3 (See Tables A25-1 and A25-2, at the end of this document).

4 During the same period, 229 reportable²⁴ pests were intercepted by CBP on agricultural commodities
5 from Thailand (Tables A25-1 and A25-2) (USDA 2007a). Of these interceptions, 215 (94%) were on cut
6 flowers, mostly orchids (*Dendrobium* spp.). The mollusc, *Succinea tenella* Morelet (Stylommatophora:
7 Succineidae), was the most commonly intercepted reportable pest from Thailand, entering on cut flower
8 shipments of *Dendrobium* spp. and other species in the orchid family (Orchidaceae). (This snail was also
9 the pest most frequently intercepted on agricultural cargo of foreign origin, in general, entering
10 Hawai'i.) Other reportable or actionable²⁵ pests intercepted included: *Spodoptera litura* (Fabricius)
11 (Lepidoptera: Noctuidae) on cut flowers of *Dendrobium* spp., other species of Orchidaceae, and the
12 lotus, *Nelumbo nucifera* Gaertn.; *Thrips palmi* Karny (Thysanoptera: Thripidae) (which is established in
13 Hawai'i) (Nishida 2002) on cut flowers of *Dendrobium* spp.; and *Sinoxylon conigerum* Gerstaecker
14 (Coleoptera: Bostrichidae) (also established, but actionable, in Hawai'i) on various non-agriculture items.

15 **A17.1.2 Imports from Japan**

16 Thirteen percent (13%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006
17 originated in Japan (Figure A17-4). The majority of the shipments (95%) arrived by aircraft (AQAS 2007).
18 Twenty-six different fruit and vegetable commodities accounted for 88% of the total shipments
19 exported from Japan. Cut flowers of 6 plant genera and other plant material of 40 genera accounted for
20 approximately 9% and 3%, respectively, of the agricultural shipments from Japan (Tables A25-1 and A25-
21 2).

22 All of the 14 reportable insect pests intercepted on agricultural cargo from Japan between 2004 and
23 2006 occurred in air shipments (USDA 2007a). Most of the pests were identified only to the family level.
24 Pests in the orders Lepidoptera and Thysanoptera, the families Aphididae, Plutellidae, Pyralidae
25 (Pyraustinae), Syrphidae, and Tortricidae, and the genera *Delia* and *Listroderes* were intercepted on
26 shipments of *Raphanus* (radish). A species belonging to the Crambidae (Pyralidae auct.) was intercepted
27 on a single shipment of cucumber, *Cucumis sativus*. Consignments of *Solanum* spp. harbored pests in the
28 Aphididae and Thripidae (Tables A25-1 and A25-2).

29 **A17.1.3 Imports from Indonesia**

30 Eleven percent (11%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006
31 originated in Indonesia (Figure A17-4). Almost all of these shipments contained plant material, with over
32 100 genera being represented. Two shipments of lumber products (less than 1% of the total shipments
33 from Indonesia) were exported to Hawai'i (Tables A25-1 and A25-2) (AQAS 2007).

34 All but 1 of the 83 reportable pests intercepted on agricultural shipments from Indonesia were found in
35 air cargo; only *Cryptotermes* sp. (Isoptera: Kalotermitidae) was found in maritime cargo, in a shipment of

²⁴ A reportable pest is one for which USDA–APHIS–PPQ may or may not require a treatment.

²⁵ An actionable pest is one for which PPQ always requires treatment.

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1 *Tectona grandis* L. f. (teak). Species of Colletotrichum, Phoma, and Cercospora were commonly
2 intercepted fungal pathogens. A majority of the insect pests were not identified to the genus level; they
3 included pests in the Aleyrodidae, Aphididae, Pseudococcidae, other Homoptera, and Tortricidae.
4 *Succinea* sp. and other unidentified molluscs were also intercepted on agricultural shipments from
5 Indonesia (Tables A25-1 and A25-2) (USDA 2007a).

6 **A17.1.4 Imports from Canada**

7 Nine percent (9%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in
8 Canada (Figure A17-4). These shipments contained mainly plant material (about 100 genera, accounting
9 for 98% of Canada's agricultural shipments), with the remaining 2% being fruit and vegetables (Tables
10 A25-1 and A25-2) (AQAS 2007).

11 No reportable or actionable pests were intercepted on cargo coming from Canada between 2004 and
12 2006 (USDA 2007a).

13 **A17.1.5 Imports from Taiwan**

14 Three percent (3%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated
15 in Taiwan (Figure A17-4). Plant material from approximately 50 genera accounted for about 80% of the
16 exports from Taiwan. The other 20% were fruit and vegetable products, such as bamboo, burdock, and
17 mushrooms (Tables A25-1 and A25-2) (AQAS 2007).

18 No reportable pests were intercepted on commercial cargo from Taiwan between 2004 and 2006 (USDA
19 2007a).

20 **A17.1.6 Pest Approach Rates in Foreign Shipments of Perishable Cargo Arriving by Aircraft**

21 AQIM data collected by CBP and containing records for the period October 2005 to April 2007, were
22 used to estimate the pest approach rate on perishable air. The data were collected at HNL following
23 port-specific standard operating procedures (Area Port of Honolulu 2005; 2006), as well as general
24 instructions in the USDA AQIM handbook (USDA 2006a). Two shipments were inspected per week.
25 During FY 2005, cut flowers were not included in the samples, whereas during FY 2006, cut flowers
26 represented half of the samples. The samples were selected based on a random sampling scheme. Table
27 B6-3 lists the relative frequencies of the countries of origin of the sampled shipments. Japan was the
28 origin of 65% of the shipments. Several other countries contributed small percentages of the shipments.
29 Most shipments were mixed, with several different commodities being listed on the manifests.

30 Of the 165 inspections that were recorded in the AQIM data set, 6 resulted in interceptions of pests
31 (Table B6-4). This yields an estimate of between 1.4% and 7.8% of air cargo shipments arriving at the
32 port of Honolulu accompanied by live pests. With one exception, *Thrips tabaci* Lindeman, which is
33 known to occur in Hawai'i (Nishida 2002), the intercepted pests were not identified to species.

Table A17-3: Countries of Origin of Randomly Selected Samples of Air Cargo Entering Hawai'i, October 2005 to April 2007

Country of Origin	Number of Samples	Percent of Total Samples
Australia	2	1.2
Canada	4	2.4
China	2	1.2
Fiji	3	3.6
Japan	108	65
Korea, South	1	0.6
New Zealand	14	8.4
Philippines	5	6.0
Taiwan	12	7.2
Thailand	13	7.8
USA	1	0.6
Grand Total	165	100

Source: AQIM

Table A17-4: Pests Intercepted on Air Cargo during AQIM at HNL between October 2005 and April 2007

Date	Origin	Infested Commodity	Pest
25-Oct-05	Japan	Eggplant	Thysanoptera, species of
28-Feb-06	Taiwan	Oriental Radish	Thysanoptera, species of
4-Oct-06	New Zealand	Asparagus	<i>Thrips tabaci</i> ; <i>Apterothrips</i> sp.
23-Oct-06	New Zealand	Asparagus	Acari, species of
7-Nov-06	Japan	Eggplant	Thysanoptera, species of
19-Dec-06	Japan	Strawberry	Lygaeidae, species of; Aphididae, species of

Note: Total sample size: 165.

A17.2 DOMESTIC IMPORTS

A large portion of the shipments of fresh agricultural products entering Hawai'i comes from the U.S. mainland (Table A25-3, at the end of this document). As mentioned previously, foreign shipments may be cleared on the U.S. mainland and then shipped domestically (Kosciuk 2007). These shipments may be repackaged and even mixed with commodities of U.S. origin (Kosciuk 2007). Such practices may compromise Hawai'i's phytosanitary security and increase risks of pest introduction. HDOA has authority to inspect agricultural commodities only, which means that its PQ inspectors are not allowed to hold mixed shipments manifested as "freight of all kinds" for inspection. In the absence of an explicit mention of agricultural commodities on the manifest, PQ inspectors can inspect a shipment only if it is referred to them by other agencies (Oishi 2007). Moreover, PQ does not have authority to hold shipments containing wood packaging material for inspection unless the manifest indicates the presence of agricultural commodities (Oishi 2007). Shipments transported by commercial carriers, such as FedEx and UPS, are often cleared at facilities on the mainland prior to entering Hawai'i (Oishi 2007). Frequently, the U.S. state, from which a commodity originated, is unknown, especially since commodities may be

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1 combined at distribution centers. Thus, it is difficult to ascertain the true origin of agricultural
2 shipments.

3 As noted above, PQ maintains two databases, that record arthropods and pathogens, intercepted on
4 commodities arriving from the U.S. mainland (HDOA 2007c). PQ inspectors typically do not inspect
5 agricultural commodities of foreign origin. However, on rare occasions when such inspections are
6 performed on foreign shipments, any pest interceptions made are recorded in the databases (Oishi
7 2007). From these databases, data were extracted only for pests intercepted on or in the following
8 sources: domestic and foreign air cargo, domestic and foreign ship cargo, amnesty programs
9 (commodities surrendered voluntarily upon arrival), baggage from domestic and foreign flights, private
10 ship's stores, air express, military air carriers, FedEx and UPS packages, and U.S. mail or post office
11 facilities. Although the pest status (present or absent) in Hawai'i was provided with each interception
12 record, the status was briefly re-evaluated by consulting databases maintained by the B.P. Bishop
13 Museum in Honolulu (<http://hbs.bishopmuseum.org/hbsdb.html>), other online databases, and the
14 scientific literature, and adjustments were made as needed. The summary of pest interceptions
15 discussed below does not include all of the pests PQ intercepted between 2004 and 2006; rather, only
16 those interception records that pertained to the source categories specified above were used.

17 PQ Specialists intercepted 1,583 specimens of plant pests (arthropods and pathogens), representing at
18 least 140 species not known to occur in Hawai'i, on shipments arriving from the U.S. mainland between
19 2004 and 2006 (Table B6-5, Table A25-3) (HDOA 2007c). Many of the pests intercepted (about 290
20 records) were not identified to genus or species, and it is likely that at least some of them are not
21 present in Hawai'i. Pests were intercepted on agricultural commodities shipped domestically, which
22 actually originated in a foreign country (Table B6-6, Table A25-3). Although their authority to inspect
23 mail facilities is limited (Oishi 2007), between 2004 and 2006, PQ Specialists intercepted 35 pests
24 (identified to species) not yet established in Hawai'i on the mail pathway, which includes the categories
25 FedEx, Air Express, and USPS (Table A17-7, Table A25-3).

26 In order to calculate approach rates of pests associated with commodities or conveyances (e.g., ships,
27 aircraft, containers) from the U.S. mainland, data concerning the total number of conveyances or
28 commodities inspected and the total number contaminated with a pest are needed. These data were
29 not available for the domestic pathways.

30

1 **Table A17-5: Number of Pests Not Known to Occur in Hawai'i Intercepted on Various**
 2 **Pathways by HDOA PQ Specialists between January 1, 2004 and December 31, 2006**

Pathway	Number of Pests ^a Intercepted
Air cargo ^b	1,249
Amnesty bin ^c	2
Baggage ^d	25
Container yard ^e	3
FedEx, Air Express ^f	34
Military air cargo	1
Private ship's stores, domestic	1
Ship's cargo ^g	267
USPS	1
Total	1,583

3 Source: HDOA 2007c

4 ^a Only records, in which the pest was identified to species, are included in this table. It is possible that some of
 5 the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those
 6 records were omitted.

7 ^b Air cargo = cargo arriving by aircraft from the U.S. mainland.

8 ^c Amnesty bin = pests found on commodities surrendered voluntarily by aircraft passengers on domestic flights.

9 ^d Baggage = pests found on an agricultural commodity carried in air passenger baggage.

10 ^e Container yard = pests intercepted on agricultural commodities awaiting distribution.

11 ^f FedEx, Air Express = pests intercepted from packages containing agricultural commodities transported by this
 12 commercial carrier.

13 ^g Ship's cargo = pests intercepted on agricultural commodities transported by ship from the U.S. mainland. This
 14 category combines records under the database fields 'ship cargo' and 'routine overtime,' since routine
 15 overtime records are interceptions made on ship's cargo.
 16
 17

1 **Table A17-6: Pests Not Known to Occur in Hawai'i that were Detected Entering the State**
 2 **through Domestic Pathways with Commodities of Foreign Origin between January 1, 2004**
 3 **and December 31, 2006**

Origin	Origin Specified on the Package	Where Intercepted	Pest ^a	Number of Records
Australia	Not specified	Protea (cut flower)	<i>Aspidiotus nerii</i>	2
Colombia	California, Florida, not specified	Carnation	<i>Cladosporium echinulatum</i>	4
	California, Florida, Georgia, not specified	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	8
	California	Aster	<i>Coleosporium asterum</i>	2
Colombia (suspected)	California	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	1
Ecuador	Not specified	Banana	<i>Dysmicoccus texensis</i>	2
	Florida	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	1
	Georgia	Carnation	<i>Cladosporium echinulatum</i>	2
	California, Florida, Ecuador	<i>Hypericum</i> sp.	<i>Uromyces triquetrus</i>	7
Guam	Not specified	Not specified	<i>Protoetia pryeri</i>	1
Italy	Not specified	Citrus	<i>Aonidiella aurantii</i>	2
Japan	Guam (Anderson Air Force Base)	Cargo deck	<i>Popillia japonica</i>	1
Mexico	Not specified	Papaya	<i>Papaya ring spot virus</i>	1
	California, not specified	Pepper	<i>Bactericera cockerelli</i>	2
	California	Citrus	<i>Aonidiella aurantii</i>	2
			<i>Marmara gulosa</i>	1
South America	California	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	2
South or Central America	Not specified	Banana	<i>Dysmicoccus texensis</i>	1
Total				32

4 Source: HDOA 2007c

5 ^a Only records, in which the pest was identified to species, are included in this table. It is possible that some of
 6 the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those
 7 records were omitted.
 8

9 **Table A17-7: Pests Not Known to Occur in Hawai'i that were Detected Entering the State via**
 10 **the Mail Pathway (FedEx, Air Express, USPS) between January 1, 2004 and December 31, 2006**

Pathway	Origin	Package Labeled From	Where Intercepted	Pest Intercepted ^a	Number of Records
Air Express	Not specified	Not specified	Hypericum	<i>Uromyces triquetrus</i>	2
			Impatiens	<i>Myrothecium roridum</i>	1
	California	California	Bouquet, mixed	<i>Puccinia helianthi</i>	1
			Sunflower	<i>Puccinia helianthi</i>	1
	Florida	Florida	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	1
	California	California	<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	1
Sunflower			<i>Puccinia helianthi</i>	7	

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Pathway	Origin	Package Labeled From	Where Intercepted	Pest Intercepted ^a	Number of Records
			Hypericum	<i>Uromyces triquetrus</i>	1
		Nevada	Sunflower	<i>Puccinia helianthi</i>	1
	Ecuador	Florida	Hypericum	<i>Uromyces triquetrus</i>	1
	Florida	Not specified	Aster	<i>Coleosporium asterum</i>	1
			Hypericum	<i>Uromyces triquetrus</i>	1
		Florida	Anthurium	<i>Myrothecium roridum</i>	1
			Gladiolus	<i>Uromyces transversalis</i>	1
			Hypericum	<i>Uromyces triquetrus</i>	1
			Salal	<i>Phyllosticta gaultheriae</i>	2
			<i>Solidago</i> sp.	<i>Coleosporium asterum</i>	1
Illinois	Illinois	Impatiens	<i>Myrothecium roridum</i>	2	
FedEx	California	California	Basil	<i>Diabrotica undecimpunctata</i>	1
	Florida	Not specified	Greens	<i>Cameraria gaultheriella</i>	1
			Salal	<i>Cameraria gaultheriella</i>	3
U.S. Mail	Texas	Not specified	Box	<i>Centruroides vittatus</i> (scorpion)	1
Total					35

1 Source: HDOA 2007c

2 ^a Only records, in which the pest was identified to species, are included in this table. It is possible that some of
3 the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those
4 records were omitted.

6 **A17.3 SUMMARY**

- 7 • Hawai'i imports approximately 80% of its goods (both agricultural and non-agricultural).
- 8 • Between 2004 and 2006, over 21,000 shipments of fresh agricultural commodities for
9 consumption from 56 countries arrived at ports-of-entry in Hawai'i.
- 10 • Cut flowers accounted for half of the agricultural shipments arriving from foreign areas of
11 origin.
- 12 • Most foreign and domestic shipments of fresh agricultural commodities arrive by aircraft.
- 13 • Consignments of agricultural commodities of foreign origin may be cleared at a port-of-
14 entry on the U.S. mainland then shipped to Hawai'i manifested as domestic cargo.
- 15 • Hawai'i imports many of its fresh agricultural commodities from the U.S. mainland.
- 16 • Quarantine pests are routinely intercepted on foreign imports.
- 17 • HDOA PQ has intercepted pests not known to occur in Hawai'i on domestic shipments of
18 fresh agricultural commodities. Some of these imports were actually of foreign origin.
- 19 • PQ does not have authority to inspect domestic shipments manifested as "freight of all
20 kinds" or WPM accompanying non-agricultural shipments.

1 **A18 “HITCHHIKERS”**

2 In the context of this analysis, a hitchhiker pest is defined as a pest present on a conveyance or shipping
3 container, but not directly associated with a commodity. Hitchhiker pests may have originally entered
4 the conveyance or container on a commodity and remained behind after unloading, or may have
5 entered the cargo hold on their own, e.g., an insect flying in during loading (Caton 2003; Caton et al.
6 2006). Loading at night has been found to lead to higher pest incidence in aircraft cargo holds than
7 loading during daytime, primarily because pests are attracted to lights at night (Caton 2003).

8 The scientific literature mentions numerous cases of hitchhiker pests that have arrived in new areas in
9 cargo holds, aircraft cabins, or shipping containers (e.g., Dale and Maddison 1984; Smith and Carter
10 1984; Takahashi 1984; Gadgil et al. 2000; Gadgil et al. 2002). For example, four species of Noctuidae and
11 several species of Coleoptera and Homoptera are thought to have arrived in Guam in the 1980s as
12 hitchhikers in the holds or cabins of aircraft (Schreiner 1991); the oriental fruit fly is believed to have
13 been brought to Hawai'i in military aircraft from the Mariana Islands during World War II (Swain 1952);
14 and the psyllid, *Heteropsylla cubana* Crawford, was introduced into Hawai'i in the holds of cargo planes
15 (Schreiner 1991).

16 The objective of this chapter is to evaluate the likelihood that exotic hitchhiker pests arrive in Hawai'i on
17 air or maritime cargo conveyances or containers. A lack of suitable data made quantitative analysis
18 difficult; therefore, risk is discussed mainly in qualitative terms.

19 Pest survival in conveyances and containers depends on the combined effects of various conditions,
20 such as temperature, relative humidity, and duration of transport. In modern commercial aircraft, cargo
21 holds are pressurized and heated, generally maintaining a temperature of about 15°C (60°F)
22 (Anonymous airline pilots ("Answerer 8" and "Answerer 11") 2007). Even when not actively heated, hold
23 temperatures after about 8 hours flying at altitude are approximately 7°C in some types of aircraft
24 (Anonymous airline pilots ("Answerer 8" and "Answerer 11") 2007). Similar information for commercial
25 maritime vessels was not available, but in cargo holds that contain fresh fruits or vegetables, or live
26 plants, the temperature would obviously have to be above freezing.

27 Most insect pests would be able to survive these conditions for several hours, as is corroborated by the
28 fact that APHIS-PPQ and CBP have intercepted over 1,000 live reportable pests in aircraft cargo holds or
29 cabins²⁶ at U.S. airports since 1990 (Table A25-4, at the end of the document) (USDA 2007a), and
30 hitchhiker pests intercepted in aircraft cargo holds and stores make up 3% of quarantine-significant
31 pests intercepted on aircraft (including interceptions in cargo and passenger baggage) nationwide
32 (Caton et al. 2006; USDA 2007a). A study by Russell (1987) reported very high survival rates of
33 mosquitoes (*Culex quinquefasciatus* Say), house flies (*Musca domestica* L.), and flour beetles (*Tribolium*
34 *confusum* Jacquelin Du Val) in unpressurized wheel bays of modern Boeing 747B aircraft at altitudes
35 greater than 10,500 meters. The study found that the temperature in the wheel bays ranged from 8°C to
36 25°C, even though the outside temperature was between -42° and -54°C. Aircraft disinfection, while

²⁶ Aircraft may have been passenger aircraft or cargo aircraft, or a combination of the two. Unreliable records and records for military aircraft were excluded.

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1 employed by some countries to reduce the spread of mosquitoes and other human disease vectors
2 (Centers for Disease Control 2007), is not performed by the United States on arriving flights (Kosciuk
3 2007).

4 At Hawai’ian airports, eight live reportable pests—all adult insects—have been intercepted in aircraft
5 cargo holds or cabins of international flights since 1990 (Table A18-1) (USDA 2007a). Between 2003 and
6 2005, an average of approximately 26 international flights²⁷ arrived in Hawai’i every day (Bureau of
7 Transportation Statistics 2006). However, the proportion of flights, where the cargo holds were
8 thoroughly inspected by APHIS-PPQ or CBP, is unknown. Given the fact that the total sample size for
9 interceptions is unknown, and several other significant data quality problems associated with PPQ/CBP
10 pest interception records, the available information does not lend itself to reliable quantitative analysis.

11 Flights from the mainland carrying cargo of U.S. origin are not pre-cleared by APHIS and are not
12 inspected by CBP upon arrival (Kosciuk 2007). At the same time, HDOA’s PQ does not routinely inspect
13 aircraft cargo holds or cabins (Oishi 2007). Thus, there are no interception records or other data that
14 could help quantify the pest risk posed by this pathway.

15 A number of scientific publications report finds of live quarantine pests in aircraft cabins (e.g., Evans et
16 al. 1963; Goh et al. 1985) and air cargo holds (e.g., Evans et al. 1963; Caton 2003; Dobbs and Brodel
17 2004). Goh et al. (1985) found that 17% of 330 arriving aircraft examined at Changi International Airport,
18 Singapore, harbored mosquitoes and other insects in the cabin. In a 5-year study at the Manila
19 International Airport in the Philippines, Basio et al. (1970) inspected over 14,000 airplanes, detecting
20 more than 700 pests, including live mosquitoes. Evans et al. (1963) found an average of one pest per
21 baggage compartment (cargo hold) and 19 pests per cabin on aircraft arriving in Honolulu, and
22 Rainwater (1963) found live agricultural pests on 16 of 2,662 aircraft arriving in Hawai’i from foreign
23 countries. At the Miami International Airport, Florida (MIA), inspections of the cockpit, galleys, exterior
24 of palletized cargo, and cargo holds of 730 aircraft resulted in the detection of 151 insects from 33
25 families in five orders, along with one plant pathogen (*Xanthomonas axonopodis* pv. *citri* [Hasse]
26 Vauterin et al.) (Dobbs and Brodel 2004). The estimated pest approach rate for foreign cargo aircraft
27 arriving at MIA was 10.4% (Dobbs and Brodel 2004). Caton (2003) reported an average of two flights
28 daily arriving at MIA from Central and South America with quarantine pests in their cargo holds,
29 estimating that one pest species per year would become established in Florida (escape detection and
30 control, find a host plant, and produce offspring) from flights originating from Central America.

31

²⁷ Flights arriving at Hickam Air Force Base and Marine Corps Base Hawai’i were omitted.

1 **Table A18-1: Reportable Pests Intercepted at Ports-of-entry in Hawai'i in Cargo Holds or**
 2 **Cabins of Aircraft of Foreign Origin, January 1, 1990–June 19, 2007**

Port-of-entry	Origin	Destination	Reportable Pest Intercepted
HI Honolulu PIS PPQ	Guam	--	<i>Adoretus sinicus</i> Burmeister (Scarabaeidae)
HI Honolulu PIS PPQ	Korea, South	Hawai'i	<i>Anomala</i> sp. (Scarabaeidae)
HI Honolulu PIS PPQ	Japan	--	<i>Spodoptera</i> sp. (Noctuidae)
HI Honolulu PIS PPQ	Japan	--	<i>Melolontha</i> sp. (Scarabaeidae)
HI Honolulu PIS PPQ	Guam	Hawai'i	Pyralidae, species of
HI Honolulu PIS PPQ	Japan	--	Cicadidae, species of
HI Honolulu PIS PPQ	Unknown	Hawai'i	Lepidoptera, species of
HI Kailua-Kona CBP	Mexico	Hawai'i	<i>Calligrapha</i> sp. (Chrysomelidae)

3 Source: USDA 2007a

4 Note: Unreliable records and records pertaining to military aircraft were omitted.

5
 6 In addition to the conveyances themselves, shipping containers may also harbor hitchhikers. Shipping
 7 containers vary in size and shape, and may be composed of plastic, metal, or other materials (or a
 8 combination of materials) (Figures A18-1 and A18-2). A single container may contain multiple shipments.
 9 Pests, including arthropods, molluscs, and weeds, have been found on the outside, as well as the inside,
 10 of shipping containers.

11 **Figure A18-1: Commercial Shipping Containers**

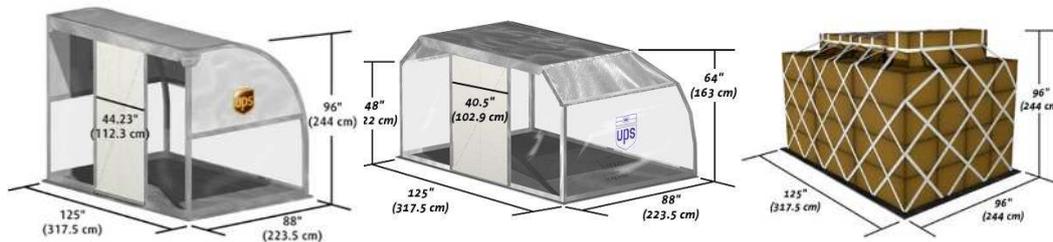


12
 13 Source: Gallmeister Internationale Spedition, <http://www.ingo-gallmeister.de>

14 Note: Both 20-foot- and 40-foot-long containers are depicted.

15

1 **Figure A18-2: Examples of Some Shipping Containers Used for Commercial Shipments via**
2 **Aircraft**



3
4 Source: USPS at <http://www.ups.com>
5 Note: Air shipping containers differ in size and shape (left and center), and may not be completely enclosed
6 (right).
7

8 Gadgil et al. (2000) inspected the exterior of 3,681 shipping containers arriving at New Zealand maritime
9 ports and found that approximately 39% were contaminated, with soil on the container bottoms being
10 the most common contaminant (31% of the containers). Fungi of taxa containing plant pathogens were
11 isolated from 83% of the soil samples; species of *Fusarium* were commonly isolated. Nematodes, of
12 which 4% were quarantine organisms for New Zealand, were isolated from 81% of the soil samples.
13 Foliage and woody material were the next common contaminants. Also, egg masses of gypsy moth,
14 *Lymantria dispar* (L.), were found on shipping containers. The authors estimated that containers from
15 South Africa had the highest rate of contamination (50%), followed by the Pacific islands (47.5%).
16 Containers from the Far East (Japan and elsewhere in East Asia) had a contamination rate of 13%. An
17 annual minimum of 36,000 contaminated containers was estimated to be entering New Zealand.

18 In another study, involving sea cargo containers arriving at Australian ports, Stanaway et al. (2001)
19 surveyed wooden components of the containers for pests, in particular, timber-infesting insects. A total
20 of 7,861 arthropods was found on or in the 3,001 containers inspected. Although no live exotic timber-
21 feeding insects were found in the containers' wooden floors, insects with the potential to infest timber
22 were found in 3.5% of the containers. In addition, 11% of the containers had insects considered stored-
23 product pests that were quarantine organisms for Australia. The authors concluded that the risk
24 associated with untreated wooden components of containers is not negligible because of the high
25 volume of container traffic and the frequency with which containers come into contact with timber
26 pests.

27 After inspecting 991 air cargo containers arriving at airports in New Zealand, Gadgil et al. (2002)
28 determined that the exterior, including the bottom, of the containers was generally clean, whereas, on
29 the inside, they found contaminants, mostly fresh leaves and twigs, in 24% of the cases. Fungi were
30 found in soil contaminating 3% of the examined containers. The detection of fresh plant material
31 containing pests, coupled with the fact that newly introduced pests have been found in close vicinity to
32 airports, led the authors to conclude that air cargo containers may provide a pathway by which exotic
33 organisms can become established.

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1 In 2006, Hawai'i received more than 1.4 million twenty-foot equivalent containers, loaded or empty, at
 2 its maritime ports from foreign or domestic origins (Table A18-2). We do not have any information on
 3 the number of air cargo containers received, which would also include most FedEx and UPS shipments.

4 If we assume a contamination rate of 10%, with 1% of the contaminants being or including quarantine
 5 organisms, and 1% of these organisms being able to establish populations in Hawai'i, we arrive at an
 6 estimate of 13 pest establishments per year from sea cargo containers alone.

7 **Table A18-2: Number of Containers Arriving from Foreign and Domestic Origins at Hawai'i**
 8 **Maritime Ports in 2006**

Port	Number of TEU ^a	Number of Boxes ^b	Containerized Cargo (tonnes)
Hilo	64,499	38,380	424,286
Honolulu	1,113,789	647,755	6,171,258
Kahului	140,147	84,053	933,715
Kaunakakai	2,984	2,413	16,133
Kawaihae	102,897	58,884	620,499
Total	1,424,316	831,485	8,165,891

9 Source: American Association of Port Authorities 2006

10 ^a TEU=Twenty-foot equivalent units (loaded and empty).

11 ^b Containers regardless of length.

12

13 **A18.1 SUMMARY**

- 14 • Aircraft cargo holds and cabins, as well as shipping containers, can harbor pests.
- 15 • Aircraft have been implicated in introducing pests into new areas.
- 16 • Inspections of aircraft cargo holds and cabins are not a common practice by either APHIS-
 17 PPQ or HDOA PQ.
- 18 • PQ inspectors do not have authority to inspect containers (neither the container surfaces
 19 nor the shipments within the container) transporting only non-agricultural commodities
 20 unless the presence of BTS is suspected or CBP refers a container to them.
- 21 • Cargo containers used in maritime shipments also are a viable pathway for the introduction
 22 of pests.
- 23 • As many as 13 pest establishments from sea cargo containers alone may occur in Hawai'i
 24 every year.

1 **A19 WOOD PACKAGING MATERIAL**

2 Wood packaging material (also known as solid-wood packing material or WPM), including dunnage,
3 crating, pallets, packing blocks, drums, cases, and skids, is used all over the world in shipments of both
4 agricultural and non-agricultural products. As it is not mandatory for importers to indicate the presence
5 of WPM on shipping manifests, port officers have to rely almost exclusively on their experience and on
6 random checks when selecting shipments, especially of non-agricultural commodities, for WPM
7 inspection (Meissner et al. 2003). Because WPM is routinely re-used and re-conditioned, its origin is not
8 necessarily the same as the origin of the commodity with which it is imported (e.g., WPM in a shipment
9 from Canada could easily have originated in some other country, such as Australia). On September 16,
10 2005, the United States started enforcing the International Plant Protection Convention’s standard ISPM
11 #15, “Guidelines for Regulating Wood Packaging Material in International Trade” (IPPC 2006). This
12 standard requires fumigation or heat treatment for all WPM entering the United States. While it is the
13 purpose of ISPM #15 to reduce the pest risk posed by WPM, there are no conclusive data available
14 showing that this objective is actually being met.

15 Hawai’i receives a variety of imports with WPM from numerous countries. It is difficult to quantify
16 exactly how much WPM is arriving and from where. The only information available for this purpose was
17 an AQIM data set containing records for the period between October of 2005 and April 2007. These data
18 represent the results of WPM inspections in maritime cargo. They were collected at the Honolulu
19 maritime port following port-specific standard operating procedures (Higa 2004) and general
20 instructions in the USDA AQIM Handbook (USDA 2006a). Two shipments were inspected per week. The
21 samples were selected by choosing one container from the first two entries each Monday. Sampling was
22 not limited to agricultural commodities, but included non-agricultural shipments as well. As the
23 selection of samples was thus randomized, the relative frequency of countries of origin (Table A19-1)
24 and commodities (Table A19-2) represented in the AQIM data set should be similar to their relative
25 frequency in the entire population of shipments entering the port of Honolulu. Almost 40% of the
26 shipments with WPM originated in China, and about 20% came from Indonesia. Peru was represented
27 by 8% and Turkey by about 5% of the shipments. A number of other countries contributed small
28 percentages of the shipments. Of the commodities, furniture was the most common with about 15%;
29 most of the other commodities were stone or stone-like products.

30

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1 **Table A19-1: Countries of Origin of Randomly Selected Samples of Maritime Cargo Entering**
 2 **Hawai'i with WPM, October 2005 to April 2007**

Country of origin	Number of samples	Percent of total samples
China	63	38.0
Indonesia	32	19.3
Peru	14	8.4
Turkey	9	5.4
India	7	4.2
Vietnam	6	3.6
Brazil	5	3.0
Italy	5	3.0
Thailand	5	3.0
Hong Kong	3	1.8
Philippines	3	1.8
Portugal	3	1.8
Egypt	2	1.2
Israel	2	1.2
New Zealand	2	1.2
Japan	1	0.6
South Korea	1	0.6
Mexico	1	0.6
Pakistan	1	0.6
Singapore	1	0.6
Total	166	100

3 Source: AQIM
 4

5 **Table A19-2: Manifested Contents of Randomly Selected Samples of Maritime Cargo of**
 6 **Foreign Origin Entering Hawai'i with WPM, October 2005 to April 2007**

Manifested as	Number of shipments	Percent of total shipments
Bamboo	1	0.6
Ceramic tile	2	1.2
Countertop	2	1.2
Furniture	26	15.7
Furniture, Bamboo stake	1	0.6
Glass, Louver	3	1.8
Granite	16	9.6
Granite product	3	1.8
Granite slab	13	7.8
Granite tile	3	1.8
Handicraft	8	4.8
Handicraft, Stone statue	1	0.6
Housing assembly	2	1.2
Limestone	4	2.4
Marble	1	0.6
Marble slab	5	3.0

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Manifested as	Number of shipments	Percent of total shipments
Marble tile	10	6.0
Pottery	2	1.2
Quartzite	2	1.2
Slate	10	6.0
Squash	1	0.6
Stone	11	6.6
Stone slab	6	3.6
Stone slate	4	1.8
Stone statue	10	6.0
Tile, Roof	3	1.8
Travertine	15	9.0
Wood packing material, Other	1	0.6
Grand Total	166	100

Source: AQIM

1
2

3 Of the 166 inspections that were recorded in the AQIM data set, 6 resulted in interceptions of pests.
4 However, it must be noted that port personnel were instructed to “inspect thoroughly at least 50
5 percent of the external surface of the [WPM] for live pests” (Higa 2004). In other words, half of the
6 wood surface may have been left unsearched; inspectors may not have looked for pests hidden inside
7 the wood; and finds of dead pests were not recorded. Further, considering the general difficulty of
8 detecting pests in or on WPM, the true number of infested shipments was almost certainly higher than
9 six. Using 10 as a more realistic number, between 3% and 11% (95% binomial confidence interval) of all
10 shipments with WPM arriving at the port of Honolulu are infested with live pests. This is a disturbingly
11 high number, especially considering that it is occurring in spite of ISPM #15 regulations.

12 Unfortunately, there are no data available to determine how much WPM is entering Hawai’i; therefore,
13 it is not possible to estimate the number of pest species that may have been, and will be, introduced
14 into Hawai’i on this pathway. However, it is certain that this number must be far from negligible.

15 According to the USDA Agricultural Quarantine Activity System Pest ID database (USDA 2007a), APHIS-
16 PPQ or CBP inspectors in Honolulu intercepted 29 pests on wood material associated with maritime
17 cargo during regular phytosanitary inspections (not AQIM data collection) between October 2005 and
18 April 2007. All of these interceptions were insects, and the large majority of them were beetles (Table
19 A19-3). Only nine of the insects were reportable pests. It is interesting to note that the latest
20 interception date recorded was December of 2006, and there are no records for the time between then
21 and April 2007.

22

1 **Table A19-3: Pests Intercepted on or in Wood Materials During Regular Phytosanitary**
 2 **Inspections of Maritime Cargo at the Port of Honolulu between October 2005 and April 2007**

Interception date	Origin	Inspected host	Pest name	Pest reportable?
1/23/2006	Peru	Granite	Bostrichidae, species	yes
5/2/2006	Indonesia	Furniture	<i>Cryptoterms</i> sp.	yes
4/11/2006	Peru	Tiles	<i>Cryptoterms</i> sp.	yes
4/20/2006	Peru	Tiles	<i>Cryptoterms</i> sp.	yes
3/23/2006	Peru	Tiles	<i>Cryptoterms</i> sp.	yes
3/22/2006	Indonesia	<i>Tectona grandis</i>	<i>Cryptoterms</i> sp.	yes
1/11/2006	China	Furniture	Scolytidae, species	yes
12/20/2006	China	Wood	<i>Xyleborus</i> sp.	yes
11/28/2005	China	Granite	<i>Xyleborus</i> sp.	yes
10/25/2006	China	Tiles	Anobiidae, species	no
4/25/2006	China	Furniture	Anobiidae, species	no
4/17/2006	China	Tiles	Anobiidae, species	no
12/9/2005	China	Tiles	<i>Arhopalus</i> sp.	no
11/15/2005	China	Tiles	Bostrichidae, species	no
11/15/2005	China	Tiles	Cleridae, species	no
4/17/2006	China	Tiles	Corticariidae, species	no
10/26/2006	India	Marble	Cryptophilini, species	no
4/17/2006	China	Tiles	<i>Cryptophilus</i> sp.	no
6/1/2006	Peru	Tiles	Erotylidae, species	no
3/30/2006	Peru	Tiles	<i>Heterobostrychus aequalis</i>	no
4/25/2006	China	Furniture	Nitidulidae, species	no
4/20/2006	Peru	Tiles	Nitidulidae, species	no
6/7/2006	India	Slate	Psocoptera, species	no
4/25/2006	China	Furniture	Psocoptera, species	no
9/21/2006	Indonesia	Wood	Silvanidae, species	no
11/28/2005	China	Granite	Silvanidae, species	no
10/27/2006	India	Marble	<i>Silvanus</i> sp.	no
12/7/2005	Turkey	Tiles	<i>Stephanopachys quadricollis</i>	no
2/8/2006	China	Tiles	<i>Typhaea stercorea</i>	no

3 Note: Not AQIM data collection.
 4

5 It is more difficult to determine how many WPM-associated pests were intercepted by HDOA inspectors,
 6 because the HDOA database of pest interceptions does not indicate clearly if a pest was associated with
 7 WPM or not. Filtering for the hosts “wood” and “crates” as indicators of an association with WPM, there
 8 were zero interception records for the period between October 2005 and April 2007, whereas for the
 9 entire period between 1990 and 2006, a mere 24 interceptions are listed (out of a total of 17,356
 10 interceptions on any host) (Table A19-4) (HDOA 2007c). Most of the pests intercepted on wood and
 11 crates are already established in Hawai’i. However, some of them (e.g., the odorous house ant,
 12 *Tapinoma sessile* [Say]) do not yet occur in Hawai’i, and have the potential to be aggressive invaders. In
 13 contrast to CBP, HDOA does not have any authority to put on hold non-agricultural shipments for the
 14 purpose of WPM inspection. This means that HDOA can inspect WPM only in agricultural shipments, or
 15 on non-agricultural shipments that have been referred to it by another agency.

1 **Table A19-4: Pests Intercepted on “Wood” or “Crates” during Phytosanitary Inspections by**
 2 **HDOA on any Pathway between January 1990 and October 2006**

Taxon	Family	Country of origin	Number of times intercepted	Status in Hawai'i
Cryptorhynchinae	Curculionidae	Indonesia	1	n/a
<i>Camponotus pennsylvanicus</i>	Formicidae	Texas	1	not yet established
<i>Camponotus</i> sp.	Formicidae	California	1	n/a
		Oregon	2	n/a
		Hawai'i	1	n/a
<i>Cryptotermes brevis</i>	Kalotermitidae	Midway Island	1	introduced
<i>Gnathaphanus picipes</i>	Carabidae	Hawai'i	1	introduced
<i>Ornithonyssus sylviarum</i>	Macronyssidae	California	2	introduced
		Midway Island	1	introduced
<i>Philonthus turbidus</i>	Staphylinidae	Thailand	1	introduced
<i>Sinoxylon conigerum</i>	Bostrichidae	California	1	introduced
<i>Solenopsis geminata</i>	Formicidae	Indonesia	1	introduced
		Oregon	1	
<i>Tapinoma sessile</i>	Formicidae	Indonesia	1	not yet established
<i>Vollenhovia</i> sp.	Formicidae	Indonesia	1	not yet established
<i>Xyleborus affinis</i>	Scolytidae	China	1	introduced
<i>Xylopsocus flavipes</i>	Bostrichidae	Hawai'i	1	not yet established
Unidentified species	Brentidae	Hawai'i	1	n/a
Total			20	

3
 4 It is likely that the APHIS-PPQ, CBP, and HDOA interceptions represent only a fraction of the pests that
 5 were actually present. Other studies have estimated that port inspections intercept only 30% or fewer of
 6 the incoming pests (Meissner et al. 2003). A recent HDOA report confirms this: “Even during the Oahu
 7 risk assessment, only about 10% of the volume was inspected, but the numbers of interceptions were
 8 about 10 times greater than the normal inspection of all of the HNL [Honolulu] cargo during that same
 9 period” (HDOA 2007d). WPM is especially difficult to inspect; pests are often hidden inside the wood,
 10 and a large part of the incoming WPM never gets inspected because it is not associated with agricultural
 11 commodities. It is also quite common that port inspectors are not sufficiently trained to detect wood-
 12 boring pests. Training provided to port inspectors along the Mexican border in 2002 made this very
 13 obvious. This training focused on methods for detecting wood-boring beetles of the family Scolytidae,
 14 and resulted in an immediate and dramatic increase in WPM pest interceptions (Table A19-5). For
 15 example, at Pharr and San Diego, the average number of intercepted scolytid specimens increased from
 16 ≤ 1 to over 100 per month as a result of the training, indicating that large numbers of scolytid pests
 17 entering the United States had gone undetected by APHIS-PPQ at these ports. Similar breaches of
 18 quarantine security probably hold true for most U.S. ports-of-entry, including Honolulu, and also apply
 19 to many non-scolytid pests associated with WPM. For example, the Honolulu interceptions do not

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1 include any snails (Table A19-4), whereas nationwide, snails represent almost 10% of all WPM
 2 interceptions (Table A19-6), and a snail was found during AQIM data collection in a sample of only 166
 3 (Table A19-7).

4 **Table A19-5: Monthly Average Number of Scolytid Specimens Found on Solid WPM before**
 5 **and after a Scolytid Detection Training at Four Major Southern Border ports in 2002**

Port	Before Training	After Training
Brownsville, TX	0	12
Laredo, TX	26	73
Pharr, TX	0.4	108
San Diego, CA	1	124

6
 7 **Table A19-6: Pest Types Intercepted on or in Wood Materials during Regular Phytosanitary**
 8 **Inspections of Maritime Cargo Nationwide between January 1985 and May 2007**

Pest type	Number of interceptions
Diseases	64
Insects	17,008
Mites	42
Molluscs	1,323
Nematodes	4
Weeds	178
Grand Total	18,619

9 Note: Not AQIM data collection.

10
 11 Specifically, pest finds recorded in the AQIM data set for Honolulu (Table B8-7) included a member of
 12 the snail family Bradybaenidae, the cerambicid, *Xylotrechus magnicollis* (Fairmaire), an unidentified
 13 member of each of the beetle families Bostrichidae and Cerambycidae, a species of *Cryptotermes*, and
 14 an unidentified noxious weed. No taxonomic information was provided for one of the interceptions. The
 15 pests were intercepted on marble slabs, granite, and stone from China, and on furniture from Indonesia.
 16 Apart from pest interceptions, there were five cases of WPM entering without proof of phytosanitary
 17 treatment (ISPM#), as required by ISPM #15, and one case of contamination with soil.

1 **Table A19-7: Pests on WPM or WPM Lacking Proof of Phytosanitary Treatment Intercepted**
 2 **during AQIM at the Honolulu Maritime Port between October 2005 and April 2007**

Origin	Infested commodity	Interception
China	Marble slab	Bostrichidae
China	Stone statue	WPM no ISPM#
China	Furniture	WPM no ISPM#
China	Slate	Soil
China	Granite	Cerambycidae
China	Stone	<i>Xylotrechus magnicollis</i> , <i>Bradybaenidae</i> sp.
Hong Kong	Furniture	WPM no ISPM#
Indonesia	Furniture	<i>Cryptoterme</i> sp.
Indonesia	Furniture	WPM no ISPM#
Indonesia	Furniture	Unidentified noxious weed
Philippines	Stone	WPM no ISPM#
Turkey	Tile, Roof	Unidentified pest

3 Note: Total sample size=166.
 4

5 Table A19-8 lists all pests intercepted on wood at any U.S. port-of-entry since 1985, demonstrating the
 6 great taxonomic variety (Table B8-9) of organisms associated with WPM. Snails were frequently found as
 7 hitchhikers on WPM. Snail invasions may have serious economic and environmental consequences. For
 8 example, *Bradybaena ravida* (Benson), which is not known to occur in Hawai'i, was rated as a high-risk
 9 quarantine pest in a USDA risk assessment for penjing from China (Cave and Redlin 1996).

10 **Table A19-8: Reportable Pests Intercepted on or in Wood Materials during Regular**
 11 **Phytosanitary Inspections of Maritime Cargo Nationwide between January 1985 and May**
 12 **2007**
 13

Taxon	Number of times intercepted
Pathogens	
<i>Ascochyta</i> sp.	1
<i>Cladosporium</i> sp.	2
<i>Cytospora</i> sp.	1
<i>Didymella</i> sp.	1
<i>Graphiola</i> sp.	1
<i>Gymnosporangium</i> sp.	1
<i>Lophodermium</i> sp.	1
<i>Mycosphaella fijiensis</i>	1
<i>Pestalotiopsis</i> sp.	2
<i>Phoma</i> sp.	5
<i>Phomopsis</i> sp.	4
<i>Puccinia</i> sp.	7
Insects	
<i>Acalles</i> sp.	1

Taxon	Number of times intercepted
<i>Acanthocephala</i> sp.	1
<i>Acanthocinus</i> sp.	4
<i>Acanthoscelides</i> sp.	1
<i>Acheta hispanicus</i>	12
<i>Acheta</i> sp.	2
<i>Acmaeodera</i> sp.	1
Acrididae, species	4
<i>Acroleucus bromelicola</i>	1
<i>Acrolophus</i> sp.	2
<i>Acrosternum millierei</i>	9
<i>Acyphoderes</i> sp.	1
<i>Adoretus sinicus</i>	12
<i>Aelia acuminata</i>	5
<i>Aeolus</i> sp.	2
<i>Aethus indicus</i>	1
<i>Agallia laevis</i>	2

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Taxon	Number of times intercepted
<i>Agallia</i> sp.	2
<i>Agapanthia irrorata</i>	1
<i>Agrilus</i> sp.	35
<i>Agrilus sulcicollis</i>	1
<i>Agriotes aequalis</i>	1
<i>Agriotes lineatus</i>	1
<i>Agriotes</i> sp.	3
Agromyzidae, species	2
<i>Agrotis exclamationis</i>	1
<i>Agrotis</i> sp.	1
Agrypninae, species	1
<i>Alaus</i> sp.	2
<i>Altica oleracea</i>	3
<i>Altica</i> sp.	22
<i>Alydus</i> sp.	2
<i>Amitermes</i> sp.	2
<i>Amphiacusta azteca</i>	1
<i>Amphicerus</i> sp.	5
<i>Anaceratagallia venosa</i>	2
<i>Anacridium aegyptium</i>	23
<i>Anasa</i> sp.	1
<i>Anastrepha</i> sp.	3
<i>Anelaphus</i> sp.	1
<i>Anomala ceramopyga</i>	1
<i>Anomala</i> sp.	2
<i>Anoplophora glabripennis</i>	6
<i>Anoplophora</i> sp.	31
<i>Anthaxia</i> sp.	22
Anthomyiidae, species	1
<i>Anthonomus</i> sp.	3
Anthribidae, species	1
<i>Anticarsia irrorata</i>	1
<i>Anurogryllus</i> sp.	1
<i>Apate</i> sp.	1
<i>Aphanus rolandri</i>	8
Aphididae, species	6
<i>Aphthona</i> sp.	2
Apidae, species	1
<i>Apion</i> sp.	41
Apionidae, species	1
<i>Apis mellifera</i>	11
<i>Apis</i> sp.	1
Apocrita, species	3
<i>Apriona</i> sp.	1
Aradidae, species	9

Taxon	Number of times intercepted
<i>Araecerus</i> sp.	5
<i>Araptus</i> sp.	1
Arctiidae, species	22
<i>Arocatus longiceps</i>	2
<i>Arocatus melanocephalus</i>	24
<i>Arocatus roeselii</i>	1
<i>Asemum</i> sp.	6
<i>Aspidiella hartii</i>	1
<i>Aspidomorpha</i> sp.	1
<i>Atta</i> sp.	1
Auchenorrhyncha, species	1
<i>Aulacaspis tubercularis</i>	2
<i>Aulacophora</i> sp.	1
<i>Autographa gamma</i>	1
<i>Bactrocera dorsalis</i>	1
<i>Bactrocera</i> sp.	2
<i>Baris</i> sp.	1
<i>Batocera rufomaculata</i>	1
<i>Batocera</i> sp.	8
<i>Belionota prasina</i>	3
<i>Belionota</i> sp.	2
<i>Beosus maritimus</i>	11
<i>Beosus quadripunctatus</i>	3
<i>Beosus</i> sp.	2
<i>Blapstinus</i> sp.	36
<i>Blissus</i> sp.	1
Bostrichidae, species	94
<i>Brachmia</i> sp.	1
<i>Brochymena</i> sp.	5
<i>Bruchidius</i> sp.	1
Bruchinae, species	1
<i>Bryothopha</i> sp.	1
<i>Bucrates capitatus</i>	1
Buprestidae, species	103
<i>Buprestis dalmatina</i>	6
<i>Buprestis haemorrhoidalis</i>	1
<i>Buprestis</i> sp.	58
<i>Cacopsylla</i> sp.	1
<i>Callidiellum</i> sp.	5
<i>Callidiellum villosulum</i>	8
<i>Callidium</i> sp.	20
<i>Calligrapha</i> sp.	1
<i>Callosobruchus</i> sp.	1
<i>Camptopus lateralis</i>	26
<i>Camptorhinus</i> sp.	1

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Taxon	Number of times intercepted
<i>Carphoborus minimus</i>	11
<i>Carphoborus pini</i>	5
<i>Carphoborus rossicus</i>	1
<i>Carphoborus</i> sp.	10
<i>Carpocoris pudicus</i>	1
<i>Caryedon</i> sp.	2
Cassidinae, species	1
Catocalinae, species	1
<i>Catolethrus</i> sp.	1
<i>Catorhintha</i> sp.	1
<i>Caulotops</i> sp.	1
Cecidomyiidae, species	10
Cecidomyiinae, species	3
<i>Centrocoris variegatus</i>	1
Cerambycidae, species	247
Cerambycinae, species	291
<i>Cerambyx</i> sp.	2
<i>Ceratagallia</i> sp.	1
Ceratitini, species	1
<i>Ceratitis capitata</i>	2
Cercopidae, species	2
<i>Ceresium</i> sp.	132
<i>Ceutorhynchus</i> sp.	4
<i>Chaetocnema concinna</i>	1
<i>Chaetocnema conducta</i>	36
<i>Chaetocnema</i> sp.	28
<i>Chaetocnema tibialis</i>	232
Chalcidoidea, species	2
<i>Chalcoises plutus</i>	1
<i>Chalcophora</i> sp.	7
<i>Chilo</i> sp.	2
<i>Chilo suppressalis</i>	10
<i>Chlorida festiva</i>	1
<i>Chlorophanus</i> sp.	1
<i>Chlorophorus annularis</i>	7
<i>Chlorophorus diadema</i>	1
<i>Chlorophorus</i> sp.	3
<i>Chramesus</i> sp.	3
Chrysauginae, species	1
Chrysobothrini, species	1
<i>Chrysobothris chryso stigma</i>	1
<i>Chrysobothris</i> sp.	74
<i>Chrysodeixis chalcites</i>	1
<i>Chrysolina bankii</i>	1
<i>Chrysolina polita</i>	1

Taxon	Number of times intercepted
<i>Chrysolina rossia</i>	2
<i>Chrysolina</i> sp.	1
<i>Chrysomela</i> sp.	1
Chrysomelidae, species	9
<i>Cicadella viridis</i>	1
Cicadellidae, species	32
<i>Cinara</i> sp.	1
Cixiidae, species	2
<i>Cleonis</i> sp.	1
<i>Cleonus</i> sp.	1
Clytini, species	3
<i>Clytus</i> sp.	1
<i>Cnaphalocrocis medinalis</i>	3
<i>Cnemonyx</i> sp.	1
<i>Cneorhinus</i> sp.	1
<i>Coccotrypes</i> sp.	22
<i>Coccus viridis</i>	2
<i>Colaspis</i> sp.	4
Coleophoridae, species	1
Coleoptera, species	50
<i>Conarthrus</i> sp.	1
<i>Conchaspis newsteadi</i>	1
<i>Conistra rubiginea</i>	1
<i>Conocephalus</i> sp.	2
<i>Conoderus</i> sp.	2
<i>Conotrachelus</i> sp.	10
<i>Copitarsia</i> sp.	1
<i>Coptocyclus sordida</i>	1
<i>Coptops</i> sp.	5
<i>Coptotermes crassus</i>	2
<i>Coptotermes</i> sp.	11
Coreidae, species	1
<i>Corizus hyoscyami</i>	3
Cossidae, species	13
Cossoninae, species	26
<i>Cossonus</i> sp.	5
<i>Cossus cossus</i>	1
Crambidae, species	3
Crambinae, species	1
<i>Crematogaster</i> sp.	37
<i>Cryphalus abietis</i>	2
<i>Cryphalus piceae</i>	4
<i>Cryphalus</i> sp.	47
<i>Cryptoblates</i> sp.	2
<i>Cryptocarenum</i> sp.	1

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Taxon	Number of times intercepted
<i>Cryptophlebia leucotreta</i>	1
<i>Cryptophlebia</i> sp.	1
Cryptorhynchinae, species	6
<i>Cryptorhynchus</i> sp.	1
<i>Cryptotermes</i> sp.	60
<i>Crypturgus cinereus</i>	12
<i>Crypturgus mediterraneus</i>	19
<i>Crypturgus numidicus</i>	5
<i>Crypturgus</i> sp.	26
Ctenuchinae, species	1
<i>Curculio</i> sp.	1
Curculionidae, species	193
Curculionoidea, species	60
<i>Cylocephala</i> sp.	5
Cyclorrhapha, species	7
<i>Cydia</i> sp.	2
<i>Cylindrocopturus</i> sp.	1
Cynipidae, species	1
<i>Cyphostethus tristriatus</i>	1
<i>Cyrtogenius luteus</i>	8
<i>Cyrtogenius</i> sp.	5
<i>Dactynotus</i> sp.	1
Delphacidae, species	1
Deltocephalinae, species	1
<i>Demonax</i> sp.	1
<i>Dendrocoris</i> sp.	2
<i>Dendroctonus mexicanus</i>	26
<i>Dendroctonus</i> sp.	19
<i>Dere thoracica</i>	1
<i>Diabrotica</i> sp.	1
<i>Diabrotica undecimpunctata</i>	1
Diaspididae, species	1
<i>Dicerca</i> sp.	1
<i>Dieuches armatipes</i>	2
<i>Dihammus</i> sp.	1
<i>Diorthus</i> sp.	1
<i>Diplotaxis</i> sp.	7
Diptera, species	14
<i>Disonycha</i> sp.	4
<i>Dolycoris baccarum</i>	17
<i>Dorytomus</i> sp.	3
<i>Draeculacephala clypeata</i>	1
<i>Drasterius bimaculatus</i>	2
<i>Drasterius</i> sp.	2
<i>Drymus sylvaticus</i>	1

Taxon	Number of times intercepted
<i>Dryocoetes autographus</i>	17
<i>Dryocoetes hectographus</i>	1
<i>Dryocoetes</i> sp.	119
<i>Dryocoetes villosus</i>	20
<i>Dysdercus</i> sp.	1
<i>Dysmicoccus neobrevipes</i>	1
<i>Edessa</i> sp.	2
Elachistidae, species	1
<i>Elaphidion</i> sp.	4
<i>Elaphria</i> sp.	1
Elateridae, species	17
Elaterinae, species	1
<i>Eleodes</i> sp.	1
<i>Emblethis denticollis</i>	3
Entiminae, species	5
<i>Epicauta</i> sp.	1
<i>Epitragus</i> sp.	9
<i>Epitrix</i> sp.	1
<i>Eremocoris fenestratus</i>	1
<i>Eremocoris</i> sp.	2
Eriococcidae, species	1
<i>Erthesina fullo</i>	5
<i>Eubulus</i> sp.	2
<i>Euconocephalus</i> sp.	2
<i>Euetheola bidentata</i>	2
<i>Euetheola</i> sp.	1
<i>Euphoria</i> sp.	2
<i>Eurydema oleraceum</i>	5
<i>Eurydema ornatum</i>	8
<i>Eurydema ventrale</i>	2
<i>Euryscelis suturalis</i>	1
<i>Eurythyrea</i> sp.	1
<i>Euschistus cornutus</i>	1
<i>Exora</i> sp.	1
<i>Eyprepocnemis plorans</i>	1
<i>Eysarcoris ventralis</i>	17
Formicidae, species	4
<i>Frankliniella</i> sp.	1
<i>Galeruca</i> sp.	3
<i>Galerucella</i> sp.	1
Galleriinae, species	1
<i>Gastrodes abietum</i>	1
<i>Gastrodes grossipes</i>	1
Gelechiidae, species	16
Gelechioidea, species	2

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Taxon	Number of times intercepted
Geometridae, species	8
<i>Geotomus punctulatus</i>	1
<i>Gerstaeckeria</i> sp.	1
<i>Giraudiella inclusa</i>	2
<i>Glenea</i> sp.	1
<i>Glyptotermes fuscus</i>	1
<i>Glyptotermes</i> sp.	2
<i>Gnathamitermes</i> sp.	1
<i>Gnathotrichus</i> sp.	108
<i>Gonioctena</i> sp.	2
<i>Gonocephalum</i> sp.	10
<i>Gonocerus acuteangulatus</i>	1
<i>Gonocerus</i> sp.	1
<i>Gonocerus venator</i>	2
<i>Grammophorus</i> sp.	1
<i>Graphosoma</i> sp.	1
Gryllidae, species	9
Gryllinae, species	1
<i>Gryllodes</i> sp.	1
<i>Gryllus bimaculatus</i>	1
<i>Gryllus campestris</i>	1
<i>Gryllus</i> sp.	43
<i>Gymnandrosoma</i> sp.	1
<i>Gypona</i> sp.	1
Hadeninae, species	1
<i>Halyomorpha picus</i>	2
<i>Heilipus</i> sp.	2
<i>Helicoverpa</i> sp.	1
<i>Helophorus</i> sp.	1
Hemiptera, species	1
Hepialidae, species	1
<i>Heraeus</i> sp.	1
<i>Herpetogramma</i> sp.	1
Hesperiidae, species	2
<i>Hesperophanes campestris</i>	1
<i>Hesperophanes</i> sp.	64
<i>Heterobostrychus aequalis</i>	43
<i>Heterobostrychus brunneus</i>	3
<i>Heterobostrychus</i> sp.	5
Heteroptera, species	4
<i>Heterotermes</i> sp.	12
<i>Hippopsis</i> sp.	1
<i>Holcostethus sphaclatus</i>	16
<i>Holcostethus vernalis</i>	1
<i>Homalodisca</i> sp.	1

Taxon	Number of times intercepted
<i>Homoeocerus marginellus</i>	1
<i>Hoplandrothrips</i> sp.	2
<i>Horvathiolus superbus</i>	3
<i>Hyalochilus ovatulus</i>	1
<i>Hylastes angustatus</i>	4
<i>Hylastes ater</i>	54
<i>Hylastes attenuatus</i>	18
<i>Hylastes cunicularius</i>	6
<i>Hylastes linearis</i>	6
<i>Hylastes</i> sp.	20
Hylesininae, species	2
<i>Hylesinus crenatus</i>	1
<i>Hylesinus</i> sp.	5
<i>Hylesinus varius</i>	11
<i>Hylobius abietis</i>	8
<i>Hylobius</i> sp.	185
<i>Hylurgops glabrotus</i>	2
<i>Hylurgops palliatus</i>	295
<i>Hylurgops</i> sp.	39
<i>Hylurgus ligniperda</i>	245
<i>Hylurgus</i> sp.	47
Hymenoptera, species	26
<i>Hypena gonospilalis</i>	1
<i>Hypena lividalis</i>	1
<i>Hypena</i> sp.	2
<i>Hypera constans</i>	1
<i>Hypera</i> sp.	10
<i>Hypocassida subferrugines</i>	1
<i>Hypocryphalus mangiferae</i>	3
<i>Hypocryphalus</i> sp.	111
<i>Hypothenemus</i> sp.	180
<i>Idiocerus</i> sp.	7
<i>Incisitermes modestus</i>	2
<i>Incisitermes</i> sp.	23
Insecta, species	4
<i>Ips acuminatus</i>	23
<i>Ips amitinus</i>	2
<i>Ips cembrae</i>	11
<i>Ips erosus</i>	474
<i>Ips mannsfeldi</i>	5
<i>Ips sexdentatus</i>	179
<i>Ips</i> sp.	99
<i>Ips typographus</i>	268
<i>Irbisia</i> sp.	1
<i>Ischnodemus</i> sp.	2

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Taxon	Number of times intercepted
Isoptera, species	5
<i>Kaloterms flavicollis</i>	5
<i>Kaloterms</i> sp.	3
Kalotermitidae, species	14
<i>Lacon</i> sp.	2
<i>Lamia</i> sp.	6
<i>Lamia textor</i>	4
Lamiinae, species	128
<i>Largus</i> sp.	1
<i>Larinus cynarae</i>	1
<i>Larinus latus</i>	1
<i>Larinus</i> sp.	4
<i>Larinus turbinatus</i>	1
Lepidoptera, species	21
<i>Leptoglossus</i> sp.	1
<i>Leptostylus</i> sp.	2
<i>Leucania</i> sp.	1
<i>Ligyrocoris</i> sp.	1
<i>Ligyрус</i> sp.	1
<i>Liogenys macropelma</i>	2
<i>Liriomyza huidobrensis</i>	1
<i>Listronotus</i> sp.	3
<i>Lixus</i> sp.	5
<i>Lobometopon metallicum</i>	1
<i>Longitarsus</i> sp.	3
Lycaenidae, species	1
Lyctidae, species	71
<i>Lyctus simplex</i>	3
<i>Lyctus</i> sp.	11
Lygaeidae, species	6
Lygaeoidea, species	8
<i>Lygaeosoma sardeum</i>	62
<i>Lygaeus equestris</i>	4
<i>Lygaeus pandurus</i>	1
<i>Lygus gemellatus</i>	1
<i>Lygus</i> sp.	5
Lymantriidae, species	2
<i>Macrocopturus cribricollis</i>	1
<i>Macroglossum stellatarum</i>	2
<i>Macroscytus</i> sp.	1
<i>Marshallius</i> sp.	2
<i>Mecaspis alternans</i>	1
<i>Mecinus circulatus</i>	1
<i>Mecinus</i> sp.	4
<i>Mecopus</i> sp.	2

Taxon	Number of times intercepted
<i>Megacyllene</i> sp.	2
<i>Megalonotus chiragrus</i>	95
<i>Melalgus</i> sp.	4
<i>Melanaspis</i> sp.	1
<i>Melanocoryphus albomaculatus</i>	24
<i>Melanophila cuspidata</i>	18
<i>Melanophila</i> sp.	43
<i>Melanoplus</i> sp.	1
Membracidae, species	2
<i>Metamasius hemipterus</i>	1
<i>Metoponium</i> sp.	1
<i>Metopoplax origani</i>	4
<i>Metopoplax</i> sp.	1
<i>Micrapate brasiliensis</i>	1
<i>Micrapate scabrata</i>	4
<i>Micrapate</i> sp.	7
<i>Microplax interruptus</i>	1
<i>Microplax</i> sp.	1
<i>Microtheca</i> sp.	1
<i>Minthea rugicollis</i>	12
<i>Minthea</i> sp.	3
Miridae, species	8
<i>Mocis frugalis</i>	2
<i>Mocis undata</i>	1
Mogoplistidae, species	5
<i>Molorchus</i> sp.	4
Molytinae, species	1
<i>Monarthrum</i> sp.	4
<i>Monochamus alternatus</i>	15
<i>Monochamus galloprovincialis</i>	2
<i>Monochamus sartor</i>	3
<i>Monochamus</i> sp.	452
<i>Monochamus sutor</i>	5
<i>Monochamus teserula</i>	1
<i>Monosteira unicastata</i>	1
Mordellidae, species	2
<i>Mormidea</i> sp.	1
<i>Myochrous</i> sp.	2
Myrmicinae, species	3
<i>Nasutitermes costalis</i>	4
<i>Nasutitermes ephratae</i>	2
<i>Nasutitermes nigriceps</i>	1
<i>Nasutitermes</i> sp.	6

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Taxon	Number of times intercepted
<i>Nemapogon</i> sp.	3
Nematocera, species	3
<i>Neoclytus olivaceus</i>	1
<i>Neoclytus</i> sp.	4
<i>Neoconocephalus guttatus</i>	1
<i>Neoconocephalus punctipes</i>	2
<i>Neoconocephalus</i> sp.	4
<i>Neotermes connezus</i>	1
<i>Neotermes modestus</i>	2
<i>Neotermes</i> sp.	10
<i>Neottiglossa</i> sp.	1
<i>Niphades</i> sp.	1
<i>Niphades variegatus</i>	1
Noctuidae, species	37
Noctuinae, species	1
Nymphalidae, species	2
<i>Nysius ericae</i>	1
<i>Nysius graminicola</i>	1
<i>Nysius senecionis</i>	1
<i>Nysius</i> sp.	81
<i>Nysius stalianus</i>	1
<i>Nysius thymi</i>	1
<i>Odontocera</i> sp.	1
Oecophoridae, species	9
Olethreutinae, species	2
<i>Omalus</i> sp.	1
Opatrinae, species	3
<i>Opogona sacchari</i>	2
<i>Opogona</i> sp.	2
<i>Orthostethus</i> sp.	1
<i>Orthotomicus erosus</i>	4
<i>Orthotomicus laricis</i>	30
<i>Orthotomicus proximus</i>	2
<i>Orthotomicus</i> sp.	36
<i>Orthotomicus suturalis</i>	3
<i>Oryctes rhinoceros</i>	2
<i>Osbornellus</i> sp.	1
<i>Ostrinia furnacalis</i>	1
<i>Otiorhynchus</i> sp.	6
<i>Oulema</i> sp.	7
<i>Ovalisia</i> sp.	2
<i>Oxycarenus pallens</i>	1
<i>Oxycarenus</i> sp.	1
<i>Oxypleurus nodieri</i>	3
<i>Ozophora</i> sp.	1

Taxon	Number of times intercepted
<i>Pachybrachius</i> sp.	1
<i>Pagiocerus</i> sp.	1
<i>Palaeocallidium</i> sp.	1
<i>Palomena prasina</i>	1
<i>Pangaeus rugiceps</i>	4
<i>Paraparomius lateralis</i>	1
<i>Pareuchaetes insulata</i>	1
<i>Parlatoria blanchardi</i>	1
<i>Paromius gracilis</i>	1
<i>Pectinophora gossypiella</i>	3
<i>Peltophorus</i> sp.	1
Pentatomidae, species	10
<i>Perissus delerei</i>	1
<i>Peritrechus gracilicornis</i>	253
<i>Phaedon cochleariae</i>	1
<i>Phaedon</i> sp.	1
<i>Phaenops</i> sp.	1
<i>Pheidole megacephala</i>	1
<i>Pheidole</i> sp.	13
Phlaeothripidae, species	4
<i>Phloeosinus rudis</i>	24
<i>Phloeosinus</i> sp.	47
<i>Phloeotribus scarabaeoides</i>	3
<i>Phloeotribus</i> sp.	4
<i>Phlogophora meticulosa</i>	1
<i>Phoracantha recurva</i>	2
<i>Phoracantha</i> sp.	3
<i>Phratora</i> sp.	1
Phycitinae, species	6
Phylinae, species	1
<i>Phyllobius</i> sp.	2
<i>Phyllophaga</i> sp.	6
<i>Phyllotreta</i> sp.	9
<i>Phymatodes</i> sp.	60
<i>Physonota</i> sp.	1
Pieridae, species	1
<i>Pieris brassicae</i>	2
<i>Pissodes castaneus</i>	12
<i>Pissodes harcyniae</i>	1
<i>Pissodes notatus</i>	1
<i>Pissodes pini</i>	10
<i>Pissodes</i> sp.	288
<i>Pityogenes bidentatus</i>	26
<i>Pityogenes bistridentatus</i>	35
<i>Pityogenes calcaratus</i>	4

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Taxon	Number of times intercepted
<i>Pityogenes chalcographus</i>	531
<i>Pityogenes quadridens</i>	7
<i>Pityogenes</i> sp.	20
<i>Pityogenes trepanatus</i>	1
<i>Pityokteines curvidens</i>	2
<i>Pityokteines</i> sp.	2
<i>Pityokteines spinidens</i>	12
<i>Pityophthorus mexicanus</i>	6
<i>Pityophthorus pityographus</i>	14
<i>Pityophthorus</i> sp.	713
<i>Placosternus</i> sp.	1
<i>Plagionotus christophi</i>	3
<i>Plagionotus</i> sp.	2
<i>Planococcus halli</i>	1
<i>Platycleis</i> sp.	1
<i>Platynota</i> sp.	1
<i>Platyplax salviae</i>	3
Platypodidae, species	54
<i>Platypus</i> sp.	12
<i>Platysenta</i> sp.	2
Plusiinae, species	1
<i>Podagrica malvae</i>	1
<i>Podagrica</i> sp.	1
<i>Polycesta</i> sp.	4
<i>Polydrusus</i> sp.	1
<i>Polygraphus poligraphus</i>	45
<i>Polygraphus proximus</i>	1
<i>Polygraphus</i> sp.	18
<i>Polygraphus subopacus</i>	2
<i>Prosoplus</i> sp.	1
<i>Prostephanus</i> sp.	2
<i>Protaetia orientalis</i>	1
Pseudococcidae, species	1
<i>Pseudohylesinus variegatus</i>	3
<i>Pseudopamera</i> sp.	2
<i>Pseudopityophthorus</i> sp.	63
<i>Pseudothysanoes</i> sp.	1
Psychidae, species	7
Psyllidae, species	1
<i>Psylliodes</i> sp.	3
<i>Pteleobius vittatus</i>	1
<i>Pycnarmon cribrata</i>	1
Pyralidae, species	8
Pyraustinae, species	5
<i>Pyrgocorypha</i> sp.	1

Taxon	Number of times intercepted
<i>Pyrrhalta</i> sp.	2
<i>Pyrrhidium sanguineum</i>	6
<i>Pyrrhidium</i> sp.	2
<i>Pyrrhocoris apterus</i>	8
<i>Raglius alboacuminatus</i>	98
<i>Reticulitermes chinensis</i>	1
<i>Reticulitermes lucifugus</i>	7
<i>Reticulitermes</i> sp.	5
<i>Reuteroscopus</i> sp.	1
<i>Rhagium mordax</i>	2
<i>Rhagium</i> sp.	13
Rhaphidophoridae, species	1
<i>Rhaphigaster nebulosa</i>	60
Rhinotermitidae, species	3
Rhopalidae, species	1
<i>Rhopalus parumpunctatus</i>	1
<i>Rhopalus</i> sp.	2
<i>Rhopalus subrufus</i>	1
<i>Rhynchaenus</i> sp.	1
<i>Rhynchites bacchus</i>	1
Rhynchitidae, species	1
<i>Rhynchophorus palmarum</i>	1
<i>Rhyncolus elongatus</i>	2
<i>Rhyncolus</i> sp.	6
<i>Rhyparida</i> sp.	2
Rhyparochromidae, species	4
<i>Rhyparochromus confusus</i>	4
<i>Rhyparochromus pini</i>	3
<i>Rhyparochromus quadratus</i>	1
<i>Rhyparochromus</i> sp.	3
<i>Rhyparochromus vulgaris</i>	45
<i>Rhyssomatus</i> sp.	2
<i>Rhytidoderes plicatus</i>	1
<i>Ricania fumosa</i>	1
Riodinidae, species	1
<i>Ropica</i> sp.	1
<i>Rugitermes</i> sp.	10
<i>Sambus</i> sp.	1
<i>Saperda carcharias</i>	5
<i>Saperda scalaris</i>	1
<i>Saperda</i> sp.	18
<i>Scantius aegyptius</i>	2
Scarabaeidae, species	7
<i>Sciocoris maculatus</i>	14
<i>Sciocoris</i> sp.	3

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Taxon	Number of times intercepted
<i>Scolopostethus affinis</i>	1
<i>Scolopostethus decoratus</i>	1
Scolytidae, species	2504
Scolytinae, species	12
<i>Scolytodes</i> sp.	2
<i>Scolytoplatypus</i> sp.	2
<i>Scolytus intricatus</i>	13
<i>Scolytus ratzeburgi</i>	2
<i>Scolytus scolytus</i>	1
<i>Scolytus</i> sp.	76
<i>Scotinophara</i> sp.	1
<i>Scyphophorus</i> sp.	1
Scythridinae, species	1
<i>Sehirus bicolor</i>	1
<i>Selepa</i> sp.	1
<i>Semanotus</i> sp.	2
<i>Semiothisa</i> sp.	1
Sesiidae, species	2
<i>Shirahoshizo</i> sp.	14
<i>Sinoxylon anale</i>	115
<i>Sinoxylon conigerum</i>	76
<i>Sinoxylon indicum</i>	1
<i>Sinoxylon</i> sp.	21
<i>Sipalinus gigas</i>	3
<i>Sipalinus</i> sp.	2
<i>Sirex noctilio</i>	8
<i>Sirex</i> sp.	3
Siricidae, species	108
<i>Sitona crinita</i>	2
<i>Sitona discoideus</i>	1
<i>Sitona humeralis</i>	5
<i>Sitona</i> sp.	147
<i>Smicronyx</i> sp.	1
Sminthuridae, species	1
<i>Solenopsis invicta</i>	1
<i>Solenopsis</i> sp.	4
<i>Spermophagus sericeus</i>	1
<i>Sphacophilus</i> sp.	1
<i>Sphenophorus</i> sp.	2
<i>Sphenoptera</i> sp.	1
Sphingidae, species	1
<i>Sphingonotus</i> sp.	1
<i>Spilosoma lubricipeda</i>	1
<i>Spilosoma</i> sp.	2
<i>Spodoptera litura</i>	4

Taxon	Number of times intercepted
<i>Spodoptera</i> sp.	2
<i>Stagonomus pusillus</i>	1
<i>Stenocarus fuliginosus</i>	2
<i>Stenoscelis</i> sp.	1
<i>Stephanopachys quadricollis</i>	37
<i>Stephanopachys</i> sp.	72
<i>Sternochetus mangiferae</i>	1
<i>Sternochetus</i> sp.	1
<i>Stictopleurus crassicornis</i>	5
<i>Stictopleurus</i> sp.	1
<i>Stizocera</i> sp.	1
<i>Stromatium barbatum</i>	2
<i>Stromatium longicorne</i>	1
<i>Synanthedon</i> sp.	1
<i>Syphrea</i> sp.	1
<i>Systema</i> sp.	1
<i>Taphropeltus contractus</i>	7
<i>Taphrorychus bicolor</i>	21
<i>Taphrorychus</i> sp.	27
<i>Taphrorychus villifrons</i>	17
<i>Targionia vitis</i>	1
<i>Teleogryllus commodus</i>	1
<i>Teleogryllus mitratus</i>	1
<i>Teleogryllus</i> sp.	2
Tenebrionidae, species	10
<i>Tentyria</i> sp.	1
Tephritidae, species	1
<i>Tephritis</i> sp.	2
<i>Termes panamaensis</i>	2
Termitidae, species	1
Tessaratomidae, species	1
<i>Tesserocerus</i> sp.	1
<i>Tetramorium</i> sp.	1
Tetrigidae, species	1
<i>Tetropium castaneum</i>	83
<i>Tetropium fuscum</i>	6
<i>Tetropium</i> sp.	134
Tettigoniidae, species	1
Thripidae, species	4
<i>Thrips meridionalis</i>	1
<i>Thrips palmi</i>	3
<i>Thyreocoris scarabaeoides</i>	1
Thysanoptera, species	1
Tineidae, species	26
Tingidae, species	1

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Taxon	Number of times intercepted
<i>Tipula marmorata</i>	1
<i>Tipula</i> sp.	1
Tipulidae, species	1
<i>Tolyte</i> sp.	1
<i>Tomarus</i> sp.	1
<i>Tomaspis inca</i>	1
<i>Tomicus minor</i>	2
<i>Tomicus piniperda</i>	149
<i>Tomicus</i> sp.	32
Tortricidae, species	8
<i>Torymus</i> sp.	6
<i>Trachyderes</i> sp.	16
<i>Tremex fusicornis</i>	1
<i>Trichoferus</i> sp.	3
<i>Trigonorhinus</i> sp.	1
<i>Trimerotropis pallidipennis</i>	2
<i>Trirhabda</i> sp.	1
<i>Trogoderma granarium</i>	12
<i>Trogoderma</i> sp.	2
<i>Trogoxylon praeustum</i>	1
<i>Trogoxylon</i> sp.	3
<i>Tropicanus</i> sp.	1
<i>Tropidothorax leucopterus</i>	3
<i>Tropistethus</i> sp.	1
<i>Trypodendron domesticum</i>	7
<i>Trypodendron signatum</i>	6
<i>Tychius</i> sp.	3
Typhlocybiniae, species	1
<i>Typophorus</i> sp.	3
<i>Ulus</i> sp.	2
<i>Urgleptes</i> sp.	1
<i>Uroleucon</i> sp.	1
<i>Xanthochilus saturnius</i>	32

Taxon	Number of times intercepted
<i>Xestocephalus</i> sp.	1
<i>Xyleborinus</i> sp.	4
<i>Xyleborus apicalis</i>	1
<i>Xyleborus eurygraphus</i>	25
<i>Xyleborus</i> sp.	38
<i>Xylechinus pilosus</i>	3
<i>Xylechinus</i> sp.	10
<i>Xylobiops</i> sp.	11
<i>Xylocopa</i> sp.	1
<i>Xylodiplosis</i> sp.	1
<i>Xylopsocus capucinus</i>	10
<i>Xyloryctes fureata</i>	1
<i>Xylosandrus morigerus</i>	1
<i>Xylosandrus</i> sp.	1
<i>Xylothrips flavipes</i>	4
<i>Xylotrechus grayi</i>	1
<i>Xylotrechus magnicollis</i>	3
<i>Xylotrechus rusticus</i>	14
<i>Xylotrechus</i> sp.	119
<i>Xystrocera</i> sp.	4
Yponomeutidae, species	1
<i>Zascelis</i> sp.	3
<i>Zootermopsis</i> sp.	1
<i>Zygogramma</i> sp.	1
Zygopinae, species	1
<i>Zygops</i> sp.	1
Mites	
Acari, species	1
<i>Ixodes hexagonus</i>	1
<i>Tetranychus</i> sp.	2

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Note: Not AQIM data collection.

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Taxon	Number of Times Intercepted
Molluscs	
<i>Achatina fulica</i>	1
<i>Achatina</i> sp.	1
<i>Acusta despecta</i>	5
<i>Acusta tourannensis</i>	1
<i>Arianta arbustorum</i>	1
<i>Arion</i> sp.	3
<i>Bradybaena seiboldtiana</i>	1
<i>Bradybaena</i> sp.	2
Bradybaenidae, species	9
<i>Candidula gigaxii</i>	1
<i>Candidula intersecta</i>	2
<i>Candidula</i> sp.	6
<i>Candidula unifasciata</i>	1
<i>Cathaica fasciola</i>	6
<i>Cathaica</i> sp.	1
<i>Cepaea</i> sp.	1
<i>Cerneuella (xerocincta)</i>	10
<i>Cerneuella</i> cf.	1
<i>Cerneuella cisalpina</i>	56
<i>Cerneuella</i> sp.	23
<i>Cerneuella virgata</i>	26
<i>Chilostoma cingulata</i>	1
<i>Cochlicella acuta</i>	6
<i>Cochlicella conoidea</i>	1
<i>Cochlicella</i> sp.	1
<i>Cornu aspersum</i>	98
<i>Cryptozona siamensis</i>	1
<i>Deroceras panormitanum</i>	1
<i>Deroceras</i> sp.	4
<i>Eobania constantinae</i>	1
<i>Eobania vermiculata</i>	13
<i>Euhadra</i> sp.	1
<i>Fruticicola fruticum</i>	1
<i>Helicarion</i> sp.	7
Helicarionidae, species	2
<i>Helicella itala</i>	6
<i>Helicella maritima</i>	5
<i>Helicella neglecta</i>	1
<i>Helicella</i> sp.	4
<i>Helicella variabilis</i>	2
<i>Helicella virgata</i>	11
Helicellidae, species	1
Helicellinae, species	19
Helicidae, species	11

Taxon	Number of Times Intercepted
<i>Helix cincta</i>	1
<i>Helix lucorum</i>	6
<i>Helix</i> sp.	5
<i>Hygromia cinctella</i>	4
Hygromiidae, species	5
<i>Karftahelix blakeana</i>	3
Limacidae, species	3
<i>Limacus maculatus</i>	1
<i>Limax cinereoniger</i>	1
<i>Limax</i> sp.	1
<i>Massylaea punica</i>	1
<i>Microxeromagna armillata</i>	5
Mollusca, species	4
<i>Monacha bincinctae</i>	1
<i>Monacha cantiana</i>	6
<i>Monacha cartusiana</i>	31
<i>Monacha</i> cf.	4
<i>Monacha</i> sp.	12
<i>Monachoides glabella</i>	1
<i>Monachoides incarnatus</i>	2
<i>Otala punctata</i>	2
<i>Otala</i> sp.	6
<i>Oxychilus</i> sp.	2
<i>Phenacolimax major</i>	1
<i>Pomacea canaliculata</i>	1
<i>Prietocella barbara</i>	16
Stylommatophora, species	1
<i>Subulina</i> sp.	1
<i>Succinea costaricana</i>	1
<i>Succinea horticola</i>	1
<i>Succinea</i> sp.	2
<i>Theba pisana</i>	62
<i>Trochoidea cretica</i>	7
<i>Trochoidea elegans</i>	3
<i>Trochoidea pyramidata</i>	2
<i>Trochoidea</i> sp.	1
<i>Trochoidea trochoides</i>	2
Vitrinidae, species	1
<i>Xerolenta obvia</i>	3
<i>Xeropicta derbentina</i>	1
<i>Xeropicta protea</i>	3
<i>Xeropicta</i> sp.	1
<i>Xerosecta cespitum</i>	5
<i>Xerotricha conspurcata</i>	399
Zonitidae, species	1

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Taxon	Number of Times Intercepted
Weeds	
Asteraceae, species	2
<i>Avena ludoviciana</i>	1
<i>Avena sterilis</i>	1
<i>Azolla pinnata</i>	1
<i>Imperata cylindrica</i>	9
<i>Ipomoea aquatica</i>	1
<i>Oryza sp.</i>	2

Taxon	Number of Times Intercepted
<i>Pennisetum polystachion</i>	1
Poaceae, species	2
<i>Saccharum sp.</i>	1
<i>Saccharum spontaneum</i>	5
<i>Setaria sp.</i>	3
<i>Solanum sp.</i>	1
<i>Tridax procumbens</i>	1

Note: Not AQIM data collection.

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2 **Table A19-9: Types of Reportable Pests Intercepted on or in Wood Materials during Regular**
 3 **Phytosanitary Inspections of Maritime Cargo Nationwide between January 1985 and May**
 4 **2007**

Pest type	Number of interceptions
Diseases	27
Insects	14,262
Mites	4
Molluscs	978
Weeds	31
Grand Total	15,301

Note: Not AQIM data collection.

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6

7 Many pests belonging to taxa that have been intercepted on WPM are already established and invasive
 8 in Hawai'i (Nishida 2002), including the following scolytid beetles (CABI 2006). The tropical nut borer,
 9 *Hypothenemus obscurus* (F.), occurs mainly in South and Central America, and attacks eucalyptus,
 10 macadamia, coffee and other hosts. The Asian ambrosia beetle, *Xylosandrus crassiusculus*
 11 (Motschulsky), is native to Asia, and feeds on coffee, sugarcane, litchi, and a large number of other
 12 species. The shot-hole borer, *Xylosandrus compactus* (Eichhoff), is native to Asia, and attacks coffee,
 13 cinnamon, and mango, among other plants. The tea shot-hole borer, *Euwallacea fornicatus* (Eichhoff), is
 14 also native to Asia; it attacks macadamia, avocado, pomegranate, guava, tea, and many other plants.
 15 The island pinhole borer, *Xyleborus perforans* (Wollaston), is native to Asia and Australia, has an
 16 immense host range (Gray and Wylie 1974), and has been intercepted by Japan and other countries
 17 from imported timber of many species and families (Ohno 1990). The brown twig beetle, *Xylosandrus*
 18 *morigerus* (Blandford), is native to Asia, and invasive in large parts of the world; it is highly polyphagous,
 19 feeding on coffee, cocoa, avocado, and teak. Likewise, the bamboo tiger longhorn beetle, *Chlorophorus*
 20 *annularis* (F.) (Cerambycidae), has been introduced and is widespread in Hawai'i (Nishida 2002; CABI
 21 2006).

22 In a recent pest risk assessment (Stanaway et al. 2001), Australian researchers surveyed the wood floors
 23 of empty sea cargo containers for dead and live pests. They found pests in 1,174 out of 3,001 containers,
 24 collecting over 7,400 insects belonging to 18 orders and at least 114 families. Most of the time, a
 25 container harbored only one or two different pest species. Also found were spiders, isopods, mites,

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1 millipedes, centipedes, scorpions, and ticks. Among the insect pests collected were Chinese rose beetle,
 2 *Adoretus sinicus* Burmeister, introduced and invasive in Hawai'i, as well as unidentified species of the
 3 genera *Hypothenemus*, *Solenopsis*, and *Vespula*. The study concluded that even though the relative
 4 frequency of sea cargo containers with wood floors infested with exotic pests is very low, this pathway
 5 represents a significant risk due to the immense volume of containers entering ports.

6 A large number of pests potentially associated with WPM have, not surprisingly, already been
 7 introduced into Hawai'i and have established populations there. However, there is still a long list of
 8 species from all over the world that are not yet known to occur in Hawai'i, but have the potential to be
 9 introduced on or in WPM (Table A19-10). This evaluation concludes that, unless more effective
 10 safeguarding measures are introduced, many of these pests may be expected to appear and cause
 11 economic, as well as ecological, damage in Hawai'i over the coming years.

12 **Table A19-10: Examples of Insects with Potential to be Introduced into Hawai'i in WPM**

Order: Family	Species	Distribution ^a	References
Coleoptera: Bostrichidae	<i>Heterobostrychus brunneus</i> (Murray)	sub-Saharan Africa, United States (CA)	Pasek 2000; Haack 2006; Schabel 2006
	<i>Sinoxylon anale</i> Lesne	Australia, Brazil, China, India, Indonesia, New Zealand, Philippines, Saudi Arabia, Southeast Asia, Sri Lanka, United States (CA, FL, MI, NY, OH, PA), Venezuela	Pasek 2000; Teixeira et al. 2002
	<i>Sinoxylon crassum</i> Lesne	East Africa, India, Pakistan, Southeast Asia	Singh and Bhandari 1987; Singh Rathore 1995; Gul and Bajwa 1997; Pasek 2000; Walker 2006
	<i>Xylothrips flavipes</i> (Illiger)	Greece, Madagascar, North Africa, Southeast Asia	Lesne 1900; Pasek 2000; Nardi 2004
Coleoptera: Buprestidae	<i>Buprestis haemorrhoidalis</i> Herbst	Canary Islands, Europe, Kazakhstan	Pasek 2000; Löbl and Smetana 2006
	<i>Melanophila cuspidata</i> (Klug)	North Africa, southern Europe	Pasek 2000; Kubán 2004
Coleoptera: Cerambycidae	<i>Callidiellum rufipenne</i> (Motschulsky)	China, Italy, Japan, Korea, Russia, Spain, Taiwan, United States (CT, NC, WA)	Hoebeker 1999; Pasek 2000
	<i>Euryscelis suturalis</i> (Olivier)	Caribbean, United States (FL)	Cazier and Lacey 1952; Pasek 2000
	<i>Monochamus alternatus</i> (Hope)	China, Japan, Korea, Laos, Taiwan, Vietnam	Pasek 2000; Kawai et al. 2006
	<i>Plagionotus christophi</i> Kraatz	Japan, Korea, northeastern China, southeastern Central Asia	Cherepanov 1988; Pasek 2000; KFS 2004

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Order: Family	Species	Distribution ^a	References
	<i>Pyrrhodium sanguineum</i> (L.)	Europe, North Africa, West Asia	Pasek 2000; Hoskovec and Rejzek 2006
	<i>Stromatium barbatum</i> (F.)	Bangladesh, Burma, East Africa, India, Pakistan	CAB 1985; Pasek 2000
	<i>Xylotrechus grayi</i> (White)	China, Japan, Korea, Taiwan	Pasek 2000; Hua 2002
	<i>Xylotrechus magnicollis</i> (Fairmaire)	Burma, China, India, Laos, Russia, Taiwan	Pasek 2000; Hua 2002
Coleoptera: Curculionidae	<i>Pissodes pini</i> (L.)	Russia, western Europe	Kulinich and Orlinskii 1998; Pasek 2000
Coleoptera: Scolytidae	<i>Carphoborus minimus</i> (F.)	Italy, Spain, Turkey	Haack 2001
	<i>Carphoborus pini</i> Eichhoff	Italy, Spain	Haack 2001
	<i>Carphoborus rossicus</i> Semenov	Germany	Haack 2001
	<i>Cryphalus asperatus</i> (Gyllenhal)	Germany, Italy	Haack 2001
	<i>Cryphalus piceae</i> (Ratzeburg)	France, Italy	Haack 2001
	<i>Crypturgus cinereus</i> (Herbst)	Australia, Belgium, Germany, Russia, Spain	Haack 2001
	<i>Crypturgus mediterraneus</i> Eichhoff	France, Italy, Netherlands, Portugal, Spain	Haack 2001
	<i>Crypturgus numidicus</i> Ferrari	Estonia, Greece, Latvia, Spain	Haack 2001
	<i>Dryocoetes autographus</i> (Ratzeburg)	Belgium, Brazil, Germany, Italy, Russia	Haack 2001
	<i>Dryocoetes villosus</i> (F.)	Belgium, France, Germany, Italy, United Kingdom	Haack 2001
	<i>Euwallacea validus</i> (Eichhoff) (= <i>Xyleborus validus</i> Eichhoff)	Burma, China, Costa Rica, Japan, Korea, Malaysia, Philippines, United States (LA, MD, NY, PA), Vietnam	Pasek 2000; Haack 2001; Cognato 2004a
	<i>Gnathotrichus materiarius</i> (Fitch)	Dominican Republic, United States (OR, SD), western Europe	Mudge et al. 2001
	<i>Hylastes angustatus</i> (Herbst)	Belgium, France	Haack 2001
	<i>Hylastes ater</i> (Paykull)	Chile, France, Germany, Italy, Spain	Haack 2001
	<i>Hylastes attenuatus</i> Erichson	France, Italy, Portugal, South Africa, Spain	Haack 2001
<i>Hylastes cunicularius</i> Erichson	Belgium, Germany, Italy, Spain	Haack 2001	
<i>Hylastes linearis</i> Erichson	Italy, Portugal, Spain	Haack 2001	

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Order: Family	Species	Distribution ^a	References
Coleoptera: Scolytidae	<i>Hylastes opacus</i> Erichson	Brazil, Canada, Russia, United States (ME, NH, NY, OR, WV)	Mudge et al. 2001; Haack 2001; 2006
	<i>Hylesinus varius</i> (F.)	Belgium, Italy, United Kingdom	Haack 2001
	<i>Hylurgops glabratus</i> (Zetterstedt)	Italy	Haack 2001
	<i>Hylurgops palliatus</i> (Gyllenhal)	Belgium, Germany, Italy, Spain, United Kingdom, United States (PA)	Haack 2001; 2006
	<i>Hylurgus ligniperda</i> (F.)	Chile, France, Italy, Portugal, Spain, United States (NY)	Haack 2001; 2006
	<i>Ips acuminatus</i> (Gyllenhal)	China, France, Italy, Russia, Spain	Haack 2001
	<i>Ips amitinus</i> (Eichhoff)	Finland, Italy	Haack 2001
	<i>Ips cembrae</i> (Heer)	Belgium, China, Germany, Italy	Haack 2001
	<i>Ips mannsfeldi</i> (Wachtl)	Spain, Turkey	Haack 2001
	<i>Ips sexdentatus</i> (Börner)	Belgium, France, Italy, Portugal, Spain	Haack 2001
	<i>Ips typographus</i> (L.)	Belgium, France, Germany, Italy, Russia	Haack 2001
	<i>Orthotomicus erosus</i> (Wollaston)	China, Mediterranean Region, United States (CA), West and Central Asia	Lee et al. 2005
	<i>Orthotomicus laricis</i> (F.)	France, Germany, Italy, Russia, Spain	Haack 2001
	<i>Orthotomicus proximus</i> (Eichhoff)	Finland, Italy	Haack 2001
	<i>Orthotomicus suturalis</i> (Gyllenhal)	Estonia, France, Germany, United Kingdom	Haack 2001
	<i>Phloeosinus rudis</i> Blandford	Belgium, Japan	Haack 2001
	<i>Phloeotribus scarabaeoides</i> (Bernard)	Asia, Mediterranean Region, southern Europe	Pasek 2000; Rodríguez et al. 2003
	<i>Pityogenes bidentatus</i> (Herbst)	France, Germany, Italy, Portugal, Spain, United States (NY)	Haack 2001; 2006
	<i>Pityogenes bistridentatus</i> (Eichhoff)	France, Italy, Spain, Turkey, United Kingdom	Haack 2001
	Coleoptera: Scolytidae	<i>Pityogenes calcaratus</i> (Eichhoff)	France, Italy, Spain
<i>Pityogenes chalcographus</i> (L.)		Belgium, Germany, Italy, Russia, Spain	Haack 2001
<i>Pityogenes quadridens</i>		Finland, Lithuania,	Haack 2001

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Order: Family	Species	Distribution ^a	References
	(Hartig)	Portugal, Spain, Turkey	
	<i>Pityogenes trepanatus</i> (Nordlinger)	Lithuania	Haack 2001
	<i>Pityokteines curvidens</i> (Germar)	France, Greece, Italy	Haack 2001
	<i>Pityokteines spinidens</i> (Reitter)	Austria, France, Germany, Italy, Russia	Haack 2001
	<i>Pityophthorus pityographus</i> (Ratzeburg)	France, Germany, Italy, Netherlands	Haack 2001
	<i>Polygraphus poligraphus</i> (L.)	Belgium, Germany, Italy, Russia, United Kingdom	Haack 2001
	<i>Polygraphus subopacus</i> Thomson	Azerbaijan, Italy	Haack 2001
	<i>Pteleobius vittatus</i> (F.)	Italy	Haack 2001
	<i>Scolytus intricatus</i> (Ratzeburg)	Belgium, France, Germany, Italy	Haack 2001
	<i>Scolytus ratzeburgi</i> Janson	Finland, Russia, Ukraine	Haack 2001
	<i>Scolytus scolytus</i> (F.)	United Kingdom	Haack 2001
	<i>Taphrorychus bicolor</i> (Herbst)	Belgium, Finland, France, Germany, Netherlands	Haack 2001
	<i>Taphrorychus villifrons</i> (Dufour)	Belgium, France, Germany, Latvia, Turkey	Haack 2001
	<i>Tomicus minor</i> (Hartig)	Brazil, Italy, New Zealand, Turkey	Haack 2001
	<i>Tomicus piniperda</i> (L.)	Belgium, France, Italy, Spain, United Kingdom, United States (OH)	Haack 2001; 2006
	<i>Trypodendron domesticum</i> (L.)	Italy, Turkey	Haack 2001
	<i>Trypodendron signatum</i> (F.)	Belgium, France, Germany, Netherlands	Haack 2001
Coleoptera: Scolytidae	<i>Xyleborinus alni</i> (Niisima)	Austria, former Czechoslovakia, Germany, Japan, Poland, Russia, United States (OR, WA)	Mudge et al. 2001
	<i>Xyleborus californicus</i> Wood	Canada, Russia, United States (AR, CA, DE, MD, OR, SC)	Mudge et al. 2001
	<i>Xyleborus eurygraphus</i> (Ratzeburg)	North Africa, southern and western Europe, Turkey	Haack 2001; Cognato 2004b
	<i>Xyleborus pfeili</i> (Ratzeburg)	Africa, Asia, Europe, New Zealand, United States (MD, OR)	Mudge et al. 2001
	<i>Xyleborus similis</i> Ferrari	Africa, Asia, Australia, Micronesia, United States (TX)	Wood 1960; Rabaglia et al. 2006

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Order: Family	Species	Distribution ^a	References
	<i>Xyleborus xylographus</i> (Say)	Canada, Caribbean, United States (CA, OR)	Mudge et al. 2001
	<i>Xylechinus pilosus</i> (Ratzeburg)	Europe	Haack 2001; Alonso-Zarazaga 2004
	<i>Xyloterinus politus</i> (Say)	Canada, United States (WA)	Mudge et al. 2001
Hymenoptera: Siricidae	<i>Sirex noctilio</i> F.	Australia, Italy, New Zealand, South Africa, Spain, United States (NY)	Hoebeke et al. 2005
Hymenoptera: Xiphydriidae	<i>Xiphydria prolongata</i> (Geoffroy)	Russia, United States (MI, NJ, OR), western Europe	Mudge et al. 2001
Isoptera: Rhinotermitidae	<i>Coptotermes crassus</i> Snyder	Mexico, Central America	Constantino 1998; Pasek 2000

^a U.S. state abbreviations: AR = Arkansas, CA = California, CT = Connecticut, DE = Delaware, FL = Florida, LA = Louisiana, MD = Maryland, ME = Maine, MI = Michigan, NC = North Carolina, NH = New Hampshire, NJ = New Jersey, NY = New York, OH = Ohio, OR = Oregon, PA = Pennsylvania, SC = South Carolina, SD = South Dakota, TX = Texas, WA = Washington, WV = West Virginia

A19.1 SUMMARY

- Hawai'i receives cargo with WPM from numerous countries all over the world.
- WPM is routinely reused and reconditioned, so that its origin usually cannot be determined.
- The effectiveness of the International Standard, ISPM #15, has not been demonstrated.
- An unfortunate lack of suitable data makes it impossible precisely to quantify the likelihood of introducing exotic pests into Hawai'i on or in WPM. However, it is likely that considerable numbers of pests have been entering Hawai'i in WPM.
- Inspectors at ports-of-entry in Hawai'i intercept only a small fraction of these pests.
- Many exotic species that have been intercepted on WPM have already established populations in Hawai'i, where they attack many economically or ecologically important hosts.
- A significant number of insects worldwide are imminent pests for Hawai'i with a potential for introduction via the WPM pathway.

1 **A20 THE MILITARY**

2 **A20.1 MILITARY PRESENCE IN HAWAI'I**

3 Because of its Central Pacific location, Hawai'i has been of strategic importance for more than half a
4 century, hence the large military presence (Kelly 1998b). Almost 100,000 military personnel and their
5 dependents made up 8% of Hawai'i's population in 1994 (Kelly 1998b), the highest proportion of any
6 state in the country. Military expenditures of \$3.2 billion in 1994 accounted for 9% of the gross state
7 product (Kelly 1998b). In 2004, defense spending was \$4.8 billion (HDBEDT 2007). The military employed
8 17,000 civilians, almost 3% of Hawai'i's workforce, with an annual payroll of \$670 million in 1994. All five
9 services were represented: Army personnel made up 44%, Navy 25%, Marine Corps 16%, Air Force 12%,
10 and Coast Guard 3% of the total. The Hawai'i National Guard accounted for almost 5,000 residents. The
11 military reduced active duty personnel in Hawai'i by 28%, from 61,019 in 1980 to 44,193 in 1994. Most
12 military personnel in Hawai'i are stationed on the island of Oahu, with fewer than 200 active duty
13 personnel assigned to other islands. There are about 100 military installations in the islands. Seventy-
14 eight percent (78%) of personnel are stationed at four: Schofield Barracks, Pearl Harbor, Marine Corps
15 Base Hawai'i (MCBH), and Hickam Air Force Base (AFB), all on Oahu. Seventy-seven percent (77%) of
16 civilian personnel work at Pearl Harbor, Hickam AFB, Tripler Army Hospital, and Fort Shafter Army Base
17 (Kelly 1998b). Approximately 12,000 military members and their families move to and from Hawai'i each
18 year (USPACOM, 1998).

19 In 1998, the United States Pacific Command (USPACOM) reported 57,987 military and 22,984 civilian
20 personnel in Hawai'i (excluding Air Guard) (USPACOM 1998). The 2000 United States Census recorded
21 39,036 military personnel in Hawai'i (Clark and Weismantle 2003). Despite declines in personnel, the
22 military budget in Hawai'i increased from \$862 million in 1977 to \$3.2 billion in 1994 (Kelly 1998b).

23 **A20.1.1 United States Pacific Command**

24 The headquarters for the USPACOM Army, Navy, Air Force, and Marine Corps are located on Oahu.
25 USPACOM's area of responsibility (AOR) extends from the west coast of the continental United States to
26 the eastern shores of Africa, and covers over 700 million km², about half of the Earth's surface. There
27 are 43 countries with over 60% of the world's population in this area. It contains countries with the
28 world's six largest armed forces: People's Republic of China, Russia, United States, India, North Korea,
29 and South Korea. Five of seven U.S. mutual defense treaties are with nations in the AOR. In 1998, the
30 command had about 300,000 military personnel deployed, about one-fifth of the total U.S. active duty
31 military force (USPACOM 1998). Most of the military traffic from the Pacific Region to Hawai'i is from
32 Guam, Japan, and Korea (Simon 2006b).

33 In addition, four sub-unified commands report to USPACOM: U.S. Forces Korea, U.S. Forces Japan,
34 Special Operations Command Pacific at Camp Smith, and the Alaskan Command. USPACOM deploys
35 about 100,000 forward forces in the western Pacific, Japan, Korea, and Guam. A second tier of forward
36 forces is based in Hawai'i and Alaska (USPACOM 1998).

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1 The U.S. Navy Pacific Fleet, headquartered at Makalapa Crater near Pearl Harbor, is the world's largest
2 naval command, with nearly half of the Navy's total strength. It is active in the Arctic, Indian, and Pacific
3 oceans, and conducts more than 200 peacetime exercises per year. In 1998, the fleet had 190 ships,
4 1,400 Navy and Marine Corps aircraft, 222,000 Navy and Marine Corps personnel, and 38 shore
5 installations. It employed 519 military and 230 civilian personnel in Hawai'i, on a payroll of \$30 million
6 and \$10 million, respectively. The total annual budget in Hawai'i was \$405 million (USPACOM 1998).

7 The U.S. Army Pacific Command (USARPAC) is headquartered at Fort Shafter. It has command and
8 control of U.S. Army forces in the Pacific, except those in Korea. Terrain in the AOR varies from arid
9 deserts and tropical rain forests to arctic tundra. Soldiers are based on the U.S. mainland (including
10 Alaska), Hawai'i, Guam, American Samoa, the CNMI, and Japan (USPACOM 1998).

11 Marine Forces Pacific (MARFORPAC) is the largest field command in the U.S. Marine Corps, deployed
12 both ashore and afloat. It is led by the Marine Force Commander. Combat and support forces were
13 more than 80,000 strong in 1998. There are two major subordinate commands: First Marine
14 Expeditionary Force, headquartered in California, and the Third Marine Expeditionary Force,
15 headquartered in Japan. An air-ground-logistics team, which numbered 6,800 marines and sailors in
16 1998, is also located at MCBH, Kaneohe Bay (USPACOM 1998).

17 Air Force Pacific (PACAF), the air component of USPACOM, is headquartered at Hickam AFB. It is
18 responsible for most Air Force units, bases, and facilities in the Pacific and Alaska. The command
19 employs military and civilian personnel in nine major locations and numerous smaller ones, primarily in
20 Hawai'i, Alaska, Japan, Guam, and South Korea. In 1998, about 300 fighter and attack aircraft were
21 assigned to the command. There were 45,930 personnel, with 32,682 on active duty, 5,051 reserve
22 components, and 8,197 civilians. Flying hours were 10,195 per month (USPACOM, 1998). PACAF has
23 about 100 bases in the Pacific (Spears 2007).

24 **A20.1.2 Military Establishments in Hawai'i**

25 The United States Department of Defense (DoD) listed 63 military installations in Hawai'i in 2004,
26 covering 9,783 hectares and broken down as follows: Army: 20 installations totaling 3,327 hectares; Air
27 Force: 6 installations totaling 1,331 hectares; Marine Corps: 6 installations totaling 1,290 hectares; and
28 Navy: 31 installations totaling 3,835 hectares (DoD 2004). This account contradicts the Hawai'i Military
29 Installation Area Handbook (USPACOM 1998), which listed land controlled by the military in Hawai'i in
30 1998 as 21,230 hectares on Oahu, 34,333 hectares on the island of Hawai'i, 779 hectares on Kauai, 44
31 hectares on Kaula (an islet about 32 km southwest of Niihau), 5 hectares on Molokai, and 2 hectares on
32 Maui, totaling 56,393 hectares and comprising 3.4% of the total land area of the state. The reason for
33 the discrepancy is unknown.

34 **A20.2 REGULATIONS**

35 DoD 4500.9-R, Defense Transportation Regulation Part V, Department of Defense Customs and Border
36 Clearance Policies and Procedures, maintains the integrity of the defense transportation system. It
37 prescribes procedures, defines responsibilities, and identifies agricultural requirements for entry into,

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1 and exit from, selected countries of the world in support of U.S. forces (DoD and APHIS, 2006). Chapter
2 505 covers agricultural cleaning and inspection requirements. Chapter 506 includes the DoD pre-
3 clearance program, and Chapter 507 includes the military customs inspector program (USTC 2006a; b;
4 c). The inter-service publication, *Quarantine Regulations of the Armed Forces* (Howard et al. 1992),
5 defines DoD quarantine policies and procedures related to agriculture. In addition, the following
6 combatant commands issue directives outlining customs and border clearance guidance: United States
7 European Command (Directive 30-3); United States Central Command (Regulation 600-10); and
8 USPACOM (Instruction 5840.3, Military Customs Inspection within the USPACOM). These publications
9 establish policy, procedures, and responsibilities for compliance with U.S. and host nation customs laws.
10 The DoD must assist and cooperate with other federal agencies when enforcing U.S. laws, regulations,
11 and agricultural customs requirements without unnecessarily delaying the movement of DoD personnel
12 and material. CBP and APHIS-PPQ are required to report promptly all detections of plant pests, diseases,
13 and soil to DoD's executive agent, the United States Transportation Command (USTRANSCOM), for
14 resolution (DoD and APHIS 2006).

15 The quarantine regulations of the armed forces require the forces to cooperate fully with other agencies
16 and comply with the regulations above. APHIS-PPQ and CBP inspectors are authorized to board ships,
17 aircraft, and other conveyances, and to inspect ports and other facilities. Commanders are required to
18 provide full support for inspections. Cooperation with foreign officials, following applicable host country
19 agreements, is also required. All examinations are subject to necessary restrictions to preserve the
20 security of classified material (Howard et al. 1992).

21 The armed forces must comply with applicable regulations published by other federal agencies
22 governing the movement of pathogens, other pests, wildlife, and arthropod vectors. Commanders of all
23 echelons are responsible within their jurisdictions. They must be cognizant of, and comply with,
24 provisions of the DoD directive 5030.49-R, Customs Inspection, and requirements of the Military
25 Customs Inspection Program. Coordination at the department level is provided by the Armed Forces
26 Pest Management Board (Howard et al. 1992).

27 **A20.3 COOPERATION BETWEEN APHIS-PPQ AND THE DEPARTMENT OF DEFENSE**

28 APHIS-PPQ and DoD have cooperated for over 30 years to safeguard U.S. agriculture and natural
29 resources from plant pests and diseases, invasive species, and noxious weeds that might be harbored
30 aboard returning aircraft and other vessels, both military and civilian (DoD and APHIS 2006). APHIS
31 program duties include facilitating pathway analyses (DoD and APHIS 2006). Appropriate armed forces
32 commanders are required to liaise with local representatives of PPQ (Howard et al. 1992).

33 The two agencies have a MOU, the current version of which was signed on May 5, 2006, and is to
34 continue for 5 years from the date of signing. Concerns include troops, mail, and material, such as rolling
35 stock, aircraft, assault vessels, household goods, ordnance, weapons, containerized cargo, and vehicles
36 in support of contingency or wartime emergencies, the Joint Chiefs of Staff, special operations, and
37 other military-sponsored exercises. More recently, WPM has been targeted for inspection (DoD and
38 APHIS 2006).

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1 APHIS-PPQ fulfills the objectives of the military agricultural pre-clearance inspection program in
2 cooperation with DoD. PPQ works with DoD to establish permanent pre-clearance positions for
3 combatant commands and, when appropriate, to provide local coordination and services to the
4 military's agricultural pre-clearance inspection program. The MOU requires PPQ and DoD to make
5 military agricultural pre-clearance inspection equivalent at all locations (DoD and APHIS 2006).
6 Permanent PPQ pre-clearance positions are established at two combatant commands: the Central
7 Command and the European Command (DoD and APHIS 2006). Despite having the largest military
8 presence of any of the theaters, the Pacific Command does not have a permanent PPQ pre-clearance
9 position.

10 **A20.4 TRAINING**

11 APHIS-PPQ cooperates with DoD to train military personnel in agricultural inspection procedures and
12 requirements within the United States prior to their deployment overseas. This activity is coordinated
13 with the DoD USTRANSCOM and occurs at the APHIS training facility in Frederick, Maryland, or at other
14 locations as determined mutually by the two agencies (DoD and APHIS, 2006). Manuals and guidelines
15 providing training for military cooperators (USDA 2002; 2003a) and options for soil treatment (USDA
16 2004) have been published.

17 **A20.5 RESEARCH AND DEVELOPMENT**

18 The MOU between DoD and APHIS-PPQ requires cooperation in research and methods development.
19 Efforts include identifying data gaps that hinder effective pest risk and pathway analyses, and perfecting
20 laboratory analysis of soil to detect pests, such as noxious weed seeds, nematodes, pathogens, snails,
21 and insects (DoD and APHIS, 2006).

22 **A20.6 RESPONSIBILITIES OF THE AGENCIES**

23 APHIS-PPQ has general phytosanitary requirements regarding all ships and aircraft, including their cargo,
24 stores, garbage, and baggage arriving in the continental United States from any outside location,
25 including Hawai'i. All are subject to inspection by PPQ. When inspection discloses items prohibited or
26 restricted by quarantine regulations, reveals a plant or animal pest, or when there is reason to presume
27 such a pest is present, an inspector may take one of several actions, such as re-export or destruction of
28 the items (Howard et al. 1992).

29 Air installation commanders or commanding officers of ships must ensure that all actions are taken to
30 comply with PPQ requirements and regulations governing the handling or disposition of baggage, cargo,
31 stores, and garbage. Garbage must be placed in leak-proof, covered containers and disposed of
32 following port procedures authorized by, or under surveillance of, PPQ. Disposal facilities to incinerate
33 or sterilize regulated garbage or other food materials of foreign origin are required (Howard et al. 1992).

34 CBP inspects non-propagative materials arriving from foreign countries, whereas PPQ inspects foreign
35 propagative material. The HDOA PQ inspects foreign trade goods only if referred to them by CBP. HDOA
36 has no authority to inspect mail or foreign goods not referred to it by CBP (Spears 2007). CBP is

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1 responsible for clearing aircraft arriving at Hickam AFB and Barber’s Point Naval Air Station. CBP inspects
2 all foreign (including military) traffic, using the Manual for Agricultural Clearance (USDA 2006c).

3 CBP has no jurisdiction in Guam. There is no general pre-clearance for military shipments or personnel
4 leaving Guam. APHIS-WS performs pre-clearance inspections for BTS. All agricultural inspection is done
5 at the first port of arrival in the U.S. mainland or in Hawai’i (Spears 2007).

6 HDOA PQ involvement in military inspection primarily entails the use of dog teams to detect BTS on
7 aircraft arriving from Guam, Saipan, and northern Australia. For other inspections, PQ becomes involved
8 only if requested, usually when prohibited items, such as exotic pets, or pests are detected in military
9 cargo or personal effects.

10 DoD official control of pests in Hawai’i is facilitated through the cooperation of island invasive species
11 committees, which have been formed on Kauai, Oahu, Molokai, Maui, and the Big Island (HEAR 2007).
12 The Coordinating Group for Alien Pest Species governs the invasive species committees. The Hawai’i
13 Invasive Species Council is a government body, at the governor’s cabinet level, established by the
14 Legislature of the State of Hawai’i with authority to provide funding and establish state policy for
15 invasive species.

16 **A20.7 MILITARY PATHWAYS FOR POTENTIAL INVASIVE SPECIES INTRODUCTION**

17 **A20.7.1 Aircraft**

18 All Navy and Marine aircraft in Hawai’i are based at MCBH on Oahu (Simon 2006b). Table A20-1
19 summarizes aircraft arrivals at MCBH in 2006. The majority of aircraft arriving at MCBH (48%) originated
20 on the U.S. mainland. Thirty-four percent (34%) came from locations within Hawai’i, and fewer than 1%
21 from U.S. ships at sea. Only 18% arrived from foreign areas, including U.S. territories. Most of these
22 aircraft came from Guam, Japan, Wake Island, and the Marshall Islands.

23 **Table A20-1: Origin of Aircraft Arrivals at MCBH during Calendar Year 2006**

Origin	Number
Continental United States	255
Hawai’i (other locations)	182
Guam	24
Japan	24
Wake Island	21
Marshall Islands	15
U.S. ships	4
Canada	3
Korea	3
Christmas Island	2
American Samoa	2
Iceland	1
Total	536

24 Source: Dinic 2007

25

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1 A total of 536 aircraft carried 7,658 crew members, 10,210 other active duty passengers, and 2,076 non-
 2 duty or retired military members for a total of 19,944 passengers arriving in Hawai'i during 2006. In
 3 total, 298,469 kg of baggage and 1,188,222 kg of cargo were carried by these flights (Dinic 2007).

4 CBP inspects cargo on all military aircraft arriving from foreign areas, including Guam, at MCBH and
 5 Hickam AFB (Simon 2006b). The agency is given as little as 2 hours advance notice of foreign aircraft
 6 arrivals. Of primary concern to the military is the potential for introduction of BTS in flights from Guam;
 7 West Nile virus and coqui frog are also concerns. BTS often is found in the vicinity of military
 8 installations and equipment in Guam. For example, in February 2007, APHIS-WS personnel trapped 272
 9 snakes around the perimeter of the Guam airfield (Salas 2007). All cargo and aircraft destined for
 10 Hawai'i are inspected with the help of specially trained detector dogs. There are 13 dog teams, 10 of
 11 which are at Anderson AFB and 3 at the naval station. Transiting aircraft remaining in Guam longer than
 12 3 hours are inspected (Spears 2007). Further, HDOA inspects every flight arriving in Hawai'i from Guam
 13 for BTS (Simon 2006b; Spears 2007).

14 Personnel arriving from overseas are required to remain aboard aircraft until they are inspected by CBP,
 15 HDOA, and APHIS. Inspection of air crews sometimes is waived by CBP. Passengers arriving from the U.S.
 16 mainland are not inspected, but are required to complete a declaration form (Spears 2007).

17 Table A20-2 presents insect interceptions in military air cargo entering Hawai'i. All are classified as
 18 hitchhikers, since they were found on non-food items.

19 **Table A20-2: Insect Interceptions in Military Air Cargo Entering Hawai'i**

Family	Species	Where Intercepted	Date	Stage	Origin	Known to Occur in Hawai'i
Psychidae	<i>Apterona helix</i> (Siebold)	Private vehicle	03-Jan-99	Larva	California	No
Otitidae	<i>Ceroxys latiusculus</i> (Loew)	Pallet	16-Oct-98	Adult	California	Yes
Carabidae	<i>Gnathaphanus picipes</i> (Macleay)	Crates	03-Apr-97	Adult	Midway Island	Yes
Staphylinidae	<i>Philonthus turbidus</i> Erichson	Crates	03-Apr-97	Adult	Midway Island	Yes
Scarabaeidae	<i>Popillia japonica</i> Newman	Cargo deck	20-Jul-04	Adult	Kadena, Japan	No
Curculionidae	Unknown sp.	Private vehicle	03-Jan-99	Adult	California	No

20 Source: HDOA 2007c

21
 22 Army air traffic arrives at Wheeler Army Airfield and Schofield Barracks. All arrivals at Wheeler are
 23 domestic, and are primarily transiting to Afghanistan and Iraq. CBP inspects the aircraft arriving from the
 24 U.S. mainland, whereas APHIS-PPQ inspects flights outbound to the mainland. Foreign flights land and
 25 are inspected at Hickam AFB (Spears 2007).

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1 CBP inspects Navy and Coast Guard aircraft landing at Barber’s Point Naval Air Station (now closed and
 2 returned to the State of Hawai’i). A major concern is the potential for aircraft from carriers arriving from
 3 foreign locations to introduce pests (Spears 2007).

4 No foreign vessels or flights are permitted to arrive at the Pacific Missile Range Facility at Barking Sands
 5 on Kauai. They arrive on Oahu first to be inspected and cleared. Flights that are precleared on the U.S.
 6 mainland may proceed directly to the Pacific Missile Range Facility (Burger 2007).

7 On Guam, military passengers arrive on contract flights at Anderson AFB. Inbound Navy aircraft may not
 8 give advance notification to the Guam Customs and Quarantine Agency, in which case, passengers
 9 disembark without being cleared. There also have been reports of Marine and Navy cargo aircraft
 10 opening holds before being cleared (Spears 2007). This is of significance to Hawai’i because any pests
 11 that become established on Guam are an imminent threat to Hawai’i.

12 **A20.7.2 Ships**

13 Large vessels periodically arrive at Pearl Harbor Naval Base (Simon 2006b). Upon arrival, Form 288, the
 14 ship arrival form, is completed (Spears 2007). Between the beginning of 2003 and May 20, 2007, 122
 15 ships arrived at the base from 14 foreign countries (Table A20-3). The largest proportion of arrivals
 16 (38%) originated in Japan, followed by 16% from Canada, 10% from Australia, 8% from Mexico, and 7%
 17 from South Korea. Ships arriving from other countries comprised 21% (Sloane 2007).

18 **Table A20-3: Origin of Foreign Ship Arrivals at Pearl Harbor Naval Base from January 1, 2003**
 19 **to May 20, 2007**

Year	2003	2004	2005	2006	2007	Total
Country	Number					
Japan	5	18	12	11		46
Canada	3	7	3	5	2	20
Australia	2	8		2		12
Mexico	1	0	7	2		10
South Korea		9				9
Chile		2		3		5
Russia	2					5
North Korea				4		4
France	1	1		1		3
Netherlands				2		2
Peru		1	1			2
Taiwan				2		2
Indonesia					1	1
Sweden			1			1
Total	14	46	24	32	3	122

20 Source: Sloane 2007

21
 22 Commanders of fully active foreign military vessels arriving in Hawai’i may be reluctant to permit CBP
 23 inspectors onboard, with the result that these vessels may not always be fully inspected. Ships arriving

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1 from the U.S. mainland are not required to disclose any foreign ports-of-call visited earlier. The origin of
2 stores procured for U.S. ships is not always known (Spears 2007).

3 **A20.7.3 Material**

4 Military cargo is difficult to track because of its complex nature, consisting of many types of goods and
5 other materials. Although most items arriving in Hawai'i have been free of foreign contaminants, such as
6 soil (Simon 2006a; b), there remains the potential for contaminated cargo or equipment to enter the
7 state as has occurred elsewhere. For example, there were 984 instances of violations of Air Force
8 quarantine regulations involving cargo shipments arriving at Dover AFB in Delaware and McGuire AFB in
9 New Jersey between 2003 and 2006. Most of the cases involved rolling stock, pallets, and aircraft
10 contaminated with soil. Military transports may carry cargo that is classified as not inspected, also a
11 violation of quarantine regulations (Spears 2007).

12 Vehicles may enter Hawai'i from any of the 43 countries in the Pacific command as well as from the
13 Middle East (Spears 2007). Marine material and vehicles come through Hickam AFB or Pearl Harbor
14 (Bookless 2007).

15 Military cargo arriving in Guam, some of which may be classified, is not subject to inspection. Most
16 rolling stock arrives on naval ships. It occasionally has been contaminated with soil, thus posing a risk of
17 introducing pest organisms. Facilities in Guam for cleaning rolling stock are inadequate. Aircraft arriving
18 in Guam are inspected only if they are carrying food items (Spears 2007).

19 **A20.7.4 Stores and Garbage**

20 The MOU directs APHIS and CBP to prepare and implement compliance agreements with DoD to
21 regulate in-flight meals on air cargo flights (DoD and APHIS 2006). Crew members aboard naval vessels
22 are instructed to consume prohibited products before arrival. Foreign military commanders are
23 informed about the stores and garbage that can be removed from their vessels. Garbage composed of
24 discarded fruit and vegetable material (wet garbage) is considered a high risk (Spears 2007).

25 DoD is responsible for the proper handling of USDA-regulated garbage aboard military conveyances
26 arriving in the United States. Regulated garbage is restricted to prevent the introduction of plant pests
27 and pathogens, and includes plant material that has been aboard any conveyance outside of the United
28 States, except Canada (DoD and APHIS 2006). Special dumpsters are used for the disposal of trash from
29 ships arriving from overseas. Honolulu Disposal, a civilian contractor, handles refuse from Navy ships,
30 and incinerates it at its facility. After use, dumpsters are treated with bleach to sanitize them (Spears
31 2007).

32 Barber's Point Coast Guard Air Station, Hickam AFB, and MCBH have approved facilities for handling
33 garbage arriving on aircraft from foreign points (USDA 2006c). Honolulu Biowaste, a civilian contractor,
34 handles refuse for the Air Force. Garbage from foreign aircraft is double-bagged and steamed-sterilized
35 (Spears 2007).

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1 Regulated garbage arriving in Guam on military flights from Japan, Taiwan, and the Philippines is
2 collected and deposited in special bins. Food from aircraft is inspected by Guam Customs and
3 Quarantine (Spears 2007).

4 **A20.7.5 Produce and Propagative Materials**

5 Most of the produce destined for military commissaries comes through California; some may originate
6 from foreign sources. HDOA regards this as a deficiency in agricultural safeguarding in Hawai'i, as
7 produce coming through the U.S. mainland from foreign sources may harbor exotic pests. All produce,
8 including that of foreign origin, must be precleared on the mainland (Spears 2007).

9 All produce for military commissaries on Guam originates in the mainland United States. Inspectors in
10 Guam occasionally have detected small insects, such thrips and aphids, in produce shipped from the
11 mainland. Produce of foreign origin found to be harboring pests is destroyed or re-exported (Spears
12 2007).

13 Military transports and cargo transiting Hawai'i en route to other Pacific islands, including Guam, are not
14 inspected or precleared by APHIS-PPQ in Hawai'i (Spears 2007). Military exchanges on Guam import
15 plants for propagation and freshly cut Christmas trees from the U.S. mainland. These practices allow for
16 the potential introduction and establishment of alien species in Guam, which subsequently could enter
17 Hawai'i via the military traffic between the two areas.

18 **A20.7.6 Household Goods**

19 The military customs inspection program for household goods was discontinued in the mid-1990s.
20 Responsibility for inspection of household good was shifted to the owner (Spears 2007). The
21 effectiveness of such self-inspections is unknown (Egan 2007). Household goods of military members are
22 shipped through a commercial port-of-entry, where they are inspected. In Hawai'i, household goods are
23 cleared at Sand Island, Honolulu (Bookless 2007; Spears 2007). The greatest risks associated with
24 household goods, such as those shipped in van-packs, are the potential presence of hitchhiking pests
25 and soil contamination.

26 **A20.8 REDEPLOYMENT AND MILITARY EXERCISES**

27 The frequent redeployment of troops and equipment into the United States from foreign regions
28 potentially creates a major pathway for introduction of alien species. The MOU requires that any aircraft
29 or ocean vessel presented for loading precleared cargo will be clean and substantially free from pests
30 (DoD and APHIS 2006). Military quarantine regulations outline measures, such as surveillance and
31 disinfection, to be used to reduce the risks of pest introduction (Howard et al. 1992).

1 **A21 A SAMPLING OF IMMINENT PEST THREATS TO HAWAI'I**

2 **A21.1 ARTHROPODS**

3 An average of about 20 exotic, terrestrial arthropods becomes established in Hawai'i every year
4 (Beardsley 1979), a rate of introduction matching or exceeding that for the entire continental United
5 States (Beardsley 1962). The latest period reported, July 1, 2005 to June 30, 2006, was typical, and saw
6 the detection of 18 arthropods new to the state (HDOA 2006). Only a small proportion of these
7 immigrants attains pest status in Hawai'i, causing economic harm and necessitating the implementation
8 of control measures. There remain, however, numerous, as-yet unintroduced arthropod species that
9 constitute major threats to the state's economy and natural environment. Some of those regarded as
10 most significant, in terms of potential economic or ecological impact, are discussed below.

11 **A21.1.1 *Aleurodicus pulvinatus* (Maskell) (Homoptera: Aleyrodidae)**

12 This whitefly is known only from the New World tropics (Martin and Watson 1998). Distributional
13 records include Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guyana, Honduras,
14 Mexico, Nicaragua, Panama, Peru, Nevis, St. Kitts, Surinam, Trinidad, and Venezuela. The host range of
15 *A. pulvinatus* is quite broad. Hosts include *Cocos nucifera* (Arecaceae), *Psidium guajava* (Myrtaceae),
16 *Coffea canephora* (Rubiaceae), *Coccoloba* spp. (Polygonaceae), *Persea americana* (Lauraceae), *Piper*
17 *nigrum* (Piperaceae), *Hura crepitans* (Euphorbiaceae), *Lacistema* sp. (Lacistemataceae), *Vismia* sp.
18 (Clusiaceae) (Martin and Watson 1998); *Echinodorus* sp. (Alismataceae), *Montrichardia arborescens*
19 (Araceae), *Chrysobalanus icaco* (Chrysobalanaceae), *Terminalia catappa* (Combretaceae), *Ficus* sp.
20 (Moraceae), *Musa* sp. (Musaceae), *Theobroma* sp. (Sterculiaceae), and *Petrea* sp. (Verbenaceae) (Kairo
21 et al. 2001).

22 As an indication of the species' invasiveness, recent surveys suggest that it is expanding its geographical
23 range in the Caribbean, the most likely mode of spread being the movement of nursery plants (Kairo et
24 al. 2001). The whitefly (as *A. iridescens* Cockerell) has been intercepted at U.S. ports on 17 occasions
25 since 1985 on various commodities, including ornamentals, from several countries (PIN 309a). It is a
26 major pest of coconut palm in the West Indies (Martin and Watson 1998). Damage caused by *A.*
27 *pulvinatus* is typical of that caused by whiteflies in general (Mound and Halsey 1978). Feeding by
28 nymphs reduces plant vigor, and the sooty molds that grow in excreted honeydew coating leaf surfaces
29 interfere with photosynthesis, further reducing plant fitness; aesthetic concerns also are raised by the
30 unsightly appearance of infestations on valuable ornamental plants (Kairo et al. 2001). Although no
31 studies have been carried out to quantify losses, the economic impact of this pest is thought potentially
32 to be high. Apart from the loss of plants and costs of their replacement, there have been the high costs
33 of control measures, and potentially adverse effects on the environment and on tourism (Kairo et al.
34 2001). The whitefly also is regarded as a minor pest of guava (Gould and Raga 2002). Given its history as
35 a pest of coconut in the West Indies, and the importance of this palm, as an ornamental plant (Neal
36 1965), to economies dependent on tourism, such as Hawai'i, it poses a significant risk to the state.
37 Introduction of the whitefly could result in the initiation of biological control programs, similar to what
38 has occurred in response to introductions of other whitefly species (e.g., Clausen 1978a). Such programs

1 would have the potential to perturb Hawai'i's native ecosystems by affecting non-target species (e.g.
2 Howarth, 1991).

3 **A21.1.2 *Anastrepha bahiensis* Lima (Diptera: Tephritidae)**

4 The geographic distribution of *A. bahiensis* comprises tropical America. It has been reported from Brazil,
5 Colombia, Panama, Trinidad (White and Elson-Harris 1992); Peru (Korytkowski and Ojeda 1968); and
6 Mexico (Hernández-Ortiz and Pérez-Alonso 1993). Hosts include *Juglans neotropica* and *J. regia*
7 (Juglandaceae), *Coffea arabica* (Rubiaceae) (White and Elson-Harris 1992); *Brosimum alicastrum*,
8 *Pseudolmedia oxyphyllaria*, *Pouroma cecropiaefolia* (Moraceae) (Hernández-Ortiz and Pérez-Alonso
9 1993; Zucchi et al. 1996); *Spondias mombin* (Anacardiaceae), *Psidium guajava* (Myrtaceae) (Sommeijer
10 1975); and *Eugenia variabilis* (Myrtaceae) (Norrbon and Kim 1988).

11 Guava is considered almost a universal host for fruit-infesting Tephritidae (Gould and Raga 2002). The
12 tree is widespread in Hawai'i (Wagner et al. 1999), and could facilitate the spread of this pest
13 throughout the state. Information on the reproductive biology of *A. bahiensis* is unavailable. Fecundity
14 of other species of *Anastrepha* ranges from 200 to about 1,500 eggs per female, and several generations
15 per year are typical (White and Elson-Harris 1992). Adults of *Anastrepha* species may fly as far as 135 km
16 (84 miles); flight thus can be an important means of spread (CABI 2006). The major means of dispersal to
17 previously uninfested areas is the transport, in international trade, of fruit containing larvae. Puparia
18 also may be disseminated, concealed in packing materials accompanying produce. Since 1984,
19 specimens of *Anastrepha* spp. have been intercepted at U.S. ports on well over 38,000 occasions (PIN
20 309a). If the biology of *A. bahiensis* is similar to that of related species, its reproductive and dispersal
21 potentials could be high. The fly represents a potential threat to crops in Hawai'i, such as coffee and
22 guava, and, because it attacks a related species, to the endemic plant, *Eugenia koolauensis* (nioi), listed
23 as Endangered in 50 CFR § 17.12). Introduction of the pest into Hawai'i also could result in the initiation
24 of chemical or biological control programs, with potential ecological consequences. Insecticides for the
25 control of fruit flies, such as *Anastrepha* spp., are used almost everywhere that guavas are grown
26 commercially (Gould and Raga 2002). *Anastrepha* spp. also have been the targets for biological control
27 programs, with some measure of success (Clausen 1978b).

28 **A21.1.3 *Anastrepha fraterculus* Wiedemann (Diptera: Tephritidae)**

29 The name *A. fraterculus* apparently represents a species complex that is as yet little studied (CABI 2006).
30 This group ranges from temporary populations in the south of Texas to Argentina (Foote et al. 1993).
31 *Anastrepha fraterculus* is extremely polyphagous. Preferred hosts are Myrtaceae, including *Eugenia* and
32 *Syzygium* spp. (CABI 2006). A few of the species' many other hosts are *Terminalia catappa*
33 (Combretaceae), *Malus pumila* and *Prunus* spp. (Rosaceae), *Annona* spp. (Annonaceae), *Citrus* spp.
34 (Rutaceae), *Coffea* spp. (Rubiaceae), *Ficus carica* (Moraceae), *Juglans* spp. (Juglandaceae), *Diospyros kaki*
35 (Ebenaceae), *Manilkara zapota* (Sapotaceae), *Persea americana* (Lauraceae), *Solanum quitoense*
36 (Solanaceae), *Theobroma cacao* (Sterculiaceae), *Olea europaea* (Oleaceae), and *Vitis vinifera* (Vitaceae).

37 Guava is listed by Aluja et al. (1987) among natural hosts of the fly. Fecundity ranges from 200 to 400
38 eggs per female (White and Elson-Harris 1992). The species is multivoltine, there being several

1 generations per year (Fletcher 1989a). Long-distance dispersal has not been reported for adults of *A.*
2 *fraterculus*. The major means for introducing the species to previously uninfested areas is the transport,
3 in international trade, of fruit containing larvae; for most regions, the most important fruits likely to be
4 infested by this species are mango and guava (CABI 2006). *Anastrepha fraterculus* is the most
5 economically important species of *Anastrepha* in Brazil and other South American countries because of
6 its broad host range (Foote et al. 1993). In Brazil, where it causes severe yield losses in apple, the pest is
7 of major concern to growers, and represents a significant constraint to fresh fruit export into countries
8 with quarantine barriers (Sugayama et al. 1996). The insect also is an important pest of guava and
9 mango, and to some extent of *Citrus* and *Prunus* spp. (CABI 2006). Even if eggs are not deposited in
10 guava fruit, or do not hatch, the oviposition punctures (stings) may render fruit unmarketable (Gould
11 and Raga 2002). *Anastrepha fraterculus* is a quarantine pest for Chile, Argentina, New Zealand, Turkey,
12 China, and eastern and southern Africa (EPPO 2005a); thus, its introduction could result in a loss of
13 domestic or foreign markets for Hawai'ian-grown commodities, such as citrus, mango, and avocado. In
14 Peru, hot water is used as a quarantine treatment for mango exported to the United States (Sharp and
15 Picho 1990), which increases production costs. *Anastrepha fraterculus* is a potential threat to native
16 plants in Hawai'i listed as threatened or endangered (50 CFR § 17.12), such as *Eugenia koolauensis*,
17 *Solanum incompletum* (popolo ku mai), and *S. sandwicense* (aiakeakua, popo lo). Its introduction into
18 the state likely would lead to the employment of biological or chemical controls, as has occurred
19 elsewhere (Clausen 1978b; Gould and Raga 2002).

20 **A21.1.4 *Anastrepha ludens* (Loew) (Diptera: Tephritidae)**

21 Originally native to Mexico, *A. ludens* presently occurs from southern Texas (temporary populations) to
22 Costa Rica (Foote et al. 1993). This is the only important *Anastrepha* species that ranges more into
23 subtropical regions, occupying the more northern portion of the range of the genus and extending
24 southward only at higher elevations; the fly is said to be able to withstand freezing weather well
25 (Weems 1963). Primary hosts are *Citrus* spp. (Rutaceae), *Mangifera indica* (Anacardiaceae), and *Prunus*
26 *persica* (Rosaceae) (CABI 2006). Other hosts include *Annona* spp. (Annonaceae), *Coffea arabica*
27 (Rubiaceae), *Passiflora edulis* (Passifloraceae), *Carica papaya* (Caricaceae), *Mammea americana*
28 (Clusiaceae), *Musa* sp. (Musaceae), *Opuntia* sp. (Cactaceae), *Persea americana* (Lauraceae), *Pouteria*
29 *sapota* (Sapotaceae), *Psidium guajava* (Myrtaceae), *Cucurbita* sp. (Cucurbitaceae), and *Inga* spp.
30 (Fabaceae) (Norrbon and Kim 1988), several of which are economically or otherwise important in
31 Hawai'i.

32 Fecundity is reported to range between 40 and 1,600 eggs per female (Liedo and Carey 1996). There are
33 four to eight generations per year (Aluja 1993). A flight range of at least 36 km (22 miles) has been
34 reported, and the regular appearance of adults in Texas at least 135 km (84 miles) from known breeding
35 sites in Mexico suggests that the migratory powers of the species are considerably greater (Fletcher
36 1989b). Similar to other *Anastrepha* species, the major means of dispersal to previously uninfested areas
37 is the transport of fruit, such as citrus and mango, and to a lesser extent peaches and guava, containing
38 larvae (CABI 2006). Because of its broad host range, including fruits of considerable economic
39 importance, such as grapefruit and orange, *A. ludens* is considered to be the most economically
40 important *Anastrepha* species threatening the United States (Foote et al. 1993). In an early study,

1 potential production losses caused by this and three other fruit fly species were conservatively
2 estimated to be 26.7 million boxes of citrus at a value of \$70.1 million (1975 farm-level prices) (Andrew
3 et al. 1977); losses at current price levels would be significantly higher. The fly is considered to be a key
4 pest of guava (Gould and Raga 2002). Quarantine treatments, such as hot water (Sharp et al. 1989a) and
5 irradiation (Hallman and Martinez 2001), have been developed to disinfest fruit, potentially increasing
6 production costs. *Anastrepha ludens* is a quarantine pest for Argentina, Brazil, Chile, Paraguay, Uruguay,
7 Turkey, China, and eastern and southern Africa (EPPO 2005a). Its introduction into Hawai'i, therefore,
8 could result in a loss of domestic or foreign markets for various commodities, such as citrus, mango,
9 papaya, and avocado, and could lead to the initiation of biological control programs, as has occurred in
10 response to the introduction of other *Anastrepha* species (Clausen 1978b).

11 **A21.1.5 *Anastrepha obliqua* (Macquart) (Diptera: Tephritidae)**

12 One of the most widespread of *Anastrepha* species (Foote et al. 1993), *A. obliqua*, ranges from Mexico
13 to Argentina and across the Caribbean (CABI 2006). This fruit fly has been recorded on more than 60
14 plant species in 24 families (Foote et al. 1993). The main wild hosts are *Spondias* spp. (Anacardiaceae);
15 *Mangifera indica* (Anacardiaceae) is the major commercial host (CABI 2006). Other hosts include citrus
16 (Rutaceae), *Annona* spp. (Annonaceae), *Carica papaya* (Caricaceae), *Coffea arabica* (Rubiaceae),
17 *Phaseolus* sp. (Fabaceae), *Prunus* spp. (Rosaceae), *Brosimum alicastrum* (Moraceae), *Eugenia* spp.
18 (Myrtaceae), *Diospyros* spp. (Ebenaceae), *Vitis vinifera* (Vitaceae), and *Pouteria* spp. (Sapotaceae)
19 (Norrbon and Kim 1988). Guava is among the natural hosts of the fly (Aluja et al. 1987), which suggests
20 that the plant also is a primary host.

21 Fecundity may exceed 1,300 eggs per female in the laboratory (Liedo and Carey 1996), but 500 to 700 is
22 the normal range under field conditions (Toledo and Lara 1996). There are four to eight generations per
23 year (Aluja, 1993). Similar to other *Anastrepha* species, the major means of dispersal to previously
24 uninfested areas is the transport of fruit, such as mango and, to a lesser extent, citrus and guava,
25 containing larvae. The species has been intercepted in France on mangoes from Mexico (CABI 2006).
26 *Anastrepha obliqua* is one of the most important fruit fly pests of mango (Foote et al. 1993). In Brazil,
27 infestations ranging from 7 to 88% in commercial crops of *Malpighia punicifolia* (Malpighiaceae) were
28 observed, leading to a downgrading of fruit quality (Ohashi et al. 1997). The fly is a major pest of
29 *Eugenia stipitata* in Peru, causing reductions in yield and fruit quality (Couturier et al. 1996), and a major
30 pest of guava (Gould and Raga 2002). Establishment of this pest in Hawai'i could cause a loss of
31 domestic or foreign markets. The species is a quarantine pest for Argentina, Uruguay, China, Taiwan,
32 Indonesia, Korea, New Zealand, Namibia, South Africa, Turkey, eastern and southern Africa, and the
33 European Union (EPPO 2005a; PRF 2007). It also represents a potential threat to native plants in Hawai'i,
34 such as *Eugenia koolauensis*. Its introduction likely would stimulate the initiation of control programs.
35 For example, biological control is employed in Brazil to suppress populations of this species in mango
36 orchards (e.g., Montoya et al. 2000).

37 **A21.1.6 *Anastrepha serpentina* (Wiedemann) (Diptera: Tephritidae)**

38 This fruit fly occurs in most countries of Central America and in South America south to Brazil and
39 Argentina (Foote et al. 1993; CABI 2006). At least 40 species in 13 plant families have been recorded as

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1 hosts of *A. serpentina* (Foote et al. 1993). Species of Sapotaceae appear to be the favored hosts. Other
2 hosts include *Citrus* spp. (Rutaceae), *Mammea americana* (Clusiaceae), *Spondias* spp. (Anacardiaceae),
3 *Malus domestica* and *Prunus persica* (Rosaceae), *Solanum lycopersicum* (Solanaceae), *Persea americana*
4 (Lauraceae), *Annona glabra* (Annonaceae), *Ficus* sp. (Moraceae), *Byrsonima crassifolia* (Malpighiaceae),
5 and *Eugenia uniflora* and *Psidium guajava* (Myrtaceae) (Eskafi and Cunningham 1987; Norrbom and Kim
6 1988).

7 Average fecundity ranges from about 80 to 100 eggs per female (CABI 2006), although a maximum of
8 almost 900 eggs per female has been recorded (Liedo and Carey 1996). There are four to eight
9 generations per year (Aluja 1993). Long-distance dispersal is accomplished by the transport of immature
10 stages in fruit or packaging (CABI 2006). *Anastrepha serpentina* is an important pest of sapote
11 (*Calocarpum* spp.), sapodilla (*Manilkara zapota*), *Lucuma salicifolia*, and other fruits in Mexico;
12 infestations in tree-ripened fruit are said frequently to be so high that growers are forced to harvest
13 early and ripen fruit artificially, which lowers its quality (Weems 1969). It also is considered a key pest of
14 guava (Gould and Raga 2002). Hot-water quarantine treatments have been developed for mango
15 infested with this pest (Sharp et al. 1989b), which increase production costs. Establishment of the fly in
16 Hawai'i could lead to the loss of domestic or foreign markets for commodities, such as citrus and
17 avocado. The fly is a quarantine pest for Argentina, Uruguay, New Zealand, Indonesia, and Taiwan (EPPO
18 2005a; PRF 2007). *Anastrepha serpentina* is a potential threat to native plants in Hawai'i listed as
19 threatened or endangered (50 CFR § 17.12), such as *Eugenia koolauensis*, *Solanum incompletum*, and *S.*
20 *sandwicense*. Its introduction into Hawai'i also could stimulate the initiation of biological control
21 programs, as has occurred in response to the introduction of other fruit fly pests (e.g., Clausen 1978b).

22 **A21.1.7 *Anastrepha striata* Schiner (Diptera: Tephritidae)**

23 This species is found throughout Central America, in South America south to Bolivia and Brazil, and in
24 the Netherlands Antilles (CABI 2006). *Psidium guajava* is the primary host (Aluja et al. 1987; CABI 2006).
25 Secondary hosts include *Citrus sinensis* (Rutaceae), *Annona muricata* (Annonaceae), *Chrysophyllum*
26 *cainito* (Sapotaceae), *Prunus persica* (Rosaceae), *Mangifera indica* (Anacardiaceae), *Persea americana*
27 (Lauraceae), *Terminalia catappa* (Combretaceae) (CABI 2006); *Manihot esculenta* (Euphorbiaceae)
28 (White and Elson-Harris 1992); *Solanum macranthum* (Solanaceae), *Eugenia uniflora* (Myrtaceae), and
29 *Passiflora edulis* (Passifloraceae) (Norrbom and Kim 1988).

30 Fecundity ranges from 100 to 800 eggs per female; there are four to eight generations per year (Aluja
31 1993). As in other *Anastrepha* species, long-distance dispersal is accomplished by the movement of
32 immature stages present in consignments of infested fruit (CABI 2006). Little detailed information is
33 available concerning the economic impact of *A. striata*. Although Weems (1982) stated that the species
34 is not considered to be of primary economic importance, it is reported to be an important pest of guava
35 in Venezuela (Marín 1973). It is listed in Gould and Raga (2002) as a key pest of guava. Norrbom (2003)
36 also considered the species to be an important pest of guava and other myrtaceous fruits. Because it is a
37 quarantine pest for New Zealand (EPPO 2005a), establishment of *A. striata* could result in a loss of that
38 market, as well as domestic markets, for Hawai'ian-grown commodities, such as citrus, mango, and
39 avocado. *Anastrepha striata* has the potential to attack federally listed (50 CFR § 17.12) native plants in

1 Hawai'i (e.g., *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*). Because it represents a
2 potential threat to citrus and other cultivated fruit crops, biological control programs could be initiated
3 against the species, as has occurred in response to the introduction of other fruit fly pests (e.g., Clausen
4 1978b).

5 **A21.1.8 *Bactrocera depressa* (Shiraki) (Diptera: Tephritidae)**

6 The geographic distribution of *B. depressa* is within temperate to tropical East Asia. It ranges from
7 Hokkaido, south through the remaining islands of Japan and the Ryukyu Archipelago, to mainland China
8 (Sichuan) and Taiwan (White and Elson-Harris 1992; Carrol et al. 2002). The species is widely distributed
9 in Korea (Han et al. 1994). Hosts are predominantly Cucurbitaceae. The fly has been recorded on
10 *Cucurbita moschata* and *C. maxima*, *Cucumis metuliferus* and *C. sativus*, *Citrullus lanatus*, *Lagenaria*
11 *siceraria*, and *Trichosanthes kirilowii* (White and Elson-Harris 1992; Mun et al. 2003). Larvae of *B.*
12 *depressa* are reported to infest fruit of tomato (*Solanum lycopersicum* [Solanaceae]) in Korea (Han et al.
13 1994) and Japan (Okadome 1962). Because *B. depressa* has been found in areas (e.g., mountainous
14 regions of the Ryukyu Islands), from which cucurbits are absent, White and Elson-Harris (1992)
15 suggested that the species probably had additional, non-cucurbit hosts.

16 No information is available on reproduction in *B. depressa*. If its biology is similar to that of other
17 *Bactrocera* species (Fletcher 1989a; CABI 2006), a high fecundity (e.g., greater than 1,000 eggs per
18 female) may be indicated, as is typical of the polyphagous dacine Tephritidae (Fletcher 1987). Migratory
19 movements are exhibited by several species of *Bactrocera*, in which flights up to 94 km (58 miles) (*B.*
20 *tryoni* [Froggatt]) have been reported (Fletcher 1989b). However, investigations into the population
21 structure of *B. depressa* by Mun et al. (2003) indicated that the frequency of long-distance dispersal in
22 this species is extremely low. Long-distance dissemination could occur via movement in infested fruit,
23 and the species potentially could be introduced into Hawai'i in commodities, such as cucurbits or
24 tomato. *Bactrocera depressa* is said to be a significant pest of *Cucurbita moschata* (pumpkin or winter
25 squash) and *C. maxima* (Hubbard squash) in Korea and Japan (Mun et al. 2003). In their survey, Han et
26 al. (1994) reported severe damage to *C. moschata* ($\geq 31\%$ of fruits); lesser damage (10 to 30%) to
27 *Citrullus lanatus* (watermelon), *Lagenaria siceraria* (bottle gourd), and ornamental pumpkin (*Cucurbita*
28 spp.); and "mild" damage ($\leq 10\%$) in tomato and melon. Damage is caused by larvae tunneling through
29 and macerating fruit tissue (Fletcher 1987). As *Bactrocera* spp. are quarantine pests for numerous
30 countries, including French Polynesia, New Caledonia, Turkey, Madagascar, Argentina, Brazil, New
31 Zealand, Syria, Uruguay, and Chile (PRF 2007), introduction of *B. depressa* into Hawai'i could result in a
32 loss of foreign, as well as domestic, markets for commodities, such as tomato and cucurbits. As a pest of
33 tomato, the fly represents a potential threat to the endemic *Solanum incompletum* and *S. sandwicense*.
34 Further, its introduction likely would result in the initiation of chemical or biological control programs
35 similar to those targeting other tephritid pests (Roessler 1989; Sivinski 1996).

36 **A21.1.9 *Bactrocera passiflorae* (Froggatt) (Diptera: Tephritidae)**

37 This tephritid is restricted to the tropical South Pacific (Fiji, Niue, Tonga, Wallis and Futuna) (CABI 2006).
38 It has been recorded on at least 55 plant species in 42 genera (SPC 2002a). Hosts include *Artocarpus*
39 *altilis* (Moraceae), *Mangifera indica* (Anacardiaceae), *Passiflora* spp. (Passifloraceae), *Carica papaya*

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1 (Caricaceae), *Citrus* spp. (Rutaceae), *Persea americana* (Lauraceae), *Theobroma cacao* (Sterculiaceae),
2 *Ochrosia oppositifolia* (Apocynaceae) (SPC 2002a; CABI 2006); *Eugenia malaccensis*, *Psidium guajava*,
3 and *P. cattleianum* (Myrtaceae), *Coffea liberica* (Rubiaceae), *Pometia pinnata* (Sapindaceae), *Santalum*
4 *yasi* (Santalaceae), *Gossypium barbadense* (Malvaceae), *Inocarpus edulis* (Fabaceae) (Simmonds 1936);
5 and *Chrysobalanus icaco* (Chrysobalanaceae) (Clausen et al. 1965).

6 No information is available on the reproductive or dispersal potentials of *B. passiflorae*. If its biology is
7 similar to that of other *Bactrocera* species (Fletcher 1989a; b), it may exhibit a high degree of fecundity
8 and mobility. The transport of infested fruit would be a major pathway for the pest to be introduced
9 into new regions (CABI 2006). The fly's association with plants, such as common guava and strawberry
10 guava, which are widespread in Hawai'i (Wagner et al. 1999), likely would facilitate its rapid spread
11 throughout the islands. What little information is available concerning the economic impact of this
12 species indicates that its potential impact may be significant. White and Elson-Harris (1992, p. 221)
13 referred to it as a "potential pest," probably because of its restricted distribution. In Fiji, infestation
14 levels have been reported to be as high as 60% in *Fortunella japonica* (kumquat), 40 to 90% in guava,
15 62% in *Syzygium malaccense*, and 20 to 25% in mango (SPC 2002a). Control measures include the
16 bagging of fruit, field sanitation, and trapping (SPC 2002a), which tend to increase production costs. The
17 species is regarded as a serious plant quarantine threat to other Pacific islands (it is a quarantine pest for
18 French Polynesia and New Caledonia [PRF 2007]), and to countries in Australasia and the Asian mainland
19 (CABI 2006). Thus, its introduction into Hawai'i could result in further losses of foreign, as well as
20 domestic, markets for such fruit fly host fruits as mango, citrus, avocado, and papaya. As it attacks
21 closely related host species, its introduction into Hawai'i also could put at risk native plants, such as
22 *Eugenia koolauensis*, *Ochrosia kilaueaensis* (holei), *Santalum freycinetianum* var. *lanaiense* (iliahi), and
23 *Solanum incompletum* and *S. sandwicense*, all listed as endangered in 50 CFR § 17.12. Its introduction
24 also could spur the initiation of biological control programs, as has occurred elsewhere (e.g., Wharton
25 1989).

26 **A21.1.10 *Bactrocera tau* (Walker) (Diptera: Tephritidae)**

27 The geographic distribution of *B. tau* is restricted to temperate to tropical countries of the Oriental
28 Region. The fly occurs in Bangladesh, Bhutan, Brunei, Burma, Cambodia, China, India, Indonesia, Laos,
29 Malaysia, Nepal, the Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam (Narayanan and Batra 1960;
30 White and Elson-Harris 1992; Waterhouse 1993b; Huque 2006). Although preferred hosts appear to be
31 species of *Cucurbitaceae*, such as *Cucumis sativus*, *Luffa acutangula*, *Cucurbita maxima*, *Trichosanthes*
32 *anguina*, *Benincasa hispida*, and *Momordica charantia*, the fly has been recorded on hosts in several
33 other families (Narayanan and Batra 1960; Batra 1968; Syed 1970; White and Elson-Harris 1992; Allwood
34 et al. 1999). These include *Mangifera foetida* and *M. indica* (Anacardiaceae), *Muntingia calabura*
35 (Elaeocarpaceae), *Citrus maxima* (Rutaceae), *Solanum lycopersicum* (Solanaceae), *Borassus flabellifer*
36 (Arecaceae), *Phaseolus vulgaris* (Fabaceae), *Strychnos* spp. (Loganiaceae), *Ficus racemosa* (Moraceae),
37 *Psidium guajava* and *Syzygium samarangense* (Myrtaceae), *Myxopyrum smilacifolium* (Oleaceae),
38 *Manilkara zapota* (Sapotaceae), and *Tetrastigma lanceolarium* (Vitaceae).

1 The fly thus poses a potential threat to several important crops in Hawai'i. Depending on cucurbit host,
2 mean fecundity ranged from 666 to 911 eggs per female (Liu and Lin 2001). The fly is said to exhibit
3 several overlapping generations throughout summer in India; there is no diapause (Batra 1968). Two
4 generations per year in Taiwan are indicated (Chen 2001). The species is reported to make migratory
5 flights (Fletcher 1989b). It has been intercepted in Japan in fresh fruits from Southeast Asia (Takeishi
6 1992), indicating that it is readily transported long distances by human agency. *Bactrocera tau* is an
7 important pest of various fruit crops, such as pumpkin, watermelon, mango, sapodilla, citrus, and
8 tomato, in India (Kapoor 1989) and China (Zhou et al. 1993), presumably causing significant yield losses.
9 In China, insecticides, such as BHC, diazinon, and trichlorfon, are applied to control the pest (Zhou et al.
10 1993; Yang et al. 1994), a practice that increases production costs. As the fly is a quarantine pest for
11 Korea (PRF 2007), its introduction could result in a loss of that market for various Hawai'i fruit crops.
12 *Bactrocera tau* represents a potential threat to native plants in Hawai'i listed as endangered in 50 CFR §
13 17.12, such as *Solanum incompletum* and *S. sandwicense*. As it is a pest of economically important crops
14 (e.g., cucurbits, citrus, mango, guava, tomato), introduction of the fly into Hawai'i likely would result in
15 the initiation of chemical or biological control programs, which have proven to be effective against it and
16 other species of fruit fly elsewhere (Clausen 1978b; Zhou et al. 1993).

17 **A21.1.11 *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae)**

18 This fruit fly is found throughout the eastern half of Queensland, eastern New South Wales, and the
19 extreme east of Victoria in Australia (CABI 2006). There also have been short-lived outbreaks in South
20 Australia. Adventive populations occur in the Austral and Society Islands and New Caledonia. The fly has
21 been recorded on plants in numerous families (CABI 2006). Hosts include *Mangifera indica*
22 (Anacardiaceae), *Annona* spp. (Annonaceae), *Carica papaya* (Caricaceae), *Terminalia aridicola*
23 (Combretaceae), *Artocarpus odoratissima* (Moraceae), *Coffea arabica* (Rubiaceae), *Eugenia uniflora*,
24 *Psidium guajava*, and *P. cattleianum* (Myrtaceae), *Olea europaea* (Oleaceae), *Nerium oleander*
25 (Apocynaceae), *Averrhoa carambola* (Oxalidaceae), *Passiflora* spp. (Passifloraceae), *Prunus persica*
26 (Rosaceae), *Diospyros kaki* (Ebenaceae), *Dimocarpus longan* and *Litchi chinensis* (Sapindaceae),
27 *Momordica charantia* (Cucurbitaceae), *Musa x paradisiaca* (Musaceae), *Citrus* spp. (Rutaceae), *Persea*
28 *americana* (Lauraceae), *Manilkara zapota* (Sapotaceae), *Solanum* spp. (Solanaceae), and *Vitis* spp.
29 (Vitaceae).

30 An average fecundity of 415 eggs per female has been reported under laboratory conditions;
31 populations under such conditions increased at more than 90% per week (Fitt 1990), indicating a
32 considerable biotic potential. There are four to five generations per year (Hely et al. 1982). The adults
33 are strong fliers. Adult flight and the transport of infested fruit are the major means of long-distance
34 dispersal (CABI 2006). The fly's association with plants, such as common guava, strawberry guava, and
35 bitter melon, which are widespread in Hawai'i (Wagner et al. 1999), likely would facilitate its rapid
36 spread throughout the islands. *Bactrocera tryoni* is the most serious insect pest of fruit and vegetable
37 crops in Australia, infesting all commercial fruit crops other than pineapple and strawberry (CABI 2006).
38 Larvae damage fruit directly by their feeding and indirectly by facilitating entry by organisms of decay. In
39 certain fruits, such as citrus, yield losses are overshadowed by the negative economic impact of lost
40 markets due to quarantine barriers (Hely et al. 1982). In Australia, potential losses to fruit flies in the

1 absence of control measures have been estimated at A\$100 million per year, and most of this is
2 attributable to *B. tryoni* (CABI 2006). As it is known to attack closely related hosts, *B. tryoni* is a potential
3 threat to endangered or threatened native plants in Hawai'i, such as *Eugenia koolauensis*, *Solanum*
4 *incompletum*, and *S. sandwicense*. Because of its status as a pest of a wide variety of crops economically
5 or otherwise important to Hawai'i, including papaya, coffee, eggplant, tomato, mango, lychee, avocado,
6 and citrus (CABI 2006), introduction of *B. tryoni* likely would trigger the initiation of control programs.
7 Biological control has proved to be at least partially effective in suppressing population densities of other
8 dacine fruit flies (Clausen 1978b).

9 **A21.1.12 *Ceratitis rosa* Karsch (Diptera: Tephritidae)**

10 The geographic distribution of *C. rosa* is restricted to subtropical and tropical Africa, the species
11 apparently being less tolerant of cold temperatures than is *Ceratitis capitata* (CABI/EPPO 1997c). It has
12 been reported from Angola, Ethiopia, Kenya, Malawi, Mali, Mauritius, Mozambique, Nigeria, Réunion,
13 Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe. Hosts include *Prunus*
14 spp. (Rosaceae), *Persea americana* (Lauraceae), *Citrus* spp. (Rutaceae), *Ficus carica* (Moraceae), *Vitis*
15 *vinifera* (Vitaceae), *Litchi chinensis* (Sapindaceae), *Mangifera indica* (Anacardiaceae), *Carica papaya*
16 (Caricaceae) (CABI/EPPO 1997c); *Averrhoa carambola* (Oxalidaceae), *Coffea arabica* (Rubiaceae),
17 *Annona reticulata* (Annonaceae), *Passiflora* sp. (Passifloraceae), *Manilkara zapota* (Sapotaceae), *Eugenia*
18 *uniflora* and *Psidium* spp. (Myrtaceae) (Grové 2001); *Strychnos spinosa* (Loganiaceae) (Weems 1966);
19 *Carissa macrocarpa* (Apocynaceae), *Ziziphus zizyphus* (Rhamnaceae), *Theobroma cacao* (Sterculiaceae),
20 *Garcinia mangostana* (Clusiaceae), *Musa* sp. (Musaceae), *Diospyros virginiana* (Ebenaceae), *Opuntia*
21 spp. (Cactaceae), *Dovyalis caffra* (Flacourtiaceae), *Solanum lycopersicum* and *S. auriculatum*
22 (Solanaceae), Cecropiaceae, Euphorbiaceae, and Podocarpaceae (White and Elson-Harris 1992).

23 In the laboratory, fecundity averaged 520 eggs per female (Monty 1973). Depending on climatic
24 conditions, there may be as many as 12 generations per year (Hill 1983). Adult flight and the transport of
25 infested fruit are the primary means of long-distance dispersal and spread to previously uninfested
26 areas (CABI/EPPO 1997c). *Ceratitis rosa* is a major pest of mango (Joubert et al. 2000) and avocado in
27 South Africa, resulting in a cull rate in the latter of 1.9% (Dennill and Erasmus 1992). Lychee fruit,
28 although a poor host, is damaged by organisms of decay introduced by ovipositing females (de Villiers
29 1990). In South Africa, infestation rates of 50 to 100% have been reported in plum (Weems 1966). After
30 its introduction into Mauritius, *C. rosa* displaced *C. capitata* from many of their shared hosts (Fitt 1989),
31 and a similar phenomenon may have occurred in Zimbabwe (Anonymous 1963), suggesting the potential
32 for *C. rosa* to become as serious a pest as *C. capitata*. Control routinely is achieved by the application of
33 insecticides (de Villiers 1978), which increases production costs. Like *C. capitata*, *C. rosa* is an
34 international quarantine pest with the potential to restrict international trade in fruit (Barnes et al.
35 2000). For example, the fly is an A1 quarantine pest for Europe, and considered by the European and
36 Mediterranean Plant Protection Organization (EPPO) the most important of all *Ceratitis* species
37 (CABI/EPPO 1997c). Its establishment in Hawai'i thus could result in a further loss of domestic or foreign
38 markets for various commodities. *Ceratitis rosa* is a potential threat to plants in Hawai'i listed as
39 threatened or endangered, such as *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*. Its
40 introduction into Hawai'i likely would result in the initiation of chemical or biological control programs,

1 as has occurred in response to the entry elsewhere of other tephritid species (Roessler 1989; Wharton
2 1989).

3 **A21.1.13 *Ceroplastes japonicus* Green (Homoptera: Coccidae)**

4 This soft scale insect is native to the Old World. It has been reported from Armenia, Azerbaijan, China,
5 Georgia, Japan, Korea, and Nepal in Asia, and, in Europe, England, France, Italy, Russia, Slovakia, and
6 Slovenia (CABI 2003; Ben-Dov et al. 2006). In China, it ranges from the temperate zone to the tropics
7 (Hua 2000). The species has been recorded on plants in at least 26 families (Ben-Dov et al. 2006). Hosts
8 include *Diospyros kaki* (Ebenaceae), *Acer* spp. (Aceraceae), *Nerium oleander* (Apocynaceae), *Ilex* spp.
9 (Aquifoliaceae), *Berberis* sp. (Berberidaceae), *Buxus sempervirens* (Buxaceae), *Cycas revoluta*
10 (Cycadaceae), *Magnolia grandiflora* (Magnoliaceae), *Ficus carica* (Moraceae), *Ziziphus* sp.
11 (Rhamnaceae), *Prunus* spp. (Rosaceae), *Citrus* spp. (Rutaceae), and *Punica granatum* (Punicaceae).
12 Several of these plants are, or are related to economically or aesthetically valuable, or endemic species
13 in Hawai'i, such as *D. kaki* (Japanese persimmon), *N. oleander* (oleander), *Cycas* spp. (cycads, sago-
14 palms), and *Buxus* and *Ziziphus* spp. (Imada et al. 2005; NASS 2006b), and thus are potentially
15 threatened by the introduction of *C. japonicus*.

16 An average fecundity as high as 1,540 eggs per female has been reported for the scale (Jiang and Gu
17 1988). There is one generation per year (CABI 2006). Natural dispersal is accomplished by first-instar
18 nymphs (crawlers), which may be carried on wind or other animals; all stages may be transported long
19 distances in consignments of plant material and produce (CABI 2006). *Ceroplastes japonicus* is reported
20 to be an important pest of several crops, including citrus, mulberry, jujube, pomegranate, tea, apple,
21 and persimmon (Dzhashi 1971; Konstantinova 1976; Luo et al. 1994; Swirski et al. 1997; CABI 2006; Ma
22 and Bai 2004). Konstantinova and Gura (1986) found the scale to infest deciduous fruits, although
23 Pfeiffer (1997) considered it to be only a minor pest in such crops. No information is available specifically
24 on the magnitude of damage (e.g., yield losses) attributed to the pest. Infestation results in reduced
25 vigor and general debility of the host, premature leaf drop and dieback of stems, and the secreted
26 honeydew may serve as a medium for the growth of sooty molds, which interfere with photosynthesis
27 and may lower the market value of fruit (CABI 2006). The species is a quarantine pest for Belarus,
28 Ukraine, New Zealand, and Peru (EPPO 2005a; PRF 2007), suggesting that its introduction could result in
29 a loss of domestic or foreign markets for Hawai'i-grown commodities. Its introduction into Hawai'i could
30 result in the initiation of chemical or biological control programs, as has occurred elsewhere (e.g., Xia et
31 al, 1985; Swirski et al. 1997; Zhou et al. 2003), thus potentially impacting native ecosystems.

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31

1 **A21.1.14 *Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae)**

2 The geographic distribution of *C. punctiferalis* extends from temperate to tropical Asia and into
3 Australasia (Australia, Papua New Guinea) (CABI 2006). This polyphagous species has been recorded on
4 plants in at least 20 families (CABI 2006). Hosts include *Carica papaya* (Caricaceae), *Gossypium*
5 *herbaceum* (Malvaceae), *Helianthus annuus* (Asteraceae), *Prunus persica* (Rosaceae), *Zea mays*
6 (Poaceae), *Citrus nobilis* (Rutaceae), *Punica granatum* (Punicaceae), *Vitis vinifera* (Vitaceae), *Zingiber*
7 *officinale* (Zingiberaceae), *Ricinus communis* (Euphorbiaceae), *Morus alba* (Moraceae), *Psidium guajava*
8 (Myrtaceae), *Macadamia integrifolia* (Proteaceae) (CABI 2006); *Diospyros kaki* (Ebenaceae) (Umeya and
9 Okada 2003); *Quercus* spp. (Fagaceae) (Park et al. 1998b); *Mangifera indica* (Anacardiaceae) (Nair 1975);
10 *Dimocarpus longan* (Sapindaceae) (Huang et al. 2000); *Pinus massoniana* (Pinaceae) (Hua 2005); and
11 *Durio zibethinus* (Bombacaceae) (Brown 1997). Several of these (e.g., papaya, guava, macadamia,
12 mango, and Japanese persimmon) are economically important crops in Hawai'i (NASS 2006b).

13 Female *C. punctiferalis* lay an average of 20 to 30 eggs on the surface of fruits or on the ear silk and
14 tassels of corn (CABI 2006). Five generations per year have been reported (Wang and Cai 1997).
15 Demographic studies indicated that, under ideal conditions, populations may increase by a factor of
16 almost 21 times per generation (Bilapate 1977). Long distance dispersal may be effected via the
17 transport of commercial consignments of fruit. For example, pear fruits from Korea were found to be
18 infested with larvae of *C. punctiferalis* at a Canadian port-of-entry (Lee et al, 2000). Since 1984, the moth
19 has been intercepted at U.S. ports on at least 79 occasions (PIN 309a). *Conogethes punctiferalis* is one of
20 the most destructive pests of peach in China and of cotton and grain sorghum in Australia, in which
21 latter country infestations of 27% of bolls and 100% of seed heads, respectively, have been reported
22 (Anonymous 1957). In grains, stems bored by the moth are easily broken down by the wind and farming
23 practices, resulting in decreased yields (CABI 2006). Yield losses were as high as 42% in castor bean
24 (Kapadia 1996), 49% in plum (Wang and Cai 1997), and 50% in grape (Ram et al, 1997). In persimmon,
25 the pest may be present as eggs and larvae on or in fruit at harvest (Tomomatsu et al. 1995). Losses in
26 persimmon crops of almost 2% have been reported, and may continue until harvest (Kim et al. 1997).
27 Annual losses in chestnut crops in parts of Zhejiang Province, China, have been estimated at 120 tonnes
28 at a value of almost \$121,000 (Xu et al. 2001). In fruit crops, injury generally occurs when fruit is nearly
29 ripe (Hely et al. 1982). Larval tunneling and attack by secondary organisms of decay may render fruit
30 valueless (Clausen 1931). As the species is a quarantine pest for countries, such as Canada, Chile, New
31 Zealand, and Peru (EPPO 2005a; PRF 2007), its introduction could result in a loss of domestic or foreign
32 markets for various agricultural commodities grown in Hawai'i. Introduction of the pest into the state
33 likely would result in the initiation of chemical or biological control programs similar to those carried out
34 in other countries (e.g., Choo et al. 1995; Wang et al. 2002), again potentially putting native Hawai'ian
35 ecosystems further at risk.

36 **A21.1.15 *Copitarsia decolora* (Guenée) (Lepidoptera: Noctuidae)**

37 This moth is reported to occur in Mexico, Guatemala, Costa Rica, Venezuela, Uruguay, Peru, Colombia,
38 Ecuador, Chile, Argentina, and Bolivia (Liberman 1986; Angulo and Olivares 2003). It has been recorded
39 on *Medicago sativa* (Fabaceae), *Capsicum frutescens* and *Solanum tuberosum* (Solanaceae), *Cynara*

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1 *scolymus* and *Helianthus* sp. (Asteraceae), *Allium* spp. (Liliaceae), *Fragaria ananassa*, *Malus pumila*, and
2 *Rubus* sp. (Rosaceae), *Simmondsia chinensis* (Simmondsiaceae), *Zea mays* and *Triticum* sp. (Poaceae),
3 *Pistacia vera* (Anacardiaceae), *Beta vulgaris* (Chenopodiaceae), *Brassica oleracea* (Brassicaceae),
4 *Dianthus caryophyllus* (Caryophyllaceae), *Feijoa sellowiana* (Myrtaceae), *Actinidia deliciosa*
5 (Actinidiaceae), *Vitis vinifera* (Vitaceae) (Angulo and Olivares 2003); and *Amaranthus cruentus*
6 (Amaranthaceae) (Guerrero et al. 2000).

7 *Copitarsia decolora* exhibited an average fecundity of 1,038 eggs per female under laboratory conditions
8 (Larraín 1996). At least four generations per year have been reported (Urra and Apablaza 2005). Long-
9 distance spread of the moth is accomplished via the movement of infested plant materials in commerce.
10 *Copitarsia* spp. frequently are intercepted on produce and cut flowers at U.S. ports (Venette and Gould
11 2006). *Copitarsia decolora* has been intercepted at U.S. ports on grape and apple from Chile (Santacroce
12 1993). In Peru, *C. decolora* is a major pest of potato (Alcala 1978), and is one of a complex of pests
13 (including *Spodoptera eridania* Stoll and agromyzid leafminers) of broad bean (*Vicia faba*), which
14 reduces yield by 50 to 60% (Gomez 1972). Defoliation on the order of 60% has been reported in rape
15 (*Brassica napus* var. *napus*), although with no appreciable effect on yield (Larraín 1996). The noctuid
16 may also constitute a significant pest of quinoa (*Chenopodium quinoa*) in Chile (Lamborot et al. 1999).
17 Gonzalez (1983) identified the moth (as *C. consueta* [Walker]) as an occasional pest in vineyards. It
18 occasionally is found on fruit trees, and the larvae may bore into immature fruits (Santacroce 1993).
19 *Copitarsia decolora* poses a potential threat to listed (50 CFR § 17.12) native plant species in Hawai'i,
20 such as *Solanum incompletum* and *S. sandwicense*. As it is known to attack cultivated crops that are
21 valuable in Hawai'i, such as brassicas and grape, its introduction could result in the initiation of chemical
22 control programs, as have targeted the pest elsewhere (e.g., Gonzalez 1983).

23 **A21.1.16 *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae)**

24 The distribution of *C. leucotreta* is restricted to subtropical and tropical Africa, where it is widespread
25 (CABI 2006). This pest attacks host plants in numerous families, including *Ananas comosus*
26 (Bromeliaceae), *Camellia sinensis* (Theaceae), *Citrus* spp. (Rutaceae), *Annona muricata* (Annonaceae),
27 *Averrhoa carambola* (Oxalidaceae), *Ceiba pentandra* (Bombacaceae), *Coffea arabica* (Rubiaceae), *Litchi*
28 *chinensis* (Sapindaceae), *Mangifera indica* (Anacardiaceae), *Olea europaea* (Oleaceae), *Persea*
29 *americana* (Lauraceae), *Punica granatum* (Punicaceae), *Ricinus communis* (Euphorbiaceae), *Zea mays*
30 (Poaceae) (CABI 2006); *Prunus* spp. (Rosaceae), *Quercus* sp. (Fagaceae), *Juglans* sp. (Juglandaceae),
31 *Macadamia integrifolia* (Proteaceae), *Vitis vinifera* (Vitaceae) (Annecke and Moran 1982);
32 *Bequaertiodendron magalismontanum* (Sapotaceae), *Calotropis procera* (Asclepiadaceae), *Capparis*
33 *tomentosa* (Capparaceae), *Catha edulis* (Celastraceae), *Cola nitida* (Sterculiaceae), *Combretum* spp.
34 (Combretaceae), *Diospyros* spp. (Ebenaceae), *Eugenia uniflora* and *Psidium guajava* (Myrtaceae), *Ficus*
35 *capensis* (Moraceae), *Garcinia mangostana* (Clusiaceae), *Abutilon* spp. and *Hibiscus* spp. (Malvaceae),
36 *Musa x paradisiaca* (Musaceae), *Phaseolus* spp. (Fabaceae), *Podocarpus falcatus* (Podocarpaceae),
37 *Schotia afra* (Caesalpiniaceae), *Triumfetta* spp. (Tiliaceae), *Ximenia caffra* (Olacaceae), and *Ziziphus* spp.
38 (Rhamnaceae) (Whittle 1984). Many of these are economically or otherwise important in Hawai'i.

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1 Depending on temperature, average fecundity was reported to range from 87 to 456 eggs per female
2 (Daiber 1980). There may be as many as five generations per year (van den Berg 2001). The capacity for
3 long-distance flight by adults is indicated by records of migrants found in Sweden, thousands of
4 kilometers beyond the natural range of the species (Svensson 2002). Dispersal over long distances also
5 may be facilitated by the transport of fruit infested with larvae (CABI 2006). The species has been
6 intercepted at U.S. ports in various fruits on more than 166 occasions (Whittle 1984; PIN 309a). In South
7 Africa, *C. leucotreta* is a major pest of citrus, guava, lychee, and avocado, in which crop losses may reach
8 80% (van den Berg 2001). The moth occasionally is an important pest of cotton (Whittle 1984), causing
9 yield losses as high as 90% (CABI 2006). Losses of up to 28% in peach crops also have been reported
10 (CABI 2006). Primary damage is caused by larvae boring into fruits (Hill, 1983). Opportunistic secondary
11 fungal and bacterial rots may cause further damage to fruits or bolls (van der Geest et al. 1991). Larvae
12 attacking the young, green fruits of guava, although unable to penetrate the skin, produce blemishes
13 (van den Berg 2001), which likely lowers market price. The moth is a quarantine pest for Korea,
14 Paraguay, Uruguay, Argentina, Brazil, Chile, New Zealand, and Indonesia (PRF 2007), suggesting that its
15 introduction could result in a loss of domestic or foreign markets for various Hawai'iian-grown
16 commodities, such as citrus, pineapple, mango, mangosteen, macadamia, lychee, and avocado.
17 Introduction of this pest into Hawai'i also poses a potential threat to native plants listed as threatened
18 or endangered, such as *Eugenia koolauensis*, *Abutilon eremitopetalum*, *A. menziesii* (kooloaula), and *A.*
19 *sandwicense*, and *Hibiscus arnottianus* ssp. *immaculatus* (kokio keokeo), *H. brackenridgei* (mao hau
20 hele), *H. clayi*, and *H. waimeae* ssp. *hannerae* (kokio keokeo).

21 **A21.1.17 *Eotetranychus cendanai* Rimando (Acari: Tetranychidae)**

22 Except for an adventive population in Guam (Nafus and Schreiner 1999), *E. cendanai* is restricted to East
23 and Southeast Asia. It occurs in Cambodia, the Philippines, Taiwan, and Thailand (Bolland et al. 1998). In
24 addition to various *Citrus* species, the mite has been recorded on *Sesbania grandiflora* (Fabaceae) and
25 *Zoysia japonica* (Poaceae) (Bolland et al. 1998).

26 Thongtab et al. (2002) studied the reproductive biology of the mite in the laboratory. Fecundity on *C.*
27 *maxima* averaged 26 eggs per female; population densities tended to increase rapidly. The calculated
28 intrinsic rate of natural increase was 0.156, indicating that the average population was growing at
29 almost 16% per day. Several generations per year are indicated (Barrion and Corpuz-Raros 1975;
30 Thongtab et al. 2002). Tetranychid mites may disperse over considerable distances naturally by
31 "ballooning" on air currents (Jeppson et al. 1975). The disjunct distribution of *E. cendanai*, with a
32 population established in Guam far from the presumed Asian center of origin of the species, suggests
33 that it has significant spread potential. The mite is listed in Waterhouse (1993b) as a widespread and
34 important pest in Thailand; although, because of its limited distribution, Gerson (2003) considered its
35 overall, global pest status to be minor. On citrus, feeding injury results in leaf and fruit drop, and fruit
36 russetting, resulting in a downgrading of its quality (Thongtab et al, 2002). The mite thus is a potential
37 threat to *Citrus* spp. in Hawai'i, which not only are commercially important (NASS 2006a), but are
38 popular as ornamental and fruit trees in residential plantings (Neal 1965). *Eotetranychus cendanai* poses
39 a potential threat to *Sesbania tomentosa*, listed in 50 CFR § 17.12 as endangered in Hawai'i. Its

1 introduction into the islands could spur the initiation of biological control programs of the kind presently
2 being considered elsewhere (e.g., Thongtab et al. 2001).

3 **A21.1.18 *Gymnandrosoma aurantianum* Lima (Lepidoptera: Tortricidae)**

4 This tortricid is known from the American tropics. It has been reported from Argentina, Brazil, Peru,
5 Ecuador, Venezuela, Colombia, French Guiana, and Surinam in South America, throughout Central
6 America, Mexico, and from Cuba, Dominica, Puerto Rico, and Trinidad and Tobago in the Caribbean
7 (White 1999; Adamski and Brown 2001). Hosts include *Cupania vernalis* and *Litchi chinensis*
8 (Sapindaceae), *Cojoba arborea* (Fabaceae), *Theobroma cacao* (Sterculiaceae), *Citrus* spp. (Rutaceae),
9 *Macadamia integrifolia* (Proteaceae), *Prunus persica* (Rosaceae), *Punica* sp. (Punicaceae), *Psidium*
10 *guajava* (Myrtaceae) (Adamski and Brown 2001); *Simarouba amara* (Simaroubaceae) (White and Tuck
11 1993); *Cocos nucifera* (Arecaceae), *Musa acuminata* (Musaceae), and *Annona* spp. (Annonaceae) (Bento
12 et al. 2001).

13 Fecundity ranges from about 150 to 200 eggs per female (Bento et al. 2001); eggs apparently are
14 deposited on mature fruit (White and Tuck 1993). The life cycle may be completed within 36 days
15 (Blanco et al. 1993). Field data indicate at least three generations per year (White 1999). Rapid, long-
16 distance dispersal probably is accomplished by larvae within fruit transported in commerce, as is
17 suggested by the record of species of *Gymnandrosoma* or *Ecdytolopha* (a closely related genus)
18 intercepted at U.S. and foreign ports in cargo or baggage (Adamski and Brown 2001; PIN 309a).
19 *Gymnandrosoma aurantianum* is an important pest of citrus in Brazil (Bento et al. 2001). Yield losses
20 have been estimated to be as high as 50% in infested areas, and total losses to the industry may reach
21 \$50 million per year. The moth also is considered to be a major pest of macadamia in Costa Rica, causing
22 reductions in yield and nut quality (Coto 1999). Damage is caused by caterpillars boring through fruits
23 and consuming seeds (Adamski and Brown 2001). Control measures typically consist of insecticidal
24 treatments (e.g., Scarpellini and dos Santos 1997), which increase costs of production. Because this pest
25 reportedly is difficult to control (Faria et al. 1998; Bento et al. 2001), its introduction could cause a loss
26 of domestic or foreign markets for Hawai'ian-produced citrus, macadamia, or lychee. *Gymnandrosoma*
27 spp. are quarantine pests for New Zealand and Venezuela (PRF 2007). *Gymnandrosoma aurantianum*
28 also has the potential to attack plants in Hawai'i of considerable aesthetic value, such as coconut (Neal
29 1965). As it represents a potential threat to citrus and macadamia production, its introduction could
30 stimulate the initiation of control programs. The pest is a candidate for biological control in Brazil
31 (Molina et al. 2005).

32 **A21.1.19 *Helicoverpa assulta* (Guenée) (Lepidoptera: Noctuidae)**

33 This moth is distributed from the temperate zone to the tropics of the Old World (CABI 2006). It occurs
34 in sub-Saharan Africa, throughout South, Southeast, and East Asia, and ranges south through Oceania to
35 Australasia. *Helicoverpa assulta* appears mainly to attack members of the Solanaceae, including
36 *Nicotiana* spp., *Datura stramonium*, *Solanum lycopersicum*, *S. melongena*, *Capsicum annum*, and
37 *Physalis* spp.; other hosts are *Cucurbita moschata* (Cucurbitaceae), *Zea mays* (Poaceae), *Crocasmia* sp.
38 (Iridaceae), *Perilla* sp. (Labiatae), *Vigna unguiculata* and *Pisum sativum* (Fabaceae), and *Piper* sp.
39 (Piperaceae) (Zhang 1994; Robinson et al. 2001; CABI 2006).

1 Fecundity ranging from 423 to 505 eggs per female has been reported, and may be influenced by host
2 plant (Nandihalli and Lee 1995a). Up to three generations per year have been reported in Japan (CABI
3 2006). *Helicoverpa* spp. (e.g., *H. zea*) are strong fliers, and may disperse long distances (Metcalf and
4 Metcalf 1993). Larvae of *H. assulta* may be moved internationally in infested commodities. The pest has
5 been intercepted at U.S. ports on at least 21 occasions, most commonly on cut flowers (PIN 309a).
6 Damage is caused by larvae boring into the fruits of hosts, which not only causes direct damage, but also
7 may facilitate the entry of bacteria causing soft rots (Park et al. 1998a). In Korea, the moth is the most
8 serious insect pest of *Capsicum annuum* (Kim et al. 2002). Yields of *C. frutescens* were reduced 10 to
9 15% in the absence of control measures (Wei 1987). Rates of damage in unprotected tobacco crops
10 exceeded 23% (Nandihalli and Lee 1995b). The species also is reported to be a major pest of corn in
11 Indonesia (Chu 1979). Insecticidal applications are a prevalent control tactic (Yang et al. 2004), which
12 raises production costs and may impact non-target arthropods. The insect represents a potential threat
13 to crops in Hawai'i, such as cucurbits, eggplant, tomato, peppers, and corn. It is a quarantine pest for
14 New Zealand (PRF 2007), suggesting that its introduction could result in the loss of that market, as well
15 as domestic markets, for Hawai'ian agricultural products. Outbreaks on crops in Hawai'i could trigger
16 biological or chemical control programs, similar to those that have been initiated against the pest
17 elsewhere (e.g., Hirai et al. 1996; Yang et al. 2004). *Helicoverpa assulta* also represents a potential threat
18 to the endangered, native Hawai'ian plants, *Vigna o-wahuensis*, *Solanum incompletum*, and *S.*
19 *sandwicense*.

20 **A21.1.20 *Hemiberlesia diffinis* (Newstead) (Homoptera: Diaspididae)**

21 This is a tropical species, known from Central and South America, and the Caribbean (Miller and
22 Davidson 1998). Plants in at least 20 families have been recorded as hosts of *H. diffinis*, including
23 *Psidium guajava* (Myrtaceae), *Persea* sp. (Lauraceae), *Prunus domestica* (Rosaceae), *Cocos* sp.
24 (Arecaceae), *Hibiscus* sp. (Malvaceae), *Manihot* sp. (Euphorbiaceae), *Theobroma* sp. (Sterculiaceae),
25 *Nerium oleander* (Apocynaceae), *Ficus* sp. (Moraceae), and *Punica* sp. (Punicaceae) (Miller and Davidson
26 1998; Ben-Dov et al. 2006). At least some hosts recorded in the United States (e.g., Nakahara 1982)
27 apparently should be considered those of a closely related species, *H. neodiffinis* Miller and Davidson,
28 which is strictly temperate in distribution and with which *H. diffinis* has long been confused (Miller and
29 Davidson 1998).

30 No information is available concerning the biology or ecology of *H. diffinis*. The reproductive potentials
31 of related species, such as *H. rapax* (Comstock), *H. lataniae* (Signoret), and *H. pitysophila* Takagi, vary,
32 with fecundities ranging between 6 and 30 to 50 eggs per female with generations numbering from 2 to
33 6 or more per year, depending on latitude (Kosztarab 1996; CABI 2006). If the reproductive biology of *H.*
34 *diffinis* is similar, a high reproductive potential for this species may be indicated. Long-distance dispersal
35 may be accomplished on plant materials transported in trade, as evidenced by several interceptions of
36 *Hemiberlesia* spp., including *H. diffinis*, on various fruits in cargo (PIN 309a). *Hemiberlesia diffinis* is
37 considered a minor pest of guava (Gould and Raga 2002). The scale is a potential threat to avocado and
38 guava production in Hawai'i, and has the potential to attack plants of aesthetic value, such as coconut
39 and oleander (Neal 1965), as well as the endemics, *Hibiscus arnottianus* ssp. *immaculatus*, *H.*
40 *brackenridgei*, *H. clayi*, and *H. waimeae* ssp. *hannerae*, listed as endangered in 50 CFR § 17.12. Its

1 introduction also could stimulate the initiation of biological control programs, similar to what has
2 occurred in response to the introduction of numerous other invasive diaspidid scales (e.g., Rosen and
3 DeBach 1978).

4 **A21.1.21 *Icerya aegyptiaca* (Douglas) (Homoptera: Margarodidae)**

5 The geographic distribution of *I. aegyptiaca* is tropical to subtropical. Its range extends from Africa
6 (Egypt, Kenya, Zanzibar), eastward through the Middle East (Israel, Yemen), South, Southeast, and East
7 Asia (China, Japan, Taiwan), and south through the Pacific to Australia (Ben-Dov et al. 2006). This species
8 is highly polyphagous. Hosts include *Artocarpus* spp. and *Ficus* spp. (Moraceae), *Annona* spp.
9 (Annonaceae), *Citrus* spp. (Rutaceae), *Cocos nucifera* and *Phoenix dactylifera* (Arecaceae), *Pandanus*
10 *odoratissimus* (Pandanaeae), *Mangifera indica* (Anacardiaceae), *Achras sapota* (Sapotaceae), *Eugenia*
11 spp., *Psidium guajava*, and *P. cattleianum* (Myrtaceae), *Solanum* spp. (Solanaceae), *Acacia* spp. and
12 *Vigna marina* (Fabaceae), *Euphorbia* sp. (Euphorbiaceae), *Hibiscus* sp. (Malvaceae), *Ochrosia* spp.
13 (Apocynaceae), *Casuarina equisetifolia* (Casuarinaceae), *Carica papaya* (Caricaceae), *Punica granatum*
14 (Punicaceae), *Zea mays* (Poaceae), *Musa* spp. (Musaceae), *Scaevola* spp. (Goodeniaceae), *Bidens pilosa*
15 (Asteraceae), *Malus pumila* (Rosaceae), *Dodonaea viscosa* (Sapindaceae), *Plumbago capensis*
16 (Plumbaginaceae), *Tectona grandis* (Verbenaceae), *Vitis vinifera* (Vitaceae) (Ben-Dov et al. 2006); *Piper*
17 *nigrum* (Piperaceae), *Persea americana* (Lauraceae), *Coffea* spp. (Rubiaceae), *Colocasia esculenta*
18 (Araceae) (CABI 2006); *Ipomoea tuba* (Convolvulaceae) (Williams and Watson 1990); and *Camellia*
19 *sinensis* (Theaceae) (Gentry 1965).

20 Depending on temperature, mean fecundity has been reported to range from 70 to 143 (maximum: 247)
21 eggs per female; there are at least two generations per year (Azab et al. 1968). Females are largely
22 sedentary, moving only when disturbed; long distance dispersal is accomplished on infested fruit,
23 cuttings, and leaves of hosts (CABI 2006). *Icerya aegyptiaca* has been reported to be a serious pest of
24 citrus, fig, and shade trees in Egypt, although it is now largely controlled by natural enemies (CABI 2006).
25 It also is a pest of breadfruit, avocado, banana, citrus, and ornamentals in the South Pacific; annona,
26 jackfruit, sapote (*Pouteria sapota*), mulberry, and guava in India; and breadfruit in the Maldives Islands.
27 Its status in relation to these hosts in Hawai'i likely would be the same. Damage to the plant is caused by
28 sap depletion; shoots dry up and die, and defoliation occurs (Waterhouse 1993a). In addition, copious
29 quantities of honeydew are produced by the scales, which may foster the growth of sooty molds over
30 the surfaces of leaves, reducing photosynthesis. Heavy infestations of breadfruit on Pacific atolls have
31 been reported to kill even mature trees, but, more often, trees are partially defoliated, reducing crop
32 yields, sometimes by 50 to 100%. Introduction of *I. aegyptiaca* could result in a loss of foreign, as well as
33 domestic, markets for Hawai'ian-grown agricultural commodities. The scale is a quarantine pest for
34 several countries other than the United States, including Syria, French Polynesia, Chile, and Korea (PRF
35 2007). As it represents a potential threat to several plants that are culturally or economically important
36 to Hawai'i, including *Pandanus tectorius* (hala), taro, citrus, mango, papaya, breadfruit, palms, koa,
37 avocado, and banana, its introduction could result in the initiation of biological control programs, which
38 have proved successful against it elsewhere (Waterhouse 1993a). The scale also poses a threat to listed
39 (50 CFR § 17.12) endemic plants in Hawai'i, such as *Scaevola coriacea* (dwarf naupaka), *Eugenia*
40 *koolauensis*, *Solanum incompletum* and *S. sandwicense*, *Vigna o-wahuensis*, *Euphorbia haeleleana*

1 (akoko), *Ochrosia kilaueaensis*, *Bidens micrantha* ssp. kalealaha (kookoolau) and *B. wiebkei* (kookoolau),
2 and *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hanneriae.

3 **A21.1.22 *Lobesia aeolopa* Meyrick (Lepidoptera: Tortricidae)**

4 The geographic distribution of this widespread species extends across four biogeographic regions: the
5 Ethiopian, Palearctic, Oriental (Razowski 2000), and Australasian (Robinson et al. 2007), from the cold
6 temperate zone to the tropics. Countries where it is reported to occur include: in Africa–Kenya,
7 Madagascar, Uganda, and Zimbabwe; in Asia–China, India, Indonesia, Japan, Korea, Malaysia, Sri Lanka,
8 Taiwan, and Thailand; and in Australasia–New Guinea and Norfolk Island (Zhang 1994; Smithers 1998;
9 Hua 2005; Robinson et al. 2007). *Lobesia aeolopa* has been recorded on a wide range of plants in several
10 families, among which are some of economic and ecological importance to Hawai'i. Hosts include
11 *Diospyros kaki* (Ebenaceae), *Hibiscus* sp. (Malvaceae), *Quercus acutissima* (Fagaceae), *Prunus yedoensis*
12 (Rosaceae), *Solidago canadensis* and *Vernonia* sp. (Asteraceae), *Caesalpinia* sp. (Fabaceae), *Actinidia*
13 *chinensis* (Actinidiaceae), *Citrus* sp. (Rutaceae), *Camellia sinensis* and *Ternstroemia gymnanthera*
14 (Theaceae), *Coffea arabica* (Rubiaceae), *Ilex integerrima* (Aquifoliaceae), *Litchi chinensis* (Sapindaceae),
15 *Mangifera indica* (Anacardiaceae), *Melochia* spp. (Sterculiaceae), *Lantana camara* (Verbenaceae),
16 *Ricinus communis* (Euphorbiaceae), *Lindera* sp. (Lauraceae), *Ulmus parvifolia* (Ulmaceae), *Vitis* spp.
17 (Vitaceae), *Zea mays* (Poaceae) (Robinson et al. 2007); and *Eucalyptus* spp. (Myrtaceae) (Nasu et al.
18 2004).

19 No information is available on the reproductive biology of *L. aeolopa*. In the related species, *L. botrana*
20 (Denis and Schiffermüller), fecundity may exceed 300 eggs per female; there may be four generations
21 per year (Avidov and Harpaz 1969). If reproduction in *L. aeolopa* is similar, its biotic potential could be
22 high. The occurrence of the species in remote areas, such as Norfolk Island (Smithers 1998),
23 demonstrates its capacity to disperse over long distances. Little information is available on the economic
24 impact of *L. aeolopa*. It is reported to be a pest of eucalyptus (Nasu et al. 2004) and tea (Sonan 1939) in
25 Japan; although, in the latter case, damage was said to be slight. Plant reproductive organs, as well as
26 leaves, are attacked. Larvae have been found in fruit of *Leucas cephalotes*, *Lantana camara*, and coffee
27 (van der Geest et al. 1991; Robinson et al. 2001), which would lower yields. As the species is a
28 quarantine pest for South Africa (DEAT 2005), its introduction could result in a loss of that market for
29 Hawai'ian-grown commodities, such as lychee, mango, and corn. *Lobesia aeolopa* has the potential to
30 attack endemic plants in Hawai'i listed as endangered or threatened (50 CFR § 17.12), and which are
31 close relatives of its known hosts, such as *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H.*
32 *clayi*, and *H. waimeae* ssp. hanneriae, and *Caesalpinia kavaiense* (uhiuhi). As a potential pest of corn, its
33 introduction could result in the initiation of chemical control programs; insecticidal use is common in
34 that crop throughout the United States (Wright and Van Duyn 1999). Other management options might
35 include biological control programs, which have proven effective against other tortricid pests in the
36 United States and elsewhere (Clausen 1978c).

37 **A21.1.23 *Lobesia botrana* (Denis & Schiffermüller) (Lepidoptera: Tortricidae)**

38 This moth is widespread in Europe (ranging as far north as Germany), occurs in Africa as far south as
39 Kenya, and ranges through the Near East into central Asia; its distribution in East Asia is restricted to

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1 Japan, where it occurs on all of the main islands (Whittle 1985). Disjunct populations have been
2 reported from the south Pacific (Samoa and Tuvalu; Hopkins 1927). Although polyphagous, *L. botrana*
3 prefers *Vitis* spp. (Vitaceae) (Whittle 1985; CABI 2006). Other hosts include *Berberis vulgaris*
4 (Berberidaceae), *Clematis vitalba* (Ranunculaceae), *Galium mollugo* (Rubiaceae), *Olea europaea*
5 (Oleaceae), *Prunus* and *Rubus* spp. (Rosaceae), *Rhus glabra* (Anacardiaceae), *Ribes* spp.
6 (Grossulariaceae), *Silene vulgaris* (Caryophyllaceae), *Solanum tuberosum* (Solanaceae), *Medicago sativa*
7 and *Trifolium pratense* (Fabaceae), *Ziziphus jujuba* (Rhamnaceae) (Whittle 1985); *Actinidia chinensis*
8 (Actinidiaceae), *Dianthus* sp. (Asteraceae), *Diospyros kaki* (Ebenaceae) (CABI 2006); *Hypericum*
9 *calycinum* (Hypericaceae), and *Punica granatum* (Punicaceae) (Robinson et al. 2001).

10 Fecundity may exceed 300 eggs per female; a maximum of four generations per year has been recorded
11 (Avidov and Harpaz 1969). Mobility of adults apparently is limited. Schmitz et al. (1996) found dispersal
12 of virgin females within vineyards rarely to exceed 80 meters. However, larvae may be moved long
13 distances within fruit in baggage or cargo; the moth has been intercepted at U.S. ports-of-entry more
14 than 80 times since 1975 (Whittle 1985; PIN 309a). *Lobesia botrana* is an important pest of grape, in
15 which losses of 80% have been reported (Whittle 1985). Apart from the direct impact of larval feeding or
16 tunneling, a major contributor to yield loss is infection of damaged berries by opportunistic saprophytes
17 or pathogens, particularly *Botrytis cinerea* (Roehrich and Boller 1991; CABI 2006). Further losses stem
18 from the time and labor spent in cleaning grape bunches of the silk webbing and feces deposited by
19 larvae, which may account for 30 to 40% of the harvesting effort (Avidov and Harpaz 1969). In
20 viticulture, the damage caused, particularly fungal contamination, interferes with the wine-making
21 process and may result in a product of low quality (Rousseau et al. 2005). *Lobesia botrana* thus
22 represents a potential threat to Hawai'i's growing winemaking industry (e.g., Shimabukuro 2004).
23 Damage to other fruit crops, such as persimmon and pome and stone fruit, may be significant (Ben-
24 Yehuda et al. 1999), and may result from larvae feeding and developing within fruit (e.g., Maison and
25 Pargade 1967). The species is a quarantine pest for South Africa, Brazil, China, Egypt, Jordan, Paraguay,
26 Uruguay, Argentina, Canada, and Chile (EPPO 2005a; PRF 2007), suggesting that its introduction could
27 result in a loss of domestic or foreign markets for Hawai'ian-grown fruits. Because it is known to feed on
28 close relatives of plants listed as threatened or endangered in Hawai'i, *L. botrana* represents a potential
29 threat to *Silene alexandri*, *S. hawaiiensis*, *S. lanceolata*, and *S. perlmanii*, and *Solanum incompletum* and
30 *S. sandwicense*. As the moth is a pest of grape and other fruit crops, its introduction could result in the
31 inauguration of biological control programs, which have proven effective against other tortricid pests in
32 the United States and elsewhere (Clausen 1978c).

33 **A21.1.24 *Mamestra brassicae* (L.) (Lepidoptera: Noctuidae)**

34 This species occurs throughout Europe, ranging into temperate and subtropical Asia, and northern Africa
35 (Carter 1984). *Mamestra brassicae* is highly polyphagous, attacking crops in several families, including
36 Brassicaceae (particularly varieties of *Brassica oleracea*), Asteraceae (*Lactuca sativa*, *Chrysanthemum*
37 sp.), Chenopodiaceae (*Beta vulgaris*), Fabaceae (*Pisum sativum*, *Phaseolus vulgaris*), Liliaceae (*Allium*
38 *sativum*), Solanaceae (*Solanum lycopersicum*, *S. tuberosum*, *Nicotiana tabacum*), Rosaceae (*Prunus*
39 *persica*), Caryophyllaceae (*Dianthus caryophyllus*), Poaceae (*Zea mays*), Vitaceae (*Vitis vinifera*),
40 Fagaceae (*Quercus* sp.), and Polygonaceae (*Rheum* sp.) (Carter 1984; Zhang 1994; CABI 2006). Although

1 brassicas are said to be the most preferred hosts (CABI 2006), Rojas et al. (2001) found no significant
2 difference in the mean number of eggs deposited on cabbage and tomato by females in choice tests.

3 Fecundity averages 500 to 1,500 eggs per female; there may be three generations per year (CABI, 2006).
4 Adults are said to be “sedentary” (Bues et al. 1988) and “non-migratory” (Poitout and Bues 1976),
5 indicating a low natural potential for long-distance dispersal. However, the pest has been intercepted at
6 U.S. ports on more than 1,100 occasions on various commodities in cargo (PIN 309a), indicating its
7 potential to move long distances rapidly by human agency. *Mamestra brassicae* is considered to be a
8 serious pest of many crops, in which even small larval populations may be quite damaging (Hill 1987).
9 Damage is caused by larvae defoliating and tunneling into the interiors of plants or plant organs,
10 including fruits, such as apple and tomato (Carter 1984; CABI 2006). Feeding damage of 50% has been
11 recorded in sugar beet (Onodera 1998). Cabbage crops may suffer losses of up to 80% (CABI 2006).
12 Under certain cropping systems, damage may be too great to produce a commercially viable cabbage
13 crop (Brandsaeter et al. 1998). Control typically involves the application of insecticides (Steene 1995;
14 Beltrami et al. 2004), which increases costs of production. As the moth is a quarantine pest for New
15 Zealand, the former states of Yugoslavia, and Southern Africa (EPPO 2005a; PRF 2007), its introduction
16 could result in a loss of foreign, as well as domestic, markets for Hawai’i agricultural commodities, such
17 as tomato, cabbage, and corn. Introduction into Hawai’i also could result in the initiation of biological
18 control programs, as has occurred elsewhere (e.g., Rost 1997), and could put at risk endangered, native
19 plants, such as *Solanum incompletum* and *S. sandwicense*.

20 **A21.1.25 *Parlatoria blanchardi* (Targioni Tozzetti) (Homoptera: Diaspididae)**

21 This scale is widespread in tropical and subtropical areas of Europe, Asia, and Africa (Watson 2005; Ben-
22 Dov et al. 2006). It also occurs in South America (Argentina, Bolivia, Brazil), parts of the Caribbean, and
23 Australia. Hosts are predominantly species of palms (Arecaceae), such as *Hyphaene thebiaca*, *Latania*
24 *sp.*, *Neowashingtonia sp.*, *Phoenix spp.*, *Pritchardia filifera*, and *Washingtonia filifera*, but the insect has
25 been recorded on plants in other families, such as *Vinca major* (Apocynaceae), *Jasminum spp.*
26 (Oleaceae), and *Ziziphus mauritiana* (Rhamnaceae) (Ben-Dov et al. 2006).

27 Fecundity averages about 10 eggs per female, with a maximum of 29 recorded (Howard 2001). There are
28 three to five overlapping generations annually (Watson 2005). Dispersal of this species may occur locally
29 via wind, birds, or insects, or long distances in the transport of infested plants. High scale densities
30 towards the end of the season may result in infestation of fruit just prior to harvest (Howard 2001), also
31 facilitating spread. The scale was introduced into the United States in 1890 on date palm offshoots from
32 Algeria and Egypt, but later eradicated (Carpenter and Elmer 1978). Since 1984, it has been intercepted
33 at U.S. ports on more than 1,300 occasions (PIN 309a). Howard (2001) and Watson (2005) summarized
34 the damage caused by this pest. Heavy infestations weaken the tree by increasing transpiration,
35 depleting nutrients and destroying chlorophyll, thus impairing photosynthesis and productivity. Feeding
36 on fronds causes necrosis of tissues and dieback. Heavily infested offshoots become stunted; attacked
37 fruit shrivels, resulting in downgrading or rejection. Yield losses as high as 70 to 80% have been
38 reported. Palms 5 to 10 years of age may be killed outright. *Parlatoria blanchardi* is the most serious
39 insect pest of date palm, *Phoenix dactylifera*, in Australia, and has been a factor in hindering the

1 development of a significant date industry in that country (Knihinicki and Flechtmann 1999). The scale
2 poses a threat to various ornamental palms in Hawai'i, which are important aesthetically and otherwise
3 to the state (Neal 1965). It also represents a potential threat to Hawai'i's endangered (50 CFR § 17.12),
4 native *Pritchardia palms* (loulou, wahane). Its introduction could spur the initiation of chemical or
5 biological control programs, as has occurred elsewhere (Carpenter and Elmer 1978).

6 **A21.1.26 *Planococcus lilacinus* (Cockerell) (Homoptera: Pseudococcidae)**

7 This tropical species ranges from South Asia through Southeast and East Asia into Melanesia and some
8 of the other island groups (Marianas, Carolines) of the Pacific. It occurs in East Africa, and has a limited
9 distribution in the Americas (CABI 1995; Ben-Dov et al. 2006). It is reported from Fujian and Guangxi in
10 China, and is established in Taiwan (Hua 2000). The host range of *P. lilacinus* includes species in at least
11 35 families, including *Mangifera indica* (Anacardiaceae), *Annona* spp. (Annonaceae), *Cordia myxa*
12 (Boraginaceae), *Rhododendron* sp. (Ericaceae), *Euphorbia pyriformis* (Euphorbiaceae), *Arachis hypogaea*
13 and *Erythrina* spp. (Fabaceae), *Artocarpus* spp. (Moraceae), *Psidium guajava* and *Eugenia* spp.
14 (Myrtaceae), *Citrus* spp. (Rutaceae), *Pandanus* sp. (Pandanaeae), *Cocos nucifera* (Arecaceae), *Gardenia*
15 *jasminoides* (Rubiaceae), *Litchi* sp. (Sapindaceae), *Punica granatum* (Punicaceae), *Zizyphus jujuba*
16 (Rhamnaceae), *Manilkara zapota* (Sapotaceae), *Solanum* spp. (Solanaceae), *Theobroma cacao*
17 (Sterculiaceae), *Vitis vinifera* (Vitaceae) (Ben-Dov et al. 2006); and *Santalum album* (Santalaceae)
18 (Rostaman 1997).

19 Fecundity has been reported to range from 55 to 152 eggs per female (Loganathan and Suresh 2001).
20 Two or three generations per year have been suggested (Ooi et al. 2002). Similar to other species of
21 Coccoidea (scale insects) (Gullan and Kosztarab 1997), local dispersal would be accomplished by newly
22 emerged crawlers. Longer-distance movement would be effected via the transport of infested plant
23 materials. The mealybug has been introduced accidentally into continental Africa within the past three
24 decades (Williams et al. 2001). Since 1984, *P. lilacinus* has been intercepted on various commodities at
25 U.S. ports on almost 1,700 occasions (PIN 309a). *Planococcus lilacinus* is a serious pest of various fruit
26 and other crops in Asia, including guava, lemon, ber, pomegranate, lychee, coffee, and cocoa (Williams
27 2004). Infestations in citrus and coffee result in premature fruit drop and heavy losses in the latter crop.
28 Feeding in coconut palm results in drying of the inflorescence and button shedding (Moore 2001). The
29 mealybug also transmits a cocoa virus in Sri Lanka (Schmutterer 1977). It has been reported to infest
30 fruit for sale in southern Asia (Williams et al. 2001). Infested fruit may be downgraded in quality or
31 become unmarketable (Ooi et al. 2002). In India, insecticides are applied to control the mealybug in
32 coffee (Williams 2004), a practice that increases production costs. Miller et al. (2002) considered the
33 species to be a major threat to U.S. agriculture. As it is a quarantine pest for Paraguay, Uruguay,
34 Argentina, Brazil, Korea, and southern Africa (EPPO 2005a; PRF 2007), its introduction could result in a
35 loss of domestic or foreign markets for Hawai'i crops, such as mango, eggplant, *Annona* spp., and lychee.
36 Other valued plants, such as hala, coconut, and *Erythrina sandwicensis* (wiliwili) (Neal 1965), potentially
37 could be at risk. This pest poses a potential threat to listed native plants in Hawai'i, such as *Eugenia*
38 *koolauensis*, *Euphorbia haeleleana*, *Gardenia brighamii* (nau) and *G. mannii* (nanu), *Santalum*
39 *freycinetianum* var. *lanaiense*, and *Solanum incompletum* and *S. sandwicense*. Its introduction could

1 result in the initiation of biological control programs, similar to what has occurred elsewhere (e.g., India;
2 Reddy et al. 1992).

3 **A21.1.27 *Planococcus minor* (Maskell) (Homoptera: Pseudococcidae)**

4 This mealybug ranges from South Asia, through parts of Southeast and East Asia (Taiwan), and into
5 several island groups of the South Pacific to Australia (Ben-Dov et al. 2006). It also is widespread in
6 South America (from southern Argentina to Guyana), southern North America (Costa Rica, Guatemala,
7 Honduras, Mexico), and the Caribbean. The species is extremely polyphagous, having been recorded on
8 plants in at least 69 families (Ben-Dov et al. 2006). Hosts include *Colocasia esculenta* (Araceae), *Abutilon*
9 sp. and *Hibiscus* spp. (Malvaceae), *Solanum* spp. (Solanaceae), *Harrisia portoricensis* (Cactaceae),
10 *Theobroma cacao* (Sterculiaceae), *Citrus* spp. (Rutaceae), *Coffea* spp. and *Gardenia jasminoides*
11 (Rubiaceae), *Mangifera indica* (Anacardiaceae), *Musa* spp. (Musaceae), *Cyperus rotundus* (Cyperaceae),
12 *Cordia alliodora* (Boraginaceae), *Eugenia* spp. and *Psidium guajava* (Myrtaceae), *Vitis vinifera* (Vitaceae),
13 *Ziziphus* sp. (Rhamnaceae), *Amaranthus* sp. (Amaranthaceae), *Annona* spp. (Annonaceae), *Helianthus* sp.
14 and *Bidens pilosa* (Asteraceae), *Euphorbia* spp. and *Manihot esculenta* (Euphorbiaceae), *Persea*
15 *americana* (Lauraceae), *Ipomoea* spp. (Convolvulaceae), *Brassica* spp. (Brassicaceae), *Cucurbita* spp.
16 (Cucurbitaceae), *Zea mays* (Poaceae), *Arachis hypogaea* and *Erythrina* sp. (Fabaceae), *Artocarpus* spp.
17 (Moraceae), *Cocos nucifera* (Arecaceae), *Pandanus* spp. (Pandanaceae), *Pyrus pyrifolia* (Rosaceae), and
18 *Asparagus plumosus* (Liliaceae).

19 Reported fecundity ranges from about 200 to over 500 eggs per female, depending on host plant; there
20 may be as many as 10 generations per year (Maity et al. 1998; Martinez and Suris, 1998; Sahoo et al.,
21 1999). As in other species of Coccoidea (Gullan and Kosztarab 1997), local dispersal would be
22 accomplished by newly emerged crawlers. Longer-distance movement would be effected via the
23 transport of infested plant materials. The mealybug has been intercepted in Japan in shipments of
24 banana fruit from the Philippines (Sugimoto 1994). It has been intercepted at U.S. ports on more than
25 4,400 occasions on commodities from various countries (PIN 309a). *Planococcus minor* is an important
26 pest of coffee in India (Reddy et al. 1997). It is a pest of durian (*Durio zibethinus*) in Thailand, causing
27 loss of yield and reduction in market value (Anonymous 2003). Infestations in other fruits may result in a
28 downgrading of quality or unmarketable fruit (Ooi et al. 2002). The mealybug is a vector of banana
29 streak virus in Cuba (González et al. 2002). Insecticidal applications provide good control of the
30 mealybug (e.g., Shukla and Tandon 1984), but increase crop production costs. Miller et al. (2002)
31 considered the species to be a major threat to U.S. agriculture. As it is a quarantine pest for Korea (PRF
32 2007), introduction of *P. minor* into Hawai'i could result in the loss of that market for important crops,
33 such as mango, avocado, banana, and cucurbits. Because it is known to feed on closely related hosts, the
34 mealybug is a potential threat to listed native plants in Hawai'i, such as *Amaranthus brownii*, *Hibiscus*
35 *arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. *hanneriae*, *Solanum*
36 *incompletum* and *S. sandwicense*, *Bidens micrantha* ssp. *kalealaha* and *B. wiebkei*, *Abutilon*
37 *eremitopetalum*, *A. menziesii*, and *A. sandwicense*, *Eugenia koolauensis*, *Euphorbia haeleleana*,
38 *Gardenia brighamii* and *G. mannii*, and *Cyperus trachysanthos* (puukaa). Because it represents a
39 potentially serious threat to economically or aesthetically valuable crops (e.g., avocado, banana, citrus,
40 coffee, mango, guava, hala, wiliwili, coconut, corn, brassicas, cucurbits), its introduction likely would

1 spur the initiation of control programs. It has been the target of a biological control program in India
2 (Reddy et al, 1997); other species of *Planococcus* have been targeted for biological control in the United
3 States and elsewhere (Bartlett 1978).

4 **A21.1.28 *Pseudaonidia trilobitiformis* (Green) (Hemiptera: Diaspididae)**

5 This scale occurs primarily in subtropical and tropical regions of Australasia, the Orient, Africa, Central
6 and South America, the Caribbean, and Florida in the United States, but also has been reported from
7 more temperate areas, such as the Republic of Georgia and Japan (Ben-Dov et al. 2006). It is extremely
8 polyphagous, having been recorded on plants in at least 47 families (Ben-Dov et al. 2006). Hosts include
9 *Agave mexicana* (Agavaceae), *Mangifera indica* (Anacardiaceae), *Carica papaya* (Caricaceae), *Diospyros*
10 *kaki* (Ebenaceae), *Quercus* sp. (Fagaceae), *Persea americana* (Lauraceae), *Hibiscus* sp. (Malvaceae),
11 *Artocarpus* spp. (Moraceae), *Punica granatum* (Punicaceae), *Coffea* spp. (Rubiaceae), *Litchi sinensis*
12 (Sapindaceae), *Psidium guajava* and *Eugenia* spp. (Myrtaceae), *Cocos nucifera* (Arecaceae), *Ziziphus*
13 *spina-christi* (Rhamnaceae), *Citrus* spp. (Rutaceae), *Santalum austro-caledonicum* (Santalaceae),
14 *Capsicum* spp. (Solanaceae), *Prunus domestica* (Rosaceae), and *Vitis vinifera* (Vitaceae).

15 No information is available on the biology of the scale. A related species, *P. duplex* (Cockerell), exhibits
16 three generations per year in Louisiana; fecundity of *P. paeoniae* (Cockerell), also known from the
17 southern United States, ranges from 30 to 50 eggs per female (Kosztarab 1996). If the biology of *P.*
18 *trilobitiformis* is similar, its reproductive potential could be high. Long-distance dispersal of *P.*
19 *trilobitiformis* likely is accomplished by transport on infested plant materials, as evidenced by numerous
20 interceptions of the species at U.S. ports (PIN 309a). *Pseudaonidia trilobitiformis* is regarded as a minor
21 pest of avocado, cacao, citrus, coconut, coffee, mango, and passion fruit (Hill 1983). The scale is a pest of
22 cashew in Brazil, requiring treatment with insecticides for its control (Silva et al. 1977), which increases
23 costs of production and may impact non-target species. It is a quarantine pest for Korea and New
24 Zealand (PRF 2007), suggesting that its introduction into Hawai'i could result in a loss of domestic or
25 foreign markets for commodities, such as mango, papaya, avocado, and lychee. *Pseudaonidia*
26 *trilobitiformis* has the potential to attack plants listed as endangered or threatened in Hawai'i, such as
27 *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. *hannerae*, and
28 *Eugenia koolauensis*. Since it poses a potential threat to citrus and other economically important crops,
29 its introduction into Hawai'i could stimulate the initiation of biological control programs, similar to those
30 that have occurred in response to the introduction of other diaspidid scales (e.g., Rosen and DeBach
31 1978).

32 **A21.1.29 *Tetranychus lambi* Pritchard & Baker (Acari: Tetranychidae)**

33 With the exception of two disjunct populations reported from Asia (Iran and Taiwan), the geographic
34 range of *T. lambi* is restricted to islands of the South Pacific, Australia, and New Zealand (Bolland et al.
35 1998). This polyphagous species has been recorded on plants in several families. Hosts include *Abutilon*
36 *tubulosum* (Malvaceae), *Acaena* sp. and *Prunus persica* (Rosaceae), *Euphorbia* sp. and *Manihot esculenta*
37 (Euphorbiaceae), *Arenga engleri* (Arecaceae), *Aspidistra* sp. (Liliaceae), *Calathea crocata* (Marantaceae),
38 *Carica papaya* (Caricaceae), *Galactia tenuiflora* (Fabaceae), *Colocasia esculenta* (Araceae), *Cucurbita*
39 spp. (Cucurbitaceae), *Goodenia ovata* (Goodeniaceae), *Homalocladium platycladum* (Polygonaceae),

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1 *Lobelia heterophylla* (Campanulaceae), *Morus alba* (Moraceae), *Musa* spp. (Musaceae), *Solanum*
2 *melongena* (Solanaceae), *Oxalis* spp. (Oxalidaceae), *Panicum maximum* (Poaceae), *Poncirus trifoliata*
3 (*Rutaceae*), *Quercus alba* (Fagaceae), and *Stephania japonica* (Menispermaceae) (Bolland et al. 1998).

4 Bonato and Gutierrez (1999) reported mean fecundity in a population reared on green bean, *Phaseolus*
5 *vulgaris*, to be approximately 134 eggs per female. The calculated net replacement rate (the number of
6 times a population increases in a generation) was 69.5, indicating considerable biotic potential. In
7 Australia, there are said to be many overlapping generations annually (Pinese and Elder 2004). As in all
8 spider mites (Tetranychidae), long-distance dispersal occurs by wind-borne individuals and in the
9 movement of infested plant materials (Jeppson et al. 1975). Little information is available on the
10 economic importance of *T. lambi*. It is considered a major pest of agriculture in much of the southern
11 and western Pacific (Waterhouse 1997). It is one of three spider mites that are significant pests of cotton
12 in Australia, causing bronzing and desiccation of leaves (OGTR 2002). In banana, attack is concentrated
13 on leaves, although, in severe outbreaks, mites may move to the fruit (Gold et al. 2002). Feeding
14 produces areas of discoloration on the fruit surface that may later dry out and crack. As indicated by its
15 reported host range, *T. lambi* is a potential threat to economically or culturally important plants in
16 Hawai'i, such as papaya, taro, cucurbits, banana, and eggplant. The mite also is a potential threat to
17 endemic Hawai'ian plants, such as *Abutilon eremitopetalum*, *A. menziesii*, and *A. sandwicense*, *Acaena*
18 *exigua* (liliwai), *Euphorbia haeleeeleana*, *Lobelia gaudichaudii* ssp. *koolauensis*, *L. monostachya*, *L.*
19 *niihauensis*, and *L. oahuensis*, *Panicum fauriei* var. *carteri* and *P. niihauense* (lauehu), and *Solanum*
20 *incompletum* and *S. sandwicense*, all listed as endangered (50 CFR § 17.12). Its introduction into Hawai'i
21 could result in the initiation of biological control programs. Natural enemies of the pest are known (e.g.,
22 Chazeau 1983), and could prove effective at regulating its numbers.

23 **A21.1.30 *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae)**

24 This armored scale is widespread in East and Southeast Asia, from Pakistan to Japan and south to
25 Indonesia (Ben-Dov et al. 2006). Adventive populations also occur in Armenia, Australia, Fiji, France, and
26 Italy. Hosts are predominantly Rutaceae, in particular, species of *Citrus* (e.g., *C. aurantium*, *C. deliciosa*,
27 *C. maxima*, *C. medica*, *C. natsudaidai*, *C. nobilis*), *Fortunella japonica*, and *Poncirus trifoliata*, but also
28 include *Damnacanthus* sp. (*Rubiaceae*) (Ben-Dov et al, 2006).

29 Fecundity averages 177 to 196 eggs per female; there are as many as three generations per year
30 (Blackburn and Miller 1984). Although *U. yanonensis* is said to have a low inherent dispersal potential
31 (CABI/EPPO 1997j), it has spread over long distances in the international movement of plant materials
32 (e.g., to southern France; Burger and Ulenberg 1990). The scale also has been intercepted at U.S. ports
33 on more than 2,800 occasions since 1984, mainly on citrus fruit (PIN 309a). *Unaspis yanonensis* is said to
34 do more damage to citrus crops in Japan than any other pest (Kukhtina 1970). Twigs, leaves, and fruits
35 may be heavily attacked, and severe infestations often result in the death of trees (Rosen and DeBach
36 1978). An inordinate amount of damage seems to be caused relative to the numbers of scales feeding
37 (Clausen, 1933). Feeding causes circular, yellowish blotches on leaves, eventually resulting in almost
38 total necrosis, and severe distortion of fruit (Blackburn and Miller 1984). Affected fruits lose their
39 commercial value (CABI/EPPO 1997j). *Unaspis yanonensis* is said to replace the closely related *U. citri* as

1 an important citrus pest in China, Taiwan, and Japan (Smith and Peña 2002). It thus is a potential threat
2 to *Citrus* spp. in Hawai'i, which not only are commercially important (NASS 2006a), but are valued as
3 ornamental and fruit trees in residential plantings (Neal 1965). The scale is a quarantine pest for Turkey,
4 Syria, Tunisia, Peru, Belarus, and East and southern Africa (EPPO 2005a; PRF 2007), suggesting that its
5 introduction could result in the loss of domestic or foreign markets for Hawai'ian-grown citrus. As *U.*
6 *yanonensis* represents a significant threat to citrus production, its introduction likely would result in the
7 initiation of chemical or biological control programs, similar to those that have occurred elsewhere. For
8 example, routine insecticidal applications have been required to control the pest in Japan and France
9 (Blackburn and Miller 1984). The scale is under apparently successful biological control in Japan (Rosen
10 1990).

11 **A21.2 PLANT PATHOGENS**

12 As indicated by the recent detection of the fungus, *Puccinia psidii* Winter (Urediniomycetes: Uredinales),
13 which produces a rust disease in the native myrtaceous plants, *Metrosideros polymorpha* (ohia lehua)
14 and the federally listed (50 CFR § 17.12) *Eugenia koolauensis* (Uchida et al. 2006), Hawai'i is vulnerable
15 to the introduction of potentially devastating invasive plant pathogens. The fungus causing ohia rust has
16 been established in Florida for many years (Burnett and Schubert 1985), and possibly entered Hawai'i on
17 plant material imported from that state. A sampling of pathogens that represent potential threats to
18 Hawai'i's plant resources is discussed below.

19 **A21.2.1 "Candidatus *Liberobacter asiaticum*" Jagoueix et al. (Alphaproteobacteria: 20 Rhizobiales)**

21 This bacterium exhibits a primarily Asian distribution, ranging from Saudi Arabia and Yemen in the west
22 to Taiwan and Japan (Ryukyu Islands) in the east (EPPO 2005d). It also occurs in Mauritius and Réunion
23 in Africa. Recently, it has been introduced into Florida (EPPO 2005b) and New Guinea (Davis et al. 2005).
24 Hosts are restricted to Rutaceae, and include *Citrus* spp. and *Fortunella* spp. (CABI/EPPO 1997d). Natural
25 infection of plants in other rutaceous genera (e.g., *Severinia*, *Feronia*) is said to be possible (Timmer et
26 al. 2000). *Liberobacter asiaticum* is spread from host to host by grafting or by an insect vector, the
27 psyllid, *Diaphorina citri* Kuwayama (Timmer et al. 2000; CABI 2006), which now occurs in Hawai'i (HDOA
28 2006). However, both graft- and insect-transmission apparently are not highly efficient. Graft-
29 transmission rates are variable because of the irregular distribution of the bacterium within hosts; most
30 vector-aided spread occurs when psyllid population densities are high and succulent growth is present
31 on both donor and receptor plants (Timmer et al. 2000). Moreover, some hosts may be more resistant
32 to the bacterium than others. For example, Schwartz et al. (1973) found that, even in areas of high
33 disease incidence, pummelo, lemon, and lime (*C. aurantiifolia*) crops maintained acceptable fruit yields
34 despite infection. Pummelo and lime are said to show some of the weakest symptoms among *Citrus* spp.
35 (CABI/EPPO 1997d). Rapid, long-distance dispersal would be facilitated most likely by the movement of
36 infected plant propagative material (CABI/EPPO 1997d). Its introduction into Florida and New Guinea
37 (where infected planting material was found; Davis et al. 2005) suggests that it is spread widely by
38 human agency.

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1 This bacterium causes the disease known as greening or Huanglongbing (Timmer et al. 2000), which is
2 one of the most devastating diseases of citrus (Garnsey 1999). According to Garnsey, no other disease so
3 completely limits citrus production or is so difficult to control. Yield losses of 30 to 100% have been
4 reported, and the impact of the disease may be so severe that large areas of citrus cultivation must be
5 abandoned (CABI/EPPO 1997d). Chronically infected trees show extensive defoliation and twig dieback;
6 fruits tend to be undersized, misshapen, and poorly colored, often with a bitter taste (Timmer et al.
7 2000), and thus are likely to be of below-market quality. In South Africa, citrus trees routinely are
8 treated with antibiotics (CABI/EPPO 1997d), which increases production costs. As the pathogen is a
9 quarantine pest for countries, such as Argentina, Brazil, Chile, Jamaica, Korea, Paraguay, Uruguay, and
10 the European Union (EPPO 2005a; PRF 2007), its introduction could result in a loss of foreign, as well as
11 domestic, markets for Hawai’ian-grown citrus. Citrus also is valued in Hawai’i as an ornamental and fruit
12 tree in residential plantings (Neal 1965). Spread of the bacterium from Florida or Asia to Hawai’i could
13 have an indirect environmental impact, spurring the initiation of chemical or biological control programs
14 targeting its vector, *D. citri*, similar to what has occurred elsewhere (CABI 2006). The survival of Hawai’i’s
15 endemic *Trioza psyllids* (Zimmerman 1948) could thereby be jeopardized.

16 **A21.2.2 *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Gammaproteobacteria:
17 *Xanthomonadales*)**

18 This bacterium is widespread in tropical and subtropical Asia, ranging from Saudi Arabia in the west to
19 Taiwan and Japan in the east, and south to Indonesia (EPPO 2005e). It also occurs in New Guinea and
20 Australia, parts of Oceania, Africa, and South America, and in Florida, where it is under official control (7
21 CFR § 301.75-1). Natural hosts are species of Rutaceae, and include *Citrus* spp., *Poncirus trifoliata*,
22 *Fortunella* spp., *Severinia buxifolia*, and *Swinglea glutinosa* (Bradbury 1986; CABI/EPPO 1997k).

23 Of the several forms of the bacterium, the Asian strain (A strain) is the most virulent and polyphagous
24 (CABI/EPPO 1997k). Evidence suggests a high reproductive rate for the species. For example, following
25 initial infection and multiplication, bacteria may emerge from leaf stomatal openings in as few as 5 days
26 to provide inoculum for further disease development (Graham et al. 2004). In experimental citrus plots,
27 Gottwald et al. (1988) found infection to increase as much as 0.9% per day, suggesting a rather high
28 biotic potential. Natural spread of the pathogen is achieved locally through the transport of propagules
29 in rain splash and on the wind; longer-distance dispersal may be effected by severe storms, such as
30 tornadoes and hurricanes (Gottwald et al., 1997). The calculated maximal distance of natural spread
31 ranged from 12 m (39 feet) to 3.5 km (2 miles) over a 4-month period (Gottwald et al. 2002b).
32 Dissemination also may occur via the movement of infected propagative material and planting stock,
33 such as budwood and rootstock seedlings (CABI/EPPO 1997k), and probably has been the predominant
34 means of spread to other continents from the species’ presumed center of origin in tropical Asia (Das
35 2003). The pathogen has been intercepted at U.S. ports on more than 60 occasions since 1988 (PIN
36 309a).

37 Citrus canker, the disease caused by this pathogen, is considered one of the most damaging to
38 commercial citrus crops, affecting both the appearance and flavor of fruits (Anonymous 1982b).
39 Infection causes necrotic lesions on leaves, stems, and fruit; trees may suffer defoliation, badly

1 blemished fruit, secondary fruit rots, premature fruit drop, twig dieback, and general decline
2 (CABI/EPPO 1997k; Schubert and Sun 2003). For example, 83 to 97% of diseased fruit in grapefruit crops
3 has been reported; canker lesions may make fresh fruit unmarketable (Das 2003). In less severe cases,
4 lesions on fruit may reduce its market value (Timmer et al. 2000; Wang et al. 2004). Control measures
5 commonly include the application of copper-based bactericides (e.g., Graham et al., 2004), which may
6 significantly increase production costs. For example, Gottwald et al. (2002a) predicted that, should the
7 disease become endemic in Florida, the high costs of chemical and other controls might make
8 impossible the profitable cultivation of some of the more susceptible citrus species, such as grapefruit.
9 These authors also estimated that establishment of the pathogen would result in severe curtailment of
10 interstate and international trade in fresh fruit, which currently represents approximately 20% of the
11 state's \$9-billion commercial citrus industry. As the bacterium is a quarantine pest for numerous
12 countries, including Argentina, Ukraine, New Zealand, Peru, Chile, Turkey, Uruguay, Thailand, and the
13 European Union (EPPO 2005a; PRF 2007), Hawai'i's citrus exports could be similarly affected. Given the
14 importance of *Citrus* spp. as fruit and ornamental trees, the spread of *X. axonopodis* pv. *citri* to Hawai'i
15 could result in initiation or expansion of chemical control programs employing the copper-based
16 compounds typically used against crop-infecting bacteria (Timmer et al. 2000). Long-term use of these
17 bactericides may result in accumulation of high levels of copper in soils, with potential phytotoxic and
18 other environmental consequences (Graham et al. 2004). Although research is still in a preliminary
19 stage, the efficacy of biological control of citrus canker, involving the release of strains of bacterial
20 species antagonistic to *X. axonopodis* pv. *citri*, also has been considered (Das 2003).

21 **A21.2.3 *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales)**

22 This fungus is thought to have originated in Southeast Asia, subsequently spreading to other tropical and
23 subtropical regions, including Australia, Africa, and South America (CABI/EPPO 1997f). In East Asia, the
24 fungus ranges from Zhejiang Province in China to Taiwan (EPPO 2005c). Potential global distribution
25 apparently is limited by cold and dry conditions (Paul et al. 2005). Hosts are principally or exclusively
26 species of *Citrus* (Rutaceae), including *C. maxima*, *C. sinensis*, *C. paradisi*, *C. limon*, *C. aurantiifolia*, and *C.*
27 *reticulata*; records of the fungus on non-citrus plants are considered doubtful, and may involve other
28 *Guignardia* species (CABI/EPPO 1997f; Farr et al. 2006). *Guignardia citricarpa* may be established in an
29 area for many years before symptoms of disease appear, and a further 5 to 30 years may pass until the
30 disease reaches epidemic proportions (Anonymous 1982a). Local spread within orchards occurs
31 primarily through the dissemination of ascospores in water and on the wind, whereas long-distance
32 dispersal is achieved by the movement of infected plant materials or nursery stock (CABI/EPPO 1997f).
33 The broad distribution of the fungus, showing establishment on four continents (EPPO 2005c), suggests
34 that it is readily dispersed via the international transport of citrus propagative material. It has been
35 intercepted on more than 6,300 occasions at U.S. ports on various citrus organs, including living plants,
36 from numerous countries (PIN 309a). Disease is caused by the anamorphic form of the fungus,
37 *Phyllosticta citricarpa* (McAlpine) van der Aa, which invades the fruit rind without harming the pulp
38 (Timmer et al. 2000). Characteristic symptoms involve the appearance of black spots on the fruit
39 surface, which range from 1 to 25 mm in diameter and may number more than 1,000; spots may
40 coalesce to affect most of the surface (Anonymous 1982a; Seymour and Burnett 1982). Severe infection
41 often causes premature fruit drop (Timmer et al. 2000). Losses exceeding 80% have been reported

1 (Seymour and Burnett 1982; CABI/EPPO 1997f). Affected fruits that mature to harvest-stage are
2 unmarketable as fresh fruit, and suitable only for lower value end uses, such as processing (Anonymous
3 1982a; Timmer et al. 2000). Ironically, although infection renders fruits unmarketable for cosmetic
4 reasons, it may improve their eating quality by making them sweeter (Anonymous 1988). The pathogen
5 is a quarantine pest for several countries, including Turkey, Peru, Uruguay, Chile, New Zealand, and the
6 European Union (PRF 2007), suggesting that its introduction could result in a loss of foreign, as well as
7 domestic, markets for Hawai'ian-grown citrus fruit.

8 **A21.2.4 *Helicobasidium mompa* Tanaka (Urediniomycetes)**

9 This fungus occurs in Asia (China, India, Indonesia, Japan, Korea, Malaysia, Taiwan) and Africa (Malawi,
10 South Africa, Uganda) (CABI 2006; Farr et al, 2006). It is known to attack at least 104 plant species in 44
11 families (Uetake et al. 2001). Hosts include *Asparagus officinalis* (Liliaceae), *Beta vulgaris*
12 (Chenopodiaceae), *Brassica oleracea* (Brassicaceae), *Citrus* sp. (Rutaceae), *Daucus carota* (Apiaceae),
13 *Diospyros kaki* (Ebenaceae), *Ficus* spp. (Moraceae), *Ipomoea batatas* (Convolvulaceae), *Glycine max*
14 (Fabaceae), *Pyrus* sp. (Rosaceae), *Sesamum orientale* (Pedaliaceae), *Solanum tuberosum* (Solanaceae),
15 *Gossypium* sp. (Malvaceae), *Camellia sinensis* (Theaceae) (Farr et al. 2006); *Vitis* sp. (Vitaceae) (Clark and
16 Moyer, 1988); and *Medicago sativa* (Fabaceae) (Sakuma et al. 1984).

17 This pathogen is dispersed in irrigation water and in infested manure, and, more commonly, by the
18 movement of infested soil, such as that eroded by heavy rains or adhering to transplants from infested
19 nurseries (Clark and Moyer 1988). Although it is primarily soilborne, infecting plants in the field, it also
20 causes a rot that continues to develop on the roots in storage, and, thus, could be transported rapidly in
21 the international root crop trade. The fungus is said to be highly virulent, exhibiting an infection rate in
22 apple of greater than 33% within 6 months in experimental field tests (Uetake et al. 2001). This fungus,
23 the causal agent of violet root rot, is known to cause serious losses in sweetpotato crops in Asia during
24 years that favor disease development (Clark and Moyer 1988). Decay of the fibrous roots progresses
25 from the tips, and may destroy the entire root system. Foliage of severely infected plants becomes
26 chlorotic; older leaves may fall prematurely. In Korea, infection rates in apple were somewhat greater
27 than 5% (Lee et al. 1995). Mortality of apple stocks in Japan was reported to be about 8% under
28 experimental conditions (Uetake et al, 2001). Soil fumigation is one means employed for control (e.g.,
29 Sakuma et al. 1984), which increases production costs. Establishment of the pathogen in Hawai'i could
30 cause a loss of foreign or domestic markets for root crops, such as sweetpotato. It is a quarantine pest
31 for New Zealand (PRF 2007). *Helicobasidium mompa* also poses a potential threat to endemic Hawai'ian
32 plants listed as threatened or endangered, such as *Solanum incompletum* and *S. sandwicense*.

33 **A21.2.5 *Scutellonema bradys* (Steiner & Le Hew) Andrásy (Tylenchida: Hoplolaimidae)**

34 This nematode is native to West Africa, but has spread to other regions of the world (CABI 2006). It has a
35 scattered distribution in the New World between the southern United States (Arkansas, Florida,
36 Louisiana) and Brazil, and in parts of the Caribbean (including Puerto Rico) (CABI 2006; Handoo 2007). In
37 Asia, it occurs in India, Pakistan, and Korea; and possibly Taiwan (Tsay 1997). Primary hosts are species
38 of *Dioscorea* (Dioscoreaceae); other hosts include *Hibiscus* spp. (Malvaceae), *Cucurbita melo*
39 (Cucurbitaceae), *Sesamum indicum* (Pedaliaceae), *Sorghum bicolor* (Poaceae), *Manihot esculenta*

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1 (Euphorbiaceae), *Cocos nucifera* (Arecaceae), *Corchorus olitorius* (Tiliaceae), *Solanum lycopersicum*
2 (Solanaceae), *Synedrella nodiflora* (Asteraceae), *Pachyrhizus erosus* (yam bean; Fabaceae) (CABI 2006);
3 *Citrus sinensis* (Rutaceae) (Mead 1987); and Convolvulaceae (Kermarrec et al. 1987). Jatala and Bridge
4 (1990) listed *Scutellonema* spp. among nematode pests of sweetpotato.

5 *Scutellonema bradys* exhibits high reproductive and dispersal potentials. In stored tubers of *Dioscorea*
6 spp. (yam), populations may increase as much as 14-fold in a 5 to 6-month period (Jatala and Bridge
7 1990). The nematode is a migratory endoparasite of roots and tubers, and may also be present in soils
8 around host plants (CABI 2006). In Florida, *Scutellonema* spp. are widespread in field and greenhouse
9 soils (O'Bannon and Duncan 1990). Imported nursery stock thus is a potential pathway for entry of *S.*
10 *bradys* into Hawai'i. Infested tubers also are known to be a major means of long-range dispersal of the
11 pest. It has moved among the islands of the Caribbean in recent decades (e.g., Degras and Kermarrec
12 1976; Kermarrec et al. 1987), and has been intercepted at U.S. ports (PIN 309²⁸) in yam tubers.
13 *Scutellonema bradys* causes a decay of yam known as "dry rot disease," resulting in blackening and
14 cracking of the skin of the tuber (Jatala and Bridge 1990). This condition causes a significant reduction in
15 the quality and marketable value of tubers. Preharvest damage to yams by *S. bradys* was as high as 40%
16 in Nigeria; losses in storage may run 80 to 100%. The nematode is a quarantine pest for French Polynesia
17 and Thailand (PRF 2007), and an A2 quarantine pest for the Caribbean Plant Protection Commission
18 (EPPO 2005a). Its introduction into Hawai'i, therefore, could result in a loss of foreign, as well as
19 domestic, markets for commodities, such as sweetpotato. As it represents a potential threat to plants,
20 such as citrus, sweetpotato, cucurbits, tomato, and coconut, its introduction also could result in the
21 increased use of nematicides, which are employed for the control of *Scutellonema* spp. elsewhere (e.g.,
22 Ogbuji 1983). Because it is known to attack related hosts, *S. bradys* represents a potential threat to
23 native plants in Hawai'i, such as *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *H. clayi*, and *H.*
24 *waimeae* ssp. *hanneriae*, and *Solanum incompletum* and *S. sandwicense*, all listed as endangered in 50
25 CFR § 17.12.

²⁸ Records from the USDA-APHIS-PPQ Port Information Network (PIN 309). Last accessed February 2007.

1 **A22 ACKNOWLEDGMENTS**

2 This report was the result of a team effort, and could not have been completed without the kindly
3 assistance and cooperation of the following individuals:

4 **USDA-APHIS-PPQ:** D. Alontaga, D. Berringer, V. Harrington, A. Nakamura, N. Nakamura, J. Pasek, T.
5 Richardson, M. Simon, M. Tanner, C. Toguchi

6 **USDA-APHIS-WS:** B. Raphael

7 **Guam Department of Agriculture:** R. Campbell

8 **HDOA Market News Section:** R. Vierra

9 **HDOA Plant Industry Division:** P. Conant, R. Heu, L. Iseke, D. Nagatani, D. Oishi, M. Onaga, C. Okada, R.
10 Tong, L. Wong

11 **USDHS-CBP:** C. Higa, J. Kosciuk, H. Montoya, J. Sawyer, L. Witmer

12 **USDOD:** L. Bookless, A. Buckman, J. Burger, P. Egan, A. Hebshi, J. Johnson, S. Lee, M. Patton

13 **USDOI Geological Survey:** L. Loope

14 **USDOT Federal Aviation Administration, Airport Division:** M. Seguin

15 **U.S. Navy:** QM1 D. Alvarado, Cmdr. C. Carter, QM1 J. Sloane, Lt. A. Torres

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1 **A25 SUPPORTING DATA TABLES**

2 **Table A25-1: Shipments of Fresh Agricultural Commodities of Foreign Origin Entered Hawai'i**
 3 **during the Period January 1, 2004 and December 31, 2006**

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
American Samoa	Airport	CF	<i>Alyxia</i>	3	68	Stems	Baggage: <i>Ceroplastes rubens</i> (arthropod), <i>Orchamoplatus mammaeferus</i> (arthropod)
American Samoa	PIS	MC	Permit Pathogen	1	100	Each	
American Samoa	PIS	PM	<i>Anthurium</i> sp.	1	7	Plant unit	
American Samoa	PIS	PM	<i>Gardenia</i> sp.	1	8	Plant unit	
American Samoa	PIS	PM	<i>Metroxylon</i> sp.	1	1.5	kg	
American Samoa	PIS	PM	<i>Metroxylon</i> sp.	not given	25	Plant unit	
American Samoa	PIS	PM	<i>Zingiber</i> sp.	1	6	Plant unit	
Argentina	PIS	PM	<i>Zea mays</i>	1	2.5	kg	
Australia	Airport	CF	<i>Banksia</i>	1	1,200	Stems	
Australia	Airport	CF	<i>Protea</i>	3	6,641	Stems	
Australia	Airport	FV	Blueberry	1	60	kg	
Australia	Airport	FV	Cassava	1	1	kg	
Australia	Airport	FV	Mango	4	4,648	kg	
Australia	Airport	FV	Strawberry	1	770	kg	
Australia	Airport	PM	<i>Anigozanthos</i> sp.	2	1,144	Plant unit	
Australia	Airport	PM	<i>Anthurium</i> sp.	1	2,686	Plant unit	
Australia	Airport	PM	<i>Arachis</i> sp.	1	10	kg	
Australia	Airport	PM	<i>Gossypium</i> sp.	1	54	kg	
Australia	Airport	PM	<i>Linum usitatissimum</i>	1	410	kg	
Australia	Airport	PM	Orchidaceae (Unknown Genus)	1	33,200	Plant unit	
Australia	Airport	PM	<i>Zygopetalum</i> sp.	1	3,900	Plant unit	
Australia	Maritime	FV	Macadamia	15	221,941	kg	
Australia	Maritime	FV	Orange	2	44,800	kg	Baggage: species of Diaspididae (arthropod)
Australia	PIS	PM	<i>Adansonia</i> sp.	1	0.01	kg	
Australia	PIS	PM	<i>Alloxylon</i> sp.	1	3	Plant unit	
Australia	PIS	PM	<i>Alpinia</i> sp.	1	2	Plant unit	
Australia	PIS	PM	<i>Anigozanthos</i> sp.	2	1,248	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Australia	PIS	PM	<i>Arachis</i> sp.	1	10	kg	
Australia	PIS	PM	<i>Araucaria</i> sp.	1	8.5	kg	
Australia	PIS	PM	<i>Brachychiton</i> sp.	1	31	Plant unit	Permit cargo: <i>Alternaria</i> sp. (pathogen)
Australia	PIS	PM	<i>Bromelia</i> sp.	1	317	Plant unit	
Australia	PIS	PM	<i>Brownea</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Callistemon</i> sp.	2	32	Plant unit	
Australia	PIS	PM	<i>Calyptrocalyx</i> sp.	1	0.075	kg	
Australia	PIS	PM	<i>Carpoxylon macrospermum</i>	1	7	kg	
Australia	PIS	PM	<i>Carpoxylon macrospermum</i>	not given	7	Plant unit	
Australia	PIS	PM	<i>Clerodendrum</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Cordyline</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Corypha</i> sp.	1	1	kg	
Australia	PIS	PM	<i>Cymbidium</i> sp.	2	29	Flask	
Australia	PIS	PM	<i>Cynodon</i> sp.	1	100	kg	
Australia	PIS	PM	<i>Dendrobium</i> sp.	1	11	Flask	
Australia	PIS	PM	<i>Dendrobium</i> sp.	not given	8	Plant unit	
Australia	PIS	PM	<i>Drymophloeus</i> sp.	1	0.5	kg	
Australia	PIS	PM	<i>Dyopsis</i> sp.	1	101	Plant unit	Permit cargo: <i>Palmicultor browni</i> (arthropod)
Australia	PIS	PM	<i>Eremophila</i> sp.	1	2	Plant unit	
Australia	PIS	PM	<i>Etilingera</i> sp.	1	23	Plant unit	
Australia	PIS	PM	<i>Eucalyptus</i> sp.	1	12	Plant unit	
Australia	PIS	PM	<i>Fagraea</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Ficus</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Gardenia</i> sp.	1	13	Plant unit	Permit cargo: species of Aleyrodidae (arthropod)
Australia	PIS	PM	<i>Geonoma</i> sp.	1	0.01	kg	
Australia	PIS	PM	<i>Grevillea</i> sp.	3	17	Plant unit	Permit cargo: <i>Phoma</i> sp. (pathogen)
Australia	PIS	PM	<i>Heliconia</i> sp.	1	24	Plant unit	
Australia	PIS	PM	<i>Heterospathe</i> sp.	1	0.5	kg	
Australia	PIS	PM	<i>Howea</i> sp.	41	789,000	Plant unit	
Australia	PIS	PM	<i>Hydriastele</i> sp.	1	15	Plant unit	
Australia	PIS	PM	<i>Kentia</i> - Use (=) <i>Gronophyllum</i>	7	108,000	Plant unit	
Australia	PIS	PM	<i>Leptospermum</i> sp.	1	1	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Australia	PIS	PM	<i>Leucaena</i> sp.	1	44	kg	
Australia	PIS	PM	<i>Licuala</i> sp.	1	0.025	kg	
Australia	PIS	PM	<i>Livistona</i> sp.	1	0.01	kg	
Australia	PIS	PM	<i>Lophanthera</i> sp.	1	2	Plant unit	
Australia	PIS	PM	<i>Maniltoa</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Melaleuca</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Michelia</i> sp.	1	50	Plant unit	
Australia	PIS	PM	<i>Murraya paniculata</i>	1	1	Plant unit	
Australia	PIS	PM	<i>Murraya</i> sp.	2	40	Plant unit	
Australia	PIS	PM	<i>Mussaenda</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Nepenthes</i> sp.	9	2,147	Plant unit	
Australia	PIS	PM	<i>Phalaenopsis</i> sp.	1	1	Flask	
Australia	PIS	PM	<i>Plumeria</i> sp.	1	2	Plant unit	
Australia	PIS	PM	<i>Polyalthia</i> sp.	1	1	Plant unit	
Australia	PIS	PM	<i>Psidium</i> sp.	1	7	Plant unit	
Australia	PIS	PM	<i>Pterocarpus</i> sp.	1	7	Plant unit	
Australia	PIS	PM	<i>Rhododendron</i> sp.	2	376	Plant unit	
Australia	PIS	PM	<i>Saraca</i> sp.	1	2	Plant unit	
Australia	PIS	PM	<i>Syzygium</i> sp.	2	16	Plant unit	
Australia	PIS	PM	<i>Toona</i> sp.	1	0.1	kg	
Australia	PIS	PM	<i>Urochloa</i> sp.	1	250	kg	
Australia	PIS	PM	<i>Vanilla</i> sp.	1	200	Plant unit	
Australia	PIS	PM	<i>Wodyetia bifurcata</i>	1	90	kg	
Australia	PIS	PM	<i>Xanthostemon</i> sp.	1	23	Plant unit	
Australia	PIS	PM	<i>Zingiber</i> sp.	1	2	Plant unit	
Australia	USPS	PM	<i>Araucaria</i> sp.	1	9	kg	
Brazil	PIS	MC	Permit Pathogen	1	29.092	kg	
Canada	Airport	FV	Blueberry	2	5,020	kg	
Canada	Airport	FV	Cherry	5	3,638	kg	
Canada	Airport	FV	Mushroom	17	1,291	kg	
Canada	Airport	FV	Pepper	2	30	kg	
Canada	Airport	FV	Tomato	9	3,462	kg	
Canada	Airport	PM	<i>Wasabia</i> sp.	1	7	Plant unit	
Canada	PIS	PM	<i>Acalypha</i> spp.	1	96	Plant unit	
Canada	PIS	PM	<i>Adiantum</i> sp.	2	255	Plant unit	
Canada	PIS	PM	<i>Aeschynanthus</i> sp.	3	600	Plant unit	
Canada	PIS	PM	<i>Agave</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Aphelandra</i> sp.	21	4,140	Plant unit	
Canada	PIS	PM	<i>Aralia</i> sp.	1	240	Plant unit	
Canada	PIS	PM	<i>Argyranthemum</i> sp.	1	336	Plant unit	
Canada	PIS	PM	Azalea - Use	6	1,161	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
			Rhododendron				
Canada	PIS	PM	<i>Begonia</i> sp.	233	66,238	Plant unit	
Canada	PIS	PM	<i>Bixa</i> sp.	2	345	Plant unit	
Canada	PIS	PM	<i>Blechnum</i> sp.	2	96	Plant unit	
Canada	PIS	PM	<i>Bolbitis</i> sp.	1	5	Plant unit	
Canada	PIS	PM	<i>Bracteantha</i> sp.	1	210	Plant unit	
Canada	PIS	PM	<i>Calathea</i> sp.	22	1,026	Plant unit	
Canada	PIS	PM	<i>Calceolaria</i> sp.	8	1,371	Plant unit	
Canada	PIS	PM	<i>Calluna</i> sp.	1	153	Plant unit	
Canada	PIS	PM	<i>Capsicum</i> sp.	13	3,750	Plant unit	
Canada	PIS	PM	<i>Chamaedorea</i> sp.	4	1,080	Plant unit	
Canada	PIS	PM	<i>Chlorophytum</i> sp.	3	750	Plant unit	
Canada	PIS	PM	<i>Chrysanthemum</i> sp.	170	30,849	Plant unit	
Canada	PIS	PM	<i>Cineraria</i> sp.	6	1,116	Plant unit	
Canada	PIS	PM	<i>Crassula</i> sp.	4	662	Plant unit	
Canada	PIS	PM	<i>Crinum</i> sp.	1	5	Plant unit	
Canada	PIS	PM	<i>Crocus</i> sp.	25	3,865	Plant unit	
Canada	PIS	PM	<i>Cryptocoryne</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Cupressus</i> sp.	8	2,568	Plant unit	
Canada	PIS	PM	<i>Cyclamen</i> sp.	96	18,471	Plant unit	
Canada	PIS	PM	<i>Cyperus</i> sp.	2	310	Plant unit	
Canada	PIS	PM	<i>Dahlia</i> sp.	1	210	Plant unit	
Canada	PIS	PM	<i>Dalea</i> sp.	2	312	Plant unit	
Canada	PIS	PM	<i>Dianthus</i> sp.	6	1,440	Plant unit	
Canada	PIS	PM	<i>Dieffenbachia</i> sp.	34	6,720	Plant unit	
Canada	PIS	PM	<i>Dizygotheca</i> sp.	1	96	Plant unit	
Canada	PIS	PM	<i>Dracaena</i> sp.	7	1,290	Plant unit	
Canada	PIS	PM	<i>Echeveria</i> sp.	2	106	Plant unit	
Canada	PIS	PM	<i>Echinodorus</i> sp.	1	5	Plant unit	
Canada	PIS	PM	<i>Euphorbia pulcherrima</i>	31	181,153	Plant unit	
Canada	PIS	PM	<i>Euphorbia</i> sp.	32	169,585	Plant unit	
Canada	PIS	PM	<i>Exacum</i> sp.	15	2,888	Plant unit	
Canada	PIS	PM	<i>Ficus</i> sp.	19	5,020	Plant unit	
Canada	PIS	PM	<i>Fittonia</i> sp.	3	440	Plant unit	
Canada	PIS	PM	<i>Gerbera</i> sp.	54	10,458	Plant unit	
Canada	PIS	PM	<i>Gloxinia</i> sp.	3	563	Plant unit	
Canada	PIS	PM	<i>Graptopetalum</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Gynura</i> sp.	11	1,743	Plant unit	
Canada	PIS	PM	<i>Hedera</i> sp.	21	1,765	Plant unit	
Canada	PIS	PM	<i>Hemigraphis</i> sp.	7	1,095	Plant unit	
Canada	PIS	PM	<i>Hoya</i> sp.	3	143	Plant unit	
Canada	PIS	PM	<i>Hyacinthus</i> sp.	25	3,746	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Canada	PIS	PM	<i>Hygrophila</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Hypericum</i> sp.	1	40	Plant unit	
Canada	PIS	PM	<i>Hypoestes</i> sp.	30	7,070	Plant unit	
Canada	PIS	PM	<i>Iris</i> sp.	16	2,500	Plant unit	
Canada	PIS	PM	<i>Juglans</i> sp.	1	5	Plant unit	
Canada	PIS	PM	<i>Kalanchoe</i> sp.	253	97,064	Plant unit	
Canada	PIS	PM	<i>Lilium</i> sp.	56	10,306	Plant unit	
Canada	PIS	PM	<i>Ludwigia</i> sp.	1	5	Plant unit	
Canada	PIS	PM	<i>Microlepia</i> sp.	1	255	Plant unit	
Canada	PIS	PM	<i>Microsorium</i> sp.	1	20	Plant unit	
Canada	PIS	PM	<i>Narcissus</i> sp.	28	3,862	Plant unit	
Canada	PIS	PM	<i>Nematanthus</i> sp.	1	40	Plant unit	
Canada	PIS	PM	<i>Oxalis</i> sp.	5	1,134	Plant unit	
Canada	PIS	PM	<i>Panax quinquefolius</i>	1	1.363	kg	
Canada	PIS	PM	<i>Pelargonium</i> sp.	1	35	Plant unit	
Canada	PIS	PM	<i>Pellaea</i> sp.	2	216	Plant unit	
Canada	PIS	PM	<i>Peperomia</i> sp.	28	6,355	Plant unit	
Canada	PIS	PM	<i>Philodendron</i> sp.	2	226	Plant unit	
Canada	PIS	PM	<i>Pilea</i> sp.	8	1,800	Plant unit	
Canada	PIS	PM	<i>Pinus</i> sp.	1	312	Plant unit	
Canada	PIS	PM	<i>Podocarpus</i> sp.	6	1,200	Plant unit	
Canada	PIS	PM	<i>Polianthes</i> sp.	1	168	Plant unit	
Canada	PIS	PM	<i>Polyanthus</i> = <i>Primula</i> X <i>Polyantha</i>	1	204	Plant unit	
Canada	PIS	PM	<i>Portulacaria</i> sp.	1	19	Plant unit	
Canada	PIS	PM	<i>Pothos</i> sp.	20	2,999	Plant unit	
Canada	PIS	PM	<i>Primula</i> sp.	17	3,342	Plant unit	
Canada	PIS	PM	<i>Pteris</i> sp.	7	1,740	Plant unit	
Canada	PIS	PM	<i>Radermachera</i> sp.	1	240	Plant unit	
Canada	PIS	PM	<i>Ranunculus</i> sp.	5	900	Plant unit	
Canada	PIS	PM	<i>Rhododendron</i> sp.	15	2,643	Plant unit	
Canada	PIS	PM	<i>Rosa</i> sp.	245	72,313	Plant unit	
Canada	PIS	PM	<i>Rosmarinus officinalis</i>	1	90	Plant unit	
Canada	PIS	PM	<i>Rosmarinus</i> sp.	1	120	Plant unit	
Canada	PIS	PM	<i>Rudbeckia</i> sp.	2	360	Plant unit	
Canada	PIS	PM	<i>Saintpaulia</i> sp.	141	31,043	Plant unit	
Canada	PIS	PM	<i>Sansevieria</i> sp.	12	2,496	Plant unit	
Canada	PIS	PM	<i>Schefflera</i> sp.	3	465	Plant unit	
Canada	PIS	PM	<i>Schlumbergera</i> sp.	21	7,326	Plant unit	
Canada	PIS	PM	<i>Scindapsus</i> sp.	11	2,994	Plant unit	
Canada	PIS	PM	<i>Sedum</i> sp.	2	49	Plant unit	
Canada	PIS	PM	<i>Selaginella</i> sp.	1	160	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Canada	PIS	PM	<i>Sempervivum</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Senecio</i> sp.	13	1,923	Plant unit	
Canada	PIS	PM	<i>Sinningia</i> sp.	10	1,714	Plant unit	
Canada	PIS	PM	<i>Stapelia</i> sp.	1	15	Plant unit	
Canada	PIS	PM	<i>Syngonium</i> sp.	2	450	Plant unit	
Canada	PIS	PM	<i>Tulipa</i> sp.	19	2,697	Plant unit	
Canada	PIS	PM	<i>Viola</i> sp.	8	2,091	Plant unit	
Canada	PIS	PM	<i>Zamioculcas</i> sp.	7	420	Plant unit	
Canada	PIS	PM	<i>Zamioculcas zamiifolia</i>	3	216	Plant unit	
Canada	PIS	PM	<i>Zygocactus</i> sp.	9	3,252	Plant unit	
Chile	Maritime	FV	Apple	11	229,494	kg	
Chile	PIS	PM	<i>Zea mays</i>	7	1,317.5	kg	
Chile	USPS	PM	<i>Allium</i> sp.	1	22	kg	
China	Airport	FV	Dasheen	1	2	kg	
China	Airport	FV	Mushroom	80	20,180	kg	
China	Airport	FV	Soybean	1	2	kg	
China	Maritime	FV	Arrowhead	4	5,877	kg	
China	Maritime	FV	Arrowroot	4	3,230	kg	
China	Maritime	FV	Burdock	2	720	kg	
China	Maritime	FV	Chestnut	2	1,130	kg	
China	Maritime	FV	Ginger, Root	4	84,660	kg	
China	Maritime	FV	Lily Bulb	1	300	kg	
China	Maritime	FV	Lotus Root	5	3,565	kg	
China	Maritime	FV	Onion	1	1,250	kg	
China	Maritime	FV	Shallot	5	4,114	kg	
China	Maritime	FV	Waterchestnut	5	3,092	kg	
China	Maritime	FV	Dasheen	3	5,535	kg	
China	Maritime	FV	Soybean	2	20,350	kg	
China	Maritime	PM	<i>Allium</i> sp.	1	30	kg	
China	Maritime	PM	<i>Amaranthus</i> sp.	1	50	kg	
China	Maritime	PM	<i>Brassica</i> sp.	1	137	kg	
China	Maritime	PM	<i>Chrysanthemum</i> sp.	1	13	kg	
China	Maritime	PM	<i>Coriandrum</i> sp.	1	13	kg	
China	Maritime	PM	<i>Cycas revoluta</i>	1	32,000	Plant unit	
China	Maritime	PM	<i>Narcissus</i> sp.	7	38,913	Plant unit	
China	Maritime	PM	<i>Phaseolus</i> sp.	3	61,661	kg	
China	Maritime	PM	<i>Raphanus</i> sp.	1	25	kg	
China	Maritime	PM	<i>Vigna</i> sp.	1	100	kg	
China	PIS	PM	<i>Adenium</i> sp.	6	550	Plant unit	Mail: <i>Planococcus minor</i> (arthropod)
China	PIS	PM	<i>Allium fistulosum</i>	1	4	kg	
China	PIS	PM	<i>Brassica</i> sp.	2	50	kg	
China	PIS	PM	<i>Camellia</i> sp.	2	260	kg	
China	PIS	PM	<i>Carmona</i> sp.	3	1,255	Plant unit	
China	PIS	PM	<i>Coriandrum</i> sp.	1	60	kg	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
China	PIS	PM	<i>Cycas revoluta</i>	1	32,000	Plant unit	
China	PIS	PM	<i>Cymbidium sp.</i>	1	5,000	Plant unit	
China	PIS	PM	<i>Dracaena sp.</i>	1	4,600	Plant unit	Permit cargo: <i>Colletotrichum</i> sp. (pathogen); <i>Polydrusus</i> sp. (arthropod)
China	PIS	PM	<i>Ficus sp.</i>	1	3	Plant unit	
China	PIS	PM	<i>Ilex sp.</i>	1	200	Plant unit	
China	PIS	PM	<i>Lactuca sp.</i>	1	50	kg	
China	PIS	PM	<i>Lagerstroemia</i> sp.	1	3	Plant unit	
China	PIS	PM	<i>Magnolia sp.</i>	1	1,980	Plant unit	
China	PIS	PM	<i>Oncidium sp.</i>	2	1,290	Flask	
China	PIS	PM	<i>Pachira aquatica</i>	1	8	Plant unit	
China	PIS	PM	<i>Pachira sp.</i>	1	150	kg	
China	PIS	PM	<i>Pachira sp.</i>	not given	3	Plant unit	
China	PIS	PM	<i>Pachira sp.</i>	2	13	Plant unit	
China	PIS	PM	<i>Paphiopedilum</i> sp.	1	594	Flask	
China	PIS	PM	<i>Phalaenopsis sp.</i>	1	6,000	Plant unit	
China	PIS	PM	<i>Phalaenopsis sp.</i>	3	1,867	Flask	
China	PIS	PM	<i>Rhapis sp.</i>	1	21	kg	
China	PIS	PM	<i>Rhapis sp.</i>	3	2,205	Plant unit	
China	PIS	PM	<i>Sabina sp.</i>	1	16	Plant unit	
China	PIS	PM	<i>Sansevieria sp.</i>	1	2	Plant unit	
China	PIS	PM	<i>Serissa sp.</i>	3	2,430	Plant unit	
China	PIS	PM	<i>Washingtonia</i> sp.	2	750	Plant unit	
China	PIS	PM	<i>Wodyetia</i> <i>bifurcata</i>	2	700	Plant unit	
China	PIS	PM	<i>Zelkova sp.</i>	1	490	Plant unit	
China	PIS	PM	<i>Zygopetalum sp.</i>	1	80	Not specified	
China	USPS	PM	<i>Allium sp.</i>	4	153	kg	
China	USPS	PM	<i>Brassica sp.</i>	25	573	kg	
China	USPS	PM	<i>Chrysanthemum</i> sp.	1	2	kg	
China	USPS	PM	<i>Lactuca sp.</i>	1	1	kg	
China	USPS	PM	<i>Raphanus sp.</i>	1	30	kg	
China	USPS	PM	<i>Spinacia sp.</i>	1	5	kg	
China	USPS	PM	<i>Vigna sp.</i>	1	44	kg	
Colombia	Airport	CF	<i>Rosa sp.</i>	1	720	Stems	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Cook Islands	Airport	CF	<i>Alyxia</i>	202	62,920	Stems	Permit cargo: <i>Phyllachora alyxiae</i> (pathogen), <i>Orchamoplatus mammaeferus</i> (arthropod), <i>Eremopeas tukeri</i> (mollusc); General cargo: <i>Ceroplastes rubens</i> (arthropod); Baggage: <i>Phyllachora alyxiae</i> (pathogen), <i>Ceroplastes rubens</i> (arthropod), <i>Orchamoplatus mammaeferus</i> (arthropod), <i>Sassetia</i> sp. (arthropod), Tettagoniidae species
Cook Islands	Airport	FV	Dasheen	2	2,316	kg	
Costa Rica	PIS	MC	Permit Pathogen	1	30	Each	
Costa Rica	PIS	PM	<i>Elaeis</i> sp.	1	3,060	Plant unit	
Denmark	USPS	PM	<i>Spinacia</i> sp.	1	1	kg	
Dominican Republic	PIS	PM	<i>Pseudophoenix</i> sp.	1	1	kg	
Ecuador	Airport	CF	<i>Rosa</i> sp.	1	1,115	Stems	
Egypt	PIS	MC	Permit Pathogen	1	2	Each	
Fiji	Airport	CF	Pandanus	1	750	Stems	
Fiji	Airport	FV	Cassava	1	60	kg	
Fiji	Airport	FV	Dasheen	56	105,869	kg	
Fiji	Airport	FV	Kava	13	2,793	kg	
Fiji	Maritime	FV	Breadfruit	2	5,495	kg	
Fiji	Maritime	FV	Ginger, Root	1	20,520	kg	
Fiji	Maritime	FV	Cassava	3	20,184	kg	
Fiji	Maritime	FV	Dasheen	73	768,870	kg	
Fiji	PIS	PM	<i>Carpodetus</i> sp.	1	6.1	kg	
Fiji	PIS	PM	<i>Carpoxydon macrospermum</i>	1	9	kg	
France	Airport	PM	<i>Zea mays</i>	2	621	kg	
France	PIS	PM	<i>Zea mays</i>	7	1,249	kg	
Germany	Airport	PM	<i>Dendrobium</i> sp.	1	2,500	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Germany	PIS	PM	<i>Agave</i> sp.	1	100	Plant unit	
Germany	PIS	PM	<i>Agave victoriae-reginae</i>	1	100	Plant unit	
Germany	PIS	PM	<i>Arenga</i> sp.	1	400	Plant unit	
Germany	PIS	PM	<i>Arisaema</i> sp.	1	0.004	kg	
Germany	PIS	PM	<i>Bismarckia</i> sp.	1	0.4	kg	
Germany	PIS	PM	<i>Borassus</i> sp.	1	1	kg	
Germany	PIS	PM	<i>Butia</i> sp.	1	0.01	kg	
Germany	PIS	PM	<i>Calypstrogyne</i> sp.	2	0.07	kg	
Germany	PIS	PM	<i>Carpoxydon macrospermum</i>	1	2.3	kg	
Germany	PIS	PM	<i>Caryota</i> sp.	1	1	kg	
Germany	PIS	PM	<i>Chamaerops</i> sp.	2	11.01	kg	
Germany	PIS	PM	<i>Clinostigma</i> sp.	1	0.01	kg	
Germany	PIS	PM	<i>Cyrtostachys</i> sp.	1	2,000	Plant unit	
Germany	PIS	PM	<i>Cyrtostachys</i> sp.	3	0.47	kg	
Germany	PIS	PM	<i>Dictyosperma</i> sp.	1	1,000	Plant unit	
Germany	PIS	PM	<i>Dictyosperma</i> sp.	2	0.77	kg	
Germany	PIS	PM	<i>Dypsis</i> sp.	2	2,000	Plant unit	
Germany	PIS	PM	<i>Dypsis</i> sp.	7	5.03	kg	
Germany	PIS	PM	<i>Elaeis</i> sp.	1	0.1	kg	
Germany	PIS	PM	<i>Ensete</i> sp.	1	100	Plant unit	
Germany	PIS	PM	<i>Euterpe</i> sp.	1	0.12	kg	
Germany	PIS	PM	<i>Gronophyllum</i> sp.	1	0.1	kg	
Germany	PIS	PM	<i>Heliconia</i> sp.	1	0.8	kg	
Germany	PIS	PM	<i>Heliconia</i> sp.	not given	300	Plant unit	
Germany	PIS	PM	<i>Heterospathe</i> sp.	1	0.1	kg	
Germany	PIS	PM	<i>Howea</i> sp.	2	0.4	kg	
Germany	PIS	PM	<i>Hydriastele</i> sp.	1	0.9	kg	
Germany	PIS	PM	<i>Hyophorbe</i> sp.	2	0.51	kg	
Germany	PIS	PM	<i>Jubaea</i> sp.	1	1	kg	
Germany	PIS	PM	<i>Latania</i> sp.	1	0.4	kg	
Germany	PIS	PM	<i>Licuala</i> sp.	4	1.76	kg	
Germany	PIS	PM	<i>Lilium</i> sp.	1	0.02	kg	
Germany	PIS	PM	<i>Lobelia</i> sp.	2	0.04	kg	
Germany	PIS	PM	<i>Marojejya</i> sp.	1	0.4	kg	
Germany	PIS	PM	<i>Musa</i> sp.	1	1,100	Plant unit	
Germany	PIS	PM	<i>Nannorrhops ritchiana</i>	1	0.1	kg	
Germany	PIS	PM	<i>Nolina</i> sp.	1	1,100	Plant unit	
Germany	PIS	PM	<i>Phoenix</i> sp.	1	1	kg	
Germany	PIS	PM	<i>Pholidostachys</i> sp.	1	0.3	kg	
Germany	PIS	PM	<i>Pseudophoenix</i> sp.	2	0.61	kg	
Germany	PIS	PM	<i>Ptychosperma</i>	2	3.52	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
			sp.				
Germany	PIS	PM	<i>Ravenala</i> sp.	1	0.01	kg	
Germany	PIS	PM	<i>Ravenea</i> sp.	1	0.01	kg	
Germany	PIS	PM	<i>Rhapis</i> sp.	1	4,000	Plant unit	
Germany	PIS	PM	<i>Rhopalostylis</i> sp.	1	0.06	kg	
Germany	PIS	PM	<i>Roystonea</i> sp.	2	0.11	kg	
Germany	PIS	PM	<i>Strelitzia</i> sp.	2	0.06	kg	
Germany	PIS	PM	<i>Syagrus</i> sp.	1	0.01	kg	
Germany	PIS	PM	<i>Trachycarpus</i> sp.	3	1.07	kg	
Germany	PIS	PM	<i>Welwitschia mirabilis</i>	1	0.007	kg	
Germany	PIS	PM	<i>Wodyetia bifurcata</i>	1	0.01	kg	
Germany	USPS	PM	<i>Agave</i> sp.	1	1	kg	
Ghana	PIS	PM	<i>Argyreia</i> sp.	1	21	kg	
Guam	PIS	PM	<i>Bromelia</i> sp.	1	25	Plant unit	
Guam	PIS	PM	<i>Euphorbia</i> sp.	1	10	Plant unit	
Guam	PIS	PM	<i>Sorghum</i> sp.	1	120	Plant unit	
Guatemala	PIS	PM	<i>Pothos</i> sp.	2	12,000	Plant unit	
Honduras	PIS	PM	<i>Acrocarpus</i> sp.	1	100	Gram	
Honduras	PIS	PM	<i>Azadirachta</i> sp.	1	200	Gram	
Honduras	PIS	PM	<i>Cajanus</i> sp.	1	200	Gram	
Honduras	PIS	PM	<i>Dalbergia</i> sp.	2	550	Gram	
Honduras	PIS	PM	<i>Eucalyptus</i> sp.	1	0.025	kg	
Honduras	PIS	PM	<i>Gliricidia</i> sp.	1	0.05	kg	
Honduras	PIS	PM	<i>Ochroma</i> sp.	1	50	Gram	
Honduras	PIS	PM	<i>Pterocarpus</i> sp.	1	50	Gram	
Honduras	PIS	PM	<i>Swietenia humilis</i>	1	1	kg	
Honduras	PIS	PM	<i>Tectona</i> sp.	1	1	kg	
Hong Kong	PIS	PM	<i>Allium fistulosum</i>	1	2	kg	
Hong Kong	PIS	PM	<i>Allium</i> sp.	2	45.46	kg	
Hong Kong	PIS	PM	<i>Brassica</i> sp.	1	12	kg	
Hong Kong	PIS	PM	<i>Coriandrum</i> sp.	1	2	kg	
Hong Kong	PIS	PM	<i>Cucumis</i> sp.	1	2	kg	
Hong Kong	PIS	PM	<i>Rhapis</i> sp.	1	5,000	Plant unit	
Hong Kong	USPS	PM	<i>Allium</i> sp.	3	52	kg	
Hong Kong	USPS	PM	<i>Amaranthus</i> sp.	1	3	kg	
Hong Kong	USPS	PM	<i>Apium</i> sp.	1	1	kg	
Hong Kong	USPS	PM	<i>Brassica</i> sp.	15	245	kg	
Hong Kong	USPS	PM	<i>Coriandrum</i> sp.	1	10	kg	
Hong Kong	USPS	PM	<i>Momordica</i> sp.	1	1	kg	
Hong Kong	USPS	PM	<i>Raphanus</i> sp.	1	3	kg	
Hong Kong	USPS	PM	<i>Solanum</i> sp.	1	1	kg	
India	PIS	PM	<i>Camellia</i> sp.	1	36	kg	
India	PIS	PM	<i>Vanilla</i> sp.	1	500	Plant unit	
Indonesia	PIS	LU	<i>Potamogeton</i> Sp.	2	150	Plant unit	
Indonesia	PIS	PM	<i>Acorus</i> sp.	12	335	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Indonesia	PIS	PM	<i>Aglaonema</i> sp.	1	7	Plant unit	
Indonesia	PIS	PM	<i>Alocasia</i> sp.	1	7	Plant unit	
Indonesia	PIS	PM	<i>Alternanthera sessilis</i>	6	155	Plant unit	
Indonesia	PIS	PM	<i>Alternanthera</i> sp.	54	11,349	Plant unit	
Indonesia	PIS	PM	<i>Alyssoides</i> sp.	1	2	kg	
Indonesia	PIS	PM	<i>Amherstia</i> sp.	1	3	Plant unit	
Indonesia	PIS	PM	<i>Ammannia</i> sp.	28	1,735	Plant unit	
Indonesia	PIS	PM	<i>Ammocharis</i> sp.	1	25	Plant unit	
Indonesia	PIS	PM	<i>Ammoricia</i> sp.	7	225	Plant unit	
Indonesia	PIS	PM	<i>Amordica</i> sp.	7	705	Plant unit	
Indonesia	PIS	PM	<i>Anubias</i> sp.	60	6,372	Plant unit	
Indonesia	PIS	PM	<i>Aponogeton</i> sp.	50	5,622	Plant unit	
Indonesia	PIS	PM	<i>Aquilaria malaccensis</i>	1	1	kg	
Indonesia	PIS	PM	<i>Aquilaria malaccensis</i>	not given	10	Plant unit	
Indonesia	PIS	PM	<i>Arenga</i> sp.	1	0.08	kg	
Indonesia	PIS	PM	<i>Artocarpus heterophyllus</i>	2	13	Plant unit	
Indonesia	PIS	PM	<i>Asplenium</i> sp.	1	7	Plant unit	
Indonesia	PIS	PM	<i>Bacopa</i> sp.	56	9,932	Plant unit	
Indonesia	PIS	PM	<i>Barringtonia</i> sp.	1	1.3	kg	
Indonesia	PIS	PM	<i>Barringtonia</i> sp.	not given	2	Plant unit	
Indonesia	PIS	PM	<i>Bauhinia</i> sp.	1	10	Plant unit	
Indonesia	PIS	PM	<i>Blyxa</i> sp.	50	7,314	Plant unit	
Indonesia	PIS	PM	<i>Cabomba</i> sp.	56	50,572	Plant unit	
Indonesia	PIS	PM	<i>Callitris</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Calyptrocalyx</i> sp.	1	0.2	kg	
Indonesia	PIS	PM	<i>Calyptrocalyx</i> sp.	not given	150	Plant unit	
Indonesia	PIS	PM	<i>Cardamine</i> sp.	13	750	Plant unit	
Indonesia	PIS	PM	<i>Caryota</i> sp.	1	0.04	kg	
Indonesia	PIS	PM	<i>Ceratophyllum</i> sp.	5	205	Plant unit	
Indonesia	PIS	PM	<i>Ceratopteris</i> sp.	28	1,665	Plant unit	
Indonesia	PIS	PM	<i>Chlorophytum</i> sp.	36	3,165	Plant unit	
Indonesia	PIS	PM	<i>Cordyline</i> sp.	15	639	Plant unit	
Indonesia	PIS	PM	<i>Crassula</i> sp.	39	3,320	Plant unit	
Indonesia	PIS	PM	<i>Croton</i> sp.	1	50	Plant unit	
Indonesia	PIS	PM	<i>Cryptocoryne</i> sp.	58	31,912	Plant unit	
Indonesia	PIS	PM	<i>Cupressus</i> sp.	1	19	Plant unit	
Indonesia	PIS	PM	<i>Cyperus</i> sp.	12	730	Plant unit	
Indonesia	PIS	PM	<i>Cyrtosperma</i> sp.	1	2	Plant unit	
Indonesia	PIS	PM	<i>Dahlia</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Dalbergia</i> sp.	1	3	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Indonesia	PIS	PM	<i>Dracaena sanderiana</i>	2	75	Plant unit	
Indonesia	PIS	PM	<i>Dracaena</i> sp.	56	3,597	Plant unit	
Indonesia	PIS	PM	<i>Drymophloeus</i> sp.	1	0.04	kg	
Indonesia	PIS	PM	<i>Drynaria</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Durio</i> sp.	1	1	kg	
Indonesia	PIS	PM	<i>Durio</i> sp.	not given	58	Plant unit	
Indonesia	PIS	PM	<i>Durio zibethinus</i>	1	43	Plant unit	
Indonesia	PIS	PM	<i>Echinodorus</i> sp.	77	28,650	Plant unit	General cargo: <i>Cercospora</i> sp. (pathogen); Permit cargo: <i>Cercospora</i> sp. (pathogen), <i>Phoma</i> sp. (pathogen), species of Homoptera (arthropod), species of Insecta (arthropod), species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	<i>Echinopsis</i> sp.	1	76	Plant unit	
Indonesia	PIS	PM	<i>Egeria</i> sp.	27	1,435	Plant unit	
Indonesia	PIS	PM	<i>Eichhornia</i> sp.	1	50	Plant unit	
Indonesia	PIS	PM	<i>Elatostema</i> sp.	1	5	Plant unit	
Indonesia	PIS	PM	<i>Eleocharis</i> sp.	54	38,020	Plant unit	
Indonesia	PIS	PM	<i>Elodea</i> sp.	38	5,980	Plant unit	
Indonesia	PIS	PM	<i>Epiphyllum</i> sp.	1	2	Plant unit	
Indonesia	PIS	PM	<i>Etlingera</i> sp.	1	2	Plant unit	
Indonesia	PIS	PM	<i>Eusteralis</i> sp.	30	3,375	Plant unit	
Indonesia	PIS	PM	<i>Garcinia dulcis</i>	1	0.1	kg	
Indonesia	PIS	PM	<i>Garcinia dulcis</i>	not given	10	Plant unit	
Indonesia	PIS	PM	<i>Garcinia mangostana</i>	1	30	Plant unit	
Indonesia	PIS	PM	<i>Glossostigma</i> sp.	35	578	Plant unit	
Indonesia	PIS	PM	<i>Gronophyllum</i> sp.	1	0.04	kg	
Indonesia	PIS	PM	<i>Gronophyllum</i> sp.	not given	200	Plant unit	
Indonesia	PIS	PM	<i>Gymnocoronis</i> sp.	27	1,050	Plant unit	
Indonesia	PIS	PM	<i>Hemigraphis</i> sp.	37	2,110	Plant unit	
Indonesia	PIS	PM	<i>Heteranthera</i> sp.	39	3,505	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Indonesia	PIS	PM	<i>Hydrocotyle</i> sp.	39	3,105	Plant unit	
Indonesia	PIS	PM	<i>Hygrophila</i> sp.	67	14,546	Plant unit	Permit cargo: <i>Phoma</i> sp. (pathogen), species of Aleyrodidae, species of Aphididae, species of Pseudococcidae
Indonesia	PIS	PM	<i>Lagarosiphon major</i>	13	650	Plant unit	
Indonesia	PIS	PM	<i>Lepisanthes</i> sp.	1	2	kg	
Indonesia	PIS	PM	<i>Lepisanthes</i> sp.	not given	11	Plant unit	
Indonesia	PIS	PM	<i>Licuala</i> sp.	1	0.04	kg	
Indonesia	PIS	PM	<i>Licuala</i> sp.	not given	50	Plant unit	
Indonesia	PIS	PM	<i>Lilaeopsis</i> sp.	16	5,185	Plant unit	
Indonesia	PIS	PM	<i>Limnophila sessiliflora</i>	1	25	Plant unit	
Indonesia	PIS	PM	<i>Limnophila</i> sp.	25	1,395	Plant unit	
Indonesia	PIS	PM	<i>Lindera</i> sp.	2	75	Plant unit	
Indonesia	PIS	PM	<i>Lindernia</i> sp.	39	3,055	Plant unit	
Indonesia	PIS	PM	<i>Lobelia</i> sp.	47	2,160	Plant unit	Permit cargo: species of Hemiptera (arthropod)
Indonesia	PIS	PM	<i>Ludwigia</i> sp.	58	19,237	Plant unit	Permit cargo: species of Mollusca
Indonesia	PIS	PM	<i>Lycopodium</i> sp.	1	49	Plant unit	
Indonesia	PIS	PM	<i>Lysimachia</i> sp.	50	6,650	Plant unit	
Indonesia	PIS	PM	<i>Mangifera indica</i>	1	1	Plant unit	Baggage: <i>Aulacaspis tubercularis</i> (arthropod)
Indonesia	PIS	PM	<i>Maniltoa</i> sp.	1	900	Plant unit	
Indonesia	PIS	PM	<i>Marattia</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Marsilea</i> sp.	14	730	Plant unit	
Indonesia	PIS	PM	<i>Mayaca fluviatilis</i>	4	400	Plant unit	
Indonesia	PIS	PM	<i>Mayaca</i> sp.	55	5,351	Plant unit	
Indonesia	PIS	PM	<i>Micranthemum</i> Sp.	46	8,307	Plant unit	
Indonesia	PIS	PM	<i>Microsorium</i> sp.	57	21,540	Plant unit	Permit cargo: <i>Herpetogramma</i> sp. (arthropod), species of

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
							Margarodidae (arthropod)
Indonesia	PIS	PM	<i>Myriophyllum</i> sp.	55	9,235	Plant unit	
Indonesia	PIS	PM	<i>Nesaea</i> sp.	36	3,685	Plant unit	
Indonesia	PIS	PM	<i>Nomaphila</i> sp.	46	10,585	Plant unit	Permit cargo: <i>Cladosporium</i> sp. (pathogen), <i>Planococcus</i> sp. (arthropod), species of Aleyrodidae (arthropod), species of Aphididae (arthropod), species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	<i>Nuphar</i> sp.	41	1,437	Plant unit	
Indonesia	PIS	PM	<i>Nymphaea</i> sp.	13	777	Plant unit	
Indonesia	PIS	PM	<i>Nymphoides</i> sp.	8	517	Plant unit	
Indonesia	PIS	PM	<i>Ophiopogon</i> sp.	39	1,222	Plant unit	Permit cargo: <i>Succinea</i> sp. (mollusc)
Indonesia	PIS	PM	<i>Osmoxylon</i> sp.	1	5	Plant unit	
Indonesia	PIS	PM	<i>Ottelia alismoides</i>	5	235	Plant unit	
Indonesia	PIS	PM	<i>Pandanus</i> sp.	1	13	Plant unit	Permit cargo: species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	<i>Philodendron</i> sp.	1	25	Plant unit	
Indonesia	PIS	PM	<i>Pinanga</i> sp.	1	0.04	kg	
Indonesia	PIS	PM	<i>Platynerium</i> sp.	2	50	Plant unit	
Indonesia	PIS	PM	<i>Pogostemon</i> sp.	11	1,830	Plant unit	
Indonesia	PIS	PM	<i>Potamogeton</i> Sp.	41	5,710	Plant unit	
Indonesia	PIS	PM	<i>Ptychosperma</i> sp.	1	500	Plant unit	
Indonesia	PIS	PM	<i>Rhapis</i> sp.	1	400	Plant unit	
Indonesia	PIS	PM	<i>Riccia</i> sp.	1	1	kg	
Indonesia	PIS	PM	<i>Riccia</i> sp.	not given	1	Plant unit	
Indonesia	PIS	PM	<i>Richea</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Rorippa nasturtium-aquaticum</i>	1	60	Plant unit	
Indonesia	PIS	PM	<i>Rorippa</i> sp.	11	525	Plant unit	
Indonesia	PIS	PM	<i>Rotala</i> sp.	60	20,305	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Indonesia	PIS	PM	<i>Rothmannia</i> sp.	1	610	Plant unit	
Indonesia	PIS	PM	<i>Sagittaria sagittifolia</i>	1	200	Plant unit	
Indonesia	PIS	PM	<i>Sagittaria</i> sp.	59	9,860	Plant unit	Permit cargo: <i>Cercospora</i> sp. (pathogen), species of Aphididae (arthropod)
Indonesia	PIS	PM	<i>Saraca</i> sp.	1	20	Plant unit	
Indonesia	PIS	PM	<i>Saururus</i> sp.	19	505	Plant unit	
Indonesia	PIS	PM	<i>Schismatoglottis</i> sp.	1	2	Plant unit	
Indonesia	PIS	PM	<i>Spathiphyllum</i> sp.	40	2,045	Plant unit	Permit cargo: <i>Aleurothrixus</i> sp. (arthropod), species of Pseudococcidae (arthropod), species of Tortricidae (arthropod)
Indonesia	PIS	PM	<i>Stenocereus</i> sp.	1	1	Plant unit	
Indonesia	PIS	PM	<i>Syngonium</i> sp.	15	425	Plant unit	
Indonesia	PIS	PM	<i>Synnema</i> sp.	29	2,310	Plant unit	
Indonesia	PIS	PM	<i>Syzygium</i> sp.	1	48	Plant unit	
Indonesia	PIS	PM	<i>Tectona</i> sp.	1	675	Plant unit	General cargo: <i>Cryptotermes</i> sp. (arthropod)
Indonesia	PIS	PM	<i>Tectona</i> sp.	2	60	kg	
Indonesia	PIS	PM	<i>Thryptomene</i> sp.	1	40	Plant unit	
Indonesia	PIS	PM	<i>Thuja</i> sp.	1	3	Plant unit	
Indonesia	PIS	PM	<i>Tonina</i> sp.	45	2,065	Plant unit	
Indonesia	PIS	PM	<i>Trapa</i> sp.	6	95	Plant unit	
Indonesia	PIS	PM	<i>Trichocoronis</i> sp.	6	532	Plant unit	
Indonesia	PIS	PM	<i>Trichomanes</i> sp.	28	1,140	Plant unit	
Indonesia	PIS	PM	<i>Vallisneria</i> sp.	60	40,696	Plant unit	Permit cargo: species of Mollusca
Indonesia	PIS	PM	<i>Vesicularia</i> - Use Moss - Bryophyta	12	23	Plant unit	
Indonesia	PIS	PM	<i>Watsonia</i> sp.	1	2	Plant unit	
Indonesia	PIS	PM	<i>Wrightia</i> sp.	1	2,000	Plant unit	
Ireland	PIS	PM	<i>Astelia</i> sp.	1	10	Plant unit	
Ireland	PIS	PM	<i>Phormium</i> sp.	4	156	Plant unit	
Israel	USPS	PM	<i>Cucumis sativus</i>	1	1	kg	
Italy	PIS	PM	<i>Cordyline</i> sp.	1	48	kg	
Italy	PIS	PM	<i>Nymphaea</i> sp.	1	0.2	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Japan	Airport	CF	<i>Dendrobium</i> sp.	247	302,895	Stems	
Japan	Airport	CF	Lotus	1	100	Stems	
Japan	Airport	CF	Oxypetalum	1	50	Stems	
Japan	Airport	CF	Paeonia	1	10	Stems	
Japan	Airport	CF	<i>Rosa</i> sp.	3	425	Stems	
Japan	Airport	CF	Stemona	1	60	Stems	
Japan	Airport	FV	Arrowroot	2	100	kg	
Japan	Airport	FV	Asparagus	1	40	kg	Permit cargo: <i>Chrysodeixis eriosoma</i> (arthropod)
Japan	Airport	FV	Burdock	120	1,615	kg	
Japan	Airport	FV	Carrot	108	1,423	kg	
Japan	Airport	FV	Cucumber	133	6,537	kg	
Japan	Airport	FV	Dasheen	6	76	kg	
Japan	Airport	FV	Eggplant	111	1,148	kg	
Japan	Airport	FV	Ginger, Bracts	339	903	kg	
Japan	Airport	FV	Leek	70	439	kg	
Japan	Airport	FV	Lily Bulb	1	5	kg	
Japan	Airport	FV	Lotus Root	63	254	kg	
Japan	Airport	FV	Melon	38	817	kg	
Japan	Airport	FV	Mushroom	592	33,059	kg	
Japan	Airport	FV	Onion	54	362	kg	
Japan	Airport	FV	Pepper	98	313	kg	
Japan	Airport	FV	Perilla	7	12	kg	
Japan	Airport	FV	Radish	208	10,942	kg	
Japan	Airport	FV	Sand Pear	3	147	kg	
Japan	Airport	FV	Strawberry	68	968	kg	
Japan	Airport	FV	Sweet Potato	1	100	kg	
Japan	Airport	FV	Tomato	109	1,253	kg	
Japan	Airport	FV	Wasabi	113	177	kg	
Japan	Airport	FV	Yam	176	3,099	kg	
Japan	Maritime	FV	Apple	4	102,810	kg	
Japan	Maritime	FV	Squash	5	2,301	kg	
Japan	Maritime	FV	Waterchestnut	3	1,350	kg	
Japan	Maritime	FV	Burdock	28	23,349.5	kg	
Japan	Maritime	FV	Dasheen	1	540	kg	
Japan	Maritime	FV	Onion	1	800	kg	
Japan	Maritime	FV	Sand Pear	11	141,825	kg	
Japan	Maritime	FV	Yam	89	48,950	kg	
Japan	Maritime	PM	<i>Allium</i> sp.	1	3	kg	
Japan	Maritime	PM	<i>Cucumis</i> sp.	1	1	kg	
Japan	Maritime	PM	<i>Raphanus</i> sp.	1	1	kg	Permit cargo: <i>Delia</i> sp. (arthropod), <i>Listroderes</i> sp. (arthropod), species of

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
							Aphididae (arthropod), species of Lepidoptera (arthropod), species of Pyraustinae (arthropod)
Japan	Maritime	PM	<i>Solanum</i> sp.	1	1	kg	Permit cargo: species of Aphididae (arthropod), species of Thripidae (arthropod), species of Thysanoptera (arthropod)
Japan	Maritime	PM	<i>Vigna</i> sp.	1	9	kg	
Japan	PIS	PM	<i>Aerides</i> sp.	1	5	Plant unit	
Japan	PIS	PM	<i>Ascocentrum</i> sp.	1	8	Plant unit	
Japan	PIS	PM	<i>Camellia</i> sp.	2	4,040	Plant unit	
Japan	PIS	PM	<i>Cattleya</i> sp.	1	2	Flask	
Japan	PIS	PM	<i>Cattleya</i> sp.	9	440	Plant unit	
Japan	PIS	PM	<i>Coelogyne</i> sp.	1	16	Plant unit	
Japan	PIS	PM	<i>Cucurbita moschata</i>	1	0.908	kg	
Japan	PIS	PM	<i>Daucus carota</i>	1	0.03	kg	
Japan	PIS	PM	<i>Dendrobium</i> sp.	3	6,503	Plant unit	
Japan	PIS	PM	<i>Encyclia</i> sp.	1	1	Plant unit	
Japan	PIS	PM	<i>Epidendrum</i> sp.	1	1	Plant unit	
Japan	PIS	PM	<i>Ficinia</i> Sp.	2	18	Plant unit	
Japan	PIS	PM	<i>Gardenia</i> sp.	1	3	Plant unit	Baggage: <i>Thrips</i> sp. (arthropod), <i>Thrips florum</i> (arthropod)
Japan	PIS	PM	<i>Laelia</i> sp.	1	3	Plant unit	
Japan	PIS	PM	<i>Monochoria</i> sp.	1	0.001	kg	
Japan	PIS	PM	<i>Nelumbo nucifera</i>	1	14	Plant unit	
Japan	PIS	PM	<i>Nuphar</i> sp.	1	16	Plant unit	
Japan	PIS	PM	<i>Nymphaea</i> sp.	2	47	Plant unit	
Japan	PIS	PM	<i>Phalaenopsis</i> sp.	2	405	Plant unit	
Japan	PIS	PM	<i>Raphanus sativus</i>	1	0.94	kg	Permit cargo: species of Plutellidae, species of Syrphidae, species of

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
							Thysanoptera, species of Tortricidae; Mail: species of Aphididae
Japan	PIS	PM	<i>Rhapis</i> sp.	3	712	Plant unit	
Japan	PIS	PM	<i>Salix</i> sp.	1	19	Plant unit	
Japan	PIS	PM	<i>Solanum melongena</i>	1	1.362	kg	
Japan	PIS	PM	<i>Sophronitis</i> sp.	1	1	Plant unit	
Japan	PIS	PM	<i>Spinacia oleracea</i>	1	2.27	kg	
Japan	PIS	PM	<i>Vanda</i> sp.	1	42	Plant unit	
Japan	PIS	PM	<i>Vigna unguiculata</i> ssp. <i>unguiculata</i>	1	13.62	kg	
Japan	USPS	PM	<i>Allium</i> sp.	1	2	kg	
Japan	USPS	PM	<i>Anthriscus</i> sp.	1	10	kg	
Japan	USPS	PM	<i>Benincasa</i> sp.	1	7	kg.	
Japan	USPS	PM	<i>Brassica</i> sp.	10	62	kg	
Japan	USPS	PM	<i>Chrysanthemum</i> sp.	1	22	kg	
Japan	USPS	PM	<i>Corchorus</i> sp.	1	11	kg	
Japan	USPS	PM	<i>Cucumis sativus</i>	6	13	kg	Permit cargo: species of Crambidae
Japan	USPS	PM	<i>Cucumis</i> sp.	1	1	kg	
Japan	USPS	PM	<i>Glycine max</i>	2	72	kg	
Japan	USPS	PM	<i>Lagenaria</i> sp.	3	11	kg	
Japan	USPS	PM	<i>Luffa</i> sp.	1	3	kg	
Japan	USPS	PM	<i>Momordica</i> sp.	4	35	kg	
Japan	USPS	PM	<i>Perilla</i> sp.	1	55	kg	
Japan	USPS	PM	<i>Raphanus</i> sp.	5	149	kg	
Japan	USPS	PM	<i>Spinacia</i> sp.	2	77	kg	
Korea, South	Airport	FV	Grape	1	52	kg	
Korea, South	Airport	FV	Pear	1	17	kg	
Korea, South	Airport	FV	Persimmon	1	1,120	kg	
Korea, South	Airport	FV	Sand Pear	1	3,400	kg	Permit cargo: species of Carposinidae (arthropod), species of Pseudococcidae (arthropod), species of Tortricidae

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
							(arthropod)
Korea, South	Maritime	FV	Garlic	1	18,500	kg	
Korea, South	Maritime	FV	Grape	1	5,100	kg	
Korea, South	Maritime	FV	Sand Pear	86	1,449,360	kg	
Korea, South	PIS	PM	<i>Cymbidium</i> sp.	1	7	Plant unit	
Korea, South	PIS	PM	<i>Phalaenopsis</i> sp.	1	30,000	Plant unit	
Korea, South	PIS	PM	<i>Zea mays</i>	2	80	kg	
Korea, South	USPS	PM	<i>Allium</i> sp.	2	4	kg	
Korea, South	USPS	PM	<i>Capsicum</i> sp.	1	1	kg	
Korea, South	USPS	PM	<i>Codonopsis</i> sp.	1	1	kg	
Korea, South	USPS	PM	<i>Cucumis sativus</i>	1	1	kg	
Korea, South	USPS	PM	<i>Lactuca</i> sp.	2	2	kg	
Korea, South	USPS	PM	<i>Lycopersicon esculentum</i>	1	1	kg	
Korea, South	USPS	PM	<i>Perilla</i> sp.	1	2	kg	
Korea, South	USPS	PM	<i>Platycodon</i> sp.	1	1	kg	
Korea, South	USPS	PM	<i>Raphanus</i> sp.	1	2	kg	
Korea, South	USPS	PM	<i>Solanum</i> sp.	1	1	kg	
Laos	PIS	PM	<i>Tectona</i> sp.	1	70	kg	
Malaysia	PIS	PM	<i>Adenium</i> sp.	2	11	Plant unit	
Malaysia	PIS	PM	<i>Allamanda</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Alocasia</i> sp.	1	20	Plant unit	
Malaysia	PIS	PM	<i>Alpinia</i> sp.	1	20	Plant unit	
Malaysia	PIS	PM	<i>Annona</i> sp.	1	19	Plant unit	
Malaysia	PIS	PM	<i>Aquilaria malaccensis</i>	1	100	Plant unit	
Malaysia	PIS	PM	<i>Bauhinia</i> sp.	3	820	Plant unit	
Malaysia	PIS	PM	<i>Bougainvillea</i> sp.	6	2,650	Plant unit	
Malaysia	PIS	PM	<i>Caladium</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Calamus</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Calliandra</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Canna</i> sp.	1	60	Plant unit	
Malaysia	PIS	PM	<i>Carica papaya</i>	1	1	Gram	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Malaysia	PIS	PM	<i>Cassia</i> sp.	1	25	Plant unit	
Malaysia	PIS	PM	<i>Chamaedorea</i> sp.	1	2,000	Plant unit	
Malaysia	PIS	PM	<i>Chrysalidocarpus</i> sp.	1	20	Plant unit	
Malaysia	PIS	PM	<i>Codiaeum</i> sp.	2	140	Plant unit	
Malaysia	PIS	PM	<i>Cordyline</i> sp.	3	220	Plant unit	
Malaysia	PIS	PM	<i>Costus</i> sp.	2	30	Plant unit	
Malaysia	PIS	PM	<i>Curcuma</i> sp.	1	1,200	Plant unit	
Malaysia	PIS	PM	<i>Cyrtostachys</i> sp.	2	105	Plant unit	
Malaysia	PIS	PM	<i>Dendrobium</i> sp.	1	1	Flask	
Malaysia	PIS	PM	<i>Dendrobium</i> sp.	not given	15	Plant unit	
Malaysia	PIS	PM	<i>Dimocarpus longan</i>	1	14	Plant unit	
Malaysia	PIS	PM	<i>Dracaena sanderiana</i>	9	85,008	Plant unit	
Malaysia	PIS	PM	<i>Dracaena</i> sp.	10	62,093	Plant unit	Permit cargo: species of Diaspididae (arthropod)
Malaysia	PIS	PM	<i>Dypsis</i> sp.	4	1,270	Plant unit	
Malaysia	PIS	PM	<i>Excoecaria</i> sp.	3	405	Plant unit	
Malaysia	PIS	PM	<i>Furcraea</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Gardenia</i> sp.	2	15	Plant unit	
Malaysia	PIS	PM	<i>Heliconia</i> sp.	2	150	Plant unit	
Malaysia	PIS	PM	<i>Hylocereus</i> sp.	1	60	Plant unit	
Malaysia	PIS	PM	<i>Ixora</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Jatropha</i> sp.	2	10	Plant unit	
Malaysia	PIS	PM	<i>Johannesteijsmannia</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Kopsia</i> sp.	2	70	Plant unit	
Malaysia	PIS	PM	<i>Lagerstroemia indica</i>	1	10	Plant unit	
Malaysia	PIS	PM	<i>Lagerstroemia</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Lantana</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Mangifera indica</i>	1	33	Plant unit	
Malaysia	PIS	PM	<i>Manilkara zapota</i>	1	2	Plant unit	
Malaysia	PIS	PM	<i>Maranta</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	Mokara	1	10	Plant unit	
Malaysia	PIS	PM	<i>Monstera deliciosa</i>	1	5	Plant unit	
Malaysia	PIS	PM	<i>Monstera</i> sp.	2	40	Plant unit	
Malaysia	PIS	PM	<i>Murraya</i> sp.	1	50	Plant unit	
Malaysia	PIS	PM	<i>Mussaenda</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Nepenthes</i> sp.	1	360	Plant unit	
Malaysia	PIS	PM	<i>Ophiopogon</i> sp.	2	70	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Malaysia	PIS	PM	<i>Pachira aquatica</i>	1	40	Plant unit	
Malaysia	PIS	PM	<i>Pachira</i> sp.	1	100	Plant unit	
Malaysia	PIS	PM	<i>Pandanus</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Peltophorum</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Philodendron</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Pleomele</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Plumeria</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Pouteria</i> sp.	1	13	Plant unit	
Malaysia	PIS	PM	<i>Pseuderanthemum</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Ravenala</i> sp.	1	10	Plant unit	
Malaysia	PIS	PM	<i>Rhapis</i> sp.	5	2,125	Plant unit	
Malaysia	PIS	PM	<i>Rhodophiala</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Roystonea</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Samanea</i> sp.	2	15	Plant unit	
Malaysia	PIS	PM	<i>Sansevieria</i> sp.	3	160	Plant unit	
Malaysia	PIS	PM	<i>Veitchia</i> sp.	2	2,100	Plant unit	
Malaysia	PIS	PM	<i>Zamia</i> sp.	1	5	Plant unit	
Malaysia	PIS	PM	<i>Zephyranthes</i> sp.	1	40	Plant unit	
Malaysia	PIS	PM	<i>Zyzygium</i> sp.	1	4	Plant unit	
Mexico	PIS	PM	<i>Psidium guajava</i>	1	0.5	kg	
Micronesia	Airport	FV	Betel-Nut	1	525	kg	
Micronesia	PIS	PM	<i>Ageratum</i> sp.	2	12	Plant unit	
Micronesia	PIS	PM	<i>Aglaia</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Aleurites</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Alocasia</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Asplenium</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Barringtonia</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Cananga</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Canavalia</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Capsicum</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Carica papaya</i>	1	5	Plant unit	
Micronesia	PIS	PM	<i>Cinnamomum</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Citrus</i> sp.	1	6	Plant unit	Baggage: <i>Aonidiella</i> sp. (arthropod)
Micronesia	PIS	PM	<i>Clerodendrum</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Clinostigma</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Cordyline</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Curcuma</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Cyathea</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Cyperus</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Davallia</i> sp.	3	15	Plant unit	
Micronesia	PIS	PM	<i>Elaeocarpus</i> sp.	2	10	Plant unit	
Micronesia	PIS	PM	<i>Eleusine</i> sp.	3	16	Plant unit	
Micronesia	PIS	PM	<i>Eugenia</i> sp.	1	5	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Micronesia	PIS	PM	<i>Eurya</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Ficus</i> sp.	2	16	Plant unit	
Micronesia	PIS	PM	<i>Garcinia</i> sp.	2	10	Plant unit	
Micronesia	PIS	PM	<i>Hedychium</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Hibiscus</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Hoya</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Hymenocallis</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Ipomoea</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Ixora</i> sp.	2	17	Plant unit	
Micronesia	PIS	PM	<i>Ludwigia</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Mammea</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Marattia</i> sp.	2	10	Plant unit	
Micronesia	PIS	PM	<i>Melastoma malabathricum</i>	2	11	Plant unit	
Micronesia	PIS	PM	<i>Metroxylon</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Microsorium</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Morinda</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Nephrolepis</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Phyllanthus</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Piper</i> sp.	1	12	Plant unit	
Micronesia	PIS	PM	<i>Premna</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Rhizophora</i> sp.	2	10	Plant unit	
Micronesia	PIS	PM	<i>Saccharum</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Scaevola</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Tacca</i> sp.	1	5	Plant unit	
Micronesia	PIS	PM	<i>Terminalia</i> sp.	1	6	Plant unit	
Micronesia	PIS	PM	<i>Thelypteris</i> sp.	2	11	Plant unit	
Micronesia	PIS	PM	<i>Zingiber</i> sp.	1	6	Plant unit	
Netherlands	Airport	CF	Alpinia	1	60	Stems	Permit cargo: <i>Planococcus</i> sp. (arthropod)
Netherlands	Airport	CF	Alstroemeria	2	350	Stems	
Netherlands	Airport	CF	Amaryllis	2	67	Stems	
Netherlands	Airport	CF	Anthurium	2	934	Stems	
Netherlands	Airport	CF	Aralia	1	100	Stems	
Netherlands	Airport	CF	Aspidistra	2	7	Stems	
Netherlands	Airport	CF	Bouvardia	1	40	Stems	
Netherlands	Airport	CF	Chrysanthemum	1	240	Stems	
Netherlands	Airport	CF	Cymbidium	1	60	Stems	
Netherlands	Airport	CF	<i>Delphinium</i> sp.	1	40	Stems	
Netherlands	Airport	CF	Dendrobium	2	160	Stems	
Netherlands	Airport	CF	Dracaena	1	10	Stems	
Netherlands	Airport	CF	<i>Echinops</i> sp.	1	45	Stems	
Netherlands	Airport	CF	Heliconia	1	31	Stems	Permit cargo: species of Lycaenidae (arthropod)
Netherlands	Airport	CF	<i>Hypericum</i> sp.	1	600	Stems	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Netherlands	Airport	CF	Leucospermum	1	160	Stems	
Netherlands	Airport	CF	<i>Liatris</i> sp.	1	40	Stems	
Netherlands	Airport	CF	<i>Lilium</i> sp.	2	380	Stems	
Netherlands	Airport	CF	Lysimachia	1	50	Stems	
Netherlands	Airport	CF	Monstera	2	140	Stems	
Netherlands	Airport	CF	Nerine	1	100	Stems	
Netherlands	Airport	CF	Ornithogalum	2	280	Stems	
Netherlands	Airport	CF	<i>Philodendron</i> sp.	1	10	Stems	
Netherlands	Airport	CF	Protea	1	40	Stems	
Netherlands	Airport	CF	<i>Rosa</i> sp.	1	280	Stems	
Netherlands	Airport	CF	Ruscus	2	80	Stems	
Netherlands	Airport	CF	<i>Solidago</i> sp.	1	50	Stems	
Netherlands	Airport	CF	Strelitzia	1	122	Stems	
Netherlands	Airport	CF	Zantedeschia	1	70	Stems	
Netherlands	Airport	PM	<i>Dendrobium</i> sp.	1	7,000	Plant unit	
Netherlands	PIS	PM	<i>Anthurium</i> sp.	3	7,000	Plant unit	
Netherlands	PIS	PM	<i>Oxalis</i> sp.	1	10,000	Plant unit	
New Zealand	Airport	CF	<i>Cymbidium</i> sp.	69	15,204	Stems	
New Zealand	Airport	FV	Apple	2	9	kg	
New Zealand	Airport	FV	Apricot	2	1,110	kg	
New Zealand	Airport	FV	Asparagus	9	10,671	kg	
New Zealand	Airport	FV	Blueberry	16	3,482.5	kg.	
New Zealand	Airport	FV	Cape Gooseberry	1	272	kg	
New Zealand	Airport	FV	Cherry	3	1,950	kg	
New Zealand	Airport	FV	Kiwi	1	118	kg	
New Zealand	Airport	FV	Onion	1	48,080	Each	
New Zealand	Airport	FV	Pumpkin	1	11,000	kg	
New Zealand	Airport	FV	Strawberry	57	51,917	kg	Permit cargo: species of Tortricidae (arthropod)
New Zealand	Airport	PM	<i>Citrus</i> sp.	1	1,000	Plant unit	
New Zealand	Maritime	FV	Macadamia	3	49,125	kg	
New Zealand	Maritime	FV	Pear	6	177,287	kg	
New Zealand	Maritime	FV	Sand Pear	4	62,922	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
New Zealand	Maritime	FV	Squash	22	316,760	kg	
New Zealand	Maritime	FV	Apple	46	2,990,291	kg	
New Zealand	Maritime	FV	Kiwi	11	189,852	kg	
New Zealand	Maritime	FV	Onion	not given	11,129	kg	
New Zealand	Maritime	FV	Onion	60	2,518,205	kg	
New Zealand	PIS	PM	<i>Agapanthus</i> sp.	2	9,000	Plant unit	
New Zealand	PIS	PM	<i>Agonis</i> sp.	1	20	Plant unit	
New Zealand	PIS	PM	<i>Blechnum</i> sp.	1	55	Plant unit	
New Zealand	PIS	PM	<i>Cedrus</i> sp.	1	0.05	kg	
New Zealand	PIS	PM	<i>Chamaelaucium</i> sp.	1	40	Plant unit	
New Zealand	PIS	PM	<i>Cryptomeria</i> sp.	1	0.23	kg	
New Zealand	PIS	PM	<i>Cupressus</i> sp.	1	0.05	kg	
New Zealand	PIS	PM	<i>Cyathea</i> sp.	1	32	Plant unit	
New Zealand	PIS	PM	<i>Dicksonia</i> sp.	1	10	Plant unit	
New Zealand	PIS	PM	<i>Erica</i> sp.	1	40	Plant unit	
New Zealand	PIS	PM	<i>Grevillea</i> sp.	1	60	Plant unit	
New Zealand	PIS	PM	<i>Leucadendron</i> sp.	1	100	Plant unit	
New Zealand	PIS	PM	<i>Passiflora</i> sp.	1	0.6	kg	
New Zealand	PIS	PM	<i>Phormium</i> sp.	1	145	Plant unit	
New Zealand	PIS	PM	<i>Protea</i> sp.	1	120	Plant unit	
New Zealand	PIS	PM	<i>Telopea</i> sp.	1	120	Plant unit	
New Zealand	PIS	PM	<i>Zephyranthes</i> sp.	1	7	kg	
Norfolk Island	PIS	PM	<i>Howea</i> sp.	4	28,000	Plant unit	
Norfolk Island	PIS	PM	<i>Rhapis</i> sp.	1	100	Plant unit	
Palau	PIS	PM	<i>Allophylus</i> sp.	1	3	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Palau	PIS	PM	<i>Alpinia</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Averrhoa</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Barringtonia</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Callicarpa</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Cassytha</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Cordyline</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Flacourtia</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Hibiscus</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Lycopodium</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Morinda</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Mussaenda</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Poa</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Premna</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Psidium</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Scaevola</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Spondias</i> sp.	1	3	Plant unit	
Palau	PIS	PM	<i>Terminalia</i> sp.	1	3	Plant unit	
Panama	PIS	PM	<i>Calathea</i> sp.	1	0.5	kg	
Panama	PIS	PM	<i>Etlingera</i> sp.	1	0.5	kg.	
Panama	PIS	PM	<i>Heliconia</i> sp.	1	0.5	kg	
Philippines	Airport	FV	Garlic	1	2	kg	
Philippines	Airport	FV	Ginger, Bracts	1	8	kg	
Philippines	Airport	FV	Mango	18	21,420	kg	Baggage: <i>Aulacaspis tubercularis</i> (arthropod), <i>Sternochetus mangiferae</i> (arthropod), species of Diaspididae (arthropod), species of Pseudococcidae (arthropod)
Philippines	PIS	PM	<i>Adiantum</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Aglaomorpha</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Aglaonema</i> sp.	1	38	Plant unit	
Philippines	PIS	PM	<i>Alocasia</i> sp.	2	12	Plant unit	
Philippines	PIS	PM	<i>Ananas comosus</i>	79	11,781,450	Plant unit	
Philippines	PIS	PM	<i>Angiopteris</i> sp.	1	8	Plant unit	
Philippines	PIS	PM	<i>Asplenium</i> sp.	1	3	Plant unit	
Philippines	PIS	PM	<i>Begonia</i> sp.	1	6	Plant unit	
Philippines	PIS	PM	<i>Blechnum</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Bolbitis</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Bougainvillea</i> sp.	1	35	Plant unit	
Philippines	PIS	PM	<i>Cordyline</i> sp.	1	500	Plant unit	
Philippines	PIS	PM	<i>Cryptanthus</i> sp.	2	1,800	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Philippines	PIS	PM	<i>Davallia</i> sp.	1	3	Plant unit	
Philippines	PIS	PM	<i>Dieffenbachia</i> sp.	1	8	Plant unit	
Philippines	PIS	PM	<i>Diplazium</i> sp.	1	5	Plant unit	
Philippines	PIS	PM	<i>Dipteris</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Dracaena sanderiana</i>	3	295	Plant unit	
Philippines	PIS	PM	<i>Dracaena</i> sp.	3	42	Plant unit	
Philippines	PIS	PM	<i>Duranta</i> sp.	1	300	Plant unit	
Philippines	PIS	PM	<i>Elaphoglossum</i> sp.	1	6	Plant unit	
Philippines	PIS	PM	<i>Euphorbia</i> sp.	1	1,200	Plant unit	
Philippines	PIS	PM	<i>Goniophlebium</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Hippeastrum</i> sp.	1	14	Plant unit	
Philippines	PIS	PM	<i>Hymenophyllum</i> sp.	1	9	Plant unit	
Philippines	PIS	PM	<i>Lecanopteris</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Lycopodium</i> sp.	2	57	Plant unit	
Philippines	PIS	PM	<i>Microsorium</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Ophiopogon</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Pachira aquatica</i>	2	220	Plant unit	
Philippines	PIS	PM	<i>Platynerium</i> sp.	1	45	Plant unit	
Philippines	PIS	PM	<i>Polypodium</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Pteris</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Pyrrosia</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Schismatoglottis</i> sp.	1	2	Plant unit	
Philippines	PIS	PM	<i>Selaginella</i> sp.	1	12	Plant unit	
Philippines	PIS	PM	<i>Spathiphyllum</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Stenochlaena</i> sp.	1	1	Plant unit	
Philippines	PIS	PM	<i>Tectaria</i> sp.	1	9	Plant unit	
Philippines	PIS	PM	<i>Thelypteris</i> sp.	1	4	Plant unit	
Philippines	PIS	PM	<i>Zamioculcas</i> sp.	1	6	Plant unit	
Singapore	PIS	PM	<i>Acorus</i> sp.	1	25	Plant unit	
Singapore	PIS	PM	<i>Aglaonema</i> sp.	1	25	Plant unit	
Singapore	PIS	PM	<i>Alternanthera sessilis</i>	3	105	Plant unit	
Singapore	PIS	PM	<i>Alternanthera</i> sp.	4	2,985	Plant unit	
Singapore	PIS	PM	<i>Ammannia</i> sp.	3	700	Plant unit	
Singapore	PIS	PM	<i>Amodica</i> sp.	1	75	Plant unit	
Singapore	PIS	PM	<i>Amorphophallus</i> sp.	1	7	Plant unit	
Singapore	PIS	PM	<i>Annona</i> sp.	1	1	Plant unit	
Singapore	PIS	PM	<i>Anubias</i> sp.	4	570	Plant unit	
Singapore	PIS	PM	<i>Aponogeton</i> sp.	4	520	Plant unit	
Singapore	PIS	PM	<i>Aranda</i> sp.	1	850	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Singapore	PIS	PM	<i>Areca</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Arenga</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Artocarpus</i> sp.	3	54	Plant unit	
Singapore	PIS	PM	<i>Baccaurea</i> sp.	1	50	Gram	
Singapore	PIS	PM	<i>Bacopa</i> sp.	4	2,325	Plant unit	
Singapore	PIS	PM	<i>Barclaya</i> sp.	1	25	Plant unit	
Singapore	PIS	PM	<i>Blyxa</i> sp.	4	1,390	Plant unit	
Singapore	PIS	PM	<i>Bolbitis</i> sp.	2	300	Plant unit	
Singapore	PIS	PM	<i>Cabomba</i> sp.	4	6,830	Plant unit	
Singapore	PIS	PM	<i>Ceratopteris</i> sp.	2	75	Plant unit	
Singapore	PIS	PM	<i>Chlorophytum</i> sp.	3	190	Plant unit	
Singapore	PIS	PM	<i>Crassula</i> sp.	3	500	Plant unit	
Singapore	PIS	PM	<i>Crinum</i> sp.	1	125	Plant unit	
Singapore	PIS	PM	<i>Cryptocoryne</i> sp.	4	3,940	Plant unit	
Singapore	PIS	PM	<i>Cyrtostachys</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Didiplis</i> sp.	1	25	Plant unit	
Singapore	PIS	PM	<i>Dimocarpus</i> sp.	1	4	Plant unit	
Singapore	PIS	PM	<i>Dracaena</i> sp.	4	550	Plant unit	
Singapore	PIS	PM	<i>Durio</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Durio</i> sp.	2	46	Plant unit	
Singapore	PIS	PM	<i>Echinodorus</i> sp.	6	4,980	Plant unit	
Singapore	PIS	PM	<i>Egeria</i> sp.	4	475	Plant unit	
Singapore	PIS	PM	<i>Elaeis</i> sp.	1	0.1	kg	
Singapore	PIS	PM	<i>Eleocharis</i> sp.	4	6,075	Plant unit	
Singapore	PIS	PM	<i>Elodea</i> sp.	4	300	Plant unit	
Singapore	PIS	PM	<i>Etlingera</i> sp.	1	1	Plant unit	
Singapore	PIS	PM	<i>Garcinia mangostana</i>	1	2	Plant unit	
Singapore	PIS	PM	<i>Garcinia</i> sp.	1	0.01	kg	
Singapore	PIS	PM	<i>Garcinia</i> sp.	not given	8	Plant unit	
Singapore	PIS	PM	<i>Glossostigma</i> sp.	4	96	Plant unit	
Singapore	PIS	PM	<i>Gymnocoronis</i> sp.	3	175	Plant unit	
Singapore	PIS	PM	<i>Hemigraphis</i> sp.	4	590	Plant unit	
Singapore	PIS	PM	<i>Heteranthera</i> sp.	4	250	Plant unit	
Singapore	PIS	PM	<i>Hydrocotyle</i> sp.	4	1,100	Plant unit	
Singapore	PIS	PM	<i>Hygrophila</i> sp.	8	6,400	Plant unit	
Singapore	PIS	PM	<i>Kaempferia</i> sp.	1	2	Plant unit	
Singapore	PIS	PM	<i>Lagarosiphon major</i>	2	50	Plant unit	
Singapore	PIS	PM	<i>Licuala</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Limnophila sessiliflora</i>	1	25	Plant unit	
Singapore	PIS	PM	<i>Limnophila</i> sp.	1	50	Plant unit	
Singapore	PIS	PM	<i>Lindernia</i> sp.	4	300	Plant unit	
Singapore	PIS	PM	<i>Livistona</i> sp.	1	0.5	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Singapore	PIS	PM	<i>Lobelia</i> sp.	4	460	Plant unit	
Singapore	PIS	PM	<i>Ludwigia</i> sp.	4	3,525	Plant unit	
Singapore	PIS	PM	<i>Lysimachia</i> sp.	4	1,955	Plant unit	
Singapore	PIS	PM	<i>Marsilea</i> sp.	2	180	Plant unit	
Singapore	PIS	PM	<i>Mayaca</i> sp.	3	875	Plant unit	
Singapore	PIS	PM	<i>Michelia</i> sp.	1	1	Plant unit	
Singapore	PIS	PM	<i>Micranthemum</i> sp.	3	1,188	Plant unit	
Singapore	PIS	PM	<i>Microsorium</i> sp.	4	1,780	Plant unit	
Singapore	PIS	PM	<i>Myriophyllum</i> sp.	4	2,090	Plant unit	
Singapore	PIS	PM	<i>Nephelium</i> sp.	3	16	Plant unit	
Singapore	PIS	PM	<i>Nesaea</i> sp.	4	1,425	Plant unit	
Singapore	PIS	PM	<i>Normanbya normanbyi</i>	1	0.5	kg	
Singapore	PIS	PM	<i>Nuphar</i> sp.	3	135	Plant unit	
Singapore	PIS	PM	<i>Nymphaea</i> sp.	2	40	Plant unit	
Singapore	PIS	PM	<i>Ophiopogon</i> sp.	4	135	Plant unit	
Singapore	PIS	PM	<i>Pinanga</i> sp.	1	0.5	kg	
Singapore	PIS	PM	<i>Pogostemon</i> sp.	4	1,125	Plant unit	
Singapore	PIS	PM	<i>Potamogeton</i> sp.	4	1,850	Plant unit	
Singapore	PIS	PM	<i>Pouteria</i> sp.	1	1	Plant unit	
Singapore	PIS	PM	<i>Psidium guajava</i>	1	1	Plant unit	
Singapore	PIS	PM	<i>Psidium</i> sp.	1	3	Plant unit	
Singapore	PIS	PM	<i>Quisqualis</i> sp.	1	1	Plant unit	
Singapore	PIS	PM	<i>Rotala</i> sp.	4	2,675	Plant unit	
Singapore	PIS	PM	<i>Sagittaria</i> sp.	4	1,970	Plant unit	
Singapore	PIS	PM	<i>Salacca</i> sp.	1	12	Plant unit	
Singapore	PIS	PM	<i>Saururus</i> sp.	1	55	Plant unit	
Singapore	PIS	PM	<i>Selaginella</i> sp.	2	200	Plant unit	
Singapore	PIS	PM	<i>Spathiphyllum</i> sp.	4	70	Plant unit	
Singapore	PIS	PM	<i>Spondias</i> sp.	1	25	Plant unit	
Singapore	PIS	PM	<i>Syzygium</i> sp.	1	2	Plant unit	
Singapore	PIS	PM	<i>Tonina</i> sp.	4	295	Plant unit	
Singapore	PIS	PM	<i>Trichomanes</i> sp.	3	85	Plant unit	
Singapore	PIS	PM	<i>Vallisneria</i> sp.	4	5,280	Plant unit	
Solomon Islands	PIS	PM	<i>Metroxylon</i> sp.	1	80	kg	
Solomon Islands	PIS	PM	<i>Rhapis</i> sp.	1	1.6	kg	
South Africa	Airport	CF	<i>Erythrina</i>	2	50	Stems	
South Africa	PIS	MC	Permit Pathogen	8	28.5	kg	
South Africa	PIS	PM	<i>Camellia</i> sp.	3	2,600	Plant unit	
South Africa	PIS	PM	<i>Erythrina</i> sp.	1	1	Plant unit	
South Africa	PIS	PM	<i>Strelitzia</i> sp.	1	22	kg	
South Africa	USPS	PM	<i>Allium</i> sp.	1	11	kg	
South Africa	USPS	PM	<i>Asparagus</i> sp.	2	16	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Spain	PIS	PM	<i>Euterpe</i> sp.	1	200	Gram	
Spain	PIS	PM	<i>Hibiscus</i> sp.	1	12	Plant unit	
Sri Lanka	PIS	PM	<i>Areca</i> sp.	1	1	kg	
Sri Lanka	PIS	PM	<i>Nepenthes</i> sp.	2	599	Plant unit	
Suriname	PIS	PM	<i>Annona</i> sp.	1	0.1	kg	
Suriname	PIS	PM	<i>Areca</i> sp.	2	4	kg.	
Suriname	PIS	PM	<i>Euterpe</i> sp.	2	0.3	kg	
Suriname	PIS	PM	<i>Heliconia</i> sp.	1	2	Plant unit	
Suriname	PIS	PM	<i>Morinda</i> sp.	1	0.1	kg	
Suriname	PIS	PM	<i>Theobroma</i> sp.	1	0.1	kg	
Sweden	PIS	PM	<i>Hoya</i> sp.	1	29	Plant unit	
Switzerland	PIS	PM	<i>Zea mays</i>	1	100	kg	
Tahiti	PIS	PM	<i>Artocarpus</i> sp.	1	73	Plant unit	
Taiwan	Airport	FV	Bamboo Shoot	10	638	kg	
Taiwan	Airport	FV	Burdock	1	20	kg	
Taiwan	Airport	FV	Mushroom	106	40,857	kg	
Taiwan	Airport	PM	<i>Apium</i> sp.	1	1	kg	
Taiwan	Airport	PM	<i>Brassica</i> sp.	1	31	kg	
Taiwan	Airport	PM	<i>Cattleya</i> sp.	2	8,520	Plant unit	
Taiwan	Airport	PM	<i>Chrysanthemum</i> sp.	1	3	kg	
Taiwan	Airport	PM	<i>Coriandrum</i> sp.	1	1	kg	
Taiwan	Airport	PM	<i>Dendrobium</i> sp.	20	671,175	Plant unit	
Taiwan	Airport	PM	<i>Lactuca</i> sp.	1	10	kg	
Taiwan	Airport	PM	<i>Lycopersicon esculentum</i>	1	1	kg	
Taiwan	Airport	PM	<i>Oncidium</i> sp.	2	84,420	Plant unit	
Taiwan	Airport	PM	<i>Paphiopedilum</i> sp.	3	7,300	Plant unit	
Taiwan	Airport	PM	<i>Phalaenopsis</i> sp.	10	291,280	Plant unit	
Taiwan	PIS	PM	<i>Adenium</i> sp.	1	0.001	kg	Mail: <i>Planococcus</i> sp. (arthropod)
Taiwan	PIS	PM	<i>Adenium</i> sp.	not given	16	Plant unit	
Taiwan	PIS	PM	<i>Adenium</i> sp.	23	1,383	Plant unit	
Taiwan	PIS	PM	<i>Aerangis ellisii</i>	1	10	Flask	
Taiwan	PIS	PM	<i>Anoectochilus</i> sp.	1	20	Flask	
Taiwan	PIS	PM	<i>Arachis</i> sp.	1	12	Plant unit	
Taiwan	PIS	PM	<i>Artocarpus</i> sp.	1	0.2	kg	
Taiwan	PIS	PM	<i>Brassica</i> sp.	1	0.454	kg	
Taiwan	PIS	PM	<i>Camellia</i> sp.	1	40	kg	
Taiwan	PIS	PM	<i>Carica papaya</i>	2	1.5	kg	
Taiwan	PIS	PM	<i>Cattleya</i> sp.	1	3,600	Plant unit	
Taiwan	PIS	PM	<i>Cattleya</i> sp.	11	5,548	Flask	
Taiwan	PIS	PM	<i>Chrysalidocarpus</i> sp.	1	0.4	kg	
Taiwan	PIS	PM	<i>Citrullus lanatus</i>	2	20.44	kg	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Taiwan	PIS	PM	<i>Cucumis melo</i>	1	9.12	kg	
Taiwan	PIS	PM	<i>Cycnoches</i> sp.	4	151	Flask	
Taiwan	PIS	PM	<i>Cymbidium</i> sp.	1	250	Flask	
Taiwan	PIS	PM	<i>Cymbidium</i> sp.	2	5,800	Plant unit	
Taiwan	PIS	PM	<i>Dendrobium</i> sp.	1	37	Plant unit	
Taiwan	PIS	PM	<i>Dendrobium</i> sp.	7	1,469	Flask	
Taiwan	PIS	PM	<i>Dracaena sanderiana</i>	2	62,640	Plant unit	
Taiwan	PIS	PM	<i>Dracaena</i> sp.	3	42,220	Plant unit	
Taiwan	PIS	PM	<i>Epidendrum</i> sp.	1	185	Flask	
Taiwan	PIS	PM	<i>Ficus</i> sp.	1	2,100	Plant unit	
Taiwan	PIS	PM	<i>Garcinia</i> sp.	1	0.86	kg	Baggage: species of Pseudococcidae (arthropod)
Taiwan	PIS	PM	<i>Hyophorbe</i> sp.	2	0.3	kg	
Taiwan	PIS	PM	<i>Ipomoea aquatica</i>	3	90.8	kg	
Taiwan	PIS	PM	<i>Lycopersicon esculentum</i>	1	0.03	kg	
Taiwan	PIS	PM	<i>Oncidium</i> sp.	15	5,224	Flask	
Taiwan	PIS	PM	<i>Pachira</i> sp.	1	23	Plant unit	
Taiwan	PIS	PM	<i>Paphiopedilum</i> sp.	13	9,479	Flask	
Taiwan	PIS	PM	<i>Phalaenopsis</i> sp.	32	32,534	Flask	
Taiwan	PIS	PM	<i>Phalaenopsis</i> sp.	34	297,682	Plant unit	
Taiwan	PIS	PM	<i>Phaseolus</i> sp.	1	360,000	Plant unit	
Taiwan	PIS	PM	<i>Raphanus sativus</i>	2	6.77	kg	
Taiwan	PIS	PM	<i>Rhapis</i> sp.	2	7.86	kg	
Taiwan	PIS	PM	<i>Rhapis</i> sp.	12	171,064	Plant unit	
Taiwan	PIS	PM	<i>Rhynchosstylis</i> sp.	2	100	Flask	
Taiwan	PIS	PM	<i>Vanda</i> sp.	1	46	Flask	
Taiwan	PIS	PM	<i>Zephyranthes</i> sp.	1	11	Plant unit	
Taiwan	PIS	PM	<i>Zygopetalum</i> sp.	1	40	Flask	
Taiwan	USPS	PM	<i>Adenium</i> sp.	1	3	Plant unit	
Taiwan	USPS	PM	<i>Adenium</i> sp.	2	2	kg	
Taiwan	USPS	PM	<i>Allium</i> sp.	22	416	kg	
Taiwan	USPS	PM	<i>Amaranthus</i> sp.	2	2	kg	
Taiwan	USPS	PM	<i>Asparagus</i> sp.	2	2	kg	
Taiwan	USPS	PM	<i>Benincasa</i> sp.	5	4	kg	
Taiwan	USPS	PM	<i>Brassica</i> sp.	25	67	kg	
Taiwan	USPS	PM	<i>Capsicum</i> sp.	6	3	kg	
Taiwan	USPS	PM	<i>Carica papaya</i>	39	53	kg	
Taiwan	USPS	PM	<i>Citrullus</i> sp.	19	99	kg	
Taiwan	USPS	PM	<i>Cucumis melo</i>	9	7	kg	
Taiwan	USPS	PM	<i>Cucumis sativus</i>	8	24	kg	
Taiwan	USPS	PM	<i>Cucumis</i> sp.	2	3	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Taiwan	USPS	PM	<i>Cucurbita</i> sp.	3	10	kg	
Taiwan	USPS	PM	<i>Glycine max</i>	1	1	kg	
Taiwan	USPS	PM	<i>Ipomoea aquatica</i>	13	460	kg	
Taiwan	USPS	PM	<i>Lactuca</i> sp.	1	1	kg	
Taiwan	USPS	PM	<i>Lagenaria</i> sp.	9	10	kg	
Taiwan	USPS	PM	<i>Luffa</i> sp.	2	2	kg	
Taiwan	USPS	PM	<i>Lycopersicon esculentum</i>	4	4	kg	
Taiwan	USPS	PM	<i>Momordica</i> sp.	5	4	kg	
Taiwan	USPS	PM	<i>Raphanus</i> sp.	13	40	kg	
Taiwan	USPS	PM	<i>Solanum</i> sp.	8	8	kg	
Taiwan	USPS	PM	<i>Spinacia</i> sp.	1	1	kg	
Taiwan	USPS	PM	<i>Vigna</i> sp.	18	114.3	kg	
Taiwan	USPS	PM	<i>Zea mays</i>	1	3	kg	
Tanzania	PIS	MC	Permit Pathogen	2	8	kg	
Thailand	Airport	CF	<i>Anthurium</i> sp.	1	50	Stems	
Thailand	Airport	CF	Calotropis	1	20	Stems	
Thailand	Airport	CF	Chrysanthemum	1	20	Stems	
Thailand	Airport	CF	Cordyline	328	12,817	Stems	
Thailand	Airport	CF	<i>Dendrobium</i> sp.	8946	10,385,365	Stems	
Thailand	Airport	CF	<i>Jasminum</i> sp.	1	300	Stems	
Thailand	Airport	CF	Lotus	107	5,778	Stems	
Thailand	Airport	CF	<i>Nelumbo</i> sp.	5	530	Stems	
Thailand	Airport	CF	Pandanus	129	13,011	Stems	
Thailand	Airport	CF	<i>Polypodium</i> sp.	531	41,104	Stems	
Thailand	Airport	CF	Polyscias	1	10	Stems	
Thailand	Airport	CF	<i>Rosa</i> sp.	1	100	Stems	
Thailand	Airport	FV	Betel-Nut	1	558	kg	
Thailand	Airport	FV	Mushroom	7	574	kg	
Thailand	Airport	PM	<i>Angraecum</i> sp.	1	800	Plant unit	
Thailand	Airport	PM	<i>Apium</i> sp.	1	1	kg	
Thailand	Airport	PM	<i>Cattleya</i> sp.	30	264,720	Plant unit	
Thailand	Airport	PM	<i>Citrullus</i> sp.	1	17	kg	
Thailand	Airport	PM	<i>Coriandrum</i> sp.	1	2	kg	
Thailand	Airport	PM	<i>Cucumis</i> sp.	1	19	kg	
Thailand	Airport	PM	<i>Cucurbita</i> sp.	1	10	kg	
Thailand	Airport	PM	<i>Cynoches</i> sp.	1	80	Plant unit	
Thailand	Airport	PM	<i>Cymbidium</i> sp.	3	9,440	Plant unit	
Thailand	Airport	PM	<i>Dendrobium</i> sp.	67	2,152,069	Plant unit	Permit cargo: <i>Adoretus sinicus</i> (arthropod), <i>Contarinia</i> sp. (arthropod), <i>Helicoverpa armigera</i> (arthropod),

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
							<i>Nilaparvata lugens</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Spodoptera litura</i> (arthropod), <i>Spodoptera</i> sp. (arthropod), <i>Succinea tenella</i> (mollusc), <i>Succinea</i> cf. <i>horticola</i> (mollusc), <i>Succinea</i> sp. (mollusc), <i>Thrips palmi</i> (arthropod), species of Cicadellidae, species of Cydnidae, species of Lepidoptera (arthropod), species of Noctuidae; General cargo: <i>Succinea tenella</i> (mollusc), species of Noctuidae (arthropod); Baggage: <i>Succinea tenella</i> (mollusc), species of Formicidae (arthropod)
Thailand	Airport	PM	<i>Epidendrum</i> sp.	2	5,280	Plant unit	
Thailand	Airport	PM	<i>Grammatophyllum</i> sp.	1	800	Plant unit	
Thailand	Airport	PM	<i>Lycopersicon</i> sp.	1	2	kg	
Thailand	Airport	PM	<i>Ocimum</i> sp.	1	3	kg	
Thailand	Airport	PM	<i>Oncidium</i> sp.	20	375,360	Plant unit	
Thailand	Airport	PM	<i>Paphiopedilum</i> sp.	11	183,700	kg	
Thailand	Airport	PM	<i>Phalaenopsis</i> sp.	10	136,480	Plant unit	
Thailand	Airport	PM	<i>Vanda</i> sp.	3	5,580	Plant unit	
Thailand	PIS	PM	<i>Acanthus</i> sp.	1	12	Plant unit	
Thailand	PIS	PM	<i>Acomis</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Adenium</i> sp.	1	110	Gram	
Thailand	PIS	PM	<i>Adenium</i> sp.	not	250	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
				given			
Thailand	PIS	PM	<i>Adenium</i> sp.	46	10,516	Plant unit	
Thailand	PIS	PM	<i>Aeridovanda</i> sp.	1	11	Plant unit	
Thailand	PIS	PM	<i>Agave</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Aglaia</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Aglaonema</i> sp.	9	703	Plant unit	
Thailand	PIS	PM	<i>Allagoptera</i> sp.	1	59	Plant unit	
Thailand	PIS	PM	<i>Allamanda</i> sp.	2	26	Plant unit	
Thailand	PIS	PM	<i>Alocasia</i> sp.	7	151	Plant unit	
Thailand	PIS	PM	<i>Aloe</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Alpinia</i> sp.	8	21	Plant unit	
Thailand	PIS	PM	<i>Alternanthera</i> sp.	3	222	Plant unit	
Thailand	PIS	PM	<i>Amherstia</i> sp.	2	21	Plant unit	
Thailand	PIS	PM	<i>Ammannia</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Amorphophallus</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Amorphophallus</i> sp.	not given	16	Plant unit	
Thailand	PIS	PM	<i>Amorphophallus</i> sp.	3	143	Plant unit	
Thailand	PIS	PM	<i>Annona</i> sp.	4	29	Plant unit	Baggage: <i>Planococcus</i> sp. (arthropod on. <i>A. cherimola</i>)
Thailand	PIS	PM	<i>Annona</i> sp.	2	0.101	kg	
Thailand	PIS	PM	<i>Anthurium</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Anthurium</i> sp.	2	10	Plant unit	
Thailand	PIS	PM	<i>Anubias</i> sp.	3	340	Plant unit	
Thailand	PIS	PM	<i>Aphananthe</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Aponogeton</i> sp.	1	90	Plant unit	
Thailand	PIS	PM	<i>Arachniodes</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Archontophoenix</i> sp.	1	4.1	kg	
Thailand	PIS	PM	<i>Areca</i> sp.	1	200	Gram	
Thailand	PIS	PM	<i>Areca</i> sp.	not given	16	Plant unit	
Thailand	PIS	PM	<i>Areca</i> sp.	2	1.6	kg	
Thailand	PIS	PM	<i>Arenga</i> sp.	1	1.7	kg	
Thailand	PIS	PM	<i>Arenga</i> sp.	not given	4	Plant unit	
Thailand	PIS	PM	<i>Arenga</i> sp.	2	230	Plant unit	
Thailand	PIS	PM	<i>Aristolochia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Artabotrys</i> sp.	1	0.2	kg	
Thailand	PIS	PM	<i>Artocarpus heterophyllus</i>	3	133	Plant unit	
Thailand	PIS	PM	<i>Artocarpus</i> sp.	1	11	Plant unit	
Thailand	PIS	PM	<i>Ascocenda</i> sp.	6	171	Flask	
Thailand	PIS	PM	<i>Ascocenda</i> sp.	20	4,624	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Ascocentrum</i> sp.	1	9	Plant unit	
Thailand	PIS	PM	<i>Ascocentrum</i> sp.	2	16	Flask	
Thailand	PIS	PM	<i>Asconopsis</i> sp.	1	30	Plant unit	
Thailand	PIS	PM	<i>Asparagus</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Aspidistra</i> sp.	1	7	Plant unit	
Thailand	PIS	PM	<i>Asplenium</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Attalea</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Averrhoa carambola</i>	1	10	Plant unit	
Thailand	PIS	PM	<i>Baccaurea</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Baccaurea</i> sp.	5	94	Plant unit	
Thailand	PIS	PM	<i>Bacopa</i> sp.	2	291	Plant unit	
Thailand	PIS	PM	<i>Bauhinia</i> sp.	1	9	Plant unit	
Thailand	PIS	PM	<i>Bauhinia</i> sp.	2	1.001	kg	
Thailand	PIS	PM	<i>Beaumontia</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Begonia</i> sp.	2	2	Plant unit	
Thailand	PIS	PM	<i>Blyxa</i> sp.	1	60	Plant unit	
Thailand	PIS	PM	<i>Bouea</i> sp.	1	1.8	kg	
Thailand	PIS	PM	<i>Bouea</i> sp.	3	113	Plant unit	
Thailand	PIS	PM	<i>Bougainvillea</i> sp.	2	609	Plant unit	
Thailand	PIS	PM	<i>Brownea</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Bulbophyllum</i> sp.	4	35	Flask	
Thailand	PIS	PM	<i>Cabomba</i> sp.	1	575	Plant unit	
Thailand	PIS	PM	<i>Caladium</i> sp.	4	14	Plant unit	
Thailand	PIS	PM	<i>Calamus</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Calathea</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Calliandra</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Calotropis</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Calyptrocalyx</i> sp.	1	0.3	kg	
Thailand	PIS	PM	<i>Calyptrocalyx</i> sp.	not given	10	Plant unit	
Thailand	PIS	PM	<i>Cananga</i> sp.	3	114	Plant unit	
Thailand	PIS	PM	<i>Capsicum</i> sp.	2	0.3	kg	
Thailand	PIS	PM	<i>Carica papaya</i>	2	0.04	kg	
Thailand	PIS	PM	<i>Carmona</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Caryota</i> sp.	1	3.2	kg	
Thailand	PIS	PM	<i>Caryota</i> sp.	not given	4	Plant unit	
Thailand	PIS	PM	<i>Cassia</i> sp.	1	0.2	kg	
Thailand	PIS	PM	<i>Cattleya</i> sp.	78	21,656	Flask	
Thailand	PIS	PM	<i>Cattleya</i> sp.	not given	21,680	Plant unit	
Thailand	PIS	PM	<i>Cattleya</i> sp.	76	563,532	Plant unit	
Thailand	PIS	PM	<i>Ceratopteris</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Cerbera</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Cestrum</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Chamaedorea</i> sp.	1	0.4	kg	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Chiloschista</i> sp.	1	24	Plant unit	
Thailand	PIS	PM	<i>Chlorophytum</i> sp.	2	17	Plant unit	
Thailand	PIS	PM	<i>Chrysalidocarpus</i> sp.	1	210	Plant unit	
Thailand	PIS	PM	<i>Chrysophyllum</i> sp.	1	60	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	<i>Citrullus</i> sp.	1	23	kg	
Thailand	PIS	PM	<i>Citrus</i> sp.	1	78	Plant unit	Baggage: <i>Parlatoria ziziphi</i> (arthropod)
Thailand	PIS	PM	<i>Clerodendrum</i> sp.	2	26	Plant unit	
Thailand	PIS	PM	<i>Coccoloba</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Codiaeum</i> sp.	2	73	Plant unit	Baggage: <i>Planococcus minor</i> (arthropod on <i>C. variegatum</i>)
Thailand	PIS	PM	<i>Coelogyne</i> sp.	1	3	Flask	
Thailand	PIS	PM	<i>Colmanara</i> sp.	1	800	Plant unit	
Thailand	PIS	PM	<i>Colmanara</i> sp.	2	148	Flask	
Thailand	PIS	PM	<i>Colocasia</i> sp.	2	70	Plant unit	
Thailand	PIS	PM	<i>Copernicia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Cordyline</i> sp.	10	213	Plant unit	
Thailand	PIS	PM	<i>Corypha</i> sp.	1	14.2	kg	
Thailand	PIS	PM	<i>Costus</i> sp.	8	67	Plant unit	
Thailand	PIS	PM	<i>Crassula</i> sp.	1	50	Plant unit	
Thailand	PIS	PM	<i>Crinum</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Crinum</i> sp.	2	34	Plant unit	
Thailand	PIS	PM	<i>Croton</i> sp.	3	211	Plant unit	Permit cargo: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	<i>Cryptocoryne</i> sp.	2	585	Plant unit	
Thailand	PIS	PM	<i>Curcuma</i> sp.	12	8,981	Plant unit	
Thailand	PIS	PM	<i>Cycas debaoensis</i>	1	8.5	kg	
Thailand	PIS	PM	<i>Cycas</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Cycas</i> sp.	2	25.6	kg	
Thailand	PIS	PM	<i>Cymbidium</i> sp.	4	7,420	Plant unit	
Thailand	PIS	PM	<i>Cymbidium</i> sp.	7	158	Flask	
Thailand	PIS	PM	<i>Cyperus</i> sp.	1	30	Plant unit	
Thailand	PIS	PM	<i>Cyrtostachys</i> sp.	2	0.11	kg	
Thailand	PIS	PM	<i>Cyrtostachys</i> sp.	21	7,792	Plant unit	
Thailand	PIS	PM	<i>Degarmoara</i> sp.	1	25	Flask	
Thailand	PIS	PM	<i>Dendrobium</i> sp.	63	23,028	Flask	
Thailand	PIS	PM	<i>Dendrobium</i> sp.	not	3	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b given	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Dendrobium</i> sp.	132	2,577,629	Plant unit	
Thailand	PIS	PM	<i>Desmos</i> sp.	2	200	Plant unit	
Thailand	PIS	PM	<i>Dieffenbachia</i> sp.	6	55	Plant unit	
Thailand	PIS	PM	<i>Dischidia</i> sp.	2	9	Plant unit	
Thailand	PIS	PM	<i>Dombeya</i> sp.	1	30	Plant unit	
Thailand	PIS	PM	<i>Doritaenopsis</i> sp.	1	9	Flask	
Thailand	PIS	PM	<i>Doritis</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Doritis</i> sp.	6	148	Flask	
Thailand	PIS	PM	<i>Doryopteris</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Dracaena sanderiana</i>	2	902	Plant unit	
Thailand	PIS	PM	<i>Dracaena</i> sp.	12	12,613	Plant unit	
Thailand	PIS	PM	<i>Drymoglossum</i> sp.	1	19	Plant unit	
Thailand	PIS	PM	<i>Dryophloeus</i> sp.	1	128	Plant unit	
Thailand	PIS	PM	<i>Drynaria</i> sp.	5	241	Plant unit	
Thailand	PIS	PM	<i>Durio</i> sp.	1	1	kg	
Thailand	PIS	PM	<i>Dyakia</i> sp.	1	100	Plant unit	
Thailand	PIS	PM	<i>Dypsis</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Echinodorus</i> sp.	3	126	Plant unit	Quarters: <i>Cercospora</i> sp. (pathogen on <i>E. cordifolius</i>)
Thailand	PIS	PM	<i>Ehretia</i> sp.	1	50	Plant unit	
Thailand	PIS	PM	<i>Elaeis</i> sp.	1	5.4	kg	
Thailand	PIS	PM	<i>Elaeis</i> sp.	not given	43	Plant unit	
Thailand	PIS	PM	<i>Elaeocarpus</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Elaphoglossum</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Eleocharis</i> sp.	1	115	Plant unit	
Thailand	PIS	PM	<i>Elodea</i> sp.	1	100	Plant unit	
Thailand	PIS	PM	<i>Embothrium</i> sp.	1	4	Plant unit	
Thailand	PIS	PM	<i>Entada</i> sp.	1	1	kg	
Thailand	PIS	PM	<i>Epidendrum</i> sp.	3	11,520	Plant unit	
Thailand	PIS	PM	<i>Epidendrum</i> sp.	4	505	Flask	
Thailand	PIS	PM	<i>Epipremnum</i> sp.	2	2	Plant unit	
Thailand	PIS	PM	<i>Erythrina</i> sp.	1	0.1	kg	Baggage: <i>Andaspis</i> sp. (arthropod)
Thailand	PIS	PM	<i>Etilingera</i> sp.	10	57	Plant unit	Baggage: <i>Thrips</i> sp. (arthropod)
Thailand	PIS	PM	<i>Eucrosia</i> sp.	1	7	Plant unit	
Thailand	PIS	PM	<i>Eugenia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Eugenia</i> sp.	not given	10	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Euonymus</i> sp.	1	100	Plant unit	
Thailand	PIS	PM	<i>Euphorbia</i> sp.	147	212,316	Plant unit	Permit cargo: species of Thripidae (arthropod); Baggage: <i>Succinea tenella</i> (mollusc), species of Thysanoptera (arthropod)
Thailand	PIS	PM	<i>Fagraea</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Fatsyhedera</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Ficus</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Fittonia</i> sp.	1	50	Plant unit	
Thailand	PIS	PM	<i>Flacourtia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Garcinia mangostana</i>	6	1,348	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	<i>Garcinia mangostana</i>	4	8.9	kg	
Thailand	PIS	PM	<i>Garcinia</i> sp.	1	0.5	kg	
Thailand	PIS	PM	<i>Garcinia</i> sp.	not given	3	Plant unit	
Thailand	PIS	PM	<i>Gardenia</i> sp.	2	1	kg	
Thailand	PIS	PM	<i>Gardenia</i> sp.	not given	11	Plant unit	
Thailand	PIS	PM	<i>Globba</i> sp.	4	175	Plant unit	
Thailand	PIS	PM	<i>Glossostigma</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Grammatophyllum</i> sp.	11	29,094	Plant unit	
Thailand	PIS	PM	<i>Grammatophyllum</i> sp.	6	730	Flask	
Thailand	PIS	PM	<i>Gronophyllum</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Gulubia</i> sp.	1	70.8	kg	
Thailand	PIS	PM	<i>Gymnocoronis</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Haworthia</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Hedychium</i> sp.	2	26	Plant unit	
Thailand	PIS	PM	<i>Heliconia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Heliconia</i> sp.	not given	7	Plant unit	
Thailand	PIS	PM	<i>Heliconia</i> sp.	14	680	Plant unit	
Thailand	PIS	PM	<i>Heteranthera</i> sp.	1	50	Plant unit	
Thailand	PIS	PM	<i>Hippeastrum</i> sp.	3	23	Plant unit	
Thailand	PIS	PM	<i>Homalomena</i> sp.	3	7	Plant unit	
Thailand	PIS	PM	<i>Howea</i> sp.	1	270	Plant unit	
Thailand	PIS	PM	<i>Hoya</i> sp.	9	10,148	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Hydrocleys</i> sp.	1	4	Plant unit	
Thailand	PIS	PM	<i>Hydrocotyle</i> sp.	2	52	Plant unit	
Thailand	PIS	PM	<i>Hygrophila</i> sp.	1	525	Plant unit	
Thailand	PIS	PM	<i>Hymenocallis</i> sp.	1	40	Plant unit	
Thailand	PIS	PM	<i>Iguanura</i> sp.	1	200	Gram	
Thailand	PIS	PM	<i>Iguanura</i> sp.	not given	12.2	kg	
Thailand	PIS	PM	<i>Iguanura</i> sp.	2	31	Plant unit	
Thailand	PIS	PM	<i>Impatiens</i> sp.	1	0.001	kg	
Thailand	PIS	PM	<i>Impatiens</i> sp.	not given	4	Plant unit	
Thailand	PIS	PM	<i>Intsia</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Ixora</i> sp.	4	328	Plant unit	Baggage: species of Aphididae (arthropod)
Thailand	PIS	PM	<i>Jasminum</i> sp.	1	2	Plant unit	Baggage: <i>Hendecasis duplifascialis</i> , species of Pyralidae (arthropods on <i>J. sambac</i>)
Thailand	PIS	PM	<i>Johannesteijsmannia</i> sp.	1	127.5	kg	
Thailand	PIS	PM	<i>Kaempferia</i> sp.	4	55	Plant unit	
Thailand	PIS	PM	<i>Kagawara</i> sp.	1	10	Flask	
Thailand	PIS	PM	<i>Kagawara</i> sp.	3	830	Plant unit	
Thailand	PIS	PM	<i>Kerriodoxa elegans</i>	1	100	Plant unit	
Thailand	PIS	PM	<i>Kingidium</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Lagerstroemia</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Lansium domesticum</i>	1	50	Plant unit	
Thailand	PIS	PM	<i>Lansium</i> sp.	1	0.5	kg	
Thailand	PIS	PM	<i>Lasia</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Lea</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Lecanopteris</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Lepisanthes</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Leucothoe</i> sp.	1	14	Plant unit	
Thailand	PIS	PM	<i>Licuala</i> sp.	1	200	Gram	
Thailand	PIS	PM	<i>Licuala</i> sp.	4	17.1	kg	
Thailand	PIS	PM	<i>Licuala</i> sp.	not given	612	Plant unit	
Thailand	PIS	PM	<i>Lilaeopsis</i> sp.	1	325	Plant unit	
Thailand	PIS	PM	<i>Lilium</i> sp.	2	34	Plant unit	
Thailand	PIS	PM	<i>Limnocharis</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Limnophila</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Lindernia</i> sp.	1	200	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Liriope</i> sp.	1	4	Plant unit	
Thailand	PIS	PM	<i>Lithocarpus</i> sp.	1	1	kg	
Thailand	PIS	PM	<i>Livistona</i> sp.	2	2,525	kg	
Thailand	PIS	PM	<i>Lobelia</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Ludwigia</i> sp.	2	54	Plant unit	
Thailand	PIS	PM	<i>Lycopodium</i> sp.	5	94	Plant unit	Permit cargo: <i>Adoretus</i> sp. (arthropod), species of Rutelinae (arthropod)
Thailand	PIS	PM	<i>Lysimachia</i> sp.	1	100	Plant unit	
Thailand	PIS	PM	<i>Macodes</i> sp.	2	105	Flask	
Thailand	PIS	PM	<i>Magnolia</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Malpighia</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Mammea</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Manettia</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Mangifera indica</i>	5	143	Plant unit	
Thailand	PIS	PM	<i>Manilkara</i> sp.	3	54	Plant unit	
Thailand	PIS	PM	<i>Marsilea</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Mayaca</i> sp.	1	65	Plant unit	
Thailand	PIS	PM	<i>Medinilla</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Melianthus</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Melientha</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Memecylon</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Mesua</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Michelia</i> sp.	4	101	Plant unit	
Thailand	PIS	PM	<i>Micranthemum</i> Sp.	1	175	Plant unit	
Thailand	PIS	PM	<i>Microsorium</i> sp.	8	1,218	Plant unit	
Thailand	PIS	PM	<i>Mokara</i> sp.	3	425	Flask	
Thailand	PIS	PM	<i>Mokara</i> sp.	5	9,550	Plant unit	
Thailand	PIS	PM	<i>Monochoria</i> sp.	1	4	Plant unit	
Thailand	PIS	PM	<i>Mussaenda</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Myriophyllum</i> sp.	2	151	Plant unit	
Thailand	PIS	PM	<i>Myrmecodia</i> sp.	1	1	Flask	
Thailand	PIS	PM	<i>Nelumbo nucifera</i>	1	0.01	kg	
Thailand	PIS	PM	<i>Nelumbo nucifera</i>	not given	20	Plant unit	Permit cargo: <i>Spodoptera litura</i> (arthropod)
Thailand	PIS	PM	<i>Nelumbo nucifera</i>	2	65	Plant unit	
Thailand	PIS	PM	<i>Nelumbo</i> sp.	3	5.28	kg	
Thailand	PIS	PM	<i>Nelumbo</i> sp.	6	433	Plant unit	
Thailand	PIS	PM	<i>Nenga</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Neofinetia falcata</i>	2	200	Plant unit	

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Neostylis</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Nepenthes</i> sp.	2	89	Plant unit	
Thailand	PIS	PM	<i>Nephelium lappaceum</i>	4	650	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	<i>Nephrolepis</i> sp.	2	2	Plant unit	
Thailand	PIS	PM	<i>Nesaea</i> sp.	1	125	Plant unit	
Thailand	PIS	PM	<i>Nymphaea</i> sp.	1	1	kg	
Thailand	PIS	PM	<i>Nymphaea</i> sp.	21	6,566	Plant unit	
Thailand	PIS	PM	<i>Nymphoides</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Odontocidium</i> sp.	1	32	Plant unit	
Thailand	PIS	PM	<i>Odontonia</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Oncidium</i> sp.	70	45,253	Flask	
Thailand	PIS	PM	<i>Oncidium</i> sp.	22	80,201	Plant unit	
Thailand	PIS	PM	<i>Ophioglossum</i> sp.	1	8	Plant unit	
Thailand	PIS	PM	<i>Ophiopogon</i> sp.	2	55	Plant unit	
Thailand	PIS	PM	<i>Orchidantha</i> sp.	1	13	Plant unit	
Thailand	PIS	PM	<i>Oroxylum</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Osmanthus</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Pachira aquatica</i>	1	2	Plant unit	
Thailand	PIS	PM	<i>Pachira</i> sp.	2	1.5	kg	
Thailand	PIS	PM	<i>Pandanus</i> sp.	1	2	kg	
Thailand	PIS	PM	<i>Pandanus</i> sp.	4	31	Plant unit	
Thailand	PIS	PM	<i>Paphiopedilum</i> sp.	14	6,007	Flask	
Thailand	PIS	PM	<i>Papilionanthe</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Paraphalaenopsis</i> sp.	1	5	Flask	
Thailand	PIS	PM	<i>Paris</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Passiflora</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Pelatantheria</i> sp.	1	14	Plant unit	
Thailand	PIS	PM	<i>Pellaea</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Peperomia</i> sp.	2	5	Plant unit	
Thailand	PIS	PM	<i>Phalaenopsis</i> sp.	7	29,777	Plant unit	
Thailand	PIS	PM	<i>Phalaenopsis</i> sp.	20	3,274	Flask	
Thailand	PIS	PM	<i>Phaseolus</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Philodendron</i> sp.	5	44	Plant unit	
Thailand	PIS	PM	<i>Philodendron</i> sp.	4	25	Plant unit	
Thailand	PIS	PM	<i>Phoenix</i> sp.	1	1.8	kg	
Thailand	PIS	PM	<i>Phoenix</i> sp.	not given	10	Plant unit	
Thailand	PIS	PM	<i>Phyllanthus</i> sp.	1	66	Plant unit	
Thailand	PIS	PM	<i>Phyllanthus</i> sp.	2	0.6	kg	
Thailand	PIS	PM	<i>Pieris formosa</i> x <i>japonica</i>	1	23	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Pieris japonica</i>	1	2	Plant unit	
Thailand	PIS	PM	<i>Pilea sp.</i>	1	2	Plant unit	
Thailand	PIS	PM	<i>Pinanga sp.</i>	1	200	Gram	
Thailand	PIS	PM	<i>Pinanga sp.</i>	not given	183	Plant unit	
Thailand	PIS	PM	<i>Pinanga sp.</i>	3	1.11	kg	
Thailand	PIS	PM	<i>Pisonia sp.</i>	1	5	Plant unit	
Thailand	PIS	PM	<i>Pithecellobium sp.</i>	1	30	Plant unit	
Thailand	PIS	PM	<i>Platycerium sp.</i>	6	249	Plant unit	
Thailand	PIS	PM	<i>Plumeria sp.</i>	15	377	Plant unit	
Thailand	PIS	PM	<i>Pogostemon sp.</i>	1	50	Plant unit	
Thailand	PIS	PM	<i>Polianthes sp.</i>	1	1,350	Plant unit	
Thailand	PIS	PM	<i>Polyalthia sp.</i>	1	6	kg	
Thailand	PIS	PM	<i>Polyalthia sp.</i>	8	13,025	Plant unit	Baggage: <i>Araecerus sp.</i> (arthropod on <i>P. longifolia</i>)
Thailand	PIS	PM	<i>Polypodium sp.</i>	2	62	Plant unit	
Thailand	PIS	PM	<i>Polyscias sp.</i>	2	5	Plant unit	
Thailand	PIS	PM	<i>Pontederia sp.</i>	1	4	Plant unit	
Thailand	PIS	PM	<i>Potamogeton sp.</i>	1	100	Plant unit	
Thailand	PIS	PM	<i>Pseuderanthemum sp.</i>	1	5	Plant unit	
Thailand	PIS	PM	<i>Psidium guajava</i>	4	103	Plant unit	
Thailand	PIS	PM	<i>Pterocarpus sp.</i>	1	20	Plant unit	
Thailand	PIS	PM	<i>Ptychosperma sp.</i>	2	459	Plant unit	
Thailand	PIS	PM	<i>Ptychosperma sp.</i>	4	130.6	kg	
Thailand	PIS	PM	<i>Punica granatum</i>	1	12	Plant unit	
Thailand	PIS	PM	<i>Pyrrisia sp.</i>	3	92	Plant unit	
Thailand	PIS	PM	<i>Randia culeata</i>	1	0.5	kg	
Thailand	PIS	PM	<i>Raphia sp.</i>	1	1.1	kg	
Thailand	PIS	PM	<i>Ravenea sp.</i>	1	2	Plant unit	
Thailand	PIS	PM	<i>Renanthera sp.</i>	1	109	Flask	
Thailand	PIS	PM	<i>Renanthera sp.</i>	5	67	Plant unit	
Thailand	PIS	PM	<i>Rhapis sp.</i>	8	2,077	Plant unit	
Thailand	PIS	PM	<i>Rhipsalis sp.</i>	1	7	Plant unit	
Thailand	PIS	PM	<i>Rhododendron sp.</i>	1	27	Plant unit	
Thailand	PIS	PM	<i>Rhoeo sp.</i>	1	20	Plant unit	
Thailand	PIS	PM	<i>Rhynchosentrum sp.</i>	2	405	Plant unit	
Thailand	PIS	PM	<i>Rhynchostylis gigantea</i>	2	26	Flask	
Thailand	PIS	PM	<i>Rhynchostylis gigantea</i>	3	1,080	Plant unit	
Thailand	PIS	PM	<i>Rhynchostylis sp.</i>	5	2,420	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Rhynchosytilis</i> sp.	8	264	Flask	
Thailand	PIS	PM	<i>Rhynchovandant he</i> sp.	1	20	Plant unit	
Thailand	PIS	PM	<i>Rorippa</i> sp.	1	75	Plant unit	
Thailand	PIS	PM	<i>Rotala</i> sp.	1	290	Plant unit	
Thailand	PIS	PM	<i>Sagittaria</i> sp.	3	260	Plant unit	
Thailand	PIS	PM	<i>Salacca</i> sp.	1	0.5	kg	
Thailand	PIS	PM	<i>Sanchezia</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Sandoricum</i> sp.	1	0.5	kg	
Thailand	PIS	PM	<i>Sansevieria</i> sp.	2	6	Plant unit	
Thailand	PIS	PM	<i>Saraca</i> sp.	5	2,110	Plant unit	
Thailand	PIS	PM	<i>Satakentia</i> sp.	3	376	Plant unit	
Thailand	PIS	PM	<i>Sauropus</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Schefflera</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Selaginella</i> sp.	2	121	Plant unit	
Thailand	PIS	PM	<i>Sesbania</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Siphokentia</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Solandra</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Solanum melongena</i>	1	0.35	kg	
Thailand	PIS	PM	<i>Solanum melongena</i>	not given	2	Plant unit	
Thailand	PIS	PM	<i>Spathiphyllum</i> sp.	3	31	Plant unit	
Thailand	PIS	PM	<i>Spathoglottis</i> sp.	1	1	Flask	
Thailand	PIS	PM	<i>Spathoglottis</i> sp.	not given	8	Plant unit	
Thailand	PIS	PM	<i>Spondias</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Spondias</i> sp.	not given	10	Plant unit	
Thailand	PIS	PM	<i>Sterculia</i> sp.	1	0.05	kg	
Thailand	PIS	PM	<i>Streblus</i> sp.	1	8	Plant unit	
Thailand	PIS	PM	<i>Strobilanthes</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Strophanthus</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Suregada</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Syagrus</i> sp.	1	10.2	kg	
Thailand	PIS	PM	<i>Syagrus</i> sp.	not given	31	Plant unit	
Thailand	PIS	PM	<i>Syngonium</i> sp.	2	900	Plant unit	
Thailand	PIS	PM	<i>Syzygium</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Tabernaemontana</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Tacca</i> sp.	4	92	Plant unit	
Thailand	PIS	PM	<i>Talauma</i> – Use (=) <i>Magnolia</i>	not given	25	Plant unit	
Thailand	PIS	PM	<i>Tamarindus indica</i>	1	0.5	kg	
Thailand	PIS	PM	<i>Tapeinochilos</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Thalia</i> sp.	1	4	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	PIS	PM	<i>Thevetia</i> sp.	1	6	Plant unit	
Thailand	PIS	PM	<i>Tonina</i> sp.	1	25	Plant unit	
Thailand	PIS	PM	<i>Trachycarpus</i> sp.	1	200	Plant unit	
Thailand	PIS	PM	<i>Tradescantia</i> sp.	1	10	Plant unit	
Thailand	PIS	PM	<i>Trapa</i> sp.	1	1	kg	
Thailand	PIS	PM	<i>Trapa</i> sp.	not given	8	Plant unit	
Thailand	PIS	PM	<i>Trichocoronis</i> sp.	2	60	Plant unit	
Thailand	PIS	PM	<i>Trichomanes</i> sp.	1	80	Plant unit	
Thailand	PIS	PM	<i>Tristellateia</i> sp.	1	3	Plant unit	
Thailand	PIS	PM	<i>Vallisneria</i> sp.	1	735	Plant unit	
Thailand	PIS	PM	<i>Vanda</i> sp.	31	19,067	Plant unit	
Thailand	PIS	PM	<i>Vanda</i> sp.	17	1,008	Flask	
Thailand	PIS	PM	<i>Vandachostylis</i> sp.	3	45	Plant unit	
Thailand	PIS	PM	<i>Vanilla</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Vascostylis</i> sp.	1	65	Plant unit	
Thailand	PIS	PM	<i>Veitchia</i> sp.	3	78	Plant unit	
Thailand	PIS	PM	<i>Vesicularia</i> – Use Moss – Bryophyta	1	1	kg	
Thailand	PIS	PM	<i>Vigna</i> sp.	1	15	kg	
Thailand	PIS	PM	<i>Wallichia</i> sp.	4	386	Plant unit	Permit cargo: species of Psyllidae (arthropod); Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	<i>Wodyetia bifurcata</i>	2	1.33	kg	
Thailand	PIS	PM	<i>Wrightia</i> sp.	5	637	Plant unit	
Thailand	PIS	PM	<i>Xanthosoma</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Xiphidium</i> sp.	1	5	Plant unit	
Thailand	PIS	PM	<i>Zamia</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Zamioculcas</i> sp.	1	2	Plant unit	
Thailand	PIS	PM	<i>Zamioculcas zamiifolia</i>	1	10	Plant unit	
Thailand	PIS	PM	<i>Zephyranthes</i> sp.	1	1	Plant unit	
Thailand	PIS	PM	<i>Zingiber</i> sp.	1	0.1	kg	
Thailand	PIS	PM	<i>Zingiber</i> sp.	11	173	Plant unit	
Thailand	PIS	PM	<i>Zygopetalum</i> sp.	10	569	Flask	
Thailand	USPS	PM	<i>Adenium</i> sp.	1	1	kg	
Thailand	USPS	PM	<i>Adenium</i> sp.	not given	600	Plant unit	
Thailand	USPS	PM	<i>Brassica</i> sp.	1	1	kg	
Thailand	USPS	PM	<i>Capsicum</i> sp.	2	4	kg	
Thailand	USPS	PM	<i>Citrullus</i> sp.	1	4	kg	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Thailand	USPS	PM	<i>Cucumis melo</i>	1	1	kg	
Thailand	USPS	PM	<i>Garcinia mangostana</i>	1	1	kg	
Thailand	USPS	PM	<i>Luffa</i> sp.	1	1	kg	
Thailand	USPS	PM	<i>Solanum</i> sp.	2	2	kg	
Tonga	Airport	CF	<i>Alyxia</i> sp.	84	9,543	Stems	Baggage: <i>Adoretus</i> sp. (arthropod), <i>Ceroplastes rubens</i> (arthropod), <i>Coccus</i> sp. (arthropod), <i>Elsinoe alyxiae</i> (pathogen), (arthropod), species of <i>Orchamoplatus mammaeferus</i> Diaspididae, species of Tortricidae
Tonga	Airport	FV	Dasheen	1	93	kg	
Tonga	Airport	FV	Kava	2	250	kg	
Tonga	Airport	FV	Yam	1	60	kg	
Tonga	Airport	PM	<i>Vanilla</i> sp.	1	208	kg	
Tonga	Maritime	FV	Yam	1	9,240	kg	
Tonga	PIS	PM	<i>Alocasia</i> sp.	1	13	Plant unit	
United Kingdom	PIS	PM	<i>Calochortus</i> sp.	1	0.001	kg	
United Kingdom	PIS	PM	<i>Cyclamen</i> sp.	1	0.001	kg	
United Kingdom	PIS	PM	<i>Lilium</i> sp.	1	0.025	kg	
United Kingdom	PIS	PM	<i>Rhodophiala</i> sp.	1	0.001	kg	
Vanuatu	Airport	FV	Kava	3	870	kg	
Viet Nam	PIS	PM	<i>Annona</i> sp.	1	50	Plant unit	Baggage: species of Pseudococcidae (arthropod on <i>A. cherimola</i>)
Viet Nam	PIS	PM	<i>Artocarpus heterophyllus</i>	1	25	Plant unit	
Viet Nam	PIS	PM	<i>Artocarpus</i> sp.	1	50	Plant unit	
Viet Nam	PIS	PM	<i>Chrysophyllum</i> sp.	1	50	Plant unit	
Viet Nam	PIS	PM	<i>Lansium domesticum</i>	1	50	Plant unit	

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Origin	Pathway	Ctype ^a	Commodity	# of ship. ^b	Quantity	Units	Reportable Pests Intercepted ^c
Viet Nam	PIS	PM	<i>Lansium</i> sp.	1	40	Plant unit	
Viet Nam	PIS	PM	<i>Mangifera indica</i>	1	25	Plant unit	
Viet Nam	PIS	PM	<i>Mangifera</i> sp.	1	49	Plant unit	
Viet Nam	PIS	PM	<i>Nephelium lappaceum</i>	1	50	Plant unit	Baggage: <i>Araecerus</i> sp. (arthropod on <i>Nephelium</i> sp.), species of Pseudococcidae (arthropod)
Viet Nam	PIS	PM	<i>Psidium</i> sp.	1	53	Plant unit	Baggage: <i>Tetraleurodes</i> sp. (arthropod)
Viet Nam	PIS	PM	<i>Sandoricum</i> sp.	1	50	Plant unit	

1 Source: AQAS 2007

2 ^a CType: CF = cut flowers; FV = fruit or vegetable; PM = plant material

3 ^b # of ship. = total number of shipments regardless of weight or amount.

4 ^c Reportable pests intercepted are pests that were intercepted on plant hosts entering Hawai'i between 2004
5 and 2006 that match plant hosts that were imported into Hawai'i during those years. Only pests reported as
6 being intercepted on permit or general cargo were affiliated with commodity imports. This is not a
7 comprehensive list of reportable pests intercepted, e.g., pests intercepted only in baggage, ship's stores,
8 quarters, or other situations are not included.

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1 **Table A25-2: Reportable Pests Intercepted on the Commodities Entering as Permit or**
 2 **General Cargo**

Country	Commodity	Where Intercepted	Reportable Pest
Australia	<i>Rhopalobaste</i> sp.	Permit cargo	<i>Palmicultor browni</i> (arthropod)
	<i>Pinus</i> sp.	Permit cargo	species of Pseudococcidae (arthropod)
Fiji	<i>Colocasia esculenta</i>	Permit cargo	<i>Paraputo leveri</i> (arthropod), species of Pseudococcidae (arthropod)
		Baggage	species of Pseudococcidae (arthropod)
Malaysia	<i>Exocaria</i> sp.	Permit cargo	<i>Conchaspis</i> sp. (arthropod)
Thailand	Orchidaceae	Permit cargo	<i>Cladosporium</i> sp. (pathogen), <i>Succinea tenella</i> (mollusc), species of Lepidoptera (arthropod), species of Noctuidae (arthropod)
		General cargo	<i>Fromundus pygmaeus</i> (arthropod), <i>Spodoptera litura</i> (arthropod), <i>Succinea tenella</i> (mollusc)

3 Source: USDA 2007a

4 Note: The commodities were not listed in the PPQ280 database (possibly not entered into the database or listed
 5 under a different host name).

Table A25-3: Fresh Fruits and Vegetables, with Accompanying Pests, from the U.S. Mainland Entered Hawai'i during the Period January 1, 2004 to December 31, 2006

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Apple	8,792,614	10,383,099	10,147,479	Air baggage: <i>Aonidiella aurantii</i> (arthropod); Air cargo: <i>Schizothyrium pomi</i> (pathogen), <i>Venturia inaequalis</i> (pathogen)
Apricot	75,398	88,128	59,160	Air cargo: <i>Hemerobius</i> sp. (arthropod)
Artichoke	275,063	409,903	356,354	Air cargo: <i>Pamlaria cynarae</i> (pathogen)
Asparagus	1,324,432	1,273,647	1,515,540	Air cargo: <i>Delia</i> sp. (arthropod), <i>Harmonia axyridis</i> (arthropod - shipment originated in Mexico, but was shipped domestically from CA)
Avocado	1,297,942	1,549,132	1,696,165	Air cargo: Avocado scab disease
Banana				Air cargo: <i>Dysmicoccus</i> sp. nr. <i>bispinosus</i> (arthropod - three interceptions made on shipments originating in Ecuador, but shipped domestically from CA); Unspecified pathway: <i>D. texensis</i> (arthropod - three interceptions made on shipments originating from Ecuador or South/Central America, but shipped domestically).
Banana: Apple	36,495	41,058	31,013	
Banana: Cavendish	13,439,028	12,440,183	14,735,130	
Banana: Specialty	107,420	101,158	113,030	
Basil	2,397	3,995	4,560	Air cargo: <i>Liriomyza</i> sp. (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Alternaria</i> sp. (pathogen)
Beans: Green	443,039	514,908	489,938	
Beans: Long	24,145	28,085	29,236	
Beans: Specialty	23,705	35,628	137,131	Air baggage: <i>Cydia dehaiana</i> (arthropod)
Berries: Other	566,858	594,764	667,049	
Bittermelon	57,695	129,544	90,890	Air cargo: <i>Alternaria</i> sp. (pathogen - origin was Mexico)
Broccoli	4,541,738	4,783,896	4,790,831	
Broccoli: Process	130	30,319	94,624	
Burdock	75,978	87,957	73,373	
Cabbage: Chinese	1,456,083	979,193	903,781	Air cargo: <i>Aceratagallia</i> sp. (arthropod), <i>Ceraphron</i> sp. (arthropod), <i>Lygus lineolaris</i> (arthropod), <i>Microtheca ochroloma</i> (arthropod), <i>Nysius raphanus</i> (arthropod)
Cabbage: Green	3,769,169	2,838,283	2,641,604	Air cargo: <i>Aceratagalia</i> sp. (arthropod), <i>Deroceras reticulatum</i> (arthropod)
Cabbage: Kai Choi	21,052	28,021	25,011	

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Cabbage: Other	62,588	74,232	74,403	Air cargo: <i>Aceratagallia californica</i> (arthropod), <i>Aceratagallia</i> sp. (arthropod), <i>Autographa californica</i> (arthropod), <i>Bactericera cockerelli</i> (arthropod), <i>Delia</i> sp. (arthropod), <i>Geocoris tristicolor</i> (arthropod), <i>Geocoris</i> sp. (Arthropod), <i>Hellula</i> sp. (arthropod), <i>Hemerobius</i> sp. (arthropod), <i>Lygus elisus</i> (arthropod), <i>Lygus lineolaris</i> (arthropod), <i>Lygus</i> sp. (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Microtheca orchrolama</i> (arthropod), <i>Nysius raphanus</i> (arthropod - at least one interception was on a shipment originating from Mexico but shipped domestically from CA), <i>Myzus ascalonicus</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Schwenkfeldina</i> sp. (arthropod), <i>Spodoptera praefica</i> (arthropod), <i>Syrphus</i> sp. (arthropod), <i>Thaumatomyia</i> sp. (arthropod); Pathway unspecified: <i>Agrotis subteraneae</i> (arthropod), <i>Chrysopius</i> sp. (arthropod)
Cabbage: Pak Choi	103,527	110,268	129,232	
Cabbage: Process	52,245	58,174	36,425	
Cabbage: Red	243,036	236,853	237,610	Air cargo: <i>Aceratagallia</i> sp. (arthropod), <i>Syrphus</i> sp. (arthropod)
Caimito	0	140	570	
Carrot	8,675,563	9,530,519	9,584,213	
Cauliflower	864,086	688,424	741,177	
Celery	4,305,277	4,182,800	4,636,244	Air cargo: <i>Diabrotica balteata</i> (arthropod), <i>Hemerobius</i> sp. (arthropod - shipment originated from Mexico but shipped domestically from CA), <i>Lygus elisus</i> (arthropod - shipment originated from Mexico but shipped domestically from CA), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod); Ship cargo: <i>Delia</i> sp. (arthropod)
Cherimoya	10,587	3,497	32,427	
Cherry	1,011,305	1,162,220	1,621,675	
Chestnut	48,228	72,141	47,050	
Citrus: Other	63,374	65,681	44,278	Air cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Marmara gulosa</i> (arthropod); Ship cargo: <i>Marmara gulosa</i> (arthropod)
Corn: Sweet	1,208,968	1,015,046	615,948	Air cargo: <i>Puccinia polygoni</i> (pathogen); Air baggage: <i>Melanaphis sorghi</i> (arthropod); Pathway unspecified: <i>Rhopalosiphum padi</i> (arthropod - Mexico origin)
Cucumber	521,340	890,103	663,745	
Cucumber: English	142,690	143,426	146,922	
Cucumber: Japanese	27,444	22,663	20,707	
Daikon: General				Air cargo: <i>Fusarium</i> sp. (pathogen)
Daikon: Chinese	2,750	1,500	870	
Daikon: Japanese	600	30	300	

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Daikon: Korean	0	849,923	4,639	
Daikon: Process	0	16,525	0	
Dasheen	71,672	52,915	83,755	
Durian	6,000	0	0	
Eggplant: General				Air cargo: <i>Lygus elisius</i> (arthropod)
Eggplant: Long	314,163	568,246	500,894	
Eggplant: Round	225,932	240,185	174,883	
Endive/Escarole				Air cargo: <i>Aceratagallia</i> sp. (arthropod), <i>Delia radicum</i> (arthropod), <i>Lygus hesperus</i> (arthropod), <i>Lygus linedaris</i> (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Microtheca ochroloma</i> (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod); Ship cargo: <i>Geocoris</i> sp. (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod); Pathway unspecified: <i>Hemerobius</i> sp. (arthropod)
	147,182	178,317	159,623	
Fruit: Other	163,323	147,340	77,064	
Fruit: Tropical	134,908	131,895	130,336	
Garlic	1,004,340	1,262,456	1,416,686	
Ginger root	278,049	109,051	49,133	
Grape	6,925,406	8,108,539	7,808,816	Air cargo: <i>Planococcus ficus</i> (arthropod)
Grapefruit				Air cargo: <i>Marmara gulosa</i> (arthropod); Ship cargo: <i>Aonidiella aurantii</i> (arthropod); Air baggage: <i>Aonidiella aurantii</i> (arthropod)
	1,382,696	1,184,107	1,236,088	
Greens: Oriental	201,051	138,154	168,729	
Greens: Other				Air cargo: <i>Autographa californica</i> (arthropod), <i>Acrosternum hilare</i> (arthropod), <i>Bactericera cockerelli</i> (arthropod), <i>Cameraria gaultheriella</i> (arthropod), <i>Delia</i> sp. (arthropod), <i>Lygus lineolaris</i> (arthropod), <i>Myzus ascalonicus</i> (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Syrphus</i> sp. (arthropod); Ship cargo: <i>Bactericera cockerelli</i> (arthropod), <i>Nysius raphanus</i> (arthropod); Federal Express: <i>Cameraria gaultheriella</i> ; Pathway unspecified: <i>Autographa californica</i> (arthropod)
	308,046	389,958	393,366	
Guava: Process	130	0	100	
Herbs and Spices				Air cargo: <i>Aphis menthaeradicis</i> (arthropod), <i>Erisiphe</i> sp. (pathogen), <i>Limax marginatus</i> (mollusc), <i>Oidium</i> sp. (pathogen), <i>Orthosia hibisci</i> (arthropod), <i>Peronospora lamii</i> (pathogen), <i>Puccinia</i> sp. (pathogen), <i>Succinea</i> sp. (mollusc)
	65,076	79,101	81,299	
Kiwi	366,239	463,156	619,042	
Leek	119,864	158,660	176,493	Air cargo: <i>Empoasca</i> sp. (arthropod)

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Lemon	2,930,645	3,122,685	3,063,077	Air cargo: <i>Aonidiella aurantii</i> (arthropod); Air baggage: <i>Aonidiella aurantii</i> (arthropod), <i>Marmara gulosa</i> (arthropod); Ship cargo: <i>Aonidiella aurantii</i> (arthropod); Pathway unspecified: <i>Lygus</i> sp. (arthropod)
Lettuce: Head	7,299,718	6,431,618	6,526,409	
Lettuce: Manoa	0	120	0	
Lettuce: Other	178,761	145,171	152,590	Air cargo: <i>Acalymna vittatus</i> (arthropod), <i>Aceratagallia californica</i> (arthropod), <i>Aceratagallia</i> sp. (arthropod), <i>Acyrtosiphon lactucae</i> (arthropod), <i>Acyrtosiphon euphorbiae</i> (arthropod), <i>Aeolothrips</i> sp. (arthropod), <i>Aphis</i> sp. (arthropod), <i>Autographa californica</i> (arthropod), <i>Bactericera cockerelli</i> (arthropod), <i>Berytinus</i> sp. (arthropod), <i>Centorhynchus</i> sp. (arthropod), <i>Ceroxys latusculus</i> (arthropod), <i>Chlorochroa sayi</i> (arthropod), <i>Chrysopa</i> sp. (arthropod), <i>Delia</i> sp. (arthropod), <i>Deltocephalinus</i> sp. (arthropod), <i>Empoasca</i> sp. (arthropod), <i>Erythroneura</i> sp. (arthropod), <i>Evania</i> sp. (arthropod), <i>Frankliniella aztecus</i> (arthropod), <i>Geocoris tricolor</i> (arthropod), <i>Geocoris</i> sp. (arthropod), <i>Hemerobius</i> sp. (arthropod), <i>Lestremia</i> sp. (arthropod), <i>Lordithon</i> sp. (arthropod), <i>Lygus elisus</i> (arthropod), <i>Lygus hesperus</i> (arthropod), <i>Lygus lineolaris</i> (arthropod), <i>Macrosiphum</i> sp. (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Microdochium panattonianum</i> (pathogen), <i>Misumenops</i> sp. (arthropod), <i>Nabis</i> sp. (arthropod), <i>Notoxus</i> sp. (arthropod)
Lettuce: Processed	6,046,469	5,673,346	6,633,087	
Lettuce: Red/Green	2,261,322	2,076,540	2,420,695	
Lettuce: Specialty	638,825	557,108	548,530	
Lime	957,652	1,101,241	1,137,461	Air cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Marmara gulosa</i> (arthropod - shipment originated from Mexico but shipped domestically from CA); Pathway unspecified: <i>Nysius raphanus</i> (arthropod - shipment originated from Mexico but shipped domestically from CA)
Longan	8,755	732	0	
Lotus root	48,449	53,230	64,133	
Luau leaf	0	0	869	
Lychee	89,788	23,326	95,680	
Mandarin	287,036	600,645	389,938	
Mango	994,361	1,445,970	1,469,309	Air cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Aulacaspis tubercularis</i> (arthropod), <i>Greenidea mangiferae</i> (arthropod), <i>Pseudocaecilius</i> sp. (arthropod); Ship cargo: <i>Aonidiella aurantii</i> (arthropod); Pathway unspecified: <i>Phoma</i> sp. (pathogen)
Melon: Cantaloupe	4,985,144	6,181,700	6,215,944	
Melon: Honeydew	2,096,839	1,937,565	2,855,238	

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Melon: Other	217,454	240,677	288,213	
Melon: Seedless Watermelon	1,532,397	1,800,206	2,405,572	
Melon: Watermelon	492,751	991,806	1,162,053	
Mushroom	0	2,398	3,217	
Mushroom: Button	2,533,675	2,719,336	2,340,266	
Mushroom: Special	414,608	444,685	423,881	
Nectarine	1,956,454	1,698,358	1,658,572	
Ong Choi	11,265	60	80	
Onion				Pathway unspecified: <i>Nysius raphanus</i> (arthropod)
Onion: Dry	13,133,405	16,156,408	15,378,400	
Onion: Green	320,493	204,969	264,866	Air cargo: <i>Lestremia</i> sp. (arthropod), <i>Lygaeus kalmii</i> (arthropod)
Onion: Specialty	106,857	101,815	126,195	
Orange	11,695,682	13,442,511	12,550,205	Air cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Chrysomphalus</i> sp. (arthropod), <i>Marmara gulosa</i> (arthropod); Ship cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Marmara gulosa</i> (arthropod); Pathway unspecified: <i>Liriomyza</i> sp. (arthropod)
Papaya	3,394	11,406	5,602	Air cargo: Papaya ring spot virus (pathogen - shipment originated from Mexico)
Papaya: Processed	0	120	0	
Parsley				Air cargo: <i>Aceratagallia</i> sp. (arthropod), <i>Aelothrips</i> sp. (arthropod), <i>Alternaria petroselini</i> (pathogen), <i>Alternaria radicina</i> (pathogen), <i>Delia</i> sp. (arthropod), <i>Chlorochroa ligata</i> (arthropod), <i>Dyaphis apiifolia</i> (arthropod), <i>Hemerobius</i> sp. (arthropod), <i>Hyadaphis foeniculi</i> (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Melagromyza</i> sp. (arthropod), <i>Microtheca ochroloma</i> (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Puccinia nitida</i> (pathogen), <i>Syrphus</i> sp. (arthropod)
Parsley: American	99,839	105,390	119,279	Air cargo: <i>Macrosteles</i> sp. (arthropod), <i>Zelus</i> sp. (arthropod)
Parsley: Chinese	59,330	68,375	103,488	
Passion fruit: Processed	123	0	40	
Pea: General				Air cargo: <i>Mayetiola</i> sp. (arthropod), <i>Nysius raphanus</i> (arthropod)
Pea: Chinese	214,084	216,481	210,460	
Pea: Sugar Snap	87,603	89,526	73,022	Air cargo: <i>Liriomyza</i> sp.
Peach	1,827,057	1,686,005	2,063,540	
Peanut	86,725	127,350	116,530	

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Pear	2,915,837	2,129,155	2,503,812	
Pepper: General				Air cargo: <i>Alternaria</i> sp. (pathogen), <i>Aulacorthum magnoliae</i> (arthropod), <i>Bactericera cockerelli</i> (arthropod), <i>Chipsasia</i> sp. (arthropod), <i>Geocoris tristicolor</i> (arthropod), <i>Hemerobius</i> sp. (arthropod), <i>Hyperaspis</i> sp. (arthropod), <i>Liriomyza</i> sp. (arthropod - some shipments originated from Mexico but were shipped domestically through CA), <i>Lygus</i> sp. (arthropod), <i>Macrosletes</i> sp., <i>Microtheca ochroloma</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Orius</i> sp. (arthropod), <i>Rhizoecus</i> sp. (arthropod), <i>Theridia murarium</i> (arthropod); Pathway unspecified: <i>Syrphus</i> sp.
Pepper: Hot	263,828	317,462	309,365	
Pepper: Sweet	1,747,046	2,091,414	2,353,883	
Persimmon	912,205	945,292	907,279	
Pineapple	160	0	380	
Plum	1,114,106	1,211,558	1,101,644	
Potato: Chipper	12,349,486	13,750,828	13,168,455	
Potato: Seed	0	0	300	
Potato: Table	17,956,886	20,308,283	20,811,710	
Pumpkin	592,457	256,650	142,973	
Radish	10,378	9,315	5,274	
Rambutan	250	0	0	
Romaine	7,106,544	7,922,485	7,792,587	See lettuce above
Roots: Other	215,542	289,556	328,136	
Soybean	564	2,001	4,301	
Spinach				Air cargo: <i>Aceratagallia</i> sp. (arthropod), <i>Alternaria</i> sp. (pathogen), <i>Cladosporium macrocarpum</i> (pathogen), <i>Empoasca</i> sp. (arthropod), <i>Geocoris</i> sp. (arthropod), <i>Lygus</i> sp. (arthropod), <i>Nysius raphanus</i> (arthropod)
Spinach: American	1,620,028	1,628,187	1,168,269	
Spinach: Chinese	1,640	60	400	
Sprouts	10,520	4,351	6,581	
Squash				Air cargo: <i>Acalymma vittatum</i> (arthropod)
Squash: Hechima	10,485	33,515	39,453	
Squash: Hyotan	42,056	96,255	44,745	
Squash: Italian	896,255	991,640	1,339,726	
Squash: Kabocha	265,916	368,056	308,038	
Squash: Other	837,945	908,791	946,499	

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Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity ^a
Squash: Togan	180	2,918	35,090	
Starfruit	12,566	17,841	25,167	
Strawberry	2,573,679	3,617,952	3,523,209	Air cargo: <i>Acyrtosiphon lactucae</i> (arthropod), <i>Acyrtosiphon rogersii</i> (arthropod), <i>Aphis ruborum</i> (arthropod), <i>Chaetosiphon fragaefolii</i> (arthropod), <i>Chaetosiphon jacobii</i> (arthropod), <i>Chaetosiphon minor</i> (arthropod), <i>Chaetosiphon thomasi</i> (arthropod), <i>Chaetosiphon</i> sp. (arthropod), <i>Myzus ascalonicus</i> (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Syrphus</i> sp. (arthropod)
Sweet potato	1,064,294	1,052,929	1,200,585	Air cargo: <i>Ferrisia</i> sp. (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Pseudococcus</i> sp. (arthropod)
Tangelo	93,083	73,166	85,182	
Tangerine	843,470	1,175,719	1,763,891	Air cargo: <i>Aonidiella aurantii</i> (arthropod), <i>Marmara gulosa</i> (arthropod); Air baggage: <i>Aonidiella aurantii</i> (arthropod)
Taro	823,921	554,745	476,272	
Taro: Chipper	160,696	137,061	466,929	
Taro: Process	360	585	44,788	
Tomato	2,957,402	4,894,736	4,267,350	Air cargo: <i>Nysius raphanus</i> (arthropod)
Tomato: Other	479,869	512,402	525,118	
Tomato: Plum	345,340	749,937	701,116	
Unavailable	0	850	7,445	
Unspecified	21,490,025	18,904,928	24,042,505	
Vegetables: Other	196,925	469,366	473,660	Air cargo: <i>Nysius raphanus</i> (arthropod)
Vegetables: Processed	270,423	308,570	174,904	
Watercress	33,060	30,319	43,896	Air cargo: <i>Aleratagallia</i> sp. (arthropod), <i>Delia</i> sp. (arthropod), <i>Empoasca</i> sp. (arthropod), <i>Euschistus tristigmus</i> (arthropod), <i>Lygus</i> sp. (arthropod), <i>Macrosteles</i> sp. (arthropod), <i>Microtheca ochroloma</i> (arthropod), <i>Microtheca</i> sp. (arthropod), <i>Myzus ascalonicus</i> (arthropod), <i>Myzus</i> sp. (arthropod), <i>Nysius raphanus</i> (arthropod), <i>Nysius</i> sp. (arthropod), <i>Physella heterostropha</i> (arthropod), <i>Physella</i> sp. (arthropod), <i>Succinea</i> sp. (mollusc), <i>Syrphus</i> sp. (arthropod)
Yam bean root	63,760	64,595	84,808	

Sources for produce shipments and intercepted pests: Vierra 2007 and HDOA 2007c, respectively. Data for exact origins of the commodities are not available.

^a Limited verification of pest status in Hawai'i was conducted using online databases, such as the Bishop Museum's Hawai'i Biological Survey Databases and the Crop Protection Compendium (CABI 2006), and scientific literature.

Table A25-4: Reportable Pests Intercepted for Hawai'i in Aircraft Cargo Holds and Cabins between January 1, 1990 and June 16, 2007

Reportable Pest ^a	Number Intercepted
Acrididae, species of	6
<i>Acroleucus vicinalis</i> (Lygaeidae)	1
Acrolophidae, species of	1
<i>Adoretus sinicus</i> (Scarabaeidae)	1
<i>Aeolus nigromaculatus</i> (Elateridae)	1
<i>Agrius</i> sp. (Sphingidae)	1
Agromyzidae, species of	1
<i>Agrotis</i> sp. (Noctuidae)	1
Aleyrodidae, species of	1
<i>Allonemobius</i> sp. (Gryllidae)	1
<i>Altica</i> sp. (Chrysomelidae)	1
Alticinae, species of (Chrysomelidae)	2
<i>Amphimallon solstitialis</i> (Scarabaeidae)	1
<i>Amphimallon</i> sp. (Scarabaeidae)	1
<i>Anastrepha</i> sp. (Tephritidae)	2
<i>Anaxipha</i> sp. (Gryllidae)	6
<i>Ancognatha scarabaeoides</i> (Scarabaeidae)	6
<i>Ancognatha</i> sp. (Scarabaeidae)	49
<i>Ancognatha ustulata</i> (Scarabaeidae)	9
<i>Anomala</i> sp. (Scarabaeidae)	21
Aphididae, species of	2
Apioninae, species of (Curculionidae)	3
<i>Archophileurus</i> sp. (Scarabaeidae)	1
<i>Arcte coerulea</i> (Noctuidae)	1
Arctiidae, species of	15
<i>Athlia rustica</i> (Scarabaeidae)	1
<i>Atractomorpha</i> sp. (Pyrgomorphidae)	1
<i>Atta sexdens</i> (Formicidae)	3
<i>Atta</i> sp. (Formicidae)	6
<i>Aulacaspis tubercularis</i> (Diaspididae)	1
<i>Aulacophora indica</i> (Chrysomelidae)	1
<i>Aulacophora nigripennis</i> (Chrysomelidae)	1
<i>Banasa</i> sp. (Pentatomidae)	1
<i>Barybas</i> sp. (Scarabaeidae)	1
<i>Berecynthus hastator</i> (Pentatomidae)	1
<i>Blapstinus</i> sp. (Tenebrionidae)	7
<i>Blissus</i> sp. (Blissidae)	1

Reportable Pest ^a	Number Intercepted
<i>Blitopertha</i> sp. (Scarabaeidae)	1
Bostrichidae, species of	3
<i>Calligrapha</i> sp. (Chrysomelidae)	1
<i>Calloplistria</i> sp. (Noctuidae)	1
Cassidinae, species of (Chrysomelidae)	1
<i>Caulopsis microprora</i> (Tettigoniidae)	1
<i>Caulopsis</i> sp. (Tettigoniidae)	1
Cerambycidae, species of	4
<i>Ceraspis centralis</i> (Scarabaeidae)	1
<i>Ceratitis capitata</i> (Tephritidae)	1
Cercopidae, species of	1
<i>Chlorotettix</i> sp. (Cicadellidae)	3
Chrysomelidae, species of	6
Cicadellidae, species of	14
Cicadidae, species of	2
Cixiidae, species of	3
<i>Cleogonus</i> sp. (Curculionidae)	1
<i>Colaspis</i> sp. (Chrysomelidae)	9
<i>Conocephalus saltator</i> (Tettigoniidae)	1
<i>Conocephalus</i> sp. (Tettigoniidae)	11
<i>Conoderus pictus</i> (Elateridae)	2
<i>Conoderus</i> sp. (Elateridae)	3
<i>Conotrachelus</i> sp. (Curculionidae)	3
<i>Cornu aspersum</i> (Helicidae)	1
Crambidae, species of	3
Crambinae, species of (Crambidae)	1
Ctenuchidae, species of	3
Curculionidae, species of	12
<i>Cyclocephala mafaffa</i> (Scarabaeidae)	1
<i>Cyclocephala</i> sp. (Scarabaeidae)	28
Cydnidae, species of	14
<i>Dallasiellus bacchinus</i> (Cydnidae)	6
Delphacidae, species of	6
Deltocephalinae, species of (Cicadellidae)	1
<i>Dichromorpha</i> sp. (Acrididae)	1
<i>Diplotaxis</i> sp. (Scarabaeidae)	8
<i>Draeculacephala clypeata</i> (Cicadellidae)	1
Dynastinae, species of	16

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Reportable Pest ^a	Number Intercepted
(Scarabaeidae)	
<i>Dyscinetus</i> sp. (Scarabaeidae)	1
<i>Earias insulana</i> (Noctuidae)	1
<i>Ecpantheria</i> sp. (Arctiidae)	1
Elateridae, species of	6
<i>Endotracha</i> sp. (Pyralidae)	1
Eneopterinae, species of (Gryllidae)	1
<i>Epitragus</i> sp. (Tenebrionidae)	3
<i>Epitrix</i> sp. (Chrysomelidae)	1
<i>Erinnyis</i> sp. (Sphingidae)	1
<i>Euconocephalus</i> sp. (Tettigoniidae)	2
<i>Eutheola</i> sp. (Scarabaeidae)	4
<i>Eulepidotis guttata</i> (Noctuidae)	3
Eumolpinae, species of (Chrysomelidae)	2
<i>Euphoria</i> sp. (Scarabaeidae)	4
<i>Eurychilella</i> sp. (Miridae)	1
<i>Euschistus</i> sp. (Pentatomidae)	2
<i>Exitianus</i> sp. (Cicadellidae)	1
<i>Exophthalmus</i> sp. (Curculionidae)	1
Flatidae, species of	1
Formicidae, species of	1
Galerucinae, species of (Chrysomelidae)	4
Gelechiidae, species of	16
<i>Geniates</i> sp. (Scarabaeidae)	3
Geometridae, species of	7
<i>Gonodonta</i> sp. (Noctuidae)	3
Gryllidae, species of	4
Gryllinae, species of (Gryllidae)	1
<i>Gryllodes</i> sp. (Gryllidae)	1
<i>Gryllotalpa</i> sp. (Gryllotalpidae)	2
<i>Gryllus capitatus</i> (Gryllidae)	1
<i>Gryllus</i> sp. (Gryllidae)	85
Herminiinae, species of (Noctuidae)	1
<i>Herpetogramma</i> sp. (Crambidae)	1
<i>Horistonotus</i> sp. (Elateridae)	1
Lagriinae, species of (Tenebrionidae)	1
Lepidoptera, species of	9
<i>Leucania inconspicua</i> (Noctuidae)	1
<i>Leucothyreus</i> sp. (Scarabaeidae)	2
<i>Ligyris</i> sp. (Scarabaeidae)	9
Limacodidae, species of	1
<i>Liogenys macropelma</i> (Scarabaeidae)	2
<i>Liogenys quadridens</i> (Scarabaeidae)	1
<i>Liogenys</i> sp. (Scarabaeidae)	6
Lycaenidae, species of	1

Reportable Pest ^a	Number Intercepted
Lygaeidae, species of	9
<i>Macropygium</i> sp. (Pentatomidae)	1
<i>Malacorhinus irregularis</i> (Chrysomelidae)	1
<i>Maladera</i> sp. (Scarabaeidae)	1
<i>Manopus</i> sp. (Scarabaeidae)	3
<i>Melanaethus spinolai</i> (Cydniidae)	2
<i>Melipotis</i> sp. (Noctuidae)	3
Meloidae, species of	1
<i>Melolontha</i> sp. (Scarabaeidae)	1
Melolonthinae, species of (Scarabaeidae)	13
Membracidae, species of	2
<i>Messor</i> sp. (Formicidae)	1
<i>Metaleptea brevicornis</i> (Acrididae)	1
<i>Metamasius hemipterus</i> (Dryophthoridae)	2
<i>Miogryllus convolutus</i> (Gryllidae)	1
Miridae, species of	11
Myrmicinae, species of (Formicidae)	6
<i>Neochetina eichhorniae</i> (Eirrhinidae)	1
<i>Neoconocephalus punctipes</i> (Tettigoniidae)	3
<i>Neoconocephalus</i> sp. (Tettigoniidae)	28
Noctuidae, species of	236
Nymphalidae, species of	1
<i>Nysius</i> sp. (Lygaeidae)	5
Oecophoridae, species of	1
Olethreutinae, species of (Tortricidae)	1
<i>Oncometopia</i> sp. (Cicadellidae)	1
<i>Orphulella punctata</i> (Acrididae)	1
Orthoptera, species of	1
<i>Palpita</i> sp. (Crambidae)	1
<i>Paragonatas divergens</i> (Rhyparochromidae)	1
<i>Pareuchaetes insulata</i> (Arctiidae)	1
<i>Parlatoria ziziphi</i> (Diaspididae)	2
Pentatomidae, species of	9
<i>Phaneroptera furcifera</i> (Tettigoniidae)	1
<i>Pheidole</i> sp. (Formicidae)	1
<i>Phelypera distigma</i> (Curculionidae)	1
<i>Phyllobius</i> sp. (Curculionidae)	1
<i>Phyllophaga</i> sp. (Scarabaeidae)	105
<i>Physonota attenuata</i> (Chrysomelidae)	1

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Reportable Pest^a	Number Intercepted
<i>Physonota</i> sp. (Chrysomelidae)	1
<i>Pintalia</i> sp. (Cixiidae)	2
<i>Plautia stali</i> (Pentatomidae)	1
<i>Plectris</i> sp. (Scarabaeidae)	14
Plusiinae, species of (Noctuidae)	1
<i>Pococera</i> sp. (Pyrilidae)	1
<i>Prepops latipennis</i> (Miridae)	1
<i>Prosapia</i> sp. (Cercopidae)	1
<i>Protaetia orientalis</i> (Scarabaeidae)	1
<i>Psylla</i> sp. (Psyllidae)	1
<i>Pteronemobius</i> sp. (Gryllidae)	1
<i>Pycnoderes</i> sp. (Miridae)	1
Pyrilidae, species of	83
Pyraustinae, species of (Crambidae)	1
<i>Pyrgocorypha</i> sp. (Tettigoniidae)	1
Pyrrhocoridae, species of	2
<i>Rhabdopterus</i> sp. (Chrysomelidae)	1
Rhopalidae, species of	2
Rhynchophorinae, species of (Curculionidae)	2
Rhyparochromidae, species of	5
Rutelinae, species of (Scarabaeidae)	3
<i>Samea ecclesialis</i> (Crambidae)	1
Saturniidae, species of	1
Scarabaeidae, species of	6
<i>Solenopsis</i> sp. (Formicidae)	1
Sphingidae, species of	29
<i>Sphingonotus</i> sp. (Acrididae)	1
<i>Spodoptera cosmioides</i> (Noctuidae)	1
<i>Spodoptera</i> sp. (Noctuidae)	3
<i>Stenacris vitreipennis</i> (Acrididae)	1
<i>Strategus</i> sp. (Scarabaeidae)	1
<i>Systema s-littera</i> (Chrysomelidae)	1
Tenebrionidae, species of	2
Tetrigidae, species of	1
Tettigoniidae, species of	6
<i>Texananus</i> sp. (Cicadellidae)	1
Tineidae, species of	4
<i>Tomarus</i> sp. (Scarabaeidae)	15
<i>Trachea atriplicis</i> (Noctuidae)	1
Typhlocybinae, species of (Cicadellidae)	1
<i>Typophorus</i> sp. (Chrysomelidae)	1
Grand Total	1,205

Risk Analysis and Management Recommendations for the Prevention and Mitigation of Terrestrial Invasive Species in the Micronesia Region

Source: USDA 2007a

- ^a Records exclude pest interceptions made on military aircraft and those for which discrepancies in the data are suspected (i.e., in cases in which it is questionable that the pest was actually intercepted in an aircraft cargo hold or cabin).