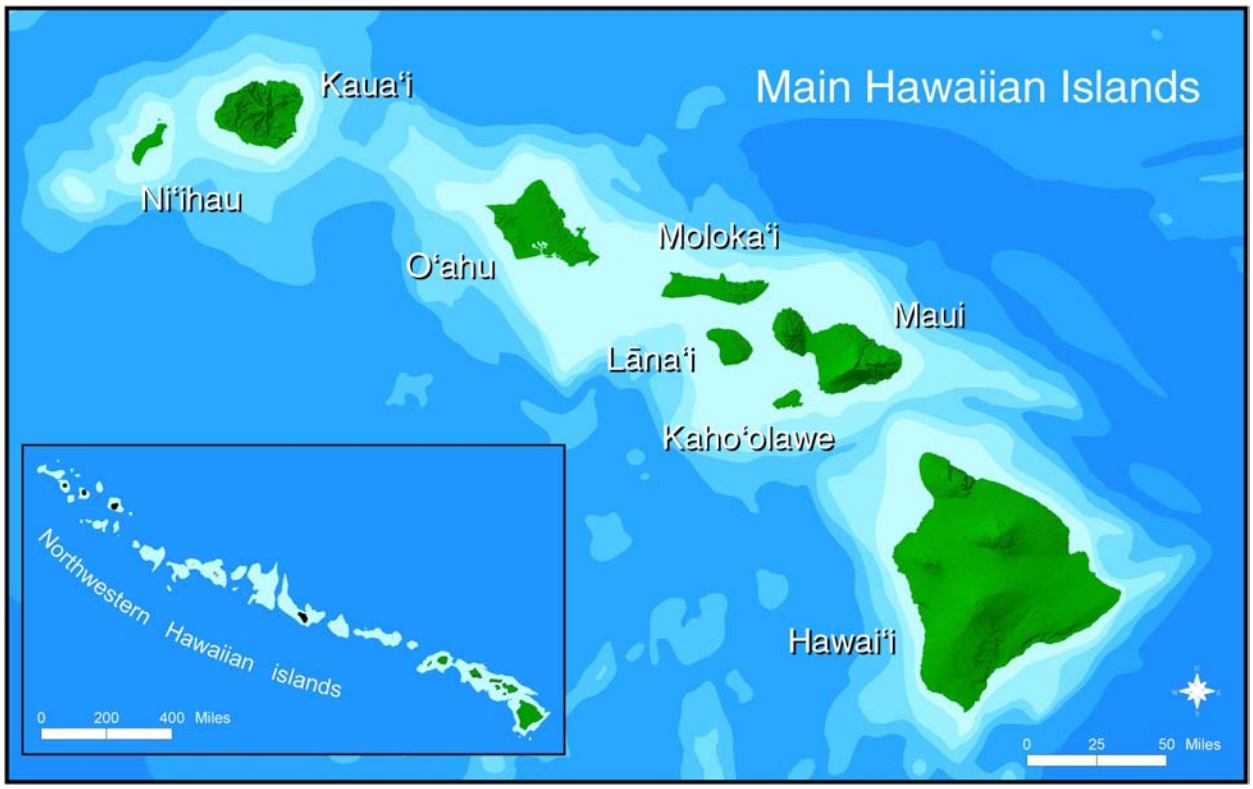
FINAL VERSION

State of Hawai‘i
Aquatic Invasive Species (AIS) Management Plan



September 2003

State of Hawai‘i
Aquatic Invasive Species Management Plan

Final Version - September 2003

The Department of Land and Natural Resources,
Division of Aquatic Resources

Prepared through:
Andrea D. Shluker, The Nature Conservancy of Hawai‘i

This plan was prepared in conjunction with numerous representatives from Federal, State, industry, and non-governmental organizations. This includes the following Steering Committee members (listed in alphabetical order): Scott Atkinson, **The Nature Conservancy,** Robbie Kane, **Hawai‘i Tourism Authority,** Earl Campbell, **US Fish and Wildlife Service,** Domingo Cravalho, **Hawai‘i Department of Agriculture,** Lu Eldredge, **Bishop Museum,** Ron Englund, **Bishop Museum,** Scott Godwin, **Bishop Museum,** Dale Hazelhurst, **Matson Shipping,** Cindy Hunter, **University of Hawai‘i,** Jo-Anne Kushima, **Department of Land and Natural Resources, Division of Aquatic Resources,** Kenneth Matsui, **Pets Pacifica/Petland,** Kim Moffie, **Hawai‘i Audubon Society/Pacific Fisheries Coalition,** Paul Murakawa, **Department of Land and Natural Resources, Division of Aquatic Resources,** Celia Smith, **University of Hawai‘i,** Mike Yamamoto, **Department of Land and Natural Resources, Division of Aquatic Resources,** Leonard Young, **Hawai‘i Department of Agriculture, Aquaculture Development Program,** Ron Weidenbach, **Hawai‘i Aquaculture Association.**

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EXECUTIVE SUMMARY

Aquatic invasive species (AIS) include species in marine and inland waters whose introductions cause or are likely to cause economic or environmental harm, and/or harm to human health. AIS are a serious problem in Hawai‘i, posing a significant threat to residents and visitors, as well as to Hawaii's native plants, animals, and associated native ecosystems. Economic impacts of AIS have also been strongly felt with the recent control and clean-up efforts associated with *Salvinia molesta* (Giant Salvinia) in Lake Wilson/Wahiawa Reservoir on O‘ahu. These control and clean-up efforts cost the State and its partners approximately one million dollars. Yet *Salvinia molesta* is only one of the many aquatic invasive species that threaten Hawai‘i, and there is a clear need for a coordinated approach in which to address AIS on a statewide level.

The purpose of this State of Hawai‘i Aquatic Invasive Species (AIS) Management Plan is to act as a tool in which to help enhance the coordination of current management efforts, identify remaining problems areas and gaps, and recommend additional actions which are needed to effectively address AIS issues in Hawai‘i. The focus of this plan is the identification of feasible, cost-effective management practices to be implemented by State, Federal, county, non-governmental, private, and volunteer entities for the environmentally sound prevention and control of aquatic invasive species in a coordinated fashion.

FEDERAL SUPPORT FOR THIS PLAN

The Federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, amended by the National Invasive Species Act of 1996, calls for the development of State and regional management plans. Using guidance from the Federal Aquatic Nuisance Species Task Force, as well as input from Hawai‘i representatives of State and Federal agencies, industry, non-governmental organizations, and other stakeholders, this plan has been developed to comprehensively address AIS issues throughout Hawai‘i. With approval of this plan by the Federal Aquatic Nuisance Species Task Force, Federal assistance for activities detailed in this plan may be made available to assist with implementation.

GOAL AND OBJECTIVES OF THE HAWAI‘I AIS MANAGEMENT PLAN

The goal of the plan stated as follows: *To minimize the harmful ecological, economic, and human health impacts of AIS through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawai‘i.* To accomplish this goal, seven objectives relating to AIS have been identified:

- COORDINATION and COLLABORATION:
  Improve the coordination and collaboration of people, resources, and efforts involved with AIS.
- PREVENTION:
  Minimize the introduction and spread of AIS into and throughout the waters of Hawai‘i.
- MONITORING and EARLY DETECTION:
  Ensure effective programs that allow for the early detection of new AIS and the monitoring of existing AIS.
- RESPONSE, ERADICATION and CONTROL:
  Establish effective systems for rapid response, eradication, control, and restoration.
- EDUCATION AND OUTREACH:
  Increase education and outreach efforts to ensure awareness throughout the State on AIS threats and solutions.
- RESEARCH:
  Increase research efforts on key AIS species, associated issues, and economic impacts to allow for more effective management.
- POLICY:
  Ensure State laws and regulations effectively promote the prevention and control of AIS.

These objectives, along with all associated strategies are summarized in Table 1 on the following pages.

PRIORITY TASKS NEEDED TO ACCOMPLISH PLAN GOAL AND OBJECTIVES

High priority for the first year is placed on the following tasks:

- **Establishment of a permanent statewide position for an Aquatic Invasive Species Coordinator;**
- **Establishment of a long-term Aquatic Invasive Species Advisory Council;**
- **Evaluation and decision upon whether AIS issues and ultimate responsibility will fall under the Division of Aquatic Resources, or a newly formed entity;**
- **Implement and fund the existing Ballast Water and Hull Fouling Prevention Program;**
- **Development of a system for streamlined reporting of, and rapid response to newly detected invaders;**
- **Securing of dedicated, long-term funding for many of the activities within the plan;**
- **Development of a system for that allows for risk assessment and a way to prioritize AIS;**
- **Increase knowledge on the biology and ecology of AIS, as well as methods for their control;**
- **Continue and increase education efforts, especially those focusing on unauthorized release of organisms.**

Table 1. Summary Table of Strategies to Achieve Objectives

1. Coordination and Collaboration	1A: Continue and improve communication and collaboration among county, State, and Federal AIS programs and activities throughout all of the Hawaiian islands. 1B: Participate in and support appropriate regional, Federal, and international efforts addressing AIS. 1C: Set priorities for the management of existing AIS so that local, state, and Federal resources can be directed to manage Hawaii's highest priority AIS in a cost-effective manner. 1D: Integrate the coordination of AIS efforts with other resource management projects and entities, such as the local, state and federal agencies responsible for chemical use, water quality, and site management, within Hawai'i. 1E: Increase existing funding sources for AIS management, and establish new long-term funding sources.
2. Prevention	2A: Identify possible vectors and pathways of AIS introductions into and throughout Hawai'i, and assess the risks and impacts of these. 2B: Increase enforcement of existing regulations associated with controlling the transport, propagation, sale, collection, possession, importation, purchase, cultivation, distribution, and introduction of AIS. 2C: Reduce the possibility for unregulated purchases of prohibited and restricted AIS stocks that are still readily obtainable for sale or trade. 2D: Work with appropriate industry representatives and user groups who may be potential pathways of AIS introductions to ensure awareness of the threats of AIS, and to develop methods to better assist in preventing the introduction and transfer of AIS. 2E: Minimize AIS introductions and transfers by researchers and others involved in AIS field activities. 2F: Improve current importation practices to effectively address AIS introductions. 2G: Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment, and hull fouling pathways (commercial and recreational). 2H: Assess and minimize activity related to planned, authorized introductions of nonnative species into freshwater systems.
3. Monitoring and Early Detection	3A: Continue current monitoring efforts to better understand the spatial and temporal distribution of AIS populations, and to detect new incipient populations. 3B: Identify gaps in current monitoring efforts referred to in Strategy 3A, and improve these efforts and the coordination of efforts among groups to better ensure detection of new or expanding AIS populations. 3C: Increase the number of knowledgeable individuals available for increased detection and monitoring efforts.
4. Response, Eradication, and Control	4A: Implement a coordinated system for rapid response efforts to contain newly detected AIS. 4B: Prioritize organisms on which to focus control efforts and develop specific control plans to address these. 4C: Integrate knowledge from efforts throughout Hawai'i, nationally, and internationally when dealing with specific species, and develop appropriate species-specific plans. 4D: Continue to develop and implement a comprehensive approach to remove and control the spread of nonnative algae AIS by utilizing mechanical removal, native grazers, and the reintroduction of native species.

-Continued on next page-

Table 1. Continued.

4. Response, Eradication and Control	4E: Continue to address removal and beach restoration strategies for native and nonnative algae species that are involved in large blooms off the island of Maui. 4F: Address harbor designs and the availability of artificial substrata to help minimize the ability for the establishment of new invertebrate arrivals, or the spread of current populations. 4G: Explore the feasibility of promoting the harvesting of potentially invasive marine fish species, such as ta'ape and roi, as a viable control mechanism. 4H: Explore and utilize the various methods available to control priority inland water AIS. 4I: Integrate restoration efforts with control and eradication of inland water AIS. 4J: Explore the feasibility and advisability of encouraging the harvesting of invasive species other than marine fish for commercial applications. 4K: Recognize that degraded habitats may facilitate the decline of native species and/or the proliferation of nonnative species.
5. Education and Outreach	5A: Increase education and outreach efforts toward those who may be potential sources for AIS introductions. 5B: Target policy makers and legislative staff for outreach efforts. 5C: Increase awareness within the scientific community and natural resource agency staff to support the management of AIS. 5D: Develop an education and training program for existing community groups and active ocean users to enable them to assist in early detection and monitoring efforts. 5E: Increase AIS awareness and interest for native species within the educational system. 5F: Raise public awareness, concern, and ultimately, the buy-in on AIS issues for all residents of and visitors to Hawai'i. 5G: Integrate AIS educational efforts into local, cultural, and ethnic community efforts. 5H: Promote clarification of issues and potential misconceptions regarding key taxa of concern, such as ta'ape and roi. 5I: Assess the effectiveness of education and outreach efforts in reaching targeted audiences and changing behavior.
6. Research	6A: Increase the knowledge base of AIS in order to develop effective prevention, control, and overall management programs. 6B: Increase the level of knowledge regarding economic impacts of AIS.
7. Policy	7A: Review the laws and regulations governing AIS in Hawai'i for gaps and overlaps and recommend changes to improve our ability to protect Hawai'i waters from the introduction and spread of AIS. 7B: Promote legislation and administrative rules that establishes or increases the State's authority to control the intentional and unintentional introduction of new species. 7C: Obtain dedicated long-term funding from the Hawai'i State Legislature to implement AIS Management Plan tasks and provide the mandatory matching funds that are needed for Federal grants.

To accomplish these strategies above, a variety of specific tasks are suggested, which are presented in Chapter 4. These tasks have been identified as being key action items in managing the issues of aquatic invasive species more effectively, before many of these species cause further damage to the State.

This plan is structured for phased or incremental implementation. It is expected that the plan is to be a work in progress, with updates made to the plan as necessary.

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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 State.

The Steering Committee and active alternates were a key component in the overall development process, and include the following, in alphabetical order: Scott Atkinson, (The Nature Conservancy), Robbie Kane, (Hawai‘i Tourism Authority), Earl Campbell, (US Fish and Wildlife Service), Domingo Cravalho, (Hawai‘i Department of Agriculture), Lu Eldredge, (Bishop Museum), Ron Englund, (Bishop Museum), Scott Godwin, (Bishop Museum), Dale Hazelhurst, (Matson Shipping), Cindy Hunter, (University of Hawai‘i), Jo-Anne Kushima, (Department of Land and Natural Resources, Division of Aquatic Resources), Kenneth Matsui, (Pets Pacifica/Petland), Kim Moffie, (Hawai‘i Audubon Society/Pacific Fisheries Coalition), Paul Murakawa, (Department of Land and Natural Resources, Division of Aquatic Resources), Celia Smith, (University of Hawai‘i), Mike Yamamoto, (Department of Land and Natural Resources, Division of Aquatic Resources), Leonard Young, (Hawai‘i Department of Agriculture, Aquaculture Development Program), Ron Weidenbach, (Hawai‘i Aquaculture Association). The development of this plan was coordinated by Andi Shluker of The Nature Conservancy of Hawai‘i.

Focus Area Groups were an instrumental component of the plan, as the bulk of the information relating to the identification of marine and inland water AIS problems, as well as specific tasks suggested for management came from questionnaires, interviews, and meetings with these participants. Focus Area Groups generally included the resource managers, researchers, and educators who are considered specialists in their field and/or who are already working to address specific AIS issues across the State. These individuals are listed by specialty in Appendix E.

Additional appreciation is extended to those who went “above and beyond”, taking on the authoring of certain sections. This includes Steering Committee representatives Domingo Cravalho, Ron Englund, Scott Godwin, Paul Murakawa, Jo-Anne Kushima, Kim Moffie, and Mike Yamamoto, as well as Dorothy Alontaga (US Department of Agriculture) and Jennifer Smith (University of Hawai‘i), and those who submitted text for the case studies. Detailed editing and/or comments supplied by Ron Weidenbach (Hawai‘i Aquaculture Association), Bruce Mundy (National Oceanic and Atmospheric Administration), John Ford (SWCA Environmental Consultants) and Kari Lloyd Jones (Contractor to The Nature Conservancy), were a critical part in moving this plan forward beyond its draft version.

Guidance from those outside of Hawai‘i also proved an invaluable asset. Special thanks go out to Scott Smith (State AIS Coordinator, Washington Department of Fish and Game), Holly Crosson (California AIS Management Plan Coordinator), Mark Systma (Oregon AIS Management Plan Coordinator) Paul Heimowitz (Pacific Region AIS Coordinator, US Fish and Wildlife Service), Dean Wilkinson (NOAA), Sharon Gross (US Fish and Wildlife Service), Shawn Alum (US Fish and Wildlife Service), and Bill Wallace (USDA), for providing direction, advice, and/or substantial comments. Appreciation goes out to the States indicated above, as well as to Alaska, Massachusetts, and Maine, for allowing free use of their plans and other documents for assistance in the creation of Hawaii's plan.

This project came into being with primary funding from the Hawai‘i Community Foundation, as well as additional funding from the Department of Land and Natural Resources, Division of Aquatic Resources and The Nature Conservancy of Hawai‘i.

As in many collaborative projects, the list of names to be thanked goes on. Though not all can be listed here, their contributions and participation were very much appreciated and played a large part in the success of the development of this plan.

CHAPTER 1: Introduction

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WHAT ARE INVASIVE SPECIES?

Invasive species pose a constant and costly threat to Hawaii's native ecosystems, ecosystem functions, biodiversity, watersheds, industries including tourism, agriculture, aquaculture, shipping, public health, and the quality of life of residents and visitors.[1]

An "invasive species" is defined as a species that is:
1) nonnative (alien) to the ecosystem under consideration, and
2) whose introduction causes or is likely to cause economic or environmental harm, or harm to human health[2].

Nonnative species refer to plants, animals, and microorganisms transported or established outside of their natural range due to the activities of humans, whether done so intentionally or not[3]. Other names commonly used for nonnative species are alien, exotic, and/or non-indigenous species. Not all nonnative species will become invasive, and not all nonnative species are undesirable in Hawai‘i. Agriculture in Hawai‘i, for example, is based almost entirely on nonnative plants. Many of the brilliant flowers such as orchids and anthuriums, and mango, coconut and banana trees which symbolize Hawai’i in the minds of visitors and residents alike are actually nonnative species (Miller and Holt 1992). However, those nonnative species that do become invasive can have significant negative economic, ecological, and human health impacts that have been extensively documented, and are further detailed in Chapter 2. It must also be noted that even species that at first may appear to be non-invasive may indeed become invasive given the right change in local habitat conditions. This might include the introduction of another alien species, environmental changes, or other factors that give it a biological advantage to allow for invasive proliferation. Because such changes can occur over a long time lag, or quite suddenly, any new introductions into the local environment warrant close scrutiny over time.

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:[4]

- 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.

Aquatic invasive species (AIS) refer to invasive plants, animals, and/or microorganisms that inhabit or complete part of their lifecycle in any type of waterway or body of water. This includes marine, brackish, and/or inland water systems. Here in Hawai‘i, a recently well-publicized aquatic invasive species is *Salvinia molesta* (Giant Salvinia). This water fern virtually covered the entire surface of the 300 acre Lake Wilson/Wahiawa Reservoir on O‘ahu, with clean-up and control costs approaching one million dollars. Giant Salvinia is only one of the many aquatic invasive species in Hawai‘i, and a coordinated approach to their management is needed.

GEOGRAPHIC SCOPE OF THE HAWAIIAN ARCHIPELAGO[5]

The State of Hawai‘i consists of 132 islands, reefs, and shoals stretching 2,400 kilometers in a northwest-southeast direction between latitudes 28°N and 19°N (Price 1983). The Hawaiian archipelago is about 4,000 kilometers from the nearest continent and 3,200 kilometers from the nearest high-island group (the Marquesas Islands of French Polynesia). The eight major high islands, located at the southeast end of the chain (Fig. 1),

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[1] Directly from the CGAPS 2003.

[2] Definition directly from the National Invasive Species Council's management plan, "Meeting the Invasive Species Challenge", 2001.

[3] Department of Land and Natural Resources, Division of Forestry and Wildlife website, Hawaii's Most Invasive Plants: An Introduction, http://www.state.hi.us/dlnr/dofaw/hortweeds/index.html

[4] Text on characteristics directly from Staples and Cowie 2001.

[5] Text for this section directly from Loope, L.L. 1999.

make up more than 99% of the total land area. These islands are part of a longer chain that was produced during at least a 70-million-year period by the northwestward movement of the ocean floor over a hot spot below the Earth's crust.

The relatively tiny eroded and submerged islands and reefs extending to the northwest are remnants of high islands that existed millions of years ago (Macdonald et al. 1983). These northwestern Hawaiian Islands extend northwest of Kauai for 1,210 kilometers, from Nihoa to Kure Atoll. About 40 emergent islands make up a total of about 10.1 square kilometers of dry land. They vary in maximum elevation from 3 to 277 meters.

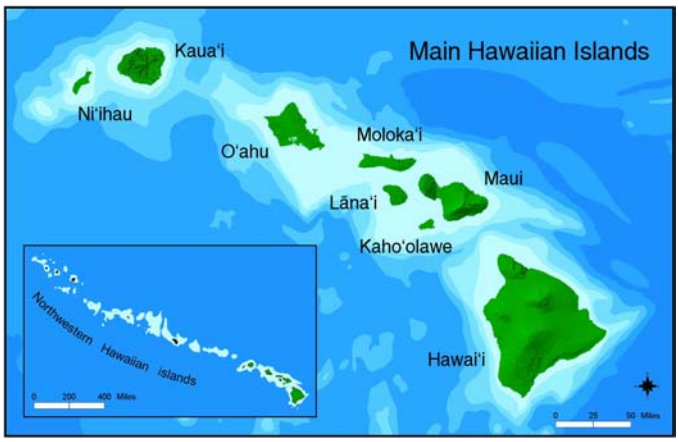

Figure 1. The Hawaiian archipelago. *Courtesy of the Hawai'i Natural Heritage Program*

BIOGEOGRAPHIC SIGNIFICANCE OF INVASIVE SPECIES MANAGEMENT IN ISLAND ECOSYSTEMS[6]

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). Smaller numbers of native species on isolated islands and the intensity of human impacts on small land areas of islands have clearly made the situation worse by increasing most islands' susceptibility to invasion.

Hawai'i is the most isolated group of oceanic islands in the world, and possesses one of the most highly endemic, fragile, and endangered biotas on earth, containing about 40% of the threatened and endangered species in the United States (Cox 1999).[7] Since Hawai'i also happens to be a major transportation hub and tourist destination with little special protection from invaders in the other 49 US states, it is already extensively invaded (Loope, pers. comm.). Unless drastic changes are made in national and State policies relating to prevention of invasions, the State is poised to receive many additional invasions in the near future. (Loope, pers. comm.).

BENEFITS OF CREATING AN AQUATIC INVASIVE SPECIES (AIS) MANAGEMENT PLAN

The Federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, (NANPCA 1990, later amended to the National Invasive Species Act of 1996) established the framework for a comprehensive AIS program. This included the establishment of a Federal Aquatic Nuisance Species Task Force, and called for the development of State and regional management plans to assist in the control of AIS. In developing the State of Hawai'i AIS Management Plan, the coordinator has closely followed the guidelines of the Federal Aquatic Nuisance Species Task Force, as presented in the "Guidance for State and Interstate Aquatic Nuisance Species Management Plans" (2000).

Financial Benefits

Should this AIS Management Plan be approved by the Federal Aquatic Nuisance Species Task Force (via submission of the plan to the Task Force by the Governor), Hawai'i will be eligible to receive Federal funding

[6] Unless indicated otherwise, text directly from Loope, L.L. 1999.

[7] Text directly from SRGII 2002a.

assistance for tasks and activities detailed in the plan. Additionally, having a coordinated plan in place will also facilitate obtaining additional funding from other sources to implement these tasks and activities.

Additional benefits[8]

Regardless of financial incentives, a State AIS management plan is a valuable and effective tool for identifying and addressing AIS problems and concerns in a climate of many jurisdictions and other interested entities. The specific benefits of AIS management plans that have been suggested by the Federal Aquatic Nuisance Species Task Force include:

- Describing multiple AIS activities underway in the geographic area covered, and providing opportunities for improving the coordination of involved organizations and the effectiveness of their activities;
- Describing and documenting AIS problems and the respective roles of the involved organizations for systematically prioritizing and resolving those problems;
- Informing the public of problems and solutions through participation in the process and by sharing the plan with the public; this should yield more support for addressing problems and for taking actions to reduce AIS impacts;
- Encouraging organizations in the same geographic area to share information, develop consistent, coordinated and complementary plans, reduce duplication of effort, and collaboratively support implementation;
- Improving collaboration between national, regional, State and local efforts.

GOAL AND OBJECTIVES OF THE HAWAI'I AIS MANAGEMENT PLAN

This goal of the Hawai'i AIS Management Plan is to: *"Minimize the harmful ecological, economic, and human health impacts of AIS, through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawai'i."*

To assist in obtaining this goal, seven major objectives have been identified:

- COORDINATION and COLLABORATION:
  Improve the coordination and collaboration of people, resources, and efforts involved with AIS.
- PREVENTION:
  Minimize the introduction and spread of AIS into and throughout the waters of Hawai'i.
- MONITORING and EARLY DETECTION:
  Ensure effective programs that allow for the early detection of new AIS and the monitoring of existing AIS.
- RESPONSE, ERADICATION and CONTROL:
  Establish effective systems for rapid response, eradication, control, and restoration.
- EDUCATION AND OUTREACH:
  Increase education and outreach efforts to ensure awareness throughout the State on AIS threats and solutions.
- RESEARCH:
  Increase research efforts on key AIS species, associated issues, and economic impacts to allow for more effective management.
- POLICY:
  Ensure State laws and regulations effectively promote the prevention and control of AIS.

Associated strategies and specific tasks pertaining to each of the above objectives are presented in Chapter 4. These tasks have been identified as being key action items in managing the issues of aquatic invasive species more effectively, before many of these species cause further damage to the State.

[8] Text directly from the Federal ANS Task Force "Guidance for State and Interstate Aquatic Nuisance Species Management Plans", http://www.anstaskforce.gov/state_guidance.htm.

Various efforts are already underway across the State to address AIS issues, and this document is not intended to "re-invent the wheel". Rather, this plan notes the current efforts, but also identifies areas for improvement. It can be thought of as a tool to provide a framework for identifying additional activities and tasks needed for the effective management of AIS in Hawai'i, and to provide opportunities for further coordination of the efforts that are already underway.

PROCESS AND PARTICIPATION

Organization:
The Division of Aquatic Resources (DAR), under the Hawai'i Department of Land and Natural Resources (DLNR), initiated the development of this comprehensive Aquatic Invasive Species Management Plan. DLNR-DAR subsequently contracted with The Nature Conservancy (TNC) of Hawai'i to coordinate the development of the plan. The development of the State of Hawai'i AIS Management Plan is being made possible through a generous grant from the Hawai'i Community Foundation.

Many individuals, organizations, and agencies were involved with the development of this plan, and as such this plan includes the direct input of numerous individuals with biological, natural resource management, and educational expertise, as well as industry and other public stakeholders. Figure 2 shows a general organizational diagram of the many entities involved.

The Steering Committee is made up of representatives from State, Federal, and private agencies, as well as representatives from the following industries: tourism, aquaculture, aquarium/pet supply, and maritime shipping. Feeding into the Steering Committee were various Focus Area Groups, which are primarily made up of individuals with biological, natural resource management, and/or educational expertise.

In addition, Affiliate members included those agencies and individuals that were interested in the development of the plan, but either due to lack of time availability, lack of resources, and/or lack of specialized knowledge, did not participate directly in the Focus Area Groups. Industry members consisted of individuals and organizations that had concerns about impacts of the plan itself, and as such, wanted to be kept abreast of the development process. All contributors are presented in Appendix E.

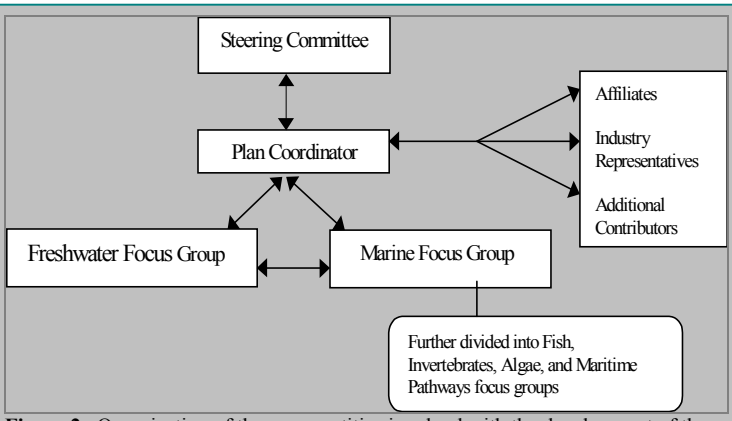

Figure 2. Organization of the many entities involved with the development of the Hawai'i Aquatic Invasive Species Management Plan.

Information Collection Process:
All representatives of the Steering Committee, Focus Area Groups, and Affiliates received initial assessment questionnaires that focused on the key objectives of the plan detailed earlier in this chapter. Input from the questionnaires was gathered via written responses, phone conversations, and personal interviews. Additional information was gathered via meetings and workshops, from agencies' web sites, published papers, current proposals and grants, as well as from other State and Federal plans. Using all of this information as a base, specific strategies and tasks were then developed to address the management of AIS in Hawai'i.

Public Meetings:
Public comment during the development of this document has been an important component. Stakeholder meetings were held on the islands of Maui, Hawai'i, and O'ahu early on in the development process. Participants at these meetings represented a range of organizations and interests, and included Federal, State, and county representatives, industry representatives, researchers, and others. These stakeholder scoping

meetings were successful in offering perspective on AIS issues, and wherever possible, comments received at these meetings have been incorporated into the plan, especially into the suggested management tasks presented in Chapter 4. A full summary of questions, comments, and responses from each of these scoping meetings is included in Appendix F.

In addition, a draft version of the plan was available for a three-week public and agency review and comment period. The draft was posted on the Department of Land and Natural Resources, Division of Aquatic Resources website, and hard copies were distributed upon request. Press releases of the public comment period and associated public information meetings were issued to all local newspapers, and related articles ran in the Maui News and the Honolulu Weekly. Notice of the public comment period was also published in additional local island newspapers and posted on electronic list-servers, as well as sent to all individuals involved with the drafting of this plan, including industry and affiliate members, and the major aquaculture development entities. Public information meetings during the public comment period were held on Kauaʻi, Molokaʻi, Lanaʻi, and in Kona on the island of Hawaiʻi. The Federal Aquatic Nuisance Species Task Force also had one-month period for preliminary review of the draft version of the plan.

Over thirty individuals and agencies submitted comments as part of this review period. All comments received during the comment period were reviewed, and many changes and suggestions have been incorporated. All written comments are available for further review as part of a separate attachment to this plan.

CLARIFICATION OF TERMINOLOGY

Appendix I features a glossary of many of the terms used in this plan. All definitions supplied are referenced from accepted sources. A few additional points are worth clarifying:

"Nuisance", or "Aquatic Nuisance Species (ANS)"
The term "nuisance species" is commonly used as a synonym for invasive species, and some of the earlier Federal legislation referring to the management of aquatic invasive species reflects this. This plan began its development as the Aquatic Nuisance Species Management Plan, but to reflect the trend in current terminology, all references to "nuisance" have been changed to "invasive". The exception is when referring to publications, groups, and/or legislation that have the word "nuisance" in the original terminology. An example of this is the Federal Aquatic Nuisance Species (ANS) Task Force.

"Nonnative" versus "Alien"
As referred to in the first part of this chapter, there are many synonyms commonly used for nonnative species, including alien, exotic, and/or non-indigenous. In an effort to be consistent with terminology throughout the plan, the term "nonnative" will be used when referring to those species that are not within their natural range or zone of dispersal. The exception to this is when referring to titles of publications, groups, and/or legislation that have terms such as alien, exotic, etc., in the original terminology. An example of this is the State's task force on ballast water and hull fouling issues, called the Alien Aquatic Organism Task Force (AAOTF).

Aquatic and Inland Water Systems
For the purposes of this plan, “aquatic” systems are generally intended to refer to all types of natural water systems (both marine and inland waters). However, artificial systems such as reservoirs, irrigation ditches, etc., are also included in this term, unless noted differently. As used in this plan, “inland waters” are meant to encompass all non-marine water bodies, and includes streams, lakes, reservoirs, ditches and flumes, springs, bogs, marshes, swamps, anchialine ponds, and estuaries. (Polhemus et al. 1992).

SCOPE AND LIMITATIONS OF THIS PLAN

Though this plan is meant to be comprehensive, there are limitations to its scope that had to be recognized during the development process. Examples of aspects of the plan that may not have been developed to their fullest include micro-organisms and wetland / estuarine systems. Micro-organisms (bacteria, viruses, diseases, protists) are certainly part of the invasive species problem, and though they are alluded to in this plan in areas

such as ballast water and hull fouling, the focus of this plan at least for the first year is largely on macro-organisms. This was done in attempt to be realistic in where efforts could be initially focused, and in no way is meant to indicate that these micro-organisms are not just as important in terms of their threats. In addition, though this plan is inclusive of all types of aquatic habitats, for various reasons, wetland and estuarine environments did not receive as much emphasis as pure freshwater or marine environments. This is not meant to imply that these environments are any less important to Hawai‘i. On the contrary, wetland and estuarine associated environments are a critical component of Hawaii's aquatic systems, and increased efforts will be made to better integrate these types of systems into the subsequent year's updates to the plan, as well as into efforts planned for the near-term.

In addition, it is recognized that there are a few native species of marine algae that are causing economic and ecological damage, due their ability to form massive blooms and show other "invasive-like" characteristics.[9] While this plan will not focus on these native species, it is emphasized that an understanding of the root causes of these native blooms will be a key component in better understanding and controlling the nonnative algal blooms.

HOW DOES THIS AIS MANAGEMENT PLAN RELATE TO THE OVERALL MANAGEMENT OF INVASIVE SPECIES IN THE STATE?

Aquatic invasive species are just one component of a serious invasive species problem that exists in Hawai‘i. In 1992, the Federal Office of Technology Assessment declared Hawaii's pest problem the worst in the nation (CGAPS 1997), in large part due to a lack of coordination between agencies responsible for addressing the issue. In response to this need, the Coordinating Group on Alien Pest Species (CGAPS) was formed in 1994 with participants from government agencies and non-government organizations that deal with invasive species issues in Hawai‘i[10]. CGAPS' efforts to address invasive species have been significant, but for various reasons these efforts have largely focused on terrestrial aspects. Through the development of this plan, there has been strong integration and cooperation with CGAPS and other participating agencies and organizations, to ensure that this plan is not an end in itself, but rather a part of the greater picture.

Also, in recognition of the ongoing need for cabinet-level participation and leadership in invasive species issues, the Hawai‘i Invasive Species Council (HISC) was formed under statutory authority this past legislative session.[11] The HISC is charged with addressing both terrestrial and aquatic invasive species issues and will provide further opportunity to integrate aquatic aspects into efforts already underway throughout the State.

In summary, the State of Hawai‘i Aquatic Invasive Species Management Plan addresses the need for coordinated thinking and planning regarding aquatic aspects of the larger invasive species issue. It is a major step in the development of a comprehensive program to protect Hawai‘i from invasive species. Though this plan specifically focuses on aquatic invasive species, it should be viewed as a component of a larger effort of addressing all invasive species, both aquatic and terrestrial, throughout the State.

[9] Native species referred to are further detailed on page 2-2 and in Appendix A, p. 11.
[10] CGAPS is further detailed on pages 2-17 and 3-19.
[11] HISC is further detailed on page 3-14.

CHAPTER 2:
Problems and Concerns

CHAPTER 2: PROBLEMS AND CONCERNS

This chapter is intended to present an overall perspective of AIS problems and issues, including specific examples associated with marine and inland water habitats of Hawai‘i. A preliminary listing of potential pathways is then presented, followed by discussion on current gaps in the prevention system, and well as the identification of specific aquatic invasive species in Hawai‘i. A case study concludes the chapter, which highlights the idea that solutions to AIS are not always straightforward.

NEGATIVE IMPACTS OF INVASIVE SPECIES[12]

Though not all introduced species will become invasive, those that do can have significant negative impacts in the areas where they become established. Sometimes the impacts are dramatic; but more often they are subtle and may escape notice for some time. Throughout the world, and in Hawai‘i, the negative impacts of invasive species include the following:

Public Health and Quality of Life Impacts

- Public health problems associated with parasites and disease;
- Impacts to humans causing annoyance, discomfort, and illness;
- Decreased recreational opportunities.

Economic Impacts

- Increased cost of doing business by interfering with current systems, processes, or equipment (such as from hull and other bio-fouling);
- Decreased property values;
- Increased production costs (through crop pests and associated increased use of chemicals, fumigation, or post-harvest treatments or processing);
- Increased quarantine problems, such as needed restrictions or requirements;
- Loss of tourism revenue;
- Near-shore fishery impacts;
- Costs associated with clean-up and control.

Cultural / Traditional Impacts

- Competition with native species used in subsistence harvesting;
- Degradation of culturally important habitats (such as Hawaiian fishponds);
- Disintegration of cultural resources (such as Hawaiian fishponds and native Hawaiian habitats) for use with cultural education and practice of traditional knowledge for children and communities.

Environmental Impacts

- Loss of native biodiversity due to:
  - invasive species preying upon native species;
  - decreased habitat availability for native species;
  - additional competition;
  - parasites and disease;
  - smothering and overgrowth (leading to loss of key reef building species);
  - genetic dilution;
- Functional changes of freshwater, estuarine, other inland waters, and nearshore marine ecosystems;
- Alterations in nutrient cycling pathways;
- Decreased water quality.

Specific examples of the above impacts in Hawai‘i are further detailed on the following pages.

[12] Overview text and categories of impacts are adapted from Staples and Cowie, 2001, and from Remec, A. and Lee, H. personal communication 2003.

SPECIFIC PROBLEMS AND CONCERNS: MARINE SYSTEMS

Despite the worldwide threat posed by non-indigenous species, very few large-scale eradication programs have been successful in the marine environment. Further, the control programs that have been successful within a marine environment dealt with harbors or embayments, leaving little guidance for addressing control issues within coral reef environments.

Marine Algae[13]

At least 19 species of macroalgae have been intentionally or passively introduced into Hawai‘i since the mid-1950s (Appendix K, Table K-2); (Doty 1961, Brostoff 1989, Rodgers and Cox 1999, Russell 1987, 1992, Woo 1999, Smith et al. 2002, Smith et al. in press). At least five have successfully established and dispersed around the Hawaiian Islands, and are now ecologically dominant in some locations, where they appear to be outcompeting native benthic species (Smith et al. 2002). Each of these five algal species has become the dominant component of a number of reef environments, with three of the species, *Gracilaria salicornia*, *Hypnea musciformis*, and *Kappaphycus* spp., forming extensive, destructive blooms. *G. salicornia* and *Kappaphycus* spp. in particular have been observed in recent surveys to be invading coral habitat and overgrowing reef building corals in Kane‘ohe Bay, the south shore of O‘ahu including the world famous Waikiki area, and the south shore of Moloka‘i, which harbors some of Hawaii's most intact and expansive coral reef ecosystems (Russell 1983, 1992, Hodgson 1994, Rodgers and Cox 1999, Nishimura 2000, Woo 1999, Eldredge and Smith 2001, Smith et al. 2002, Smith et al. in press). These species thus pose an immediate threat to the health of Hawaii's coral reef ecosystems (Smith et al. 2002, Smith et al. in press).

Native Algae Species Are Also of Concern for Hawai‘i[14]

Though they do not fall under the definition of AIS because of their native status, a few native macroalgae species also form large blooms and cause substantial problems in Hawai‘i.[15] These native species are acknowledged in this plan because they pose the same threats as their nonnative/invasive counterparts. To propose to address the threats associated with nonnative/invasive algae blooms, without considering these native blooms as well, would present an incomplete picture, and subsequently lead to incomplete management solutions.

Most of the significant native algal blooms in Hawai‘i have persistently occurred in coastal Maui waters, and involve the green algal species *Cladophora sericea* and *Ulva fasciata.* As an example, for at least the last decade, heavy blooms of the native *U. fasciata* (and the nonnative *H. musciformis)* in the north Kihei -Waipuilani area of Maui, as well as substantial blooms of the native *C. sericea* on the northwestern coast of Maui, have led to massive accumulations of the alga upon the associated beaches. The extent of the accumulation has led to a decrease in recreational use of the areas due to the strong offensive odor that is produced from the rotting algae, combined with the issue that many feel the nearshore waters are too polluted with algae to swim. Given that the stretches of beach where these blooms occur are lined with large condominium complexes and are popular tourist destinations, the impacts from the blooms on the areas is considered quite severe, and is harmful to the economy as detailed below.

As stated in the introduction, while this plan will not focus on these native species, it is emphasized that understanding the root cause of these native blooms will be a key component in better understanding and controlling the nonnative algal blooms.

Ecological Effects of Algal Blooms (of both nonnative and native species)

Algal blooms pose a severe threat to near shore ecosystems, as the algae can quickly invade habitats typically dominated by corals and other native diverse algal and invertebrate communities. Algae overgrow and subsequently kill coral by smothering, shading and abrasion. Such increases in benthic algal abundance at the expense of coral can lead to reduced organism diversity on reefs (McClanahan et al. 1999). Indeed, in the past several years, algae blooms on Hawaii's coral reefs have caused decreases in biodiversity and coral cover (Rodgers and Cox 1999, Woo 1999, Nishimura 2000, Smith et al. 2002). This decrease in biodiversity can ultimately lead to the degradation of the physical structure and biological complexity of reefs (Done 1992). Further, these introduced macroalgal species are

[13] Adapted and excerpts taken directly from the grant proposals by Atkinson et al. 2003a and Smith et al. 2002.

[14] Adapted and excepts taken directly from Coloma-Agaran, G. 2003.

[15] Three native algae species that have posed concern in Hawai‘i are detailed in Appendix A, page 11.

able to overgrow and subsequently kill reef building coral (Woo 1999, Smith and Conklin unpublished data) as a result of increased growth rates. Once this so called 'phase-shift' has occurred, there is no indication that the reef community will ever be able to recover and shift back to dominance by reef building corals.

Economic Costs of Algal Blooms (of both introduced and native species)[16]

In addition to the ecological damage caused by blooms, extensive economic costs are also incurred. Hotel and condominium owners in the impacted north Kihei - Waipuilani area of Maui contribute $50,000 each year to clean the algae off the beaches. Further, a recent study (Cesar et al. in press) funded by the Hawai'i Coral Reef Initiative Research Program estimates that on Maui's Kihei coast, over $20 million in potential revenue is lost each year to algal blooms. This loss in potential revenue is a result of reduced property values and reduced occupancy rates in hotels and condominiums in impacted areas, as well as direct costs associated with the removal of the rotting and foul smelling algae off the beaches. Specifically, these blooms are estimated to depress property values by $9.4 million annually, and to decrease hotel and condominium rental income by $10.8 million annually. The resulting tax loss to the State from this one community due to these algal blooms is estimated to be in excess of $1.8 million annually.

Though There is No Easy Solution, There is a Need for Action

Though the impact of nonnative algal blooms is substantial where they do occur, currently the blooms appear to be occurring in relatively discrete areas, as supported by the following observations:

- The island of Hawai'i has relatively few species of nonnative algae. Populations and associated blooms seem to be isolated in the Kona and Hilo areas near the harbors, including at the Kaloko Fishpond at Kaloko-Honokohau National Historical Park and at Pu'ukohola Heiau National Historic site.
- While the population of *G. salicornia* on Moloka'i is large, it also appears to be primarily restricted to the southeastern coast.
- Large areas of O'ahu and Maui do not yet have extensive nonnative algae blooms, though the current populations are known to be spreading.

These somewhat discrete geographical distributions offer some hope for controlling the expansion of the harmful blooms, before they spread to other areas. However, in the past several years there has been strong evidence that several species of nonnative algae are rapidly spreading into new areas, suggesting that Hawaii's reefs are increasingly at risk (Rodgers and Cox 1999, Smith et al. 2002, Smith et al. in press). This suggests that without human intervention, these blooms will continue and the nonnative species are likely to spread, thereby increasing the problems at other sites throughout the State of Hawai'i in years to come.

Marine Fish

A Brief History of Introduced Marine Fish to Hawai'i

Thirty-four species of marine fishes have been introduced into Hawaiian waters, and at least twenty of these introduced species have become established (see Appendix K, Table K-1) (Englund and Eldredge 2001; Eldredge and Carlton 2002). Of those that have become established, thirteen species have been authorized, planned releases and at least seven species were accidental introductions (Englund and Eldredge 2001). Potentially, many more cases exist but have gone undocumented in Hawai'i.

Introductions for Fisheries Purposes

Between 1955 and 1961, the State of Hawai'i introduced eleven species of shallow water snappers and groupers to O'ahu and the island of Hawai'i as potential food fish (Oda and Parrish 1981). Of these eleven species, three are known to be established in the nearshore reef fisheries of Hawai'i: *Lutjanus kasmira* (blueline snapper or ta'ape), *Cephalopholis argus* (peacock grouper or roi), and *Lutjanus fulvus* (to'au) (Oda and Parrish 1981).

[16] Text taken directly from Atkinson et al 2003a, and Davidson, K. et al (eds). 2003.

Ta‘ape and Roi - Are they a Problem?[17]

Ta‘ape (*Lutjanus kasmira*/blueline snapper) and roi (*Cephalopholis argus*/peacock grouper) were introduced by the State as food fish in the late 1950s. However, there are strong differences of opinions among some fishers and researchers as to the level of impact these species have on the native fish and associated fisheries. Many fishers and aquarium collectors blame a decrease in fish abundance and associated catch on the prevalence of the introduced roi and ta‘ape. However, researchers in this field contend that roi and ta‘ape may have less impact than is thought by the fishers and aquarium collectors, and research to date suggests that ta‘ape and roi may not necessarily be biological concerns in regard to native fisheries. Because of the differing opinions as to whether ta‘ape and roi are a problem in terms of AIS, a primary focus of this plan in regards to marine fish species should be to better understand the true impacts of ta‘ape and roi upon the native species. Funding and studies to better understand these impacts are currently underway, as detailed in Appendix C.

Other Fishery-Related Introductions (Intentional and Unintentional)[18]

Several species of tilapia have been introduced from Africa to Hawai‘i and other tropical Pacific Islands. For example, *Oreochromis mossambicus* (Mozambique tilapia) was purposely introduced to Hawai‘i and elsewhere for aquatic weed control, food, and as a tuna baitfish (Nelson and Eldredge 1991). *Sarotherodon melanotheron* (salt-water tilapia) accidentally escaped from confinement in Hawai‘i, where it was being evaluated as a tuna baitfish (Randall 1987).

Are All Tilapia Considered Invasive?

Tilapia species are difficult to identify, even for the experts. To complicate matters, many species freely interbreed, producing fertile hybrids with characteristics of both parents.[1] For these reasons, tilapia will generally be addressed collectively in this plan, though it is noted that not all tilapia species are considered invasive, and some tilapia species are important food fish in Hawai‘i.

[1]Yamamoto and Tagawa 2000

Tilapia: Marine or Inland Water Species?

Tilapia are generally considered to be an inland water (in freshwater and brackish water environments) fish, but in Hawai‘i, they live in a variety of habitats, from cold water reservoirs to warmer shoreline waters off Waikiki.[1] Because of the ability of some tilapia species to proliferate in marine waters, they are included in this section discussing marine issues.

[1] Yamamoto and Tagawa 2000

A species of baitfish, the Marquesan sardine (*Sardinella marquesensis),* was purposely introduced into Hawai‘i for aku fishing (Williams and Clarke 1983). With this species came two other fishes, the mullet (*Valamugil engeli)* and the goatfish (*Upeneus vittatus*), which were inadvertently introduced to Hawai‘i with the Marquesan sardine. The former may be displacing native mullet (*Mugil cephalus*) in some estuaries and aquaculture operations (Eldredge 1987, 1994). Ecological effects of the introduced goatfish are unknown (Randall 1987).

Fisheries-related introductions declined to a low level by the early 1960s.[19] The most notable exception is the nonnative goldspot herring (*Herklotsichthys quadrimaculatus*) that was accidentally introduced via transport of live bait to the islands in 1972 (Baldwin, 1984). This species has displaced the earlier introduced Marquesan sardine (*Sardinella marquesensis*) in many areas (Williams & Clarke 1983).

Non Fishery-based Introductions[20]

The introductions of marine fishes for planned, government sanctioned fisheries purposes (enhancement, bait culture) was the dominant pathway for establishment of nonnative fishes from territorial days through ca. 1960. After this time, it is thought that a primary source of introductions occurred through non-sanctioned sources, suspected to be mostly from shipping (ballast water or hull fouling) or related to the aquarium hobby.

Introductions of nonnative marine fishes via shipping were first recorded after World War II, and this pathway is of increasing concern. Several nonnative fish species were recorded by Chapman & Schultz (1952) from a drydock that was moved to Pearl Harbor from Guam ca. 1949, though none of these species are known to have

[17] This section compiled from Birkeland, Dierking, Friedlander, Parrish, and Walsh, personal communication.

[18] Unless indicated differently with footnotes, text from this section excerpted directly from DeMartini et al. 1999, and includes references from that paper.

[19] Text for this paragraph supplied by B. Mundy (NOAA Fisheries).

[20] Text for this section supplied by B. Mundy (NOAA Fisheries) and E. Baumgartner (University of Hawai‘i).

established reproducing populations in Hawai‘i. Perhaps more significant is the establishment of three introduced small cryptic fish species that probably arrived via shipping sources more recently: 1) The mangrove blenny, *Omobranchus rotundiceps obliquus*, documented in 1955 (Strasburg 1956), is found throughout O‘ahu; 2) the tasseled blenny, *Parablennius thysanius*, documented in 1991 (Springer 1991), remains confined to South Kane‘ohe Bay, O‘ahu, and 3) the fang blenny, *Omobranchus ferox*, documented in 2000 (Englund and Baumgartner 2000, Yamamato and Tagawa 2000), has begun to spread from the Halawa estuary in O‘ahu throughout the Honolulu Harbor area.

As may be expected with these cryptic species, the effects of these fish on native populations are unclear. Small fishes tend to be overlooked and ignored in many studies; because of this, small invaders may not be noticed, or may be ignored as insignificant until they have become extremely successful in the invaded community (Baltz 1991). Further, in many communities, the effects of these fish upon the ecosystem are unknown because the native community of small cryptic fishes is also largely unstudied. However, preliminary work has shown that population size of *O.r.obliquus* has been negatively correlated with population size of the native goby *Eviota susanae*, although the underlying reason for this relationship is uncertain. Additionally, the examination of stomach contents has indicated potential dietary overlap between *P. thysanius* and *E. susanae,* as both species primarily consume small crustaceans. However, the species composition of the diet may not be identical because the taxonomic level of examination was relatively high. These preliminary studies suggest that effects may be present, and that these introduced cryptic species may, in fact, be considered invasive species, once more information is known.

Appearances of nonnative marine fishes popular in the aquarium trade in open waters of the State have also increased in the past 40 years, although almost all such introductions have been of single or a few individuals that failed to establish reproducing populations. Examples of observations documented in publications include: the emperor angelfish (*Pomacanthus imperator*) in the 1980s (Randall 1987); the panther or humpback grouper (*Cromileptes altivelis*) in the mid-1980s and 1990s (Randall 1980; Randall & Heemstra 1991); and the south seas devil (*Chrysiptera taupou*) on O‘ahu in 2002 (Scott 2003), among others. In addition, other nonnative fishes popular in the aquarium hobby have been reported by underwater photographers and other divers, but records of these have not been confirmed or published. As alluded to earlier, it is important to point out that most of these cannot be attributed with certainty to a specific method of introduction, but it is clear that these introductions were not authorized.

Offshore Cage Aquaculture: A New Area of Concern for Marine Fish Introductions?

Applications have been submitted to the State for the importation of nonnative stocks to be used in open-water marine cages. However, to date, these applications have been denied, and no nonnative species have been allowed for this type of use in Hawai‘i.

Marine Invertebrates

How Many Nonnative Marine Invertebrate Species are Here? [21]

Through the Hawai‘i Biological Survey at the Bishop Museum, 201 marine and brackish water invertebrate species have been identified as introduced to Hawai’i, and 86 cryptogenic (not demonstratively native or introduced) (Appendix K, Table K-1). In total, this makes up about 7% of the known marine and brackish water invertebrate fauna in the Hawaiian islands (4099 species). Of the 287 introduced and cryptogenic species, 248 (87%) have become established, 15 (5%) arrived but failed to become established, 6 (2%) were intercepted, and the population status of 18 species (6%) is unknown.

Marine invertebrate Pathways

The greatest number of marine invertebrates have probably arrived in Hawai‘i through hull fouling, but many may have arrived with solid ballast and in ballast water.

A number of purposeful introductions of commercially important shellfish are also well documented for Hawai‘i, including mangrove crab (*Scylla serrata)* from Samoa; oysters *(Crassostrea* spp.) from San Francisco; and littleneck

[21] Text from this section taken directly from Preskitt et al. 2001, Eldredge and Carlton 2002, and from Eldredge, L. (Bishop Museum), personal communication, 2003.

clams (*Tapes japonicum*) from Japan.[22] Ecological impacts are largely unknown for these introductions, but *Crassostrea* spp. is very dominant in Pearl Harbor West Loch and *S. serrata* is common in brackish seawater systems, including mangroves and fishponds, and is a generalist feeder.[23]

Distribution of Nonnative Marine Invertebrates[24]

The majority of the nonnative marine invertebrates in the main Hawaiian Islands have been recorded within harbors, yacht basins, and embayments. Few nonnative marine invertebrates have been recorded from reef areas outside these habitats, but this may be an artifact of the sampling effort that has focused on these altered habitats. The makeup of the nonnative and cryptogenic marine invertebrate fauna in harbors and yacht basins throughout the main Hawaiian Islands has shown to be quite consistent, and represents roughly 20% of the fauna identified from the surveys (Coles et al. 1997, 1999 a, b). Surveys that have been conducted on remote reef areas, such as the Northwestern Hawaiian Islands (Defelice et al. 2002, Godwin personal communication 2003), have shown a small percentage of nonnative marine invertebrates that are also recorded in the harbors of the main Hawaiian Islands. Considering the minimal exposure to anthropogenic influences these remote areas receive, even this small occurrence of nonnative marine invertebrates demonstrates the potential for dispersal from harbor environments to outside reef environments.

Some examples of nonnative marine invertebrate species that have been recorded outside of harbor environments in the main Hawaiian Islands include the intertidal barnacle *Chthamalus proteus*, subtidal octocoral *Carijoa riisei,* and the hydroid *Pennaria disticha,* all from the Tropical Western Atlantic, and the Indo-Pacific stomatopod *Gonodactylaceus falcatus*. The hydroid *Pennaria disticha* has been recorded commonly in harbors and embayments throughout the main Hawaiian Islands and also has been

Three Examples of Marine Invertebrate AIS in Hawai‘i

***Carijoa riisei* (Snowflake Coral)**

Carijoa riisei is an octocoral first reported in Hawai‘i in 1972. Up until recently, *C. riisei* appeared to be a relatively benign introduction thought to be occupying previously underutilized habitat and producing no recognized negative impacts on the overall reef community.

However, observations in 2001 have elevated its invasive status, as a large-scale survey of the Maui Black Coral Bed revealed that *C. riisei* have virtually exploded in abundance at many stations at depths between 75-100m. This depth represents the lower limits of the black corals *Antipathes dichotoma* and *A. grandis,* the two species that make up 100% of the commercial harvest of black coral collected annually from the Maui Bed. This fishery produces over $30 million in annual retail sales of precious coral jewelry (Grigg 2001). The 2001 survey showed that up to 90% of the black coral colonies of both species that occur in this zone are dead, having been overgrown by *C. riisei.* Though the black corals that occur in this depth range are too deep to be harvested by traditional methods, this segment of the population is important as a source of larvae for re-seeding the shallower portions of the population that are subject to harvest, and *C. riisei* is now considered the most invasive marine invertebrate on Hawaiian reefs.

***Chthamalus proteus* (Caribbean Barnacle)**

This small barnacle lives in the high intertidal and is thought to have arrived in Hawai‘i sometime after 1972. It is now the most abundant organism in the upper intertidal areas in many harbors and bays throughout the main Hawaiian Islands, and it occurs as far west as Midway and Guam.

It can likely cause negative impacts on native species in habitats in which it has become established, though these may be subtle and remain largely untested. However, *C. proteus* is likely to have been responsible for almost completely displacing another nonnative barnacle, *Balanus amphitrite*, in some areas where they co-occur.

***Gonodactylus falcatus* (Philippine mantis shrimp)**

The first reported sighting of this stomatopod was in Kane‘ohe Bay in 1954. These crustaceans are generally carnivores, using their powerful claws to snap at prey. As an aggressive species, this one has been shown to drive out the native stomatopod *Pseudosquilla ciliata,* and has almost completely replaced it in the coral heads of the shallow reefs of O‘ahu.

-Text for these three species supplied by Grigg, R., Zabin, C., and Godwin, S. respectively, as part of larger descriptions found in Appendix A.

[22] Text directly from DeMartini et al. 1999.

[23] Coles, S. (Bishop Museum), personal communication. 2003.

[24] This section compiled by Godwin, S. (Bishop Museum) and Coles, S. (Bishop Museum)

documented on over half of the Northwestern Hawaiian Islands (Defelice et al. 2002, Godwin personal communication 2003). All of these species have the potential to compete for food resources and space in coral reef environments, with the exception of *C. proteus*, which has the potential for these effects within the intertidal community.

SPECIFIC PROBLEMS AND CONCERNS: INLAND WATER SYSTEMS

A History of Introductions[25]

Today, more than 50 species of nonnative fishes, invertebrates, reptiles, amphibians and plants are established in Hawaii's streams, reservoirs, and other inland waters. Some of these plants and animals were intentionally released (both through authorized and unauthorized introductions) with the hope that they would become established, and in some way improve the quality of life in Hawai‘i. Other species were simply dumped in streams and other inland waters, likely without thought given to possible consequences. Mixed in with these two groups were "hitchhikers" like nonnative diseases, parasites, and snails that were accidentally introduced at the same time.

Hawai‘i has a long history of inland water introductions, going at least as far back as the 1800s. With the arrival of the first immigrants from Asia, many of the species introduced at this time were brought for food purposes, and include Chinese catfish (*Clarias fuscus*), ricepaddy eel (*Monopterus albus*), snakehead (*Channa maculata*), common carp (*Cyprinus carpio*), Japanese weather fish or dojo (*Misgurnus anguillicaudatus*), and soft shelled turtles (*Trachemys scripta elegans, Pelodiscus sinensis, Palea steindachneri*). A few additional species, such as goldfish (*Carassius auratus*), were introduced for ornamental purposes.

During the early 1900s, and through the 1960s, several species of poecilids (locally known as topminnows, medaka, or tabai) were released by the State into streams and reservoirs for mosquito control. Various species of tilapia (*Oreochromis, Sarotherodon*, and *Tilapia* spp. and their hybrids) were brought in to help the sugar plantations control weeds in their irrigation systems and to provide baitfish for the aku / skipjack tuna (*Katsuwonus pelamis*) fishery. Several species of sportfish, including trout (*Oncorhynchus, Salmo*, and *Salvelinus* spp.), large and small mouth bass (*Micropterus dolomieu*), tucunare (*Cichla ocellaris*), oscar (*Astronotus ocellatus*), and channel catfish (*Ictalurus punctatus*) were brought in by the State for recreation purposes.

By the 1970s, over 70 different species had been intentionally introduced into the inland water ecosystems, and approximately half had become established. At that time, there was also an increase in knowledge regarding native and introduced species, which led to a decline in new introductions. Previously unappreciated, the native flora and fauna of Hawai‘i became recognized as being unique and precious in their own right. The focus shifted from 'improving' these resources to preserving what was left. There was a sharp decline in State sponsored introductions of nonnative species, and a system was established for the Hawai‘i Department of Agriculture (HDOA) to review requests for new imports by others (further detailed in Chapter 3 and Appendix H of this plan).

Despite this new awareness of the impact that nonnative species were having on the inland water ecosystems, during the 1980's and 1990's more nonnative species appeared in Hawaii's inland waters, through both authorized and accidental introductions. Species such as the convict cichlid (*Archocentrus nigrofasciatus*), midas cichlid (*Amphilophus citrinellus*), johanni cichlid (*Melanochromis johannii*), jewel cichlid (*Hemichromis elongatus*), suckermouth catfish (*Hypostomus cf. watawata*), armored catfish (*Liposarcus* -previously *Pterygoplichthys-multiradiatus*), stickfish (*Xenentodon cancila*), apple snail (*Pomacea* spp.), and grass shrimp (*Neocaridina denticulata sinensis*) can all trace their origins to aquatic species distributors and hobby enthusiasts. The Asiatic clam (*Corbicula fluminea*), which is now widely distributed in streams, reservoirs, and taro patches on Kaua‘i, Maui and O‘ahu, is thought to have been smuggled in for food purposes.

[25] Text from this section taken directly from the DLNR-DAR website, http://www.state.hi.us/dlnr/dar/stream_aliens.htm, key author: Mike Yamamoto, and from Yamamoto and Tagawa 2000.

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The results of these introductions are varied. Some of the impacts that these nonnative species are having on our native freshwater animals and habitats are readily apparent with both direct and indirect effects. Direct effects are seen with the smallmouth bass and jewel cichlids for example, both of which are voracious predators that feed on native ʻoʻopu (gobies) and ʻopae (shrimp). Indirect effects are seen with the suckermouth catfish and crayfish; these species can cause serious erosion and increased water turbidity as a result of digging their habitat holes into the stream and reservoir banks. Even smaller, seemingly harmless fish, such as the guppy or the swordtail, have been shown to be carriers of parasites that can spread to native species like the ʻoʻopu. At least some of these parasites might also be introduced aquatic species that may be having adverse impacts on the native stream fishes (Font and Tate 1994).

Freshwater Plants:

Freshwater habitats in Hawaiʻi are especially vulnerable to invasions by nonnative species, as there are almost no native freshwater plant species other than algae in streams and ponds.[26] Hawaiʻi directly experienced the high costs and difficulties associated with control efforts of aquatic invasive plants during the recent infestation of giant salvinia (*Salvinia molesta)* in Lake Wilson/Wahiawa Reservoir, Oʻahu (which is further detailed in Case Study 2). This invasive water fern covered virtually the entire surface of the 300-acre reservoir, and clean-up costs approached one million dollars. Other species of freshwater aquatic plants that have proved to be invasive include water hyacinth *(Eichhornia crassipes*), water lettuce (*Pistia stratiotes*) and elodea (*Egeria densa*).

Freshwater invasive aquatic plants can alter the productivity of fresh water systems, reduce fishery yields, change surface water chemistry (with unknown effects), can form thick mats which prevent oxygen absorption into the water (leading to fish die-offs), and block light, shading out underwater plants on the bottom.[27]

Impacts of Inland Water AIS on Wetlands and Waterbirds[28]

Between the 1780's and 1980's, Hawaiʻi lost an estimated 31% of its coastal wetlands (Dahl 1990). This estimate, however, did not examine site quality, and losses are believed to be much greater. The primary threats to Hawaiian wetlands and the native biota are altered hydrology, environmental contaminants, and invasive species (USFWS 1999).

In addition to providing habitat for native plants, insects, crustaceans, and mollusks, Hawaiian wetlands are also habitat for 6 endangered Hawaiian waterbirds, 5 of which require wetlands for their survival. The decline of these latter 5 species' populations can be correlated to loss of wetland habitat throughout the Hawaiian Islands. In addition to direct habitat loss, introduced predators and invasive aquatic plants further degrade remaining habitat for these species.

These habitats are also important to the 36 species of migratory waterfowl and 48 species of migratory shorebirds that are reported for Hawaiʻi. Of these, 14 waterfowl species and 20 shorebird species are occasional to common visitors (Pyle 2002) that depend on Hawaii's wetlands for stopover or wintering habitat.

In lowlands, fresh and brackish water wetlands are heavily altered by humans and typically dominated by dense mats of the invasive species such as red mangrove (*Rhizophora mangle*), pickleweed (*Batis maritima*), and California grass (*Brachiaria mutica*) among others. These plants have a tendency to encroach on prime waterbird feeding, loafing, and nesting areas (banks and shallow emergent zones) and degrade habitat value.

Invasive waterbirds also pose problems for native species. The Cattle Egret (*Bulbulcus ibis*) introduced to Hawaiʻi for insect control, consume insects and small vertebrates. They are confirmed predators of seabird chicks and suspected predators of Hawaiian waterbird chicks. Cattle Egrets are the subject of control at wildlife sanctuaries and at airports, where they pose an aircraft strike hazard. The Mallard (*A. platyrhyncos*) and various Mallard breeds were introduced to Hawai'i for food and for aquatic weed and snail control. Both Cattle Egrets and feral Mallards are believed to compete with native waterbirds for limited aquatic resources.

[26] These first two sentences taken from Staples and Cowie 2001.

[27] Taken directly from Staples and Cowie 2001

[28] Text adapted from text submitted by K. Uyehara, with additional input from R. Shallenberger (TNC) and G. Smith (USFWS).

Inland Water Insects:

Some of the most deadly human diseases in the world are spread by flies and mosquitoes, including dengue fever, malaria, yellow fever, encephalitis, West Nile virus (further detailed in Case Study 7) and many others. Because of their potential as disease vectors, aquatic insect species pose a large threat to human health and well-being in Hawai‘i. In addition, because of the potential to harm tourism, by either spreading disease or making outdoor activities uncomfortable, aquatic invasive insects could have a major detrimental effect on Hawaii's economy.

The small size and relative ease with which aquatic insects can be unknowingly transported adds to the ability for aquatic invasive insects to spread beyond their natural range. Potential pathways of invasion by aquatic insects include being transported and imported in: recycled material such as tires, aquatic plants, aquaculture material, ship ballast, boats, shipments with aquarium fish, airplanes, building material, greenhouse plants, imported soil, and in baitfish or other moist packing material. Islands with direct flights to Hawai‘i, such as Tahiti, and more recently the Cook Islands, have numerous harmful species of aquatic insects that have in the past easily spread between those island groups. It is foreseeable that these insects could also be spread to Hawai‘i via these direct flights.

POTENTIAL PATHWAYS[29]

This section highlights some of the priority pathways and mechanisms by which aquatic invasive species may have been imported or through which they are likely to arrive. This is a first step in addressing introductions, and efforts are still needed to create a more comprehensive list of known and suspected transport mechanisms. This will then serve as a baseline for risk analysis and risk management strategies, which are needed for the identification, design, and prioritization of appropriate counteractions to reduce the risks posed by these pathways.

For marine nonnative introductions, the mechanism that is focused on to the greatest extent both in Hawai‘i and elsewhere, is the international and domestic shipping industry. In the past, research activities and stocking programs were also key mechanisms for marine introductions into Hawai‘i. Examples of additional potential mechanisms for introduction and transport include fisheries activities, aquaculture, and the water garden and aquarium industries.

For inland water nonnative introductions, authorized introductions played the largest role in the past, and still occur to a very limited extent. Additional mechanisms include escapees or releases associated with organisms from the aquaculture, aquarium, and water garden industries, from producer to consumer.

Potential Mechanisms for Introduction:

I. Commercial Shipping – cargo vessels, fishing boats, and towed platforms

A) Ballast water and sediments
- -Planktonic organisms and larvae
- -Adult organisms

B) Vessel hulls, seachests and pipe systems
- -Fouling organisms – algae, adult fish and invertebrates and larvae released by adult organisms

C) Live holding and bait wells
- -Release of baitfish/invertebrates
- -Release of sediments
- -Release of associated symbiots and pathogens

D) Fisheries gear and debris
- -Fouling organisms on nets and floats

II. Recreational Boating

A) Hull fouling and bio fouling on structures besides the hull (e.g., outboard motors)
- -see above with commercial shipping

B) Other factors
- -livewells, waterlines

III. Aquaculture, Aquarium, Water Garden and Other Industries, from Producer to Consumer

A) Accidental release of target organisms from culture/grow-out facilities

B) Accidental release of non-target organisms
- -Epiphytic organisms
- -Pathogens

C) Unauthorized, intentional release of organisms (largely a result of consumers or hobbyists)

IV. Government Programs and Research

A) Authorized release
- -Bio-control

[29] Many thanks to S. Godwin of the Bishop Museum for the creation of this preliminary list and for allowing its use in this document. This list originally appeared in the proposal by Eldredge and Godwin, "HCRI-RP Year 6, Determination of present and potential mechanisms for the introduction and dispersal of marine alien species to the Main Hawaiian Islands," 2003, and has been altered and expanded to from its original version.

-Stocking programs
B) Un-authorized or unintentional release
-Accidental release of experimental target organisms
-Release of associated pathogens and symbiots

V. Private Sector
A) Live seafood shipments
B) Aquarium release
C) Release for cultural practices
D) Illegal and/or accidental imports
-Foreign Cargo, Domestic Cargo
-Foreign Passengers, Domestic Passengers
-Mail
-Private Aircraft and Vessels

VI. Marine Debris
A) Fouling organisms on abandoned nets and floats

Potential Mechanisms for Dispersal after Introduction:

I. Commercial and Private Shipping
A) Ballast water and sediments
-Planktonic organisms
-Adult organisms
B) Vessel hulls, seachests and pipe systems
- Fouling organisms
- Release of larvae
C) Fishing gear and debris
-Fouling and sediments on nets and floats

II. Recreational Boating
A) Hull fouling and bio fouling on structures besides the hull (e.g., outboard motors)
B) Other factors
-livewells, waterlines

III. Aquaculture, Aquarium, Water Garden and Other Industries, from Producer to Consumer
A) Interisland transport of stock
B) Unauthorized, intentional release of organisms (largely a result of consumers or hobbyists)
C) Unintentional escape

IV. Government Programs and Research
A) Authorized release of target species
-Stocking programs
-Bio-control
B) Inadvertent release through interisland transport
-Including research activities

V. Private Sector
A) Live seafood shipments
B) Interisland transport of aquarium pets
C) Recreational boating (also referred to in II above)
D) Diving and snorkeling activities

VI. Marine Debris
A) Fouling organisms on abandoned nets and floats

VII. Natural Dispersal
A) Natural Dispersal (passive and active)
-once established, many AIS can disperse naturally without the assistance of human activities

IDENTIFYING GAPS IN THE PREVENTION SYSTEM

Despite the efforts of many agencies and efforts described in this AIS Management Plan, unwanted nonnative species (both aquatic and terrestrial) are still entering Hawai‘i (Hurley 2001, Kraus and Cravalho 2001, HDOA 2002). As we move forward with the development of an AIS Management Program for the State, those involved with the managing of aquatic species will need to work closely with those managing terrestrial invasives on many levels, but especially in addressing prevention systems.

The areas of concern described below were initially drawn from interviews and other research carried out in the course of drafting the 1992 report by Miller and Holt, entitled, "The Alien Pest Species Invasion in Hawai‘i: Background Study and Recommendations for Interagency Planning", which focused largely on terrestrial species. These areas of concern are presented again in this management plan to emphasize that many of these aspects still need to be addressed in order to have an effective prevention system for unwanted invasive and pest species in Hawai‘i.[30]

Building on Earlier Efforts

An original version of this section entitled, "Problems in the Prevention System", was developed for the 1992 report, "The Alien Pest Species Invasion in Hawai‘i: Background Study and Recommendations for Interagency Planning", principal authors S. Miller and A. Holt. Much text from the original report remains, and this has not been paraphrased or re-worded; many thanks go out to the authors of the 1992 report for their contributions.

This section is not meant to place blame or point fingers. Rather, it is to identify key aspects of concern that may exist in the current system. All agencies referred to herein are welcome and encouraged to address any inaccuracies and/or recent efforts that may not be noted. The 1992 report is available online at http://www.hear.org/articles/pdfs/tnchnrpp1992.pdf.

Potential Problems in the Prevention System

1. It is theorized that a large proportion of the total passenger, cargo, and other traffic entering Hawai‘i may be un-inspected, including materials known to be significant sources of new aquatic invasive species.

   FOREIGN CARGO

   Customs Border Protection (DHS-CBP) and U.S. Fish and Wildlife Service use various techniques to process and inspect cargo, including the use of manifests submitted by transportation carriers and shippers. Theft, improperly manifested, or smuggling of foreign goods poses a potential source of accidental or illegal introductions.

   DOMESTIC CARGO

   Hawai‘i Department of Agriculture, Plant Quarantine Branch (HDOA-PQB) relies upon the transportation companies and shippers to properly manifest agricultural items arriving as cargo. It is the responsibility of the carrier to ensure that shipments are properly declared, labeled, and available for inspection and clearance. Inspections conducted are random in nature and based upon the level of risk the commodities may pose. For example, a shipment of cut flowers would pose a low-risk for pest introductions, whereas produce would be a moderate level, and propagative plants and live animals, which includes aquatic organisms, would be a high-risk category. Since other non-agricultural cargo does not require inspection by HDOA, it too may pose a source for new pest introductions either as smuggled items or in association with the imported commodities.

   FOREIGN PASSENGERS

   Customs Border Protection (DHS-CBP) inspects all passengers using a variety of techniques. Prior data, history, intelligence, risk, and technology are used to target more detailed inspection of passengers and goods which pose higher risk, without using limited resources for further inspection of those who pose low risk. Given the daily number of passengers requiring timely processing, undeclared prohibited goods could be missed.

   DOMESTIC PASSENGERS

   Prior to arrival into Hawai‘i, it is mandatory for an arriving passenger or crewmember to complete and sign an agricultural declaration form declaring any plants, animals, soil, or other materials in their possession. It is also the responsibility of the transportation carrier to distribute and collect

[30] Thanks to D. Cravalho and N. Reimer of the Hawai‘i Department of Agriculture, and to D. Alontaga of the U.S. Department of Agriculture, for their time spent researching, updating, and editing text from Miller and Holt (1992) to accurately reflect the current situation for presentation in this plan.

these forms and deliver it immediately upon arrival to HDOA for clearance. Compliance in obtaining these forms from the carriers has improved, however the reliability of items actually being declared is felt to be suspect. Since 1993, HDOA in cooperation with Hawai‘i Department of Transportation (HDOT), has placed various “Amnesty Bins” in strategic arrival areas to provide passengers with a last resort to dispose of illegal items prior to claiming their baggage. To date, numerous discoveries of regulated produce, such as untreated Florida citrus, have been normal. However, recently a live ball python was also found in one of these receptacles. To supplement this phase of the inspection process, canine detector teams were implemented to assist in the clearance of baggage. However, due to budget shortfalls and staff shortages, this process has been reduced, thus further reducing the amount of adequate passenger clearance conducted by HDOA.

MAIL

Due to the limited authority to inspect first-class mail, only a small fraction of mail entering Hawai‘i is examined. This represents the most difficult problem since first-class mail is protected against inspection without a warrant under Federal statutes. Other classes of mail can be inspected, but personnel and equipment availability limits the level of examination; in addition the U.S. Postal Service’s mandate to protect mail delivery against delay is another concern for enhanced inspection capabilities. Mail-order and internet companies provide additional unregulated sources for pest introduction by offering for sale a variety of items including seeds, plants, insects and other animals. Many of these businesses are unaware of Hawaii's import requirements and freely mail material to Hawai‘i without any notice to potential customers about agricultural quarantine restrictions. Receiving agricultural items through the mail without proper State or Federal permits is a violation of existing regulations.

PRIVATE AIRCRAFT AND VESSELS

While foreign aircraft and vessels must report their cargo to DHS-CBP for potential inspections by U.S. Fish and Wildlife Service, domestic private aircraft and vessels present a challenge to HDOA. Most, if not all aircraft arrivals are unscheduled with a lack of understanding or knowledge of Hawaii's inspectional requirements. Private yachts arriving at public harbor facilities are easier to manage, but private marinas and offshore moored vessels pose a different challenge and are rarely monitored or inspected. HDOA, however, believes that the risk of prohibited items coming in through this route is comparatively low.

INCREASED INSPECTION DEMANDS AND ADDITIONAL PORTS OF ENTRY

Growth in inspectional staff, training and equipment has not kept pace with the increased growth of incoming traffic. Over the past decade, staffing has actually declined despite an increase in air and sea arrivals. Similarly, these limited staff positions have been more thinly spread as the number of inspection sites has grown and an increase in domestic arrivals. With future plans for an international airport on Maui and the potential for opening other new ports of entry, thus resulting in an increase number of flights, there is a clear need to develop strategies for a comprehensive invasive species and pest prevention plan. The disparity between inspection capacity and need will only widen unless plans and budgets for new air and sea ports incorporate design features and adequate staffing to facilitate inspection.

2. The effectiveness of inspections is hampered by inadequate sampling strategies.

TARGETING INSPECTIONS

Regulatory agencies agree that in the face of inadequate resources for inspection of all incoming traffic, it is essential to target inspections at the most likely sources of pest introductions. The effort to inspect a portion of the traffic entering Hawai‘i does not take full advantage of available technologies and strategies to target pathways. Existing databases provide detailed interception information for targeting risk, but are limited in scope and could be improved. A reporting system is currently being developed for the island of Maui which, in the future, may be implemented on a statewide basis to evaluate pest risk and pathway assessments.

TESTED SAMPLING STRATEGIES

State and Federal inspectors use a variety of technologies including x-ray, detector dogs, and manual inspections. What is needed is a way to comprehensively evaluate the effectiveness of current and potential techniques to determine the best use for each pathway. Information about the evaluations and techniques could be better shared

between the State and Federal inspection agencies to reduce duplication.

INSPECTOR TRAINING

The detection of potential pest organisms requires a high level of expertise due to the large volume and diverse origins of traffic through the State. No individual inspector, regardless of available training, can know the multitude of types of insects, plants, animals and other organisms that may pass through an inspection station, nor its various life stages, modes of transport and pest potential. New Zealand employs the use of specialization among inspectors as a key to a successful detection program. The development of a structured formal training program as well as refresher courses would certainly boost the inspection dependability.

AIRPORT DESIGN AND FLIGHT SCHEDULES

There are two factors that affect the adequate inspection of inbound domestic traffic: (1) various flights arrive in a small window period instead of being more evenly distributed over the course of the day; and (2) the physical layout of the airport allows for quick exit by passengers with or without their baggage. Due to flights arriving at the same time and the quick departure of passengers with their baggage, it makes it very challenging to adequately monitor this inspection activity.

3. Lack of dedicated law enforcement capabilities and resources.

   State law provides for penalties of $5,000-$200,000 for illegal importation of State-prohibited species, with or without additional imprisonment. However, though these penalties are in place, problems arise when possible violations to quarantine laws and regulations are discovered, but staff are not properly trained, nor have the resources to conduct an investigation. In the past, other Federal law enforcement agents and investigators from the Attorney General's office were solicited to help develop cases, however due to increasing budget constraints, available law enforcement personnel have dwindled due to other priorities. To prevent the further increase of illegal introductions, it is imperative that a dedicated law enforcement staff be established and funded to conduct investigations.

4. Federal quarantine programs do not adequately address Hawaii's special vulnerability to foreign pests

FOREIGN IMPORTS WITH HAWAI'I AS FIRST PORT OF ENTRY

Federal inspectors regulate foreign imports based on Federal regulations and international trade agreements. Hawaii's State regulations restrict or prohibit entry of certain organisms, which do not require Federal action or are not covered by Federal regulations. For example, Hawaii's list of prohibited or restricted taxa includes vertebrates for which Customs Border Protection (DHS-CBP) has no inspection authority. Sharing and support between Federal and State inspectors is restricted due to their differing authority.

Even after Federal inspectors have released a shipment that the shipper declares will be sent to the mainland, it can still pose a risk if it somehow remains in Hawaii as its final destination. Without close monitoring by the State, items that the State would only allow to transit to the mainland may end up remaining in Hawai'i.

FOREIGN IMPORTS DESTINED TO HAWAI'I FROM OTHER U.S. PORTS OF ENTRY

Foreign goods can enter Hawai'i as if they were "domestic" shipments, because these goods may have been released by Federal inspectors at another U.S. port of entry. Again, some of the species and articles of concern to the State of Hawai'i would not be stopped by the Federal inspectors, due to the different regulatory authority given Federal and State inspectors.

Potential Problems in the Control System

1. Response to new infestations is frequently delayed by jurisdictional or organizational problems, allowing pests to become established and, in some cases, to spread beyond control.

   NO CLEAR REPORTING MECHANISM FOR THE PUBLIC

   Prior to the establishment of the "Pest Hotline" in 1992 by HDOA, there was no clear reporting mechanism for the public or agency staff that detected pest infestations. In the past, people have either failed to report the infestation or may have called a number of agencies without clear direction, therefore failing to result in any prompt action. Usually only clear and concise pest-specific contingency or control programs like the brown tree snake program that was developed as a cooperative effort between involved agencies have

been effective. As such, the "Pest Hotline" must become known as well as the "dial 911" program has been for police or other emergencies.

UNCLEAR OR CONFLICTING AGENCY JURISDICTION

Most agency programs have evolved to address a particular segment of a pest problem. For example, HDOA controls agricultural pests, HDOH controls human disease vectors and DLNR controls forest pests. Consequently, gaps occur between the involved agencies. It is often difficult to determine the extent of an infestation without doing considerable field surveys. If the organism is not specifically identified as a pest on a particular State list, questions over authority and jurisdiction to take some kind of action may further delay a response to the infestation. Further compounding the problem are privacy issues, whereby control efforts on private property may be delayed or even stymied due to the landowners rights to expectation of privacy. This year, SB 1505 (Act 085) was passed and signed into law to address this issue by the establishment of the Hawai'i Invasive Species Council (HISC), as detailed in Appendix J.

LITTLE CONTINGENCY OR COOPERATIVE PLANNING

Contingency plans help agencies to prepare for a predicted pest introduction. They are used to identify the responsible agencies that cooperate in response to incipient infestations by establishing agreements in advance as to the respective duties and commitments and preparing to use the best available methods and tools to combat invasive species within a timely fashion. Examples of contingency plans that have been developed include brown tree snake response program, rabies, and several serious human health diseases.

Cooperative plans bring agencies and landowners together to control an established pest in a given geographical area. The statewide development of the Invasive Species Committees in each county have resulted in the extension of private partnerships with agencies to control invasive species such as coqui frogs, miconia, thorny kiawe, and fountain grass to name a few. Ongoing discussions for other programs are presently underway.

LITTLE SURVEILLANCE MONITORING TO TRACK INFESTATIONS AND SUPPORT PROMPT DECISION MAKING

The full ranges of most of the serious, established AIS in Hawai'i are not completely mapped, and no system exists to systematically locate and map these or new pests. Many control agencies have mapped significant weeds, diseases, and some other pest species within their individual project areas, and a few on-going projects (i.e., such as with marine algae AIS) are monitoring the spread of an infestation or the effectiveness of a control effort. However, these are generally not shared or compatible systems, and are not adequate to support statewide multi-agency planning for more effective control. A clear picture of the size and distribution of a pest population is needed to allow agency staff to be successful in their decisions and actions to control AIS.

2. Interisland spread is a major, largely unregulated problem

A number of serious AIS are established in Hawai'i but have not yet invaded all islands or island districts. In spite of preclearance inspections for produce and other selected items in interisland traffic by HDOA, and targeted efforts by HDOA and DLNR to prevent the spread of several serious terrestrial pests (e.g., papaya ring-spot virus, banana poka), uninfested portions of the State remain highly vulnerable to the spread of established invasive species. Potential vectors for the spread of these AIS include both commercial and noncommercial transport of ornamental plants and aquarium organisms, interisland mail, and organisms associated with hull fouling on boats, among others. Additional vectors exist for the interisland transfer of terrestrial pests as well. Although several small-scale or informal efforts are underway, no island currently has a multiagency plan to protect it against this interisland spread of invasive species.

3. Control efforts are not taking fullest advantage of available technologies

COORDINATED EXPANSION OF BIOLOGICAL CONTROL PROGRAMS

Although Hawaii's biological control programs have been pioneering and productive, they have two major needs. One, is that while programs used to generally include rigorous pretesting of proposed organisms to minimize the risk to many nontarget species of commercial interest, they less often, although just as necessary, included testing for other potential negative environmental impacts. Such impacts may include enhancing the targeted pest, interacting with other organisms to create new pest problems or attacking

nonpestiferous or beneficial organisms. This is changing however, and negative impacts on endemic, indigenous, introduced, nonpestiferous, and beneficial organisms are routinely tested before biocontrol organisms are allowed entry into the State.

The second need is to support long-term monitoring of all releases to determine their efficacy as well as their direct and indirect effects on the environment. This has been a problem but recent introductions for biocontrol efforts by HDOA now include a post release evaluation program. The existing facilities and program personnel are highly challenged to meet these needs. Agriculture and natural area biological control researchers have collaborated, but they have not yet developed a cooperative, long-range strategy to develop facilities and make the best possible use of available resources.

RESEARCH ON PEST BIOLOGY AND CONTROL METHODS

Control programs can be greatly enhanced through biological research to identify pests' vulnerabilities (e.g., the best time of year or life-phase to control a population) and research to refine control methods. The University of Hawai'i cooperative Extension Service, HDOA, HARC (Hawai'i Agricultural Research Center), USDA-ARS (Agricultural Research Service), UH-Horticulture Department (through its Integrated Pest Management Project) and others in the agricultural sector sponsor such work on selected environmental pests. This is not enough, however, to keep up with the flow of new pest species, including aquatic invasive species.

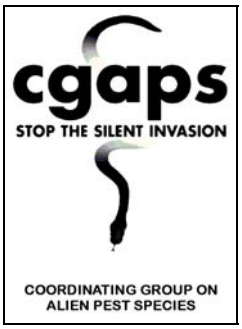
4. Agency mandates sometimes call for maintenance of AIS or potential AIS as resources for recreational fishing, commercial crops, aesthetic resources, or other values.

   A number of nonnative species established in Hawai'i have proven value for certain industries such as aquaculture, aquarium and pet stores, and landscaping, but are also known to be serious threats to other natural resources. Multiple species of inland water fish, apple snails, certain types of marine algae, some inland water plants, as well as other nonnative aquatic species are known to impact native species, desirable crops, or other resources, but will most likely continue to be maintained in Hawai'i because of their economic, recreational, aesthetic, or other values.

ADDRESSING GAPS IN THE PREVENTION SYSTEM:

THE COORDINATING GROUP ON ALIEN PEST SPECIES (CGAPS) IS WORKING TO ADDRESS "BIG PICTURE" ITEMS

The previous pages identified many of the concerns that exist in Hawaii's system for the prevention of invasive species introductions. In response to some of these "big picture" concerns, State and Federal agencies and non-profit conservation organizations have banded together through the Coordinating Group on Alien Pest Species (CGAPS)[31], to identify and correct a number of these concerns. Specifically, in the coming years, CGAPS will be working with the newly formed Hawai'i Invasive Species Council (HISC),[32] to address the following issues, many of which were detailed in the preceding pages[33]:



Overarching Issues

- Leadership and commitment are needed within all sectors of Hawai'i State Government to adequately address biosecurity issues related to invasive alien species.
- There are no programs in the State budget devoted exclusively to invasive alien species.
- Most costs of invasive alien species are borne by society at large.
- There is a lack of awareness of invasive species issues, and few programs dedicated to raising public awareness.
- Hawaii's present biosecurity system lacks the proper funding to support both current efforts and an expanded system that adequately incorporates prevention, early detection, rapid response, and on-going control for terrestrial and aquatic invasive pests.

Prevention Issues

- International trade agreements and other Federal programs do not protect Hawai'i from the full range of pests. Federal trade agreements pre-empt State laws, allowing import of known pests despite the State of Hawaii's formal objections.
- Much of the traffic entering Hawai'i currently goes un-inspected—passenger, cargo, ballast water, military and postal, including materials known to be significant sources of new alien pests. The State of Hawai'i doesn't have adequate funds to do quarantine at ports of entry but there are currently sources of Federal funds that may be available.
- Inter-island spread of invasive alien species is a major, largely unregulated problem.
- Penalties are inadequately enforced for illegal introductions of invasive alien species. State and Federal laws allow for significant fines and imprisonment, but stiff penalties are rarely imposed.
- There are opportunities to get Federal law enforcement agencies to enforce Hawai'i State Law related to invasive alien species.
- Jurisdictional and organizational problems delay responses to new alien pest species infestations, allowing pests to become established or to spread beyond control.
- The current prohibited species review process for plants is complex and cumbersome, allowing known invasive plants to be imported, sold, or spread to new areas.

Early Detection & Rapid Response Issues

- There are no programs to conduct monitoring for new pests around ports of entry. State and Federal management agencies in Hawai'i do not have the capability to conduct early detection in the field at the scale that is needed.
- There are currently no agencies or protocols in place to conduct regular, comprehensive monitoring for aquatic invasive species.
- Agencies do not have the capability to conduct rapid response to newly arrived pests.
- Efforts relating to monitoring and early eradication need to be formalized between agencies and adequately supported.

Issues Regarding Ongoing Control of Established Pests

- Funding for the control of broadly dispersed pests that impact natural resources, agriculture, and human health is grossly under-funded. There is a need to adequately assess and provide the proper resources to insure these efforts are effective.
- There is a need to review and revise regulations related to techniques used for invasive alien species control, including biocontrol techniques.

Because many of these issues are not AIS specific, in combination with the fact that CGAPS is already working to address these big picture items for all invasive species, many of these aspects are not specifically dealt with in this plan as far as recommended tasks. It is emphasized however, that these items do encompass aspects of aquatic invasive species, and there needs to be close collaboration between those working on AIS issues and those involved in CGAPS and HISC.

[31] Further details on CGAPS are found on page 3-19.

[32] Further details on HISC are found on page 3-14 and Appendix J

[33] Text supplied by C. Martin (CGAPS), from, "Gaps in Hawaii's Biosecurity Against Invasive Pest Species", July 2003.

IDENTIFICATION OF AQUATIC INVASIVE SPECIES IN HAWAI'I

Why Is This Section Included in This Plan?

The main purpose of this section is to present an overview of the aquatic species that are considered to be invasive, or have the potential to be invasive in Hawai'i.

This section and associated species listings are meant to assist in prioritizing management efforts, including addressing associated pathways, monitoring and control activities, education and outreach efforts, and further research. By identifying the species that are invasive or have the potential to be invasive, it also helps to educate resource managers, policy makers, researchers, educators, industry, and the general public about the wide range of aquatic invasive species and associated issues that exist in Hawai'i.

'Invasive Species' Defined:[1]

An invasive species is defined as a species that is:

1) nonnative (alien) to the ecosystem under consideration, and

2) whose introduction causes or is likely to cause economic or environmental harm, or harm to human health.

[1] Definition directly from the National Invasive Species Council's Management Plan, "Meeting the Invasive Species Challenge", 2001.

This section is also required component of State AIS Management Plans, as specified by the Federal Aquatic Nuisance Species (ANS) Task Force. Other states have described the purpose of this section in the following terms, which are appropriate for Hawaii's plan as well:

- "Draft lists are intended to provide a basis for discussion and further work identifying the presence, distribution, status, and threat of these species. They will be updated, maintained, categorized and standardized as new information is received and assimilated." (Washington State)

- "…(The list) provides a planning tool for setting priorities and direction to ensure coordinated interagency action. In and of itself, the list is not a regulation or law…" (Maine)

What Will Happen to Those Species Listed in this Section?

This is not a regulatory list of any kind, though it does refer to some species that are already regulated per the process of importation through the Hawai'i Department of Agriculture (further detailed in Chapter 3 and Appendix H of this plan). For the species already established in Hawai'i, the objective should be to prevent their further spread, particularly to the more pristine inland water and coastal habitats located throughout the State. In the case of species not established in Hawai'i, the goal must be to minimize their introduction, release, and/or establishment.

Who Determines What Species Are Considered Invasive?

Determining what species are considered invasive can be a contentious issue, and indeed the selection of some of the species in the following pages has resulted in much discussion. However, the preponderance of data and growing trend in invasive species management points to the need for a precautionary approach. While the specific biology of invasive species varies enormously, some or all of the following general life history characteristics apply to many invasive species (both terrestrial and aquatic) worldwide:[34]

- 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;
- have reproductive characteristics that allow for rapid population growth.

In all cases, the species designated in this plan as being invasive have been identified by researchers and resource managers knowledgeable about the species themselves. This includes knowledge of certain life history traits that

[34] Text on characteristics directly from Staples and Cowie 2001.

suggest the potential for invasiveness, as well as knowledge of associated problems the species may present (or has presented) to Hawai‘i.

There has been much work done nationally and internationally on the issue of risk assessment to determine invasiveness of a species. This plan specifically lists (as an action item in Strategy 1C) the need for the development of a formal quantitative and objective risk assessment appropriate for Hawaii's aquatic invasive species, using efforts done elsewhere as a base. However, in the prelim, it is still necessary to identify species that are known or considered to be invasive, according to general agreement among knowledgeable observers.

A Representation of the Vast Scope of AIS in Hawai‘i

The original intent of this section was to identify “all known and suspected AIS concerns…even if no consensus exists about which species warrant attention”, per the guidelines from the Federal ANS Task Force. However when creating this section, it became clear that there is still some disagreement among resource managers/researchers and industry members, as well between resource managers and researchers themselves, over which species should be considered invasive.

Further, while the number of nonnative aquatic species in Hawai‘i is still being assessed, it is clear that the number is large: there are over 343 documented introduced or cryptogenic marine and brackish water species[35], over 50 established introduced inland water species (many more of which were introduced, but are not known to be established)[36], and an additional approximate 300+ introduced aquatic insects[37]. (A preliminary listing of nonnative species in Hawai‘i is presented in Appendix K.) Additional work is needed to more formally and objectively assess the presence, distribution, life history traits, status, and threat of many of these nonnative aquatic species in Hawai‘i before a list of all suspected aquatic invasive species can be created.

As such, the species listed here are presented as examples for a representation of the vast scope of AIS in the State, and should not be considered the sole threats to the aquatic ecosystems of Hawai‘i. These selections were based upon demonstrated invasiveness in Hawai‘i or elsewhere, and/or the potential to cause serious problems should the species spread beyond its current range.

A Need To Be Aware of Not Only Established Species, But Also of Those That Are Not Yet In Hawaiian Waters

In addition to the species listed in the next few pages that are already in Hawaiian waters, a separate listing includes species, though not yet established, that may have the ability to become potential threats if they escape or are released into the aquatic environment. In the preparation of this listing, concerns were raised by some industry members that listing species not yet in Hawaii's aquatic systems would be overstating the issues. However, prevention of potential problems is a major component of efforts elsewhere, both nationally and internationally, addressing invasive species. As such, this latter listing will also include some species that have been found in Hawai‘i only once or a few times, as well as some species that may have never been found in Hawai‘i. Listing of these types of species is not meant to overstate the problem, but rather to help raise awareness levels that there is potential for additional invasions to occur.

Working with Industry in Addressing Specific Aquatic Invasive Species

Some of the species presented here are also a key component of the aquaculture, nursery, and/or aquarium industries, all of which are valued industries in Hawai‘i. While it is recognized that some of these species are important economically or may have some other beneficial value, this does not negate impacts the species may have upon native species or associated systems. Further, their potential economic value should not preclude them from being considered aquatic invasive species, per the definitions supplied earlier in this section and in the glossary.

Management efforts for species that are important commercially, but also pose threats as AIS, will need to be assessed thoroughly, and will likely be focused on moving in the direction of better containment, best management practices, and possible biological or chemical control of escaped organisms. Concerted efforts to educate the public about the dangers of releasing species into our inland and marine waters must also be continued. The importance of

[35] Eldredge and Carlton 2002.

[36] Yamamoto and Tagawa 2002.

[37] R. Englund (Bishop Museum), personal communication, 2003

resource managers working with industry representatives in developing an effective long-term management program for many of these species should not be understated. These actions, combined with proactive efforts by industry members who understand the importance of limiting the spread of species into the natural environments, will allow us to find workable solutions for AIS issues.

Future Versions of This Section

As referred to above, additional efforts will be needed to convert this section to a workable list of priority species in which to focus attention and resources. In that process, efforts will need to include prioritization on an island by island basis, as well as factoring in the potential success of control efforts.

Management Classes[38]

Management Classes are used when listing nonnative species already in Hawai‘i that are known to be invasive or thought to present a risk of becoming invasive. Management classes are based on those presented by Washington and Oregon in their State Aquatic Invasive Species Management Plans. This was done to help allow for consistency and coordination with management efforts of aquatic invasive species in those Western States. Suggested Management Classes are based upon the extent of the invasion within the State (incipient or established) and the degree to which the State's current management capabilities can effectively control these species. Priority management actions to be taken for these species are discussed within each Management Class.

There may be overlap in some of the categories, and some species may fit into more than one category. It is acknowledged that this is not a perfected system, but it is intended to be a starting point.

These management classes are suggested solely for the purpose of preliminary prioritization of management efforts, and are subject to change. The management classes are not intended to be used as regulation or permitting, as Hawai‘i already has an extensive permitting and review process, which is detailed Appendix H of this plan.

Descriptions of each species, including why it is included, the extent of the problem, management suggestions, and status for importation is included in Appendix A. The following listings should only be used in conjunction with those descriptions.

Management Class 1:
Limited or Incipient Populations

Includes species that have limited or incipient populations within State waters.

Primary management actions include:

- Rapid response efforts for the eradication of pioneering populations;
- Prevention of further introductions of new populations;
- Prevention of dispersal into new waters;
- Issuance of alerts and educational materials to help with detection of additional infestations;
- Systematic monitoring of natural waterways to detect additional populations;

Marine Species	Inland Water Species
Algae	Plants
Dictyota flabellata **(Phaeophyta, brown algae)**	*Typha latifolia* **(Common cattail)**

[38] These management classes are based on those presented by both Washington and Oregon State, to have consistency in the divisions. Introductory paragraphs taken from the Washington State ANS Management Plan, 2001.

Management Class 2:

Established, Potential For Impact, Some Practical Control Techniques Available

Includes species present and established in Hawai‘i with known impacts (or potential for impact), that may be mitigated or controlled with appropriate management techniques. This category also includes species that are approved for import and managed under other regulations for commercial or recreational purposes, but may still have known or potential impacts on native species, ecosystems, or the human use of these ecosystems.

Species Identified are Examples of AIS in Hawai‘i

Species listed in all of these Management Classes are presented as examples for a representation of the vast scope of AIS in the State. They should not be considered the sole threats to the aquatic ecosystems of Hawai‘i.

The species listed are also intended to provide a basis for discussion, and to illustrate species for each Management Category.

Additional work is needed to identify the presence, distribution, status, and threat of many of the known nonnative species in Hawai‘i, before a list of all suspected AIS could be created.

Primary management actions include:

- Prevention of further introductions and dispersal to new waters;
- Control of population range;
- Mitigation of impacts;
- Resource managers, researchers, and industry representatives working together to find long-term solutions for those species considered to be important for recreation or commercial purposes.

Marine Species	**Inland Water Species**
Algae	Plants
Kappaphycus spp. **(Rhodophyta, red alga)**	*Salvinia molesta* **(Kariba weed)**
Gracilaria salicornia **(Rhodophyta, red alga)***	*Eichhornia crassipes* **(Water hyacinth)***
	Pistia stratioides **(Water lettuce)***
	Egeria densa **(Elodea or Anacharis)**
	Rhizophora mangle **(Mangroves)**
	Batis maritima **(Pickleweed)**
Invertebrates	Invertebrates
Scylla serrata **(Samoan crab)***	*Pomacea* sp. **(Apple snails)***
	Fish
	Micropterus dolomieui **(Smallmouth bass)***
	Hemichromis elongatus **(Jewel cichlid)***
	Tilapia spp. **(Tilapia)*, ****
	Clarias fuscus **(Chinese catfish, puntat, paltat)***
	Hypostomus c.f. watwata **(Armored catfish) ***
	Poecilids*, **
	Reptiles and Amphibians
	Trachemys scripta elegans, Pelodiscus sinensis and *Palea steindachneri* **(Freshwater turtles)***
	Waterbirds
	Anas platyrhynchos **(Mallard, feral)**
	Anas wyvilliana x A. platyrhynchos **(Koloa x Mallard hybrid)**
	Bulbulcus ibis **(Cattle Egret)**

* Indicates that species is valued for recreational purposes or commercially cultivated in Hawai‘i.

** There are many species of tilapia and poecilids in Hawai‘i, and not all tilapia or poecilid species are considered invasive. However, due to taxonomic uncertainty and hybridization that exists within each of these species, tilapia and poecilids will each be addressed collectively in the plan, at least for this first year’s version.

Management Class 3:
Established, Potential for Impacts, No Known Effective or Practical Control Techniques

Includes species established in Hawai‘i, with known impacts (or potential for impact), but with no known available effective or appropriate effective management techniques. This category also includes some species that are considered to be so widespread that known control techniques may not be feasible.

Primary management actions include:

- Prevention of further introductions;
- Mitigation of impacts;
- Further evaluation and research of potential control methods.

Marine Species	Inland Water Species
Algae *Acanthopora spicifera* **(Rhodophyta, red algae)** *Hypnea musciformis* **(Rhodophyta, red alga)**	Invertebrates *Macrobrachium lar* **(Tahitian prawn)** *Neocaridina denticulata sinensis* **(Grass Shrimp)** *Corbicula fluminea* **(Asiatic Clam)** *Myzobdella lugubris* **(Leech)** Trichoptera **(Caddisflies)** Culicidae **(Mosquitoes)**
Invertebrates *Carijoa riisei* **(Snowflake coral)** *Chtamalus proteus* **(Caribbean barnacle)** *Gonodactylus falcatus* **(Philippine mantis shrimp)**	
Fish *Valamugil engeli* **(Australian mullet)**	Reptiles and Amphibians *Bufo marinus, Rana catesbeiana*, and *Rana rugosa* **(Toad and Frogs)**

Management Class 4:
Established; Impacts Unclear

Includes species that are established in the waters of Hawai‘i and may have the potential to cause impacts, but current knowledge is insufficient to determine if control actions are warranted.

Primary management actions include:

- Prevention of further introductions;
- Further research to evaluate their invasive potential;
- Continued monitoring of existing populations to determine rate of spread.

Marine Species	Inland Water Species
Algae *Avrainvillea amadelpha* **(Chlorophyta-green alga)**	Fish *Misgurnus anguillicaudatus* **(Dojo, Weather loach, Japanese weatherfish)**
Invertebrates *Mycale armata* **(Orange sponge)** *Sigmadocia caerulea* **(Blue Caribbean Sponge)** *Pennaria distica* **(Christmas tree hydroid)** *Amthia distans* **(Bushy bryozoan)** *Schizoporella errata* **(Branching bryozoan)** *Didemnum candidum* **(White didemnid)**	Waterbirds *Anas platyrhynchos domesticus* **(Mallard breeds, feral, e.g., Khaki Campbells, Indian Runners, Pekin)**
Fish *Lutjanus kasmira* **(Ta‘ape, blueline snapper)** *Cephalopholis argus* **(Roi, peacock grouper)** *Lutjanus fulvus* **(To‘au)** *Herklotsichthys quadrimaculatus* **(Goldspot herring)** *Omobranchus rotundiceps obliquus, O. ferox*, and *Parablennius thysanius* **(Blennies)**	

Examples of Potential AIS: AIS that are Of Concern, Though Not Yet Established In Hawai'i

Species are included here for their potential to be introduced into Hawaiian waters and to cause negative impacts. Another reason for listing these species here is that if they were introduced to Hawai'i and become established, it would help to facilitate their introduction to other areas, such as additional Pacific Islands.

The following species have been selected based upon invasive characteristics displayed in areas with similar environmental conditions as Hawai'i, as well as the existence of viable pathways that can facilitate the transport of these species into the waters of Hawai'i. Some of the examples are currently imported, but governed by restrictions of HDOA (detailed in Chapter 3 and Appendix H) to prevent the introduction into State waters. Other examples are of concern due to the potential for inadvertent introductions through various anthropogenic means. This listing should be considered a work in progress, and is not presented as a complete listing of all species that have the potential to invade Hawai'i.

Marine Species

Algae
Caulerpa taxifolia – Mediterranean Strain **(Chlorophyta, green algae)**

Invertebrates
Musculista senhousia **(Asian Mussel)**
Mytilopsis sallei **(Black striped mussel)**
Carcinus maenus **(Green crab)**
Eriocheir sinensis **(Chinese mitten crab)**
Cnidarians **(Jellyfish, sea anemones and corals)**
- *Scyphozoa* **(Jellyfish)**
- *Anthozoa*
  - *Octocorallia*
  - *Hexacorallia*
- *Hydroza*

Inland Water Species

Fish
Piranha[a]
Anguilla sp.**(Freshwater eels)**

Invertebrates
LEECHES
Placobdelloides bdellae **(Leech)**

INSECTS
Ceratopogonidae and Simuliidae **(Nono Flies)**

MOLLUSKS
Marisa cornuarietis **(Giant ramshorn snail)**
Dreissena polymorpha **(Zebra mussel)**
Limnoperna fortunei **(Golden mussel)**

REPTILES AND AMPHIBIANS
Xenopus laevis **(African clawed frog)**
Inland water snakes

Other Species
Boiga irregularis (Brown tree snake)[b]

[a] There are many species of piranha; they belong to the genera *Pygocentrus* and *Serrasalmus.*
[b] Brown tree snakes are a terrestrial species. The species is included here because Federal legislation addressing funding, interdiction, and control of the brown tree snake is part of Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990.

EXAMINING THE IDEA OF 'PEST TO PROFIT': PROBLEM OR SOLUTION?

The Case of the Apple Snails[39]

Apple snails (*Pomacea canaliculata*; "channeled apple snail") pose complex management issues in Hawai'i. Native to South America, channeled apple snails were introduced to Hawai'i in the early 1990's, to some taro farms for use as a secondary cultured species to be sold to restaurants (Kubota 2003).

The species is now known to be invasive in natural and agricultural inland water systems of Hawai'i, but some representatives of the aquaculture industry also feel strongly that the species has significant commercial potential.

Invasive in Other Locations

In other parts of the world, apple snails are an extremely serious pest in rice paddies, causing huge losses, especially in areas of Asia, including Cambodia, Hong Kong, Japan, Indonesia, Malaysia, Philippines, southern China, Taiwan, and Thailand. In the US, they have been introduced not only to Hawai'i but also to California, Florida, North Carolina, and Texas. Their potential as rice pests as well as pests of natural wetland ecosystems has led to their being given high priority by the U.S. Department of Agriculture as a serious threat should they spread or be introduced more widely. The State of Mississippi, because of concern that apple snails might establish there, has placed a quarantine on imports from the above states, prohibiting import of all ornamental plants, nursery stock, or any other plants, soil, sand, peat, or any other articles that may be responsible for movement of apple snails, unless accompanied by extremely rigorous certifications.

Impact on Taro Production

Economically, the Hawai'i taro industry currently generates about $3 million in annual revenues (HASS 2003). In addition, the taro crop is considered extremely culturally important in Hawai'i.

According to Sea Grant website, "apple snails were intentionally introduced in some taro patches in the hopes that they could be harvested as native[40] escargot. Instead, [due to their voraciousness] the snails destroyed many taro foodcrops and proved to be too small and unpalatable for consumption." The snails create holes in the fleshy part of the taro plant, the corm, which is the part of the plant that is made into poi (Kubota 2003), a favored traditional food throughout the islands. These holes then leave the associated plant more susceptible to disease (Kubota 2003). In addition, the snails can kill the young plants directly by eating the stems (Kubota 2003).

Control Options and 'Pest to Profit'

As far as control efforts are concerned, mechanical removal via hand picking is commonly employed. Other removal efforts have included the use of ducks to feed on the snails, pesticides such as 'snail bait' (used for various garden snails), suction devices, and modification of culturing conditions for taro, including drying out the fields (Weidenbach pers. comm; TenBruggencate 1997). Researchers at the University of Hawai'i are also looking at additional control options (Ako in Kubota 2003).

As an alternative control option, Hawai'i Sea Grant has been active in promoting the 'pest to profit' concept with the channeled apple snail. As part of this concept, a preliminary study was completed in 2000 to determine the "qualitative and quantitative feed requirements for cultivating snails collected from the wild" that would "result in a texture and taste desired by high-end restaurant chefs" (Sea Grant 2000). At the same time, Sea Grant also supported an extension effort to promote the channeled apple snail as "Hawaiian Escargot"[41], which includes marketing the snail to upper-end restaurants (Sea Grant 2000). This helped to ensure adequate markets for both aquaculturists and collectors. (Weidenbach, pers. comm.)

Proponents of this idea suggest that this is an effective way to encourage the harvesting and subsequent control of an invasive species, thereby turning a problem into a financial opportunity.

There are now channeled apple snail farm operations on O'ahu, Kaua'i, and Maui. Farmers obtain the snails either through collection from the taro patches and cultivate them to market size, or the farmers are self-sufficient and are able to breed their own snails (Sea Grant 2000; Cowie, pers. comm). These culture operations are regulated and licensed by the State, and transport of live snails between the islands is prohibited. Operational practices vary among the different farms:

[39] If not referenced otherwise, information in this section is from personal communication with Cowie, R.H. (University of Hawai'i), Tamaru, C. (Hawai'i Sea Grant), or refers to aspects that are considered common knowledge in Hawai'i.

[40] These snails are not native to Hawai'i. The term native, as it is presented here, was part of an original quote.

[41] Hawaiian Escargot is a trademark of BoKe' Farms of Hawai'i.

Boke‘ Farms on O‘ahu operates within a completely closed water system and ships only processed, vacuum packed products, but this is not the case with all farms. It is also speculated that there is unregulated culture and/or collection of apple snails, and they are readily available live in open markets in Chinatown on O‘ahu, and other locations.

A Range of Management Issues to Be Addressed

In regards to management issues, there are at least four key groups that need to be considered:

- **Apple snail farmers.** Some farmers and/or collectors have expressed concerns that they are currently unable to supply the existing market because of restrictions prohibiting the interisland transport of live channeled apple snails, and want to see these regulations relaxed. Other farmers support the interisland restrictions on live snails and feel that interisland transport should be limited to processed snails, and that retailing of live snails should be banned.
- **Sea Grant and other aquaculture development entities.** These groups will be continuing the responsible promotion of the channeled apple snail collection and culture, as the preliminary data indicate that it can result in a significant decrease in the wild snail population (Tamaru, 1999). The challenge is to establish a sustained enterprise, which will require a combination of collection and culture. Before simply dismissing the idea, they would like to have researchers and resource managers consider the merits of this innovative approach.
- **Resource managers and researchers.** Many in this group have raised strong concerns about the promotion of channeled apple snails (and other invasive species) for commercial uses. Specifically, concerns have been raised that it will be easier to supply an increased demand for snails by additional culturing of the species, as opposed to encouraging additional collecting of snails from the wild. These opponents to ‘pest for profit’ programs feel that this would likely encourage additional farming, both regulated and unregulated, of the species. This could potentially counteract any associated control benefits from which the collecting idea originally stemmed. In addition, there are concerns that an increase in farming (regulated or unregulated) of these snails could lead to escapees into new areas, and hence spread the snails into as yet uninfested locales. This would then exacerbate the pest problem. (It should also be noted that there are also some researchers who are working with apple snails, and are not necessarily opposed to the idea of commercial use.)
- **Taro farmers.** Taro growers have expressed strong concerns about the proliferation of apple snails. In a recent newspaper article, taro farmers from Kaua‘i and Maui reported their crop production to be down by at least 50 percent from previous years. Though many factors are involved, they say the biggest problem is crop damage as a result of the apple snails (Kubota 2003). The Hawai‘i Agriculture Statistics Service (HASS 2003) also points to the channeled apple snail as a major pest species that multiply rapidly and can devour significant taro foliage resulting in stunted corms. HASS (2003) adds that farmers are forced to spend considerable time and money to control these snails.

Sources:

Cowie, R.H. 2003. Personal communication.

HASS, 2000, 2003. Hawai‘i Agricultural Statistics Service. P.O. Box 22159, Honolulu, HI 96823-2159. http://www.nass.usda.gov/hi/rlsetoc.htm

Kubota, G.T. 2003. "Poi takes a pounding – damaged crops have growers reducing supplies". *The Honolulu Advertiser*, May 16, 2003, p. A1, A8.

Sea Grant. 2000. "Highlights in Aquatic Nuisance Species Research and Outreach", in *Aquatic Nuisance Species Report: An update on Sea Grant Research and Outreach Projects*.

Sea Grant Website: http://www.sg.ohio-state.edu/publications/ANSreport/applesnail.pdf

Tamaru, C.S. 1999. Control of the apple snail (*Pomacea canaliculata*), Planning Project. *Contract #40785. Final Report. Submitted to the Department of Hawaiian Homelands, State of Hawai‘i,* 20 pp.

Tamaru C.S 2003. Personal communication.

TenBruggencate, J. 1997. "Some Hawai‘i pests arrived by invitation". *The Honolulu Advertiser*, February 17, 1997.

CHAPTER 3: Existing Authorities and Programs

CHAPTER 3. EXISTING AUTHORITIES AND PROGRAMS

Relevant agencies and programs that currently address AIS issues at the Federal and State level are described in this chapter. For the Federal programs, emphasis is placed on those that have been active in Hawai‘i or are considered necessary to facilitate the implementation of this plan.

FEDERAL AIS AUTHORITIES AND PROGRAMS

No single Federal agency has clear authority over all aspects of AIS management, but many agencies have programs and responsibilities that address aspects of the problem, such as importation, interstate transport, exclusion, control, and eradication. Federal activities on AIS management are coordinated through the Federal Aquatic Nuisance Species (ANS) Task Force. Brief descriptions of key acts, executive orders, and other relevant laws regarding the invasive species follows. Descriptions of Federal agencies involved in AIS issues are also included in the subsequent section.

FEDERAL ACTS, ORDERS, AND LAWS[42]

This Section highlights and briefly describes the following Federal acts, orders, and laws that are relevant to AIS
(Listed in chronological order):

Lacey Act (1900; amended in 1998)
Animal Damage Control Act (1931)
National Environmental Policy Act (1970)
Coastal Zone Management Act (1972)
Endangered Species Act (1973)
Federal Noxious Weed Act (1974)
Nonindigenous Aquatic Nuisance Prevention and Control Act (1990)
Alien Species Prevention Enforcement Act (1992)
National Invasive Species Act (1996)
Executive Order 13112 (1999)
Plant Protection Act (2000)
Animal Health Protection Act (2002)

Lacey Act (1900; amended in 1998)

This is the first Federal Act that tries to control migrations and importations of non-indigenous species. It prohibits the import of a list of designated species and other vertebrates, mollusks, and crustacea that are "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States". The Lacey Act declares importation or transportation of any live wildlife as injurious and prohibited, except as provided for under the Act, but allows for the import of almost all species for scientific, medical, education, exhibition, or propagation purposes. The Act also prohibits the intrastate transport of any wildlife whose taking or sale is prohibited in the State of origin. The U.S. Fish and Wildlife Service is the lead agency for enforcing the Lacey Act’s prohibition of fish and wildlife imports.

Animal Damage Control Act (1931)

This Act gives the US Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) the authority to control wildlife damage on Federal, State, or private land. It protects field crops, vegetables, fruits, nuts, horticultural crops, commercial forests; freshwater aquaculture ponds and marine species cultivation areas; livestock on public and private range and in feedlots; public and private buildings and facilities; civilian and military aircraft; and public health.

[42] Thanks to Kimberly Moffie, Pacific Fisheries Coalition, for doing much of the research for this section, and to B. Wallace, D.Alontaga, and C. Russell, (all with U.S. Department of Agriculture - USDA) for supplying and editing text on Acts relating to USDA.

National Environmental Policy Act of 1970 (NEPA; 42 U.S.C.A. §§ 4321 to 4370e)

NEPA requires the consideration of environmental impacts for any Federal action, including direct Federal activities, permitting, and Federal funding of activities by another entity.

NEPA environmental documents may include a "finding of no significant impact (FONSI)", an "environmental assessment (EA)", or a full "environmental impact statement (EIS)". Potential impacts of invasive species–both direct and indirect–may be among the issues that should be considered under NEPA.

Coastal Zone Management Act of 1972[43] (CZMA; 16 U.S.C. §§1451 to 1465)

In recognition of the increasing pressures of over-development upon the nation's coastal resources, Congress enacted the Coastal Zone Management Act (CZMA) in 1972. The CZMA encourages states to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. A unique feature of the CZMA is that participation by states is voluntary. To encourage states to participate, the act makes Federal financial assistance available to any coastal State or territory that is willing to develop and implement a comprehensive coastal management program.

CZMA is the authorizing Federal legislation for the Hawai'i Coastal Zone Management Program, discussed on under State authorities later in this chapter.

Endangered Species Act of 1973 (ESA; 16 U.S.C.A. §§ 1531 to 1544)

The purpose of the ESA is to protect endangered and threatened species. When nonnative invasive species threaten endangered species, this Act could be used as basis for their eradication by the Department of Interior (USFWS) or by the Department of Commerce (NOAA).

Federal Noxious Weed Act (1974; 7 U.S.C. § 360)

Although the Plant Protection Act superseded and repealed most of the Federal Noxious Weed Act of 1974 (FNWA), it left intact section 15 of the act, "Management of undesirable plants on Federal lands" (7 U.S.C. 2814). Section 15 of the FNWA requires 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)). The Act also requires the Federal land management agencies to enter into cooperative agreements to coordinate the management of undesirable plant species on Federal lands where similar programs are being implemented on State and private lands in the same area (7 U.S.C. 2814(c)). The Secretaries of Agriculture and the Interior must coordinate their respective control, research, and educational efforts relating to noxious weeds (7 U.S.C. 2814(f)). USDA's Departmental Regulation 9500-10 sets forth Departmental policy relating to the management and coordination of noxious weeds activities among the agencies within USDA and other entities.

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA; Title I of P. NO. 101-646, 16 U.S.C. § 4701 et seq.)

This Act established a Federal program to prevent the introduction of, and to control the spread of, introduced aquatic invasive species and the brown tree snake. NANPCA established the framework for a comprehensive Aquatic Nuisance Species program, which included the development of a Federal Aquatic Nuisance Species Task Force, as well as called for the development of State and regional management plans to assist in the control of AIS.[44]

The U.S. Fish and Wildlife Service, the U.S. Coast Guard, the Environmental Protection Agency, the Army Corps of Engineers, and the National Oceanic and Atmospheric Administration share responsibilities for implementing this effort. They act cooperatively as members of an Aquatic Nuisance Species Task Force to develop a program for protection, monitoring, control, and research. The Act directs the Task Force to:

- identify areas where ballast water exchange does not pose an environmental threat;

[43] Text directly from the US Department of Energy (DOE) environmental policy and guidance website, http://tis.eh.doe.gov/oepa/law_sum/CZMA.HTM

- assess whether aquatic invasive species threaten the ecological characteristics and economic uses of U.S. waters other than the Great Lakes;
- determine the need for controls on vessels entering U.S. waters other than the Great Lakes; and
- identify and evaluate approaches for reducing the risk of adverse consequences associated with intentional introduction of aquatic organisms.

Under NANPCA, State governors are authorized to submit comprehensive management plans to the Task Force for approval that identifies those areas or activities within the State for which technical, enforcement, or financial assistance is needed to eliminate or reduce the environmental, public health, and safety risks associated with aquatic invasive species. Grants are authorized to states for implementing approved management plans, with a maximum Federal share of 75% of the cost of each comprehensive management plan.

Alien Species Prevention Enforcement Act of 1992 (P.L. 102-393)

The Alien Species Prevention Enforcement Act of 1992 (Section 631 of the Treasury, Postal Service and General Government Appropriations for Fiscal Year 1993) makes it illegal to ship certain categories of plants and animals through the mail. The prohibited species are certain injurious animals, plant pests, plants and materials under Federal quarantine, and certain plants and animals under the Lacey Act, a law that pertains to illegal trade in fish, wildlife, and plants.[45]

National Invasive Species Act of 1996 (NISA; P.L. 104-332)

In 1996, NISA amended NANPCA to mandate regulations to prevent the introduction and spread of aquatic invasive species into the Great Lakes through ballast waters and other vessel operations.

The Act requires a U.S. Coast Guard study and report to Congress on the effectiveness of existing shoreside ballast water facilities used by crude oil tankers in the coastwise trade off Alaska as well as studies of Lake Champlain, the Chesapeake Bay, San Francisco Bay, Honolulu Harbor, the Columbia River system, other estuaries of national significance, and other waters.

The Act also authorized funding for research on aquatic invasive species prevention and control in the Chesapeake Bay, the Gulf of Mexico, the Pacific Coast, the Atlantic Coast, and the San Francisco Bay-Delta Estuary.

In addition, NISA required a ballast water management program to demonstrate technologies and practices to prevent aquatic nonindigenous species from being introduced into and spread through ballast water in U.S. waters. It modified: (1) the composition and research priorities of the Aquatic Nuisance Species Task Force; and (2) zebra mussel demonstration program requirements.

Executive Order 13112 (1999)

President Clinton signed Executive Order 13112 on Invasive Species (64 Fed. Reg. 6193) on February 3, 1999. The Executive Order seeks to prevent the introduction of invasive species, provide for their control, and minimize their impacts through better coordination of Federal agency efforts under a National Invasive Species Management Plan, to be developed by an interagency Invasive Species Council. The Order directs all Federal agencies to address invasive species concerns as well as refrain from actions likely to increase invasive species problems. A draft version of the National Management Plans was produced on October 2, 2000.

Plant Protection Act (2000; 7 U.S.C. 7701 *et seq*.)

The Plant Protection Act, which consolidated the authorities in the Plant Quarantine Act, Federal Plant Pest Act, Federal Noxious Weed Act, and other plant-related statutes, authorizes USDA to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism, noxious weed, article, or means of conveyance if the Secretary of Agriculture determines that the prohibition or restriction is necessary to prevent the introduction into the United States, or the dissemination within the United States, of a plant pest or noxious weed. A "plant pest" is defined as any living stage of any of the following that can directly or indirectly cause damage to, or cause disease in any plant or plant product: A protozoan, nonhuman animal, parasitic plant, bacterium, fungus, virus or viroid, infectious agent or other pathogen, or any article similar to or allied with any of those articles. A "noxious

[45] Text directly from the U.S. House Committee on Agriculture's website, www.agriculture.house.gov

weed" is defined as a plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment.

The PPA specifically authorizes USDA to hold, seize, quarantine, treat, apply other remedial measures to destroy or otherwise dispose of any plant, plant pest, noxious weed, biological control organism, plant product, article or means of conveyance that is moving (or has moved) into or through the United States or interstate, if USDA considers it necessary in order to prevent the dissemination of a plant pest or noxious weed that is new to or not known to be widely prevalent or distributed within or throughout the United States. This authority extends to progeny of prohibited items moved in violation of the PPA. The PPA also authorizes USDA to order an owner, or an agent of the owner, of a plant, biological control organism, plant product, plant pest, noxious weed, article, or means of conveyance to treat, destroy, or otherwise dispose of those items. In addition, when a State is unable or unwilling to take the necessary action to prevent the dissemination of a plant pest or noxious weed, the Secretary has the authority to declare an extraordinary emergency and take the actions described in this paragraph within a State (i.e., when interstate movement is not involved).

The PPA specifically authorizes USDA to develop integrated management plans for noxious weeds for the geographic region or ecological range where the noxious weed is found in the United States.

In addition, the PPA authorizes USDA to cooperate with other Federal agencies or entities, States or political subdivisions of States, national governments, local governments of other nations, domestic or international organizations, domestic or international associations, and other persons to carry out the provisions of the PPA.

Animal Health Protection Act (2002; 7 U.S.C. 8301, et seq.)

The Animal Health Protection Act (AHPA), passed as part of the 2002 Farm Bill, consolidated and modernized most of USDA's animal quarantine and related laws, providing a flexible statutory framework to protect domestic livestock from foreign pests and diseases. The AHPA authorizes USDA to promulgate regulations and take measures to prevent the introduction and dissemination of pests and diseases of livestock. The scope of such regulatory authority extends to the movement of all members of the animal kingdom, domestic and wild, except man. The fact that a pest or disease primarily affects animals other than livestock, including man, does not limit USDA's authority to regulate a species, so long as it carries a pest or disease of livestock. Further, the AHPA defines "livestock" to mean all farm-raised animals, clarifying USDA authority to conduct animal health protection activities in connection with farm-raised aquatic animals.

Under the AHPA, USDA is authorized to seize, quarantine, treat, destroy, dispose of, or take other remedial action with respect to animals, animal products, other material, and means of conveyance that move or are handled in interstate or foreign commerce and that may carry or are affected by a pest or disease of livestock. The Act further authorizes USDA to cooperate with States and other entities in carrying out its various responsibilities to control or eradicate pests or diseases of livestock. In cases where State action is inadequate to control or eradicate a pest or disease, the Secretary, in consultation with the State, may determine that an extraordinary emergency exists and take actions within the State.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; TIAS 8249)[46]

The CITES treaty is the international vehicle for controlling trade in species considered by signatory nations to be threatened with extinction.

[46] CITES is not truly a 'law', but an international treaty that the US is a party to.

FEDERAL AGENCIES THAT ADDRESS AIS ISSUES

This section provides a brief discussion of agencies on a Federal level that are addressing aquatic invasive species issues. Not every Federal agency is listed, or are all activities of each agency. Rather, this section is intended to summarize relevant Federal authorities that are involved with AIS issues both nationally and in Hawai‘i, to better understand the resources that are available to help address the problems and concerns identified in the plan.

The following descriptions have been supplied either directly by representatives of the respective agencies and/or obtained from websites and supplied to the agency representatives for approval. Additional information or clarification on the activities of these or other Federal agencies that may not be yet listed is welcomed and encouraged for subsequent versions of this plan.

This Section Highlights the Following Federal Agencies:

Environmental Protection Agency (EPA)
National Oceanic and Atmospheric Administration (NOAA)
Office of Oceanic and Atmospheric Research (OAR)
National Ocean Service (NOS)
NOAA Fisheries / National Marine Fisheries Service (NMFS)
United States Army Corps of Engineers
United States Department of Agriculture (USDA)
Animal and Plant Health Inspection Service (APHIS)
Forest Service, Agricultural Research Service, Cooperative State Research, Education, and Extension Service.
United States Department of Defense (DoD)
United States Department of Homeland Security (DHS)
Customs and Border Protection (CBP)
United States Coast Guard (USCG)
United States Fish and Wildlife Service (USFWS)
United States Geological Survey (USGS)

Environmental Protection Agency (EPA)

The Environmental Protection Agency’s Office of Wetlands, Oceans and Watersheds (OWOW) promotes a watershed approach to manage, protect, and restore our marine and fresh waters. OWOW is part of a government-wide effort to address the threat of AIS. It studies and improves national programs to find ways to combat the invasive species problem. OWOW is working with partners in the government, public and private sectors; taking steps to prevent and control invasive species releases; and setting measurable goals to chart our progress and improve our programs. Some of its current activities include: working within the EPA’s Office of Water and with other EPA offices to develop and advance the Agency's efforts on invasive species, and participating in interagency and international organizations and programs charged with reducing, preventing, or recovering from invasive species impact.

National Oceanic and Atmospheric Administration (NOAA), Department of Commerce

NOAA is the primary Federal agency charged with management of marine resources. In addition, it is the lead agency on oceanographic information. In addition to management activities, NOAA has an extensive research program related to marine and coastal resources. NOAA is the co-chair of the Aquatic Nuisance Species Task Force and has been designated the Department of Commerce lead as co-chair of the National Invasive Species Council. NOAA line agencies involved in aquatic invasive species issues include (listed in order of their current magnitude of efforts on the Federal level): the Office of Oceanic and Atmospheric Research, the National Ocean Service, and the NOAA Fisheries

NOAA - Office of Oceanic and Atmospheric Research (OAR)

National Sea Grant Program: The National Sea Grant Program is a partnership between the nation's universities and NOAA (under OAR) that began in 1966. Under §1202(f) of NANPCA, the National Sea Grant program has a competitive grant program for research and education and outreach proposals on aquatic invasive species. In addition, individual State sea grant programs have funded similar proposals out of their core funds. Past projects and research in Hawai‘i include a baseline biodiversity assessment of natural harbors in Hawai‘i, a study of non-indigenous marine sponges in the Hawaiian Islands, and a look at the control of channeled apple snails. Currently, the Hawai‘i office fund two grants for research on the invasive coral, *Carijoa riisei*. Otherwise, they have little activity at present but have included marine introduced species as new focal area in their 2005-2007 biennial plan, and will be asking for proposals on AIS problems during those years

The Sea Grant Nonindigenous Species Site (SGNIS), http://www.sgnis.org, is a project of the National Sea Grant College Program, produced by the Great Lakes Sea Grant Network. It is a national information center that contains a comprehensive collection of research publications and education materials produced by Sea Grant programs and other research institutions across the country on zebra mussels and other aquatic invasive species.

Under §1104 of NANPCA, NOAA and the U.S. Fish and Wildlife Service are authorized to conduct a ballast water management demonstration program for the development of new technologies for ballast water management. Each year a competitive grant program is conducted for the funding of promising new technologies. Within NOAA, this program is administered by OAR.

NOAA's Great Lakes Environmental Research Laboratory (GLERL), which falls under OAR, has conducted research on aspects of ballast water and the ecological impacts of invasive species in freshwater systems. In 2003, NOAA established a National Center for Research on Aquatic Invasive Species within GLERL.

NOAA - National Ocean Service (NOS)

The National Centers for Coastal Ocean Science is developing an early warning system for introductions of aquatic invasive species. The pilot for this system was a system for Hawai'i which should be operational in the fall of 2003 (further detailed in Task 3A3).

The National Estuarine Research Reserve System and the National Marine Sanctuary program have conducted monitoring activities for nonindigenous species in a number of sites.

The national Coastal Zone Management program is administered by NOS. Invasive species is one of the issues that can be addressed through this program. Initial funding for a Hawaiian AIS Ballast Water Coordinator was funded through this program.

NOS also provides funding for control of non-native algae on Hawaiian reef systems and other marine aquatic invasive species issues through the Hawai'i Coral Reef Initiative Research Program

NOAA Fisheries / National Marine Fisheries Service (NMFS)

NOAA Fisheries is charged with rebuilding and maintaining sustainable fisheries. Invasive species may have a direct impact on such resources. In addition, the Magnuson-Stevens Act gives NOAA Fisheries responsibility for protecting and maintaining essential fish habitat.

NOAA Fisheries is also responsible for implementation of the Endangered Species Act of 1973 for marine and anadromous species.

The National Marine Fisheries Service Pacific Islands Fisheries Science Center (PIFSC; i.e., the Honolulu Laboratory) is involved in AIS issues in several ways, including involvement on the Hawai'i Department of Agriculture Subcommittee on Marine and Invertebrate Animals, where they provide biology-based evaluations of permit requests for importations of nonindigenous species; representation the State's Hull Fouling and Ballast Water Alien Aquatic Organism Task Force, and supporting NOS National Centers for Coastal Ocean Science with biological information for their introduced marine species early warning system pilot project, and in funding and implementation of various marine AIS research studies.

US Army Corps of Engineers

The US Army Corps of Engineers provides engineering, construction, and environmental project services for the military and local governments. Congress authorizes the Corps to assist local governments with their water resource development needs. As part of project development and management, the Corps conducts aquatic nuisance species research and control. The Aquatic Nuisance Species Research Program (ANSRP), Aquatic Plant Control Research Program (APCRP), and Ecosystem Management and Restoration Research Program (EMRRP) have been developed to provide managers and operators with ecological information, assessment tools, and strategies on prevention, control, and management of aquatic nuisance species.

United States Department of Agriculture (USDA)

The U.S. Department of Agriculture (USDA) provides leadership on food, agriculture, natural resources, and related issues by:

- Enhancing economic opportunities for agricultural products;
- Supporting increased economic opportunities and improved quality of life in rural America;
- Enhancing protection and safety of the Nation's agriculture and food supply;
- Improving the Nation's nutrition and health; and
- Protecting and enhancing the Nation's natural resource base and environment.

USDA - Forest Service, Agricultural Research Service, Cooperative State Research, Education, and Extension Service.

The Forest Service, under USDA, has played a significant role in collaboratively addressing invasive species threats at the local, State, national and international levels with diverse and wide-ranging activities, though to date, these activities have been largely terrestrial in focus. USDA is also involved with invasive species on many other levels through their research and extension arms, including the Agricultural Research Service, and the Cooperative State Research, Education, and Extension Service. In Hawai'i, because aquatic aspects of invasive species fall largely, though not solely under the Animal and Plant Health Inspection Service (APHIS), this program is further described below:

USDA – Animal and Plant Health Inspection Service (APHIS)

USDA's Animal and Plant Health Inspection Service is an action-oriented agency that works with other Federal agencies, Congress, States, agricultural interests, and the general public to carry out its mission to protect the health and value of American agriculture and natural resources. APHIS guards against the introduction or reemergence of animal and plant pests and diseases that could limit production and damage export markets. At the same time, APHIS monitors and responds to potential acts of agricultural bioterrorism, invasive species, diseases of wildlife and livestock, and conflicts between humans and wildlife. APHIS also addresses sanitary and phytosanitary trade barriers and certain issues relating to the humane treatment of animals. Finally, APHIS ensures that biotechnology-derived agricultural products are safe for release in the environment.

APHIS is organized into six operational program units—Animal Care, Biotechnology Regulatory Services, International Services, Plant Protection and Quarantine, Veterinary Services, and Wildlife Services (The activities of three of these units are described below) —and three management support units. APHIS activities are carried out under the provisions of several Federal laws. Recent acts of Congress, including the Plant Protection Act (2000), the Animal Health Protection Act (2002), and the Public Health Security and Bioterrorism Preparedness Act (2002), have expanded the scope of APHIS' mission and provided for additional protective responsibilities.

Plant Protection and Quarantine (PPQ) is the unit that safeguards agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds. Fulfillment of its safeguarding role ensures an abundant, high-quality, and varied food supply, strengthens the marketability of U.S. agriculture in domestic and international commerce, and contributes to the preservation of the global environment. APHIS/ PPQ has the primary exclusion function through inspection of propagative material and regulatory policy, and treatment support to Department of Homeland; Customs and Border Protection (DHS/ CBP). PPQ carries out secondary exclusion through Smuggling Interdiction and Trade Compliance (SITC), pest detection, and response.

Veterinary Services (VS) is the animal health arm of APHIS. VS is dedicated to protecting the health, quality, and productivity of the Nation's livestock and facilitating agricultural trade, serving the livestock producers (including the aquaculture industry) of this country as well as the consumers of animal products and citizens concerned about public health and environmental safety. VS animal health programs involve five major activities: Keeping foreign animal diseases from entering the country, providing an emergency response when exotic livestock diseases slip past U.S. borders, controlling or eradicating major domestic livestock diseases, preventing the interstate spread of diseases, and facilitating exports by attesting to the health status of outgoing animals.

Wildlife Services (WS) assists in solving problems that are created when species of wildlife cause damage to agriculture, urban, or natural resources or are threats to human health and safety. WS is a Federal cooperative program that responds to requests by persons and agencies needing help in controlling wildlife damage. Wildlife

Services have been involved in various aquatic and terrestrial invasive species issues in Hawai‘i, such as efforts with the brown tree snake and coqui frogs.

United States Department of Defense (DoD)[47]

The Department of Defense manages over 25 million acres of lands within military installations. The DoD controls and manages invasive species in accordance with the individual plans governing each installation or base. The goals of the Defense's Invasive Species Management Program are prevention, control of invasive species present on DoD installations, and restoration using native plants.

In Hawai‘i, the Marine Corps Base Hawai‘i (MCBH) has been an early leader in invasive species control, especially of aquatic invasives in coastal wetland environments at their Mokapu Peninsula, windward O'ahu location. About fifty percent of their total natural resources management efforts address some aspect of the invasive species problem. The Marine Corps Base Hawai‘i is featured in Case Study 6, in Chapter 5 of this document.

United States Department of Homeland Security (DHS)

The Department of Homeland Security (DHS) was created on March 1 of 2003.

DHS - Customs and Border Protection (CBP)

Customs and Border Protection (CBP), one component of DHS, combines parts of USDA-APHIS-PPQ (detailed on previous pages), Immigration and Naturalization Services, and Customs into one agency. CBP's primary mission is to keep terrorist and terrorist weapons out of the United States. The legacy missions of the three former agencies still apply to CBP including protecting American agriculture and natural resources.

DHS-CBP is very restricted in what they can enforce, but the agriculture component in CBP is very interested in cooperating with other agencies and interests in Hawai‘i to the extent the agency will allow. Policies and directives are being developed as the agency evolves. USDA-APHIS-PPQ will continue to be responsible for domestic programs, including the predeparture program in Hawai‘i, changes in regulations, new regulations, coordination with the Plant Board, scientific aspects relating to risk management and identification, treatments of commodities, and many other responsibilities involving international trade and agreements, and preclearence of commodities in other countries. DHS-CBP is responsible for foreign arrivals and inspections of passengers, cargo, aircraft, vessels, other means of conveyance, and mail at nearly 700 Air/Sea Ports of Entry in the US.

DHS - United States Coast Guard (USCG)

The Coast Guard, which is under the Department of Homeland Security, has initiated a regulatory and policy guideline process to comply with the National Invasive Species Act of 1996. Ship ballast water, and hull fouling by marine organisms are among the most significant pathways for the introduction and spread of marine aquatic invasive species (AIS). These rules establish mandatory ballast water management and reporting requirements for vessels operating upon United States waters. Failure to comply with the applicable rules may result in enforcement action including civil and criminal penalties.

The Coast Guard proposes to implement a national ballast water program in 2003-04 that maximizes the use of existing ballast water management methods and fosters the development of ballast water treatment technologies. The regulatory steps toward this end include:

- A requirement that all vessels conduct active ballast water management.
- The establishment of penalties for failure to report ballast water management practices.
- A program to provide incentive for ship owners and operators to actively collaborate in projects testing ballast water treatment technologies.
- Development of a regulatory standard for the treatment of ballast water and the associated certification protocols.

The Coast Guard is also engaged in foreign negotiations through the International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC) to address AIS and ballast water issues. The MEPC Ballast Water Working Group is working to develop an international convention for the control and management of ship's

[47] Text on DoD taken directly from National Invasive Species Council 2001, text on MCBH supplied by D. Drigot, personal comm.

ballast water and sediments. Current status of the effort is to have a draft convention completed in time for a proposed diplomatic conference on the topic in 2004.

United States Fish and Wildlife Service (USFWS), U.S. Department of Interior

The U.S. Fish and Wildlife Service (USFWS) has multiple programs that address AIS prevention and control. USFWS serves as co-chair of the Federal Aquatic Nuisance Species (ANS) Task Force, and is the Federal agency that provides Federal funding for the implementation of State and regional AIS management plans which have been approved by the Federal ANS Task Force. USFWS also provides technical assistance to states regarding AIS management. In addition to a regional AIS Coordinator based in the USFWS Pacific Region office in Oregon, USFWS maintains an Invasive Species Coordinator at the Pacific Islands Field Office in Honolulu and a number of other Hawaii-based staff that work on AIS-related projects. USFWS prevention programs include the 100th Meridian Initiative, which focuses on preventing the western spread of zebra mussels. USFWS refuges and programs such as Partners for Fish and Wildlife support invasive species control programs as part of their overall habitat restoration activities.

The U.S. Fish and Wildlife Service administers the Lacey Act, which prohibits importation and interstate delivery of listed species. The USFWS Enforcement Division has responsibility for all imports of wildlife or wild plants into the United States from foreign sources. The wildlife inspectors are responsible for ensuring that all wildlife, wild plants, and related products entering or leaving the United States are in compliance with Federal and State laws and international treaties, including the Endangered Species Act (ESA) and the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES). In Honolulu, four inspectors and two special agents carry out the work of USFWS at the Honolulu International Airport and the Honolulu Harbor.

United States Geological Survey (USGS), U.S. Department of Interior

The USGS, a bureau of the Department of the Interior, is tasked with providing scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy and mineral resources; and enhance and protect our quality of life.

USGS's Nonindigenous Aquatic Species (NAS) Information Resource Website

The NAS website, http://nas.er.usgs.gov, has been established as a central repository for accurate and spatially referenced biogeographic accounts of nonindigenous aquatic species. Provided are scientific reports, online/realtime queries, spatial data sets, regional contact lists, and general information. The data is made available for use by biologists, interagency groups, and the general public. The geographical coverage is the United States.

USGS's Hawaiian Ecosystems at Risk (HEAR) Project

The mission of the Hawaiian Ecosystems at Risk project (HEAR) is to provide technology, methods, and information to decision-makers, resource managers, and the general public to help support effective science-based management of harmful nonnative species in Hawai‘i and the Pacific.

The Hawaiian Ecosystems at Risk (HEAR) project originated at the USGS's Haleakala Field Station (Maui, Hawai‘i) of the Pacific Island Ecosystems Research Center (PIERC) the U.S. Geological Survey's Biological Resources Division. Currently, HEAR is sponsored through PIERC by funding from the Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII).

STATE AIS AUTHORITIES, PROGRAMS, AND ACTS[48]

In Hawai‘i, many State agencies have authority over and regulatory roles in managing natural resources. While many agencies have some authority to regulate AIS, the Hawai‘i Department of Agriculture (HDOA) and the Department of Land and Natural Resources (DLNR) have primary authority for many aspects relating to AIS. However, even with the myriad of involved entities, no centralized authority or management structure exists to coordinate AIS activities in Hawai‘i.

To help address this issue, on May 23, 2003, Governor Linda Lingle signed SB 1505 into law, which provides statutory authority for the Hawai‘i Invasive Species Council, (further detailed on page 3-14), to deal with the invasive species problem. This council was initially authorized with an executive order by former Governor Cayetano in 2002-03. This is a first step towards establishing a centralized State authority to coordinate AIS activities.

The following section describes the existing State level authorities that various State agencies have for managing AIS.

This Section Highlights the Following State Agencies and Programs that Address AIS Issues:

Hawai‘i Department of Agriculture (HDOA)
Statutory Authority and Regulations
Plant Imports
Import Requests
Animal Lists

Hawai‘i Department of Health (HDOH)
Environmental Planning Office
Environmental Management Division - Clean Water Branch
Environmental Services Division - Vector Control Branch

Hawai‘i Department o f Land and Natural Resources (DLNR)
Division of Aquatic Resources

Hawai‘i Invasive Species Council (HISC)

Hawai‘i Office of Planning
Hawai‘i Coastal Zone Management (CZM) Program

University of Hawai‘i (UH)
Center for Conservation Research and Training (CCRT)
Hawai‘i Coral Reef Initiative Research Program (HCRI-RP)
Waikiki Aquarium

Hawai‘i Department of Agriculture (HDOA)[49]

The Hawai‘i Department of Agriculture is the lead State agency in protecting Hawaii's agricultural and horticultural industries, animal and public health, natural resources and environment from the introduction of invasive species. To accomplish this task, the HDOA has charged the Plant Quarantine Branch (PQB) of the Plant Industry Division with being the 'First Line of Defense' against pests entering Hawai‘i by:

- Preventing the introduction of invasive plant species, harmful insects and other invertebrate species, animal and plant diseases, illegal non-domestic animals, and other pest species from entering Hawai‘i;
- Preventing the further spread of pest species (animals and plants) from one island to another island, or from an infested area to an uninfested area on the same island; and
- Facilitating the export of allowable agricultural materials to other states, territories, or foreign areas by the establishment of a nursery certification and plant inspection program.

HDOA's Statutory Authority and Regulations

The importation of plants, non-domestic animals and microorganisms into Hawai‘i are regulated in slightly different ways by the Hawai’i Department of Agriculture (HDOA):

- 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;

[48] Prepared by Kimberly Moffie, Pacific Fisheries Coalition

[49] Author: Domingo Cravalho, Hawai‘i Department of Agriculture

- Non-domestic animals are either listed as prohibited, restricted or conditionally approved under a permit system with unlisted animals deemed prohibited until reviewed by the Board of Agriculture for future listing; and
- Certain microorganisms require a permit for import and are either listed as restricted or selected human pathogens, or require a letter of authorization for entry for non-restricted listed microorganisms with unlisted microorganisms being restricted, but subject to Board of Agriculture approval for listing or entry.

To accomplish program goals, the HDOA obtains its authority from Hawai‘i Revised Statutes Chapter 150A entitled the “Plant and Non-Domestic Animal Quarantine” law. Pursuant to this statutory authority the following Hawai‘i Administrative Rules (HAR) were promulgated:

- Chapter 4-70, HAR: *Plant Import Rules*
- Chapter 4-71, HAR: *Non-Domestic Animal Import Rules*
- Chapter 4-71A, HAR: *Microorganism Import Rules*
- Chapter 4-72, HAR: *Plant Intrastate Rules*
- Chapter 4-73, HAR: *Plant Export Rules*

Plant Imports under HDOA

The import of plants into the State is regulated by the HDOA. However, not all plants require permits. At present there are currently 12 plant crops that are regulated to some degree under HAR chapter 4-70, which includes the following: sugarcane and grasses, pineapple and other bromeliads, coffee, cruciferous vegetables, orchids, banana, passion fruit, pine, coconut, hosts of European corn borer, palms, and hosts of Caribbean fruit fly.

HDOA’s Noxious Weed List

The HDOA’s Plant Pest Control Branch establishes criteria for the designation, control, or eradication of noxious weeds. Plants that are designated as noxious weeds and are listed under HAR chapter 4-68, entitled "Noxious Weeds Rules", are restricted from entry into Hawai‘i except by permit issued by the Plant Quarantine Branch.

At present the State noxious weed list does not include any aquatic invasive species. However, the 2003 Legislature adopted and Governor Lingle signed into law Act 085, which states that no person shall import, offer for sale, or sell any *Salvinia molesta*, *Salvinia minima* and *Pistia stratiotes* plants or portions thereof within the State.

HDOA Import Requests for Non-Domestic Animals

Permits are required for all live non-domestic animals in any stage of development that are imported into the State of Hawai‘i. Application requests are reviewed by the appropriate HDOA’s Plant Quarantine Branch (PQB) specialist to determine the entry status of the organism, as well as any permit requirements and conditions that must be met before a permit is issued. A detailed description of the permit process is presented in Appendix H

If the Board approves the request and the organism is proposed for listing, then the appropriate list found under H.A.R. Chapter 4-71 will need to be amended to include the requested organism by following the rulemaking process as required by H.R.S. Chapter 91 requirements. Once the list amendments are completed the permit requirements and conditions must then be addressed by the Board prior to entry of the organism under permit.

HDOA Animal Lists: Hawai‘i Administrative Rules Chapter 4-71

The importation of non-domestic animals, which includes aquatic species, is regulated by a permit system pursuant to H.A.R. § 4-71. Included in this administrative rule are the following lists of non-domestic animals that are maintained by the Board of Agriculture:

- List of Prohibited Animals, which include organisms that are prohibited from entry;
- List of Restricted Animals, which requires a permit for both import into and possession in the State. The restricted list further consists of a Part A section, whereby animals on this list are allowed for government use, and a Part B section, which allows for private use; and
- List of Conditionally Approved Animals, which requires a permit for import only.

Any organism that is not listed on any of the lists is considered prohibited until a review for future placement is determined by the Board of Agriculture.

Animals that are on the conditionally approved list are allowed for import under permit for individual possession, businesses, or institutions. The permitted uses of conditionally approved animals may include for the pet/resale trade, retail sales, food consumption and classroom use to name a few.

Animals on Part A of the restricted list are allowed for research by universities or government agencies, exhibition in municipal zoos or government-affiliated aquariums, for other institutions for medical or scientific purposes, or for other purposes as specified by the Board.

Animals on Part B of the restricted list are allowed for private and commercial use, including research, zoological parks, or aquaculture production.

Hawai‘i Department of Health (HDOH)

The mission of the Department of Health is to provide leadership to monitor, promote, protect, and enhance the health and environmental well-being of all of Hawaii's people. Aquatic invasive species issues primarily fall under HDOH's Environmental Health Administration, under the following three divisions and offices:

Environmental Planning Office

The mission of the Environmental Planning Office is to enhance environmental management by the other offices and divisions within the Environmental Health Administration through providing planning assistance, coordination services, information management and legislative support. The Environmental Planning Office is currently developing and applying a biological assessment methodology, which uses native and introduced species' composition along with habitat and water chemistry data to evaluate the health of a stream.

Environmental Management Division - Clean Water Branch

The Clean Water Branch administers and enforces statewide water pollution laws and rules, including the National Pollutant. This is achieved through permitting of point sources, compliance monitoring, inspections, investigations of complaints, ambient water quality monitoring, and public education. Major activities potentially relating to the management of aquatic invasive species are highlighted below, under their specific sections of the CWB:

Engineering Section: Administers the National Pollutant Discharge Elimination System (NPDES) permit program for the U.S. Environmental Protection Agency.

Monitoring and Analysis Section: Identifies sources of pollution through area surveillance, routine inspections, and investigation of complaints. Evaluates public health significance of pollutants and determine compliance with public health rules and permit conditions through coastal water sampling, and special studies. Conducts studies of the impact of pollutants on fish and other marine life.

Enforcement and Compliance Section: Conducts analysis of all NPDES, general, and stormwater permits for compliance with effluent limitations, best management practices, other permit conditions, and water quality Standards. Determines compliance with permit conditions via site inspection, source testing and special studies; and corrective measures through administrative or court actions.

Polluted Runoff Control Program: Fosters partnerships with other agencies involved in nonpoint source pollution control. Promotes community-based watershed management through education and voluntary compliance with environmental management standards. Provides Federal funding for demonstration of best management practice projects from the public and private sectors relating to non point source control. Encourages and supports programs for environmental education.

Environmental Health Services Division - Vector Control Branch

The Vector Control Branch (VCB) is a statewide regulatory program, mandated by law, with a large and diverse area of responsibility. The VCB safeguards public health by ensuring abatement, containment, eradication, and suppression of disease outbreaks and alien immigrant insect vectors and zoonotic diseases, reduction of vector populations, and prevention of the entry of alien species. Increased attention has been focused on the State's programs which address alien species, biological terrorism threats, and responses to requests from citizens and visitors to Hawai‘i.

In recent years, the program has also been proactive with other agencies in a partnership working to collectively to address vector control issues and concerns in public health and the environment. Partnership agencies include the State Departments of Agriculture, Attorney General, Transportation, and Land and Natural Resources, the University of Hawai‘i, Bishop Museum, and The Nature Conservancy, among others. This approach is implemented through inspections, consultations, control and abatement activities, enforcement, residential surveys, surveillance and applied research.

The goal of the Vector Control Branch is to prevent the occurrence and transmission of vector-borne diseases and health related injuries to the general public and visitors to the State of Hawai‘i.

Hawai‘i Department of Land and Natural Resources (DLNR)

Division of Aquatic Resources (DAR)

The Division of Aquatic Resources (DAR) is one of eleven divisions within the Department of Land and Natural Resources (DLNR). DLNR is legislatively authorized to manage the aquatic resources of the State (H.R.S. § 187A-2(1)) and is responsible for conserving, protecting, and enhancing the State's renewable resources of aquatic life and habitat; managing non-commercial use of these resources; promoting, developing and enhancing opportunities for public recreational fishing; managing commercial use of Hawaii's aquatic resources; and promoting the development and utilization of these resources.

DAR's Statutory Authority: Release of Aquatic Life

No person shall release any live non-native fish or other live non-native aquatic life being held in an aquarium or other confinement for scientific study, exhibition, display, sale, or for any other purpose, into any waters of the State, except as provided in Section 187A-2(4) H.R.S. (H.R.S. § 187A-6.5) The DLNR or its agents may seize, confiscate, or destroy as a public nuisance, any fish or other aquatic life found in any waters of the State and whose importation is prohibited or restricted pursuant to rules of the department of agriculture. A violation is a petty misdemeanor, punishable by a minimum of $250 for a first offense, $500 for a second, and $1,000 for a third or subsequent offenses. (H.R.S. § 187A-13). The Board of Land and Natural Resources may set, charge, and collect administrative fines and to recover administrative fees and costs, including attorney's fees and costs, or bring legal action to recover administrative fines, fees, and costs, including attorney's fees and costs, or payment for damages or for the cost to correct damages. (H.R.S. §187A-12.5).

An animal species advisory commission exists within the DLNR, which may serve in an advisory capacity to the BLNR on every proposal for the deliberate introduction of aquatic life and wildlife by the department into any habitat within the State, whether the proposed introduction is from outside the State into the State, or from one area in the State into another area within the State. (H.R.S. §197-2). There is an aquatic life and wildlife advisory committee in each county of the State of Hawaii for the consideration of any matter affecting the taking and conservation of aquatic life and wildlife within the county, including proposed rules and their enforcement. (H.R.S. §197-4).

No species of aquatic life or wildlife may be deliberately introduced by the department into the State of Hawai‘i, whether it be from outside the State into the State or from one area within the State to another area in the State, unless the introduction is recommended by the DLNR and authorized by its rules. (H.R.S. §197-3). The department, in determining whether to recommend the deliberate introduction of aquatic life and wildlife, must determine:

- The factors which limit the distribution and abundance of the species in its native habitat have been studied and its probably dispersal patter appraised;
- Whether in the area where the species is proposed to be introduced there is or had been stock of a desirable, ecologically comparable indigenous species which can be increased or rehabilitated by reintroduction or by encouraging extension of its range;
- Whether the species proposed to be introduced would threaten the existence and stability of any indigenous species as predator; competitor for food, cover, or breeding sites; or in any other way arising from its characteristics and ecological requirements;
- The availability of socially acceptable methods of eliminating the species or keeping it under control in the area where it is proposed to be introduced and in adjoining areas;

- The extent to which the species will enhance the economic and aesthetic values of the area where it is proposed to be introduced;
- That the individuals to be introduced are free from communicable diseases and parasites and that there is no reason to believe that any communicable disease or parasite constitutes an important factor in the control of population; and
- That there is no foreseeable risk of conflict on account of the introduction with land use policies in the area where a species is proposed to be introduced or in adjoining areas to which the species might spread.

Before any species of aquatic life is introduced into a habitat, the suitability of the introduction must be tested, if there is an experimental area available that can be fully controlled with a habitat typical of the area where the species is proposed to be introduced. (H.R.S. §197-3). When a species of aquatic life or wildlife is deliberately introduced into a habitat and until the species becomes established on a stable basis, the department will conduct studies of the introduced species in its new habitat, including studies of its rate of spread and impact on the habitat. (H.R.S. §197-3). The DLNR may adopt rules concerning the protection and propagation of introduced and transplanted aquatic life, or the conservation and allocation of the natural supply of aquatic life in any area. The rules may include size limits, bag limits, open and closed fishing seasons specification and numbers of fishing or taking gear which may be used or possessed; and prescribe and limit the kind and amount of bait that may be used in taking aquatic life, and the conditions for entry into areas for taking aquatic life in any area.(H.R.S. §187A-5).

DAR's Statutory Authority: Ballast Water

The DLNR is designated as the lead State agency for preventing the introduction of alien aquatic organisms and carrying out the destruction of them through the regulation of ballast water discharges and hull fouling organisms. (H.R.S. § 187A-32 (a)). The department may establish an interagency team to address the concerns relating to alien aquatic organisms. (H.R.S. § 187A-32 (a)). The DLNR may adopt rules, including penalties and standards for the department and the United States Coast Guard to use as part of their respective inspection protocols. (H.R.S. § 187A-32 (b)). The rules may also include implementation for a course of action in relation to the arrival or pending arrival of a high-risk vessel. High-risk vessels may include fishing and recreational vessels and floating platforms, such as barges, dry docks, drilling rigs, or cranes, which have spent extended periods of time tied up in out-of-State ports. (H.R.S. § 187A- 32). Further details of the Ballast Water Management Program are detailed at the end of this section, on page 3-21.

DAR's Statutory Authority: Aquaculture

The DLNR may issue to any qualified aquaculturist a license to fish, possess, rear, and sell any aquatic life whose fishing, possession, or sale is prohibited by closed season, minimum size, or bag limit; provided that the qualified aquaculturist rears or reared the aquatic life in an aquaculture facility. (H.R.S. §187A-3.5). The DLNR may further issue to any person a license to possess or sell or offer for sale any aquatic life whose possession or sale is prohibited by a closed season, minimum size, or bag limit; provided that the aquatic life was reared by a licensed qualified aquaculturist in an aquaculture facility. (H.R.S. §187A-3.5).

The DLNR issues the above permits to qualified aquaculturists for *local* species. A local species is one that is already present in Hawai‘i and does not need to be imported. This would probably not include an alien species unless the species was already established in Hawai‘i.

The HDOA, through their programs, oversees and regulates the importation of *non-local* species. This means that if a person wants to aquaculture a species not found in Hawai‘i and it would need to be imported, they would submit their request to import the species to the HDOA.

Hawai‘i Invasive Species Council (HISC)

On June 21, 2002, then-Governor Benjamin Cayetano signed Executive Order 2002- 03, creating the Hawai‘i Invasive Species Council. The Council’s special purpose is to foster coordinated approaches that support local initiatives for the prevention and control of invasive species, by providing policy level direction and planning for the State that includes legislation, funding, and program direction for all State departments responsible for invasive species issues. The members are to include the chairs or directors of various State departments, the president of UH, as well as representatives from the Federal and private sector.

The 2003 Hawai'i State Legislature passed SB 1505 to statutorily establish the Hawai'i Invasive Species Council to address the invasive species problem, as authorized by Executive Order 2002-03. Governor Linda Lingle signed it into law on May 23, 2003 (Act 85). The purpose of Act 85 is to provide statutory authority to the Hawai'i invasive species council to continue its special purpose to foster and organize coordinated approaches among various executive departments, Federal agencies, and international and local initiatives for the prevention and control of invasive species.

Hawai'i Office of Planning

Hawai'i Coastal Zone Management (CZM) Program

Under Hawai'i Revised Statutes, Chapter 205A, CZM is tasked with protecting valuable coastal ecosystems from disruption and minimizing adverse impacts on all coastal ecosystems as well as promoting the protection, use, and development of marine and coastal resources to assure their sustainability.

Currently, development of the State's comprehensive program to prevent the introduction and dispersal of alien aquatic organisms through ballast water and on the hulls of vessels arriving in Hawaiian waters is being conducted by DLNR with support from CZM Hawai'i through funds from the National Oceanic and Atmospheric Administration (NOAA). Year one CZM Hawai'i funds supported the project coordinator position, on-going project research, the convening of the newly re-organized Alien Aquatic Organism Task Force, and the development of the ballast water exchange and reporting program component of the State's comprehensive prevention plan.

CZM Hawai'i continues to provide funding support to DLNR in developing the State's ballast water and hull fouling alien aquatic organism prevention program. Additional CZM Hawai'i funds will enable DLNR to complete the administrative rule process to implement the ballast water exchange and reporting component and develop the hull fouling component of the State's comprehensive prevention program.

University of Hawai'i (UH)

Researchers and students from the University of Hawai'i have been an integral part of many facets addressing AIS, in both marine and inland water systems. Key programs relating to AIS within the University of Hawai'i are undertaken in the following units:

- Department of Botany
- Center for Conservation Research and Training (CCRT)
- Department of Education
- Hawai'i Coral Reef Initiative Research Program (HCRI-RP)
- Hawaiian Institute of Marine Biology (HIMB)
- The Waikiki Aquarium
- Department of Zoology, including the Hawai'i Cooperative Fishery Unit, an adjunct of the Department of Zoology
- Other programs, including those on community college campuses.

Representatives from the Botany, Biology, and Zoology departments have been instrumental in spearheading efforts for the understanding of biological and ecological aspects of algae blooms in Hawai'i, and in leading other efforts associated with the Marine Algae Group (MAG).

CCRT, the Hawai'i Coral Reef Initiative Research Program (HCRI-RP), and the Waikiki Aquarium are further detailed below:

- ***University of Hawaii's Center for Conservation Research and Training (CCRT)***

  Formed in 1993, the mission of Center for Conservation Research and Training is to begin to address Hawaii's extinction crisis through enhanced research and training in the field of conservation biology.

  The CCRT is tracking all alien non-marine mollusks that get into the State, and in particular monitoring the spread of the various species of Ampullariidae (apple snails) that have already been introduced, and undertaking taxonomic, phylogenetic and biogeographic work on Ampullariidae to investigate the origins relationships and geographic origins of the species introduced to the State.

  CCRT houses many research and training units, including the Hawai'i Natural Heritage Program and the Hawai'i Stream Research Center, which are described below.

- ***CCRT- Hawai'i Natural Heritage Program (HINHP) and Marine Gap Analysis of Hawai‘i (MGAP)***

  The Hawai'i Natural Heritage Program is a non-profit affiliate of The Center for Conservation Research and Training. HINHP is also part of NatureServe, an international network of databases. HINHP compiles and maintains detailed, comprehensive information on Hawaii's rarest biological resources. HINHP's mission is to synthesize, interpret, and distribute this information to a wide set of appropriate users toward making a positive impact on biodiversity protection. The HINHP database is the State's largest computerized inventory of endangered, threatened, and rare plants, animals, and ecosystems, extracted from all available sources.

  The HINHP has recently expanded its scope to include tracking information on the distribution and abundance of near-shore marine species and natural communities, through its Marine Gap Analysis (MGAP) of Hawai‘i program. Working with DAR and the Hawai‘i Community Foundation, MGAP is developing a comprehensive marine database to provide a repository and on-going information management and dissemination function for biogeographic information recorded by research and management institutions. MGAP is also developing a Decision Support System to enable rapid review of marine species and natural community information. In addition to tracking native species and natural communities, MGAP is also developing a clearinghouse for information on factors, which degrade marine natural resources including invasive species.

- ***CCRT- The Hawai‘i Stream Research Center (HSRC)***

  Under CCRT, The Hawai‘i Stream Research Center (HSRC) on the island of Kaua‘i, is a field research laboratory focusing on studies in Hawaiian freshwater ecology. HSRC was established in July 1996 as a cooperative project between CCRT, the State Department of Land and Natural Resources, Division of Aquatic Resources, and the National Tropical Botanical Garden (Limahuli Gardens). The mission of the Hawai‘i Stream Research Center is “to assist the State of Hawai‘i in its efforts to develop responsible, effective, science-based management policies and strategies which provide for the long-term sustainability and enhancement of aquatic ecosystems”. To fulfill its mission, the HSRC is pursuing basic and applied research directed at understanding the ecological functioning of Hawaiian streams in relation to riparian zones, watersheds, estuaries, and nearshore marine habitat.

- ***Hawai‘i Coral Reef Initiative Research Program (HCRI-RP)***

  In 1998, the Hawaii Coral Reef Initiative Research Program (HCRI-RP) was established to support scientific research and monitoring to enhance the State’s capacity to manage its coral reef resources.

  HCRI-RP is jointly managed by Hawaii's Department of Land and Natural Resources, Division of Aquatic Resources (DAR) and the University of Hawai‘i (UH) through a Management Committee. At present, the Committee has three representatives from DAR, one from the US Fish and Wildlife Service, two from the University of Hawaii, and one from the Pacific Science Association/Bishop Museum.

  HCRI-RP sponsors monitoring of the State's coral reefs and research on the major threats to them. Results provide resource managers with information to help effectively and efficiently manage Hawaii's coral reefs. Over its first five years, the program received nearly $4 million in Congressional funding through the National Oceanic and Atmospheric Administration's Center for Sponsored Coastal Ocean Research (NOAA/CSCOR), home of the Coastal Ocean Program (NOAA/COP). NOAA/COP is part of the National Ocean Service (NOAA/NOS) and the National Centers for Coastal Ocean Science.

  HCRI-RP has been a major funder of recent AIS projects in Hawai‘i. The priorities that have been set for the upcoming fiscal year (2003-2004) continue to focus on aquatic invasive species, and include the following:

  - Establish protocols for culturing and distributing marine animals and native species to control and /or eradicate alien and invasive species threatening Hawaii's coral reef ecosystems.
  - Assess the presence and monitor the growth and spread of alien invertebrate, algae, and vertebrate species, particularly those that pose the greatest potential threat to the main Hawaiian Islands’ coral reef ecosystems.
  - Assess the effectiveness of management measures to prevent the introduction and establishment of marine alien species - particularly with respect to maritime shipping.
  - Assess the effectiveness of nearshore marine alien species permitting procedures in Hawai‘i and develop recommendations for improving permitting procedures.

- ***University of Hawaii's Waikiki Aquarium***

  The Waikiki Aquarium, founded in 1904, is the third oldest public aquarium in the United States. A part of the University of Hawai‘i since 1919, the Waikiki Aquarium's mission supports excellence in education, research, and conservation. Ongoing volunteer nonnative algae clean-ups were initiated by the Aquarium in August, 2002, in collaboration with The Nature Conservancy, the Department of Land and Natural Resources, and other University of Hawai‘i Researchers. The Aquarium will install an interactive outdoor exhibit highlighting the issues of invasive algae on Hawaii's reefs in early 2004.

CITY AND COUNTY PROGRAMS

Maui County, Department of Public Works and Environmental Management (DPWEM):

Maui County Department of Public Works and Environmental Management (DPWEM) has jurisdiction and responsibility for the removal of algae off the beaches under HCR 405. This includes both native and nonnative species. Maui County is working in a cooperative partnership with the EPA in a $250,000 grant to collect, remove, and compost algae in the North Kihei area. $50,000 of the grant will go to University of Hawai‘i researchers to study the underlying causes of the profuse bloom of nonnative *Hypnea musciformis* and the native *Ulva fasciata,* and to determine possible means by which this growth may be reduced**.**

Editor's Note: Additional City and County agencies and organizations have been involved to various degrees in assisting with the management of both aquatic and terrestrial invasive species. Descriptions of such efforts have been requested and are encouraged to be submitted for incorporation into subsequent drafts of this plan.

ADDITIONAL ORGANIZATIONS AND GROUPS[50]

In addition to Federal and State authorities, a number of additional organizations play a key role in addressing AIS issues Hawai'i. These organizations include NGOs (non-governmental organizations), and multi-partnership groups.

The following section describes some of these groups (listed alphabetically) who are involved in ongoing AIS efforts and programs in Hawai'i. This listing should be considered a work in progress, and it is hoped that additional groups involved in AIS efforts will submit descriptions of their efforts for future versions of this plan.

This Section Highlights the Following Entities:

Bernice Pauahi Bishop Museum (Bishop Museum)
Coordinating Group on Alien Pest Species (CGAPS)
Hawai'i Audubon Society / Pacific Fisheries Coalition
Marine Algae Group and Network (MAGNET)
The Nature Conservancy (TNC)
Reef Check
ReefWatchers
Waipuilani Beach Association
Additional Community Groups / Site-Specific Efforts

Bernice Pauahi Bishop Museum (Bishop Museum)

Soon after its founding in 1889, the Bishop Museum established programs to study and document the plants and animals of Hawai'i. That effort has become the largest single source of information on Hawaiian organisms. Virtually all definitive published treatments and manuals of Hawaiian organisms, beginning with *Fauna Hawaiiensis* in 1890, have been produced by the Museum or in close collaboration with the Museum. Bishop Museum has the world's largest biological collections from Hawai'i (ca 20,000,000 specimens), is conducting field surveys to document the distribution of these organisms, and is organizing information from its collections and the associated scientific literature into a comprehensive computerized database. This information will be used to assist natural resource agencies in the management of Hawaii's precious and fragile biota for years to come. Key projects associated with the Bishop Museum include:

- **Hawai'i Biological Survey (HBS):** Established by the State Legislature as a program of the Bishop Museum, HBS is an ongoing natural history inventory of the Hawaiian Archipelago. It was created to locate, identify, and evaluate all native and nonnative species of flora and fauna within the State and maintain the reference collections of that flora and fauna for a wide range of uses. In accordance with related activities in other Federal, State, and private agencies, the HBS will gather, analyze, and disseminate the biological information necessary for the wise stewardship of Hawaii's biological resources. The HBS will conduct a coordinated inventory and monitoring program to assess the overall status and trends in the abundance, health, and distribution of plants and animals, as well as the ecosystems upon which they depend.

- **Checklist of the Marine Invertebrates of the Hawaiian Islands:** Comprehensive information on the designation of nonindigenous or cryptogenic status of Hawaiian marine invertebrates has been developed in the Checklist of the Marine Invertebrates of the Hawaiian Islands. This effort was initiated in the mid 1960's as a 3x5 card file, in an attempt to keep track of the marine biota of the Hawaiian Islands. The Invertebrate Checklist can now be viewed in a static outline form arranged in phylogenic order grouped by major taxonomic level, or it can by searched by phylum, class, order, family, species, or biogeographic status (i.e., native or introduced). The list is still considered to be preliminary, and will be updated periodically. The Checklist is available at http://www2.bishopmuseum.org/HBS/invert/list_home.htm.

- **Trading Cards and Website:** Each year, the Hawai'i Biological Survey produces a series of trading cards highlighting native and invasive species in Hawaii's ecosystem. These cards are given out to schoolchildren in the State through events sponsored by the Bishop Museum. Each card has an image of the organism on one side and brief information about their biology, origin, and distribution in Hawai'i on the reverse. The associated website supplements the information on these cards, providing additional information about each plant and animal. This site can be accessed at http://hbs.bishopmuseum.org/good-bad/list.html

[50] This section compiled by K. Moffie, Pacific Fisheries Coalition and A. Shluker, The Nature Conservancy. In most cases, descriptions are supplied directly from the respective organizations, via representatives or from the websites listed

Coordinating Group on Alien Pest Species (CGAPS) / Island Invasive Species Committees (ISCs)

The Coordinating Group on Alien Pest Species (CGAPS) is a statewide multi-agency partnership to coordinate more effective protection for Hawaii's economy, environment, health, and way of life from harmful nonnative pests. CGAPS was formed in 1995 and includes over 25 public and private agencies and organizations. CGAPS participants include: the Hawai‘i Department of Agriculture, Hawai‘i Department of Health, Hawai‘i Department of Land and Natural Resources, Hawai‘i Department of Transportation, Hawai‘i Farm Bureau Federation, Hawai‘i Visitors Bureau, National Park Service, The Nature Conservancy of Hawai‘i, U.S. Customs Service, U.S. Department of Agriculture, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Navy, and the U.S. Postal Service. It has served as an umbrella organization to help garner support for island Invasive Species Committees (ISCs). ISCs have formed on each island using permanent staff as well as volunteers to act as early detection and rapid response teams to conduct control work on invasive species. Currently, activities and members of CGAPS and ISCs are largely terrestrial focused. However, increased focus on AIS issues has been identified as a key need within CGAPS, and the Steering Committee of CGAPS has recently begun to better incorporate AIS issues into their program.

Hawai‘i Audubon Society/Pacific Fisheries Coalition

The Pacific Fisheries Coalition represents a unique collaboration between conservationists and fishermen to promote the protection and responsible use of marine resources through education and advocacy in Hawai‘i and the Pacific. It is a joint project of the Hawai‘i Audubon Society and the Hawai‘i Fishermen’s Foundation. The Pacific Fisheries Coalition is active in getting AIS legislation passed at the Hawai‘i State Legislature, produces educational and outreach materials on AIS issues, and writes in-depth reports on the legal structure of AIS issues.

Marine Algae Group and Network (MAGNET)

The Marine Algae Group (MAG) component is an informal partnership of biologists, natural resource managers, and educators focused on developing ways to control the spread of nonnative algae. This group is testing a suite of approaches; designed to control the spread of nonnative algae, while attempting to shift the competitive advantages back toward native coral and algae species. Many agencies and organizations are involved in MAG, including the University of Hawai‘i, the Waikiki Aquarium, The Nature Conservancy of Hawai‘i, the Department of Land and Natural Resources-Division of Aquatic Resources, the National Park Service, Hawai‘i Coral Reef Research Initiative Research Program, Reef Check, and private dive operators, among others. This extensive partnership comprises one of the State's largest multi-agency efforts to protect our outstanding marine resources from the direct threat of AIS.

The Network (NET) component is composed of individual citizens, groups, volunteer organizations, businesses and others who are helping to support and carry out control efforts of marine algae AIS. This is a loosely affiliated network, open to all individuals, groups, organizations, and businesses interested in algae issues, both native and invasive, in Hawai‘i. The Network component is still in the process of forming, and it is hoped that MAGNET will help to bring together the various entities involved with algae issues across the State.

Earlier names for what is now being called MAGNET, include the Alien Algae Working Group (AAWG), the Alien Algae Research Team (AART), and the Alien Limu Group (ALG). These names have been used previously in various announcements and proposals, and they are presented here only to clarify that while the names themselves are no longer active, the group they all refer to is still active in leading the efforts for the research and management of invasive algae species.

The Nature Conservancy (TNC)

The Nature Conservancy is an international non-profit conservation organization devoted to protecting the world’s outstanding natural ecosystems, with an emphasis on conserving areas of high biological diversity. The Nature Conservancy has focused for the past several decades on the conservation of native forests and the prevention of introduction and spread of invasive species.

In 2001, TNC-Hawai‘i initiated a Marine and Coastal Conservation Program, which emphasizes the protection of coral reef ecosystems. As part of this program, TNC-Hawai‘i has been actively involved in efforts to address the spread of aquatic invasive species, including coordinating the development of this AIS Management Plan. In addition, TNC-Hawai‘i has been actively involved in the Marine Algae Group (MAG), as defined above, including

organizing volunteer events and securing funding through outside grant sources for a variety of marine algae AIS related efforts.

Reef Check

Reef Check is an international network of volunteers. Teams of divers are matched with marine scientists to assess coral reef health using a standardized protocol. The very first Reef Check was conducted on Kauaʻi in 1997 and the program is now found in over 50 countries worldwide. The program is very active on Oʻahu, with 16 Reef Checks planned for 2003 and quarterly training taking place at the Waikiki Aquarium. Reef Check volunteers are also active in other marine conservation causes, such as the "Aʻohe Limuʻe – No Alien Algae," nonnative algae removal efforts in Waikiki, and with REEF fish surveys. Information is disseminated at the local level via an email mailing list, currently numbering 230 volunteers.

ReefWatchers

A volunteer monitoring organization formed in 1998 to conduct transect surveys for specific fishes and intertidal animals in support of DAR's management objectives. The goal of ReefWatchers (some 120 volunteers strong) is to record information about specific sites and detect change over time. Several of the 17 survey sites have been in existence since 1998 or '99, and data reported over that time is compiled in an excel database, made available for university researchers and resource managers. On June 1, 2003 a collaborative (between UH researchers, Sea Grant, and the National Park Service, and funded by the Hawaiʻi Community Foundation), pilot workshop on Alien and Aggressive Algae Species was held for 25 ReefWatchers. The first ReefWatcher Guide to Alien Algae species was distributed at the workshop.

Waipuilani Beach Association

This group helps to fund, guide, and oversee the supervision of beach maintenance for the removal of algae accumulations in north Kihei, Maui.

Additional Community Groups and/or Site-Specific Efforts:

Many community and volunteer groups throughout the State are undertaking additional efforts addressing AIS. This includes site-specific restoration efforts, such as the removal of AIS like mangrove and pickleweed among others. Groups include (in alphabetical order): Friends of Heʻeia, Friends of Hoʻomaluhia Botanical Garden, the Kahea Loko Project, Kailua Bay Advisory Council, Kailua Neighborhood Board, Kawai Nui Heritage Foundation, Paepae o Heʻeiʻa, Sierra Club, Youth for Environmental Service, as well as school groups. Many additional groups exist, and it is hoped they will all become identified in subsequent versions of this plan.

HAWAII'S BALLAST WATER AND HULL FOULING ALIEN AQUATIC ORGANISM PREVENTION PROGRAM[51,52]

Summary

The primary purpose of this program is to minimize the introductions of alien aquatic organisms and pathogens into State marine waters from ballast water discharge, ballast sediments, and hull fouling.

In 2001, the Department of Land and Natural Resources (DLNR) was awarded Federal grant monies through the Hawai'i Coastal Zone Management (CZM) Program, to begin efforts to develop a Ballast Water and Hull Fouling Prevention Program for the State of Hawai'i. A temporary staff position was established within the Division of Aquatic Resources (DAR) for a project coordinator, to oversee the development of the State's comprehensive Ballast Water and Hull Fouling Program and to coordinate efforts to re-establish an interagency task force.

The State's comprehensive program is being developed in two phases. The Phase I focuses primarily on issues related to ballast water introductions. Proposed administrative rules relating to ballast water have been drafted, and are detailed below. Phase II, which focuses on hull fouling, still needs to be developed. This will require significantly more time, as there is still much research in progress worldwide to adequately address the concerns and problems associated with hull fouling as a pathway for aquatic invasive species introductions.

The development of Phase II (hull fouling component) will require additional funds and effort. Without dedicated funds it is unknown when or if, regulations or administrative rules will be developed for the hull-fouling portion of the prevention program. Additional funds will also be needed to implement and enforce the administrative rules that have already been drafted for the Phase I (ballast water exchange component). Specific aspects of the ballast water component that remain unfunded include monitoring, processing of reports, and enforcement of activities.

The Need to Address Maritime Pathways

Hawaii's isolation, and it's lack of a large manufacturing base and lack of sustainable extractable natural resources, means that most of the food, manufactured goods, fuel and raw materials needed to support our lifestyle here in Hawai'i must be imported. The vast majority of these supplies come in on ships. Bi-weekly container ships, petroleum tankers, foreign fishing vessels, cruise ships, bulk carriers, roll-on roll-offs, and oversea barges are the main vessels for commercial maritime activity in Hawaiian waters.

These large commercial vessels come to Hawai'i from all over the Pacific, Atlantic, and Indian Oceans. Foreign fishing vessels visit Hawai'i to re-fuel and/or re-provision. Sometimes they trans-ship their cargo to their homeport and continue fishing for several more months before returning home. In addition, cruise ships visit Hawai'i from all over the Pacific. For many years the role played by maritime vessels in the spread of nonnative aquatic species was largely unrecognized. Today, they are known to be the primary pathway of marine nonnative species. In addition to their cargo and crew, vessels provide three pathways for the transfer and spread of nonnative aquatic species: 1) ballast water, 2) ballast sediment, and 3) hull fouling.

Ballast Water, Ballast Sediment, And Hull Fouling Described

All large commercial vessels use ballast in some form to control the stability of the vessel, and ensure sufficient vessel displacement for effective propulsion. In the early days, ballasting or stabilizing the vessel was achieved with the use of rocks, sand, or any other easily obtained heavy material that could be loaded on to the vessels and disposed of easily. Later, with the development of pumps, water storage tanks and piping systems, water became the ballast of choice.

Ballast water is usually taken into the ballast tanks when cargo is being offloaded and discharged when cargo is being loaded. Ballast water quantities are

[51] Text for this section taken, in most case directly, from information presented to the 2002-2003 Alien Aquatic Organism Task Force; specifically, the documents titled "State of Hawaii's Ballast Water, Ballast Sediment, and Hull Fouling Management Program Guidelines" and "Alien Aquatic Organism Task Force", which were prepared by P. Murakawa (DLNR-DAR), J. Kushima (DLNR-DAR), and S. Godwin (Bishop Museum).

[52] Though the term 'nonnative' is used predominately throughout this plan, the synonym 'alien' is used here and in the following pages describing this program. This is to reflect the use of 'alien' in the official title of the program, as determined by associated legislation.

adjusted on the open ocean, to compensate for weather (storms), fuel consumption, and for the overall safety of the ship and it's crew. When ships take in water for ballast in port, they also take in whatever organisms (larvae, cysts, pathogens) are present in that water. These organisms are then transported, and are potentially introduced into the waters of the ports along the vessels' routes as ballast tanks are emptied for cargo loading.

Ballast sediment occurs when water containing large amounts of particulate matter (plankton, organic and inorganic detritus) mixed in the water column is pumped into the ballast tanks. These particulates enter the ballast tanks and over time settle to the bottom of the tanks. Ballast sediment is difficult to dispose of. Disposal may be done in mid-ocean, but normally is done only when the vessel is in port or dry dock. Sediment in the ballast tanks gets stirred up every time the tanks are refilled and the organisms in the sediment get re-suspended and may be discharged when ballast tanks are emptied.

Hull fouling is the attachment of organisms to the hull of ships, barges, floating dry docks, and other floating or submerged surfaces. These organisms increase drag, resulting in slower speeds and higher fuel consumption.

Scope of the Problem

Ballast water, ballast sediment, and hull fouling are all pathways for the introduction of nonnative aquatic organisms into Hawai‘i. These pathways can introduce alien species that can have dramatic economic and environmental consequences. Potential impacts include: reduced commercial production in fisheries, changes to the ecosystem, destruction of habitat, displacing indigenous species, and negatively affecting people’s health via pathogens and bacteria.

A variety of organisms can be transported via ballast water, ballast sediment and hull fouling. Pathogens that can be transported via these pathways include dinoflagellates that can cause poisoning in shellfish, *Vibrio cholerae*, which causes cholera in humans, and *Clostridium botulinum C*, which causes botulism in animals and possibly humans, and was found in ballast sediment of a vessel from Southeast Asia. Ballast sediment also contains resting stages of dinoflagellates and diatoms, and adult stages of crabs, snails, clams, worms, and burrowing fish.

Hull fouling may be the most underestimated pathway for nonnative introductions. Fouling organisms are divided into two categories, micro- and macro-sessile. Micro-sessile organisms include diatoms, algae, and bacteria. Macro-sessile organisms include mollusks, sea squirts, sponges, sea anemones, bryozoans, tubeworms, polychaetes, and barnacles. Both these categories of organisms can live on the hulls, and distribute propagules to wherever the vessel goes. If a vessel that is fouled with nonnative species runs aground, then it is likely that many of these species will be distributed at the grounding site.

In Hawai‘i, examples of nonnative species that are considered to have arrived in Hawai‘i as a result of hull fouling include *Acanthopora spicifera*, which arrived on the hull of a barge from Guam in 1950, and the introduced barnacle *Chthamalus proteus*, which is now present on all of the main islands, except Kaho’olawe, which does not receive commercial traffic.

Authority for the Program

1) Session Laws of Hawai‘i 1997, Act 237

In the Session Laws of 1997, Act 237 authorized the Chairperson of the Department of Land and Natural Resources (DLNR) to establish an Alien Aquatic Organism Task Force (AAOTF), consisting of representatives from State and Federal agencies, private shipping and boating industries, and the scientific community. The purpose of the AAOTF was to develop a plan to prevent the introduction and dispersal of alien aquatic organisms in the ballast water and on the hulls of vessels into Hawaiian waters. The AAOTF submitted a report of its findings and recommendations in December of 1997, in the "Report to the Nineteenth Legislature Regular Session of 1998 on Findings of the Alien Aquatic Organism Task Force". These findings are presented on the following pages.

2) Session Laws of Hawai‘i 2000, Chapter 187A, Part III, Section 187A- 32

The AAOTF was not extended by the Legislature and was subsequently disbanded in 1998. However, as a result of the Task Force's report, the Legislature established Act 134 in the Session Laws of 2000, which subsequently became Chapter 187A, Part III, Section 187A- 32, Hawai‘i Revised Statues (HRS), titled Alien Aquatic Organisms. Chapter 187A, Part III, Section 187A- 32:

1) Designated the Department of Land and Natural Resources (DLNR) as the lead agency for preventing the introductions and carrying out the eradication of alien aquatic organisms through the regulation of ballast water discharges and hull fouling.

2) Gave DLNR the authority to re-establish an interagency task force to address concerns relating to alien aquatic organisms
3) Gave DLNR the authority to adopt administrative rules, including penalties, to carry out the intent of this law.
4) Gave the Governor authority to enter into an agreement with the U.S. Secretary of Transportation to carry out the purpose of this section, including but not limited to the enforcement of State law.

Update on the Key Findings and Recommendations From the Original AAOTF (1997):

In 1997, the Alien Aquatic Organism Task Force (AAOTF) was established to address ballast water and hull fouling issues in Hawai'i, as further detailed in the beginning of this chapter. In December of 1997, the AAOTF submitted a report of its findings and recommendations in the "Report to the Nineteenth Legislature Regular Session of 1998 on Findings of the Alien Aquatic Organism Task Force". This section outlines these recommendations, with information summarizing progress that has been made with each[53].

1) Development of inspection protocols for the U.S. Coast Guard to use when inspecting ballast tanks and hulls.

DLNR-DAR, the State's designated lead agency for ballast water and hull fouling management, does not currently have the expertise required to meet the recommendation made by the original AAOTF. The current AAOTF agrees that the USCG is the lead agency for the development and enforcement of the inspection protocols for ballast tanks and hull fouling. These protocols need to be established at the Federal level to maintain consistency within the nation's shipping industry.

The current AAOTF proposed to consider and adopt the U.S. Coast Guard protocols for inspections of ballast tanks and hull fouling with, perhaps, additional requirements to address unique concerns for the State of Hawai'i. The current AAOTF has also approved proposed administrative rules for the State of Hawai'i Ballast Water and Hull Fouling Alien Aquatic Organism Prevention Program. The administrative rules would require that vessels have a ballast water management plan. The management plan would be designed specifically for the vessel and would include procedures for the proper disposal of ballast sediment and at least one of the following ballast water management practices:

- Mid ocean ballast water exchange
- Retain all ballast water on board the vessel
- Treat ballast water to remove or kill aquatic invasive species in a manner that is at least as effective as a mid ocean ballast water exchange
- Use an alternative environmentally sound method of ballast water management that has been approved by the USCG

2) Adoption of voluntary ballast water exchange guidelines developed by the International Maritime Organization (IMO).

The IMO adopted Resolution A.868 (20) (Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens) in 1997.

All vessels registered to the IMO shall comply with IMO resolution A.868 (20), thus following all port requirements and have a vessel specific ballast water management plan. For Hawai'i, the proposed port requirement will be mandatory ballast water exchange or any other ballast water management practice mentioned in the previous section.

According to the proposed State of Hawai'i Ballast Water and Hull Fouling Alien Aquatic Organism Prevention Program, if a vessel complies with A.868 (20), then it fulfills the State of Hawai'i requirements for ballast water exchange and ballast sediment.

3) *Continuation of ongoing studies related to the impacts of nonnative aquatic organisms in Hawaiian waters.*

The Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources has and will continue to fund studies related to the impacts of alien aquatic organisms. Details of related studies can be found in Appendices C and D:

4) Inclusion of ballast water and hull fouling issues in DLNR and HDOA education and information programs

DLNR-DAR has an education coordinator and an associated education and information program

[53] Many thanks to P. Murakawa of DLNR-DAR for researching the current status of these recommendations and writing the accompanying text.

intended for the industry, various sectors of the public, and the schools. However, ballast and hull fouling aspects have yet to be incorporated into this program, and as such, this recommendation still needs to be addressed.

5) Designation of a lead agency responsible for promulgating administrative rules to address ballast water and hull fouling issues.

Chapter 187A, Part III, Section 187A- 32, Hawai'i Revised Statues (HRS), titled Alien Aquatic Organisms, designated the Department of Land and Natural Resources (DLNR) as the lead agency for preventing the introductions and carrying out the eradication of alien aquatic organisms through the regulation of ballast water discharges and hull fouling. Activities of the DLNR relating to ballast water and hull fouling issues are detailed in-depth at the beginning of this section.

Recent Efforts

In 2001, the Hawai'i Coastal Zone Management Program (CZM) awarded DLNR-DAR a contract for their proposal, "Ballast Water and Hull Fouling Alien Aquatic Organism Prevention Program". Under this contract, the AAOTF was re-established, and a temporary coordinator position was created to address ballast water, ballast sediment, and hull fouling issues. Many of the members of this original task force are a part of the re-established task force, as listed in Appendix E.

Phase I: BALLAST WATER ALIEN AQUATIC ORGANISM PREVENTION PROGRAM[54]

The Department of Land and Natural Resources (DLNR)' Division of Aquatic Resources (DAR), working with the Alien Aquatic Organism Task Force (AAOTF), is proposing a mandatory ballast water management plan for all vessels entering State marine waters. The management plan includes procedures for ballast water exchange, including ballast water discharge, ballast water reporting, and ballast sediment disposal. These aspects are detailed in administrative rules, which have recently been drafted, and are summarized below. At this point, additional funding is needed to further develop, implement, and enforce these administrative rules.

[54] Text in this section provided by P. Murakawa and J. Kushima, both of DLNR-DAR.

Ballast Water Exchange Management Plan

General Requirements

All vessels carrying ballast water are required, unless exempt, to carry out a mid ocean ballast water exchange or form of ballast water treatment before entering State waters. Mid-ocean means open waters beyond Hawaii's Exclusive Economic Zone, from an area no closer than 200 miles from any Hawaiian shoreline and a depth exceeding 2000 meters.

The purpose of this exchange requirement is to limit the possibility of transferring alien aquatic organisms and pathogens into State marine waters.

Any vessel conforming to International Maritime Organization (IMO) Resolution A 868 (20), (Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens), will be considered to be in compliance with this requirement.

Mid-Ocean Ballast Water Exchange Methods

A mid-ocean ballast water exchange can be accomplished by two methods: 1) a sequential empty and refill method, or 2) by the flow through method.

1. Sequential empty-refill method

This method entails complete emptying of the ballast tanks and refilling them with mid ocean water until all ballast tanks on the vessel are exchanged. The sequential empty-refill method may lead to significant loss in stability and bow slamming. Bow slamming occurs when the forward ballast tanks are emptied and the bow is not submerged enough. In this situation, when the vessel goes over or through a wave, the bow raises off the surface, then slams onto the ocean surface as it descends.

2. Flow through method

The flow through method involves pumping mid-ocean water into full ballast tanks until approximately three times the tank capacity is exchanged. This method does not alter the stability, stress and ship attitude, and thus the flow through method may be more favorable than the sequential method. There are also some drawbacks to this method. It takes longer, removal and replacement of covers to assure proper venting is labor intensive and overflow of ballast water on deck is dangerous for deckhands.

Exceptions to the general requirements

1) The master of a vessel bound for State marine waters is not required to perform a ballast water

exchange if the master determines that the exchange would threaten the safety or stability of the vessel, its crew, or its passengers because of adverse weather, vessel architectural design, equipment failure, or any other extraordinary conditions.

2) A vessel may be exempt if: a) it has a United States Coast Guard (USCG) or State approved ballast water treatment system, b) it is a vessel of the Department of Defense (DOD) and the USCG, c) any vessel that discharges ballast water or sediment only at the location where the ballast water or sediment originated and did not mix with any water or sediment other than mid- ocean waters, d) it is a vessel of innocent passage or force majeure, and/or e) it is a vessel that it is equipped with permanent ballast, freshwater, or treated ballast, or will not discharge ballast water into State marine waters.

Discharging requirements

All vessels carrying ballast water that meet the requirements for a mandatory ballast water discharge, but not able to execute a mid ocean exchange or have its ballast water treated by an approved treatment method, will be required to have the master obtain approval from the DLNR to discharge ballast water.

Reporting requirements

This component is still being addressed to determine the details of how to incorporate the reporting needs of DLNR with that of the USCG, to allow for a streamlined system requiring only one form. However, it is anticipated that for all vessels entering State marine waters carrying ballast water, but not including DOD and USCG vessels and vessels of innocent passage, the USCG ballast water reporting form must be submitted to the DLNR, 48 hours prior to the vessel entering State marine waters. This form can be sent to DLNR by email or facsimile, and DLNR will be investigating the various means available for report submission before this detail is finalized. This form must be kept on board for two years.

Submission of this form to DLNR does not relieve the master of reporting to the USCG as required.

Compliance requirements

The DLNR, in coordination with the USCG, will conduct periodic boarding of vessels entering State marine waters to determine if compliance with the State's Ballast Water Management Plan is being followed. The representatives may ask to see the vessel's logbook to check for ballast water exchange entry and crosscheck it with the ballast water reporting form. If applicable, water samples may be taken by the representative to verify if a mid ocean ballast exchange was conducted. Anyone found in non-compliance with any of the requirements of the State of Hawaii's Ballast Water Exchange Management Plan is subject to fines and/or imprisonment.

Ballast Water Sediment Management Plan

General requirements

All vessels (including vessels at dry dock) are required to dispose of ballast sediment in accordance with applicable laws and regulations. Ballast sediment is defined as any settling particulate matter (organic or inorganic) that is found inside a ballast tank. Sediment may contain pathogens, and resting and motile benthic organisms.

The purpose of this requirement is to prevent the dumping of ballast sediment, along with any aquatic organisms and pathogens that may be in the sediment, into State marine waters.

The approved disposal method of ballast sediment is mid ocean disposal or controlled arrangements in port or dry dock.

Exceptions to the general requirements

NONE.

Reporting requirements

NONE, though inspectors may ask to view maintenance records to determine when most recent disposal of ballast sediment took place.

Compliance requirements

If anyone is found illegally dumping or disposing of ballast sediment into State marine waters, they will be subject to fines and/or imprisonment.

Phase II: HULL FOULING PREVENTION PROGRAM[55]

The second component (hull fouling) of the State's comprehensive ballast water and hull fouling prevention program still needs to be developed. It has been determined that hull fouling is an important pathway for the transport and introduction of marine nonnative species to Hawai'i. The development and

[55] Text for this section provided by S. Godwin (Bishop Museum), J. Kushima (DLNR-DAR) and P. Murakawa (DLNR-DAR)

implementation of a systematic approach for the prevention of marine species introductions through hull fouling poses complex challenges. The process to develop this component is in its infancy, and much effort will be required to develop this management component and corresponding administrative rules. In this initial stage, the approach would be to target vessels or floating platforms that are not part of the regular vessel arrival pattern. The guidelines for identifying these unique arrivals are being developed at this time through the AAOTF.

General requirements

Still needs to be developed. At present, initial steps to identify criteria that will support a risk assessment strategy for hull fouling are being developed by a group of stakeholders through the AAOTF. These stakeholders represent the maritime industry and aquatic resource management community. At this point in the process, the focus of the criteria will be on overseas arrivals that fall into one of a few high-risk categories that will be determined by the group. The goal of the risk assessment process at this time will be to minimize marine nonnative species introductions through hull fouling by the use of information resources provided by the State of Hawai‘i Department of Transportation, Harbors Division and the United State Coast Guard.

Exceptions to the general requirements

The exceptions to the general requirements will be developed once administrative rules have been developed.

Reporting requirements

Separate reporting requirements for hull fouling will be integrated with ballast water reporting criteria.

Compliance requirements

Compliance will be based on the risk assessment guidelines provided to port authorities.

Next Steps

Though the State Legislature provided the legal mandate (Act 134, later revised to Chapter 187A-31, Hawai‘i Revised Statues) for the Department of Land and Natural Resources to be the lead agency in preventing the introductions of alien aquatic organisms through the regulation of ballast water discharges and hull fouling, this mandate was unfunded.

During the course of developing the Ballast Water and Hull Fouling Alien Aquatic Organism Prevention Program, it became evident that further development and implementation (including the adopting of the proposed administrative rules) of an effective program will require permanent funds, as well as staff designated specifically to this program.

In addition, though much effort has been put into the Ballast Water Management Program, gaps remain that need to be addressed for effective management of the issue. These are identified in task 2G4, and include the aspects below. (Some of these are being addressed on a national level, and State efforts will need to coordinate with these national efforts to prevent duplication):

- Alternative methods for ballast water treatment to be used for interisland barges and other interisland vessels or towed platform traffic;
- Development of a risk assessment method/matrix for prioritizing vessels for ballast water management decisions, including boarded inspections;
- Develop a web-based ballast water reporting process to increase compliance with the mandatory reporting regulation of the US Coast Guard;
- Method for verification of ballast water exchange;
- Exploration of alternative treatment methods for ballast water exchange;
- Dissemination of information to the public relating to ballast water issues.

IDENTIFYING GAPS IN POLICIES AND LAWS AFFECTING AIS IN HAWAI‘I

In addition to the identification of the gaps in the current prevention system that was discussed in Chapter 2, there is also is a need to assess current governmental policies and laws for their effectiveness in addressing AIS issues in Hawai‘i. Currently two such assessments are being undertaken by the Pacific Fisheries Coalition/Hawai‘i Audubon Society and The Nature Conservancy:

1. Pacific Fisheries Coalition's Legal Analysis of Current AIS Laws In Hawai‘i

Pacific Fisheries Coalition is currently conducting a legal analysis of current AIS laws in Hawai'i and making recommendations for change. It is assessing the effectiveness of aquatic invasive species permitting procedures in Hawai'i and developing recommendations for improving permitting procedures. A full report of this legal analysis is anticipated to be available in the late fall of 2003. This analysis will address:

- Current status of Federal, State, County, and international laws and regulations that apply or may apply to the introduction of AIS;
- Limitations of such laws and regulations in curbing the introduction of marine species that are potentially harmful to coral reef ecosystems;
- Effectiveness of penalties for the violations of laws and regulations;
- Permitting process and post-permitting process;
- State and Federal agency authorities and gaps in authorities; and
- Recommendations to improve the permitting process.

2. The Nature Conservancy's Evaluation of Programs and Policies Affecting Invasive Species Issues Throughout the Asia-Pacific Region

The Nature Conservancy, Asia-Pacific region, has hired a contractor to evaluate all programs and policies affecting invasive species issues through the region, which includes AIS issues in Hawai‘i. This work will include:

- Drafting a model biosecurity bill and introducing legislation based on that model on one island nation and Hawai‘i;
- Surveying international laws and models regarding intentional introduction of all fauna and flora (focusing on Australia and New Zealand);
- Continuing to survey and review laws in the Pacific Rim, including any proposed biosecurity legislation;
- Researching Federal pre-emption issues for states wanting to enact stricter quarantine laws than Federal regulations;
- Building a communications infrastructure for the Pacific Island nations in partnership with existing organizations such as GISP (Global Invasive Species Programme) ISSG (Invasive Species Specialist Group), APEC (Asia Pacific Economic Cooperation), etc. This network will include Hawai'i as a hub for activities.

CHAPTER 4:
Proposed Actions

CHAPTER 4:
SPECIFIC MANAGEMENT ACTIONS PROPOSED

GOAL OF THE HAWAIʻI AIS MANAGEMENT PLAN:

To minimize the harmful ecological, economic, and human health impacts of AIS through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawaiʻi.

To assist in obtaining the goal of the Hawaiʻi AIS Management Plan, seven major objectives have been identified:

- **COORDINATION and COLLABORATION:**
  Improve the coordination and collaboration of people, resources, and efforts involved with AIS.
- **PREVENTION:**
  Minimize the introduction and spread of AIS into and throughout the waters of Hawaiʻi.
- **MONITORING and EARLY DETECTION:**
  Ensure effective programs that allow for the early detection of new AIS and the monitoring of existing AIS.
- **RESPONSE, ERADICATION and CONTROL:**
  Establish effective systems for rapid response, eradication, control, and restoration.
- **EDUCATION AND OUTREACH:**
  Increase education and outreach efforts to ensure awareness throughout the State on AIS threats and solutions.
- **RESEARCH:**
  Increase research efforts on key AIS species, associated issues, and economic impacts to allow for more effective management.
- **POLICY:**
  Ensure State laws and regulations effectively promote the prevention and control of AIS.

Associated strategies and specific tasks pertaining to each of the above objectives are presented in this chapter. These tasks have been identified as being key action items in managing the issues of aquatic invasive species more effectively, before many of these species cause further damage to the State**.**

Input Process

This component of the AIS Management Plan was made with the input of numerous individuals, gathered via written responses to questionnaires, phone conversations, and personal interviews. Information has also been gathered from agency and organization web sites, from current proposals and grants regarding AIS, from meetings and workshops regarding AIS, from published papers and chapters from books and in a few cases, from other States' plans. Using this information as a base, specific strategies and tasks have then been developed that are appropriate for Hawaiʻi, and are presented here.

Scope of the Strategies and Tasks

While the following information does incorporate strategies and tasks relating to specific islands, it is meant to be statewide in nature. As such, it is suggested and anticipated that each island will eventually develop its own island-specific strategies and associated tasks to address specific AIS, while still coordinating with statewide efforts.

Funding of Tasks and Implementation

Many of the suggested tasks in the following pages will require additional funding sources in order to be implemented. The tasks presented here are what "should" happen in order to have an effective statewide AIS management program for Hawai‘i. It is realized that due to funding issues, some of these tasks will not be implemented, and many may likely not begin implementation within the year given.

Being Realistic About Task Implementation

It is emphasized that for many of the tasks presented here, funding has not yet been identified.

The State of Hawai‘i, like many other states across the nation, is currently undergoing budgetary restrictions, and financial support for many of these tasks is uncertain at this point.

It is realized that due to funding issues, some of these tasks may not get implemented, and further, many may not begin implementation within the suggested year given.

Entities Associated with each Task

The entities listed in parentheses after each task are meant to represent the suggested key implementation entities. In most cases, this includes those entities that have the responsibility and/or authority to implement the appropriate tasks. In order to be most effective, these tasks will require political will and a sense of proactive action by the lead entities listed.

The entities are presented here as a guideline, and as these tasks get implemented, it is likely that some of these entities will change. A more detailed implementation table referred to in Chapter 6 splits out these entities into lead entities and cooperating entities,

Year Associated with each Task

The year associated with each of the tasks indicates the suggested year in which to begin implementation. It is recognized that for some of these tasks, this may be extremely optimistic. However, as referred to above, these tasks are presented as what should happen, if Hawai‘i truly wants to address its aquatic invasive species problem.

Comments and Updates Associated with each Task

Because Hawai‘i has no true comprehensive AIS program as of yet, many details are included in with the following tasks. These “comments” and “background” text are intended to give the reader a better sense of the task itself, why it is suggested, and/or activities already underway relating to the task. It is hoped that after reading information presented in other parts of the plan, in association with comments and background text presented with these tasks, the reader should have a solid understanding not only of the issues facing Hawai‘i in terms of AIS, but also of the solutions. It is anticipated that future years' version of this plan would have less of this informational text associated with each task, as those involved in AIS issues become more aware of the associated details.

The objectives, strategies, and tasks will come under regular review, as this plan is intended to adapt to new knowledge and circumstances.

OBJECTIVE 1- COORDINATION AND COLLABORATION:

Improve the coordination and collaboration of people, resources, and efforts involved with AIS.

Table 2. Summary Table of Strategies and Tasks to Accomplish Objective 1

Strategy 1A. Continue and improve communication and collaboration among county, State, and Federal AIS programs and activities.
1A1. Support the formation and maintenance of the Hawai'i Invasive Species Council.
1A2. Increase the promotion of AIS issues on a statewide level through CGAPS.
1A3. Determine the ability of the Invasive Species Committees to address AIS issues.
1A4. Evaluate and determine whether AIS issues will continue to fall under the Division of Aquatic Resources, or a newly formed entity/division/commission.
1A5. Identify all community groups, including native Hawaiian and other cultural groups, associated with AIS management efforts throughout the State.
1A6. Ensure coordination with, and input from, the diverse industry and professional groups affected by AIS management efforts.
1A7. Create a statewide AIS Advisory Council and associated council subgroups
1A8. Create and fund a position for a FTE Statewide Coordinator for AIS issues.
1A9. Create a new position to oversee marine algae control efforts and help coordinate volunteer events throughout the State.
1A10. Create and fund positions, to employ personnel that are focused solely on AIS.
1A11. Increase the integration of AIS issues into existing conferences.
1A12. Hold an annual conference on the topic of AIS in Hawai'i.
1A13. Create a centralized communications forum.
1A14. Create a centralized website for AIS issues in Hawai'i.
1A15. Evaluate current available databases, and integrate those efforts to allow for a centralized database for Hawai'i AIS, with GIS capabilities.
1A16. Develop a centralized system for the recording of stocking activities across the State.
Strategy 1B. Participate in and support appropriate regional, Federal, and international efforts addressing AIS.
1B1. Participate in appropriate national and international conferences dealing with the management and control of AIS issues.
1B2. Develop the Pacific Island Regional Panel on AIS for the Federal ANS Task Force, while also staying involved in the Western Regional Panel.
1B3. Continue and expand participation in regional, national, and international efforts and task forces focusing on AIS issues.
1B4. Secure assistance and input from, and form partnerships with other countries, such as Australia and New Zealand.
Strategy 1C. Set priorities for the management of existing AIS so that local, State, and Federal resources can be directed to manage Hawaii's highest priority AIS in a cost-effective manner.
1C1. Establish a subcommittee to formally assess the priority species to focus on, using the species presented in the AIS Management Plan as a starting point for discussion.
1C2. Develop an objective and testable risk-assessment strategy based on ecology, biology, economics, and other parameters to use as a tool in identifying priority species for management.
1C3. Develop and implement a method to identify priority sites of concern regarding Aquatic Invasive Species.
Strategy 1D. Integrate the coordination of AIS efforts with other resource management projects and entities, such as the local, State and Federal agencies responsible for chemical use, water quality, and site management, within Hawai'i.
1D1. Keep abreast of issues related to current resource management projects, and communicate with the individuals and agencies leading those projects to ensure that AIS issues are considered.
Strategy 1E. Increase existing funding sources for AIS management, and establish new long-term funding sources.
1E1. Identify and apply for grant funding, available in Hawai'i and nationally.
1E2. Establish stable, long-term funding to assist in the implementation of some of the AIS management activities identified in this plan.

OBJECTIVE 1 - COORDINATION AND COLLABORATION:

Improve the coordination and collaboration of people, resources, and efforts involved with AIS.

STRATEGY 1A. Continue and improve communication and collaboration among county, State, and Federal AIS programs and activities throughout all of the Hawaiian Islands.

Working with Existing Entities and Organizations in the State:

1A1. Support the formation and maintenance of the Hawai'i Invasive Species Council.
(DLNR, HDOA, HI AIS Advisory Council) YEAR 1

Background: The Hawai'i Invasive Species Council is described in Chapter 3, and associated legislation is presented in Appendix J. The council's special purpose is to foster coordinated approaches that support local initiatives for the prevention and control of invasive species, by providing policy level direction and planning for the State that includes legislation, funding, and program direction for all State departments responsible for invasive species issues.

How do all these Entities Work Together?

A schematic showing the relationship of many of the entities referred to tasks 1A1- 1A7 is shown in Figure 3, at the end of task 1A7.

It is anticipated that the Hawai'i Invasive Species Council (HISC), the Coordinating Group on Alien Pest Species (CGAPS), the proposed Hawai'i AIS Advisory Council, and others will all work closely together to find solutions for aquatic invasive species issues throughout the State, while also avoiding duplication and overlap in efforts.

A formal mechanism for ensuring communication between the HISC, CGAPS, and the Hawai'i AIS Advisory Council will be a key component of early discussions, once this plan is approved.

1A2. Increase the promotion of AIS issues on a statewide level through the Coordinating Group on Alien Pest Species (CGAPS).
(HI AIS Advisory Council, AIS Coordinator) YEAR 1.

Background: The Coordinating Group on Alien Pest Species (CGAPS) is a statewide multi-agency partnership formed to allow more effective protection of Hawaii's economy, environment, health, and way of life from harmful nonnative pests. CGAPS was formed in 1995 and includes over 25 public and private agencies and organizations. It has served as an umbrella organization to help garner support for island Invasive Species Committees (ISCs). CGAPS' involvement with aquatic aspects of invasive species has been limited up to this point, but efforts have been recently made to better include aquatic issues. This includes the addition of two members of the AIS Management Plan Steering Committee to the Steering Committee of CGAPS.

1A3. Determine the ability of the Invasive Species Committees (ISCs) on each island to address AIS issues.
(AIS Coordinator, ISCs, CGAPS, HI AIS Advisory Council, USFWS, DLNR) YEAR 1

Background: Invasive Species Committees (ISCs) are voluntary partnerships among local, State and Federal governments; environmental organizations; agricultural, development, trade and tourism groups; and private industry and individuals, that exist at island-level on O'ahu, Maui, Moloka'i, Kaua'i, and the Big Island. ISCs have formed to prevent new invasive species infestations in Hawai'i, eradicate incipient invasive species, and stop established invasive species from spreading. Each of the named islands has its own ISC field team, which puts the committee's plans into action and acts as a rapid response team to prevent and control designated priority species before they spread further. Up to this point, the focus has been on terrestrial species, with little or no involvement with aquatic invasive species, (though the Kaua'i ISC (KISC) is already addressing cattails). Efforts will be made beginning in year 1 to assess whether involvement in the ISCs will be an effective way to help address AIS issues on a large-scale.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
DOCARE	Division of Conservation & Resources Enforcement
EPA	Environmental Protection Agency
HAS	Hawai'i Audubon Society
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
MAG	Marine Algae Group
NOAA	National Oceanic and Atmospheric Administration
TNC	The Nature Conservancy
UH	University of Hawai'i
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

1A4. Evaluate and determine whether AIS issues and ultimate responsibility will fall under the Division of Aquatic Resources, or a newly formed entity/division/commission that would have the mission of specifically dealing with all invasive species, both terrestrial and aquatic.
(DLNR, Hawai'i Invasive Species Council, HI AIS Advisory Council, USFWS) YEAR 1.

Comment: Efforts still need to be made to assess the best organizational structure that would allow the State to most effectively deal with AIS. However, through the development of this plan, it appears that most of those involved would agree that this would best be served either by 1) a new separate division within DLNR; or, 2) an autonomous commission directly overseen by the Governor's office. Once formed, this entity would include those positions listed in 1A8, 1A9, and 1A10, as well as be directly involved with the AIS Advisory Council referred to in 1A7. Ideally, this would ultimately include personnel and resources that currently lie within the DLNR divisions of DAR, DOFAW, and DOCARE, as well as personnel from HDOA, who are already working with invasive species issues.

A New Division to Address Invasive Species?

Exploration and possible restructuring to create a new division with the sole focus of addressing invasive species throughout the State is proposed under Strategy 1A. Branches within the division would likely be terrestrial, aquatic, and enforcement.

A restructuring resulting in a division solely dedicated to invasive species would allow for better coordination with other departments and agencies, as well as for clear responsibilities and mandates. It is thought that this central, dedicated, and coordinated entity specifically focused invasive species issues would allow the State to better address the serious invasive species problem that is heavily impacting Hawai'i.

If this restructuring should occur, it is realized that it would likely not happen in the immediate future. Currently, the Division of Aquatic Resources, under the Department of Land and Natural Resources (DLNR-DAR) has the lead role in addressing AIS under its authority and responsibility for the management of many of the inland waterways as well as State marine waters. As such, the DLNR is currently listed as a key entity in many of the tasks in the following pages.

However, though the Division of Aquatic Resources, through the DLNR may have the authority and responsibility to carry out many of these tasks, it is also realized that due to current budget restraints, current administrative directives and restrictions, and the demand on the Division's resources, that their abilities to implement all of the tasks as they are listed with might not be feasible with the current government structure or funding. This is why a close evaluation of what entity will have ultimate responsibility of invasive species issues in the State is considered a priority task.

1A5. Identify all community groups, including native Hawaiian and other cultural groups, associated with AIS management efforts throughout the State. –Also referred to under Education and Outreach.
(AIS Coordinator) YEAR 2

Update: Currently, there are various site-based restoration efforts, such as by the community group, Paepae o He'ei'a, which addresses aquatic invasive species issues in association with local restoration efforts of culturally significant areas. These groups need to be better identified and supported by resource managers, researchers, and educators involved in AIS issues, to better share in the knowledge and experience of managing AIS.

1A6. Ensure coordination with, and input from, the diverse industry and professional groups affected by (or potentially affected by) AIS management efforts.
(HI AIS Advisory Council, AIS Coordinator, DLNR) ONGOING

Comment: Unlike many other states and countries, most of the industries in Hawai'i have not for the most part, been strongly negatively impacted by AIS. Through the development of this plan, the concern voiced by many of the industry and industry-development representatives appeared to be associated more with the impacts of the plan itself and associated management efforts, than with the direct impact of Aquatic Invasive Species. This may change in the future, but it is clear that there is a need to continue to involve and engage industry representatives and others who may be affected by AIS management efforts. The best method to approach this has not been determined, but would likely include an "industry advisory group" which would directly report to the above AIS Technical Advisory Council, as well as to the proposed Statewide AIS Coordinator referred to in 1A8.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
DOCARE	Division of Conservation & Resources Enforcement
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HDOH	Hawai'i Department of Health
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Creation of new entities/positions:

1A7. Create a statewide AIS Advisory Council and associated council subgroups that will outline priorities for addressing AIS, oversee rapid response teams, and centralize the reporting and coordination of AIS activities.

(AIS Management Plan Steering Committee, AIS Coordinator, DLNR, USFWS) YEAR 1

Council Update: This AIS Advisory Council should report to the head of DLNR, (or new entity as referred to in 1A4), to CGAPS, the Hawai'i Invasive Species Council referred to in 1A1, and to the Governor. The AIS Advisory Council should include those who have true expertise and/or experience in the science, management, or education aspects of AIS. An AIS Management Plan Steering Committee has been formed for assistance in the development of this Plan; it is hoped that many of the members of this Committee will continue to work together beyond the approval of this plan, forming (with others) the Hawai'i AIS Advisory Council, a long-term entity. To be most effective, this council will need legislative support and funding, as referred to in Objective 7.

Subgroup Update Through the development of this plan, it became clear that collaboration and communication among those working in specific areas are a key to effective management of AIS in the State. The Focus Area Groups used in this plan, and further detailed in Chapter 1, were a first step in this direction. The individuals involved in these groups indicated that it would be beneficial to continue and more formally develop these entities. These groups would largely form their own mandate, and are listed in this plan to ensure support and assistance in their development and coordination. It is suggested that these groups are to not be additional layer of government, but rather to work together as part of the AIS Advisory Council.

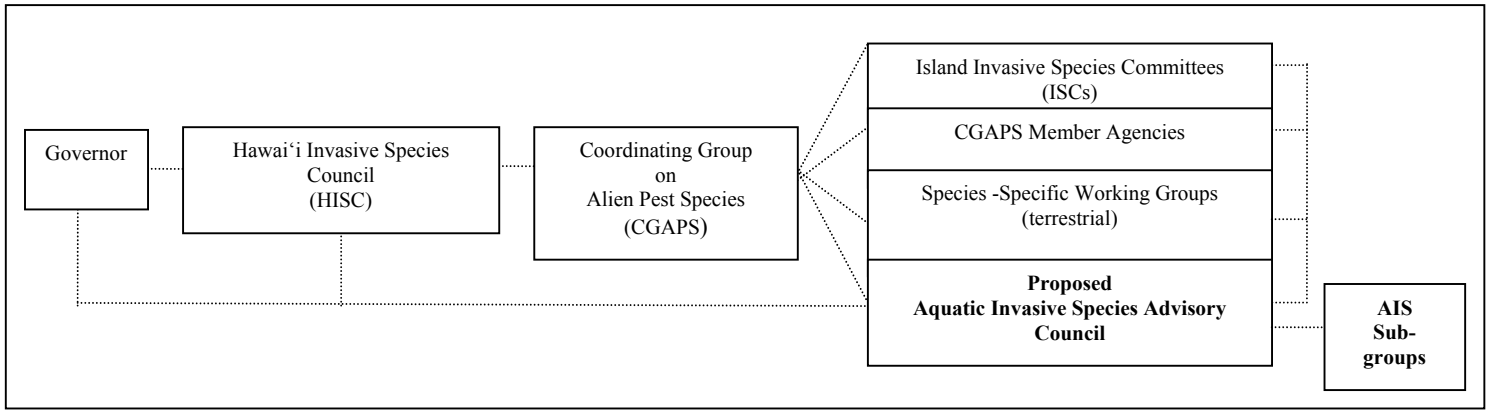

Figure 3. The above diagram is intended to represent communication and advisory lines only. It is presented to give a clearer picture of where the proposed Aquatic Invasive Species Advisory Council and sub-groups would fit in with current entities dedicated to invasive species. Dotted lines represent direct communication channels. Relationships among the above ISCs, CGAPs Member Agencies, Species-Specific Working Groups and AIS Sub-groups are not presented in the interest of maintaining readability in this diagram**.**

1A8. Create and fund a position for a FTE Statewide Coordinator for AIS issues.

(DLNR) YEAR 1

Comment: The AIS Coordinator would facilitate the Hawai'i AIS Advisory Council referred to in 1A7, and be the point of contact for the Federal AIS Task Force, appropriate regional panels, and other government agencies and non-governmental organizations throughout the State. This position is a key recommendation for effective management of AIS issues in Hawai'i, and is listed as a lead entity for the implementation of numerous tasks within this plan. Establishing this position as a paid, long-term position has proven to be a key aspect of successful efforts in other states.

Currently DLNR's Division of Forestry and Wildlife (DOFAW) sponsors a permanent position for an Invasive Species Coordinator. This position is responsible for organizing and implementing programs for DOFAW, to better protect

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Hawaii's native species and terrestrial ecosystems from nonnative species of plants and animals. However, given the vast array of the terrestrial-related invasive species issues within the State, it is unrealistic to expect DOFAW's Invasive Species Coordinator to also deal with AIS. As such, a comparable FTE position in DLNR's Division of Aquatic Resources is needed.

1A9. Create a new position to oversee marine algae control efforts and help coordinate volunteer events throughout the State.

(TNC, ReefCheck) YEAR 1-2

Update: The Marine and Coastal Program of The Nature Conservancy of O'ahu is looking to create and fund this position to begin in years 1-2. This position would direct large-scale control efforts using a mechanized device, further referred to in Appendix B, and oversee the current nonnative algae clean-up events and additional community based efforts. This position would include maintaining an email list, website, and/or newsletter for those involved with marine algae control efforts, as well as to ensure that everyone is on the same "where, when, what and how page" with community events. This position would also assist the AIS Coordinator and the Marine AIS Biologist referred to in Tasks 1A8 and 1A10 in identifying and developing solutions to address algae AIS issues.

1A10. Create (or reassign) and fund additional positions, to employ personnel that are focused solely on AIS issues, including implementing tasks included in this plan. In addition to the statewide AIS Coordinator referred to in task 1A6, this would include:

(DLNR, USFWS, NOAA)

1) **1 FTE Ballast Water and Hull Fouling Coordinator (YEAR 1-2)**
2) **1 FTE Marine Algal Ecologist (YEAR 1-2)**
3) **1 FTE USFWS AIS Agency Staff (YEAR 1-2)**
4) **1 FTE Marine Invasive Species Biologist (YEAR 2-3)**
5) **1 FTE Inland-water Invasive Species Biologist (YEAR 2-3)**
6) **2-4 field technicians per island (YEARS 3-5)**

Comment: Given the large scope and threat of AIS in Hawai'i, additional staffing is clearly needed. These positions would work with the proposed AIS Coordinator to help coordinate and carry out marine and inland water AIS efforts throughout the State, including surveying, monitoring, rapid response teams, education efforts, island working groups, volunteer efforts, clean-up events, and other specific tasks outlined in this plan. Though these positions are considered integral to the implementation of multiple tasks included in this plan, they will not be listed as a lead entity with any task until it is clearer as to when and how these positions would be funded.

Update: DLNR-DAR has recently been awarded a NOAA grant to assist with funding an of Marine Algal Ecologist, beginning in Jan 2004, for a one year period, with the hope of a second year of funding. The Marine Algal Ecologist will hold a series of staff training workshops for DAR and other State agencies and Federal partners on the role of algae in Hawaiian coral reef management, algal invasive species management, and the utility of restoring native algal habitat. The Marine Algal Ecologist will assist staff biologists in conducting rapid ecological assessments of the nearshore coral reef habitats and assist on monitoring of coral reef areas as appropriate.

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Activities and Projects:

1A11. Increase the integration of AIS issues into existing conferences in Hawai‘i.

(AIS Coordinator, HI AIS Advisory Council, DLNR, Bishop Museum, UH) YEAR 1

Update: There are various conferences on conservation issues being held in Hawai‘i, including the Hawai‘i Conservation Conference, the Hawai‘i Aquatics Conference, and others. It is crucial to continue to include AIS topics in these conferences, to ensure awareness of the issues on a statewide level and to help promote collaboration in finding solutions.

1A12. Hold an annual conference on the topic of AIS in Hawai‘i.

(AIS Coordinator, HI AIS Advisory Council, DLNR) YEAR 3

Comment: AIS issues, though currently included in conferences referred to in 1A11, generally represent only a very small portion of the topics presented. AIS issues in Hawai‘i are significant enough in scope to warrant a conference dedicated solely to these issues. An alternative would be to extend some existing conferences an additional day, to focus on AIS issues

1A13. Create a centralized communications forum (such as a list-server) to focus on Hawaii's AIS issues.

(AIS Coordinator) YEAR 1

Comment: This forum could be both species-specific as well as for AIS in general. The forum should include current programs, goals, and outcomes of the programs. Currently, listservers exist for the CGAPs and ISCs groups listed above in 1A2 and 1A3 as well as national servers such as ALIENS. However, there is a need for a focus discussion group on AIS issues in Hawai‘i.

1A14. Create a centralized website for AIS issues in Hawai‘i.

(AIS Coordinator, HCRI-RP) Year 1

Comment: Currently, multiple entities have websites with information on AIS in Hawai‘i, including the University of Hawai‘i, DLNR-DAR, and the Bishop Museum, among others. However, there is no centralized site that provides an easy stop to access the wealth of information and concerns about AIS in Hawai‘i. This centralized site would have links to existing sites, be a site to post new information and updates, and have links to researchers who are working on a specific area or species. Ultimately, a system would be set up for users to record observations of invasive species, as well as look up invasive potential / ranking of specific species.

1A15. Evaluate current available databases, and integrate those efforts to allow for a centralized database for Hawai‘i AIS that allows for coordination with existing regional and national AIS databases. -This is also referred to in Task 3B1.

(AIS Coordinator, HI AIS Advisory Council, UH, Bishop Museum, DLNR) YEAR 3

Comment: Like the websites above, there are various databases, which have information on Hawaii's nonnative and invasive aquatic species. This includes the Hawai‘i Biological Survey (Bishop Museum); a freshwater-specific Hawai‘i Watersheds Database, which is a combined effort of Hawai‘i Department of Education, the EPA, and the Hawai‘i Department of Health); as well as Federal databases such as such as those by USDA and the US Geological Survey, among others. In addition, DLNR-DAR in Hilo is also in the process of developing a stream database identifying known aliens, with the goal of making this web accessible. However, there is currently a lack of integration among all these data sets.

1A16. Develop a centralized system for the recording of activities relating to the stocking of nonnative species across the State.

(DLNR, UH-SeaGrant, HDOA, HDOH) YEAR 2

Comment: Various entities are involved with the stocking of private aquatic systems throughout the State for aquaculture, recreational fishing, and other purposes. DLNR and HDOA are also involved, to a limited extent in stocking certain reservoirs, lakes, streams and/or other waterways. To have a better sense of these activities as well as their implications, it is important to better understand what species are being stocked at what locations, and to what extent.

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STRATEGY 1B. Participate in and support appropriate regional, Federal, and international efforts addressing AIS.

1B1. Participate in appropriate national and international conferences dealing with the management and control of AIS issues.
(HI AIS Advisory Council, AIS Coordinator, UH, Bishop Museum, DLNR) ONGOING

Update: These conferences function to increase knowledge of efforts and successes elsewhere, as well as to ensure awareness of Hawaii's issues outside of Hawai'i. At the recent Marine BioInvasions Conference, there was a strong representation by the above listed groups, including multiple presentations by representatives from UH, DAR and Bishop Museum. Funding for attendance and participation of resource managers, scientists, and graduate students in these conferences needs to be identified to continue their involvement.

1B2. Develop the Pacific Island Regional Panel on AIS for the Federal ANS Task Force, while also staying actively involved in the Western Regional Panel.
(HI AIS Advisory Council, USFWS, NOAA, AIS Coordinator, HDOA, DLNR, UH, Bishop Museum) YEAR 2

Update: Currently Hawai'i does not actively participate in any of the Federal ANS Task Force sanctioned regional panels, but is loosely affiliated with the Western Regional Panel. At the most recent Federal ANS Task Force Meeting in November 2002, presenters from Hawai'i suggested to the Federal Task Force that the development of a Pacific Island Regional Panel would be a valuable entity in which to integrate concerns of Hawai'i with other Pacific Islands. The Task Force agreed, and encouraged representatives from Hawai'i to move forward with putting together a proposal for this idea. Though Hawai'i will move forward in forming the Pacific Regional Panel, due to commonalties with other West Coast States, it is also important for Hawai'i be actively involved with the Western Regional Panel, including attending regular panel meetings, and participating actively on appropriate committees, such as the existing Coastal Committee.

1B3. Continue and expand participation in regional, national, and international efforts and task forces focusing on AIS issues, such as Federal ballast water and hull fouling activities, the Pacific Ballast Water Group, International Maritime Organization (IMO), Global Invasive Species Programme (GISP), Invasive Species Advisory Council (ISAC), South Pacific Regional Environment Programme (SPREP), and others.
(HI AIS Advisory Council, AIS Coordinator, USFWS, Bishop Museum, UH, DLNR, NOAA) ONGOING

1B4. Secure assistance and input from, and form partnerships with other countries, such as Australia and New Zealand, which have taken the lead in dealing with AIS issues.
(HI AIS Advisory Council, AIS Coordinator, Bishop Museum) YEAR 1

STRATEGY 1C: Set priorities for the management of existing AIS so that local, State, and Federal resources can be directed to manage Hawaii's highest priority AIS in a cost-effective manner.

1C1. Establish a subcommittee to formally assess the priority species and pathways to focus on, using the species and pathways presented in the AIS Management Plan as a starting point for discussion.
(HI AIS Advisory Council, AIS Coordinator, DLNR, CGAPS, HDOA) YEAR 1

Update: A preliminary listing of examples of AIS species and pathways to be aware of is included in this plan. It is noted that this is just a first step in the effort to address priority species, and it is expected that this listing will be modified at least yearly, with the input of a more defined risk assessment process.

1C2. Develop an objective and testable risk-assessment strategy based on ecology, biology, economics, and other parameters to use as a tool by the subcommittee referred to above (as well as others), in identifying priority species for management.
(HI AIS Advisory Council, AIS Coordinator, HDOA, UH, Bishop Museum, DLNR, CGAPS) YEAR 2

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Update: Various models have been developed for this purpose, as well as additional risk assessment procedures that have been developed by other states, as well as national and international groups. For example, the Federal ANS Task Force has a generic risk assessment document, and Hawai'i has a "Weed Risk Assessment Model". Though this latter model is terrestrial-based, it could likely be expanded as well as incorporated with other models and procedures being developed elsewhere, to be an effective tool in identifying priority species for the management of aquatic invasives in Hawai'i.

1C3. Develop and implement a method to identify priority sites of concern regarding Aquatic Invasive Species, including housing this method within a GIS database, or other appropriate system.
(HI AIS Advisory Council, AIS Coordinator, MAG and AIS Advisory Council subgroups referred to in 1A7, DLNR) YEAR 1-2

STRATEGY 1D: Integrate the coordination of AIS efforts with other resource management projects and entities, such as the local, State and Federal agencies responsible for chemical use, water quality, and site management within Hawai'i.

1D1. Keep abreast of issues related to current resource management projects, and communicate with the individuals and agencies leading those projects to ensure that AIS issues are considered.
(AIS Coordinator, HI AIS Advisory Council, HDOH, USFWS, NOAA) YEAR 1

STRATEGY 1E. Increase existing funding sources for AIS management, and establish new long-term funding sources.

1E1. Identify and apply for grant funding, available in Hawai'i and nationally.
(AIS Coordinator, HI AIS Advisory Council and subgroups, UH, Bishop, DLNR, USFWS, NOAA, others) YEAR 1-5

1E2. Establish stable, long-term funding to assist in the implementation of some of the AIS management activities identified in this plan.
(HI Invasive Species Council, HI AIS Advisory Council, State Legislature, CGAPS, AIS Coordinator) YEAR 2

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OBJECTIVE 2 - PREVENTION:

Minimize the introduction and spread of AIS into and throughout the waters of Hawai‘i.

Table 3. Summary Table of Strategies and Tasks to Accomplish Objective 2

Strategy 2A: Identify possible vectors and pathways of AIS introductions into and throughout Hawai‘i, and assess the risks and impacts.
2A1. Perform an inventory and risk assessment of the discharge, overflow, and storm/flood containment systems.
2A2. Assess the impacts of hull fouling and ballast water for the introduction and dispersal of marine AIS throughout Hawai‘i.
2A3. Perform an inventory and associated risk assessment of the mosquito and other insect species arriving by aircraft, vessel, or other means.
2A4. Further expand upon the pathways list presented in this plan to create a more comprehensive identification.
2A5. Perform a risk analysis to identify and assess the potential of current practices to introduce and transport AIS.
Strategy 2B: Increase enforcement of existing regulations associated with controlling the transport, propagation, sale, collection, possession, importation, purchase, cultivation, distribution, and introduction of AIS.
2B1. Increase staffing at HDOA to effectively enforce current regulations.
2B2. Provide additional training to enable USDA and HDOA to be able to better identify and stop unauthorized shipments.
2B3. Ensure that there is adequate staffing and that clear guidelines exist for inspectors /enforcement officers.
2B4. Improve coordination and cooperation between HDOA and USDA.
2B5. Continue to enforce procedures and restrictions and review if further restrictions are appropriate.
2B6. Explore the feasibility of working with the Department of Homeland Security (DHS) personnel to increase the use of resources available to detect incoming shipments of AIS.
2B7. Continue monitoring efforts of effluent and discharge systems, and increase efforts if needed.
2B8. Identify "ecologically sensitive" marine and freshwater areas that have little to no AIS, and identify and implement additional precautionary protocols for those areas.
Strategy 2C: Reduce the possibility for unregulated purchases of prohibited and restricted AIS stocks that are still readily obtainable for sale or trade.
2C1. Increase the frequency of inspections of local vendors by HDOA and DLNR.
2C2. Work with US Department of Agriculture, to identify online vendors of federally noxious weeds and regulated plant species.
2C3. Develop a program to identify mail order and online vendors who are selling Hawai‘i prohibited and restricted stocks.
Strategy 2D: Work with appropriate industry representatives and user groups who may be potential pathways of AIS introductions to ensure awareness of the threats of AIS, and to develop methods to better assist in preventing the introduction and transfer of AIS.
2D1. Work with aquarium, water garden, and other appropriate industries to educate about the importance of not releasing unwanted ornamentals into aquatic systems.
2D2. Designate a place(s) on each island where people can dispose of unwanted fish and other aquatic organisms.
2D3. Work with aquariums, pet shops, and the Humane Society to encourage acceptance of unwanted aquarium species.
2D4. Work with the aquaculture industry, aquaculture development programs, and wetland agriculture representatives to ensure that farmers understand the importance of containment systems.
2D5. Work with the aquaculture industry to use only native species for open ocean, cage culture, or ocean-based fishpond aquaculture as there is a high probability of escape.
2D6. Explore the creation of best management practices to reduce the introduction and spread of AIS from vector industries.
2D7. Increase the trade, cultivation, purchase and interest in native species within the hobby trades and industries.
Strategy 2E: Minimize AIS introductions and transfers by researchers and others involved in AIS field activities.
2E1. Establish protocols to minimize the spread of AIS into the wild from research, monitoring and control activities.
2E2. Establish new, and/or utilize existing regulations and protocols for in-water (non lab) based-research experiments.
Strategy 2F: Improve current importation practices to effectively address AIS introductions.
2F1. Perform an interagency review to assess the current system regarding regulation of plant imports, including adding known AIS plant species to existing regulation HDOA lists.
2F2. Assess whether current systems for disease sampling of shipments and stocks of live fish are considered "adequate".
Strategy 2G: Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment, and hull fouling pathways (commercial and recreational).
2G1. Develop administrative rules to minimize the introductions of AIS via ballast water, ballast sediment, and hull fouling.
2G2. Adequately implement and enforce the administrative rules referred to in task 2G1.
2G3. Continue the efforts of the Ballast Water and Hull Fouling Prevention Program and associated task force.
2G4. Identify and address gaps in the Ballast Water Prevention Program.
2G5. Form rapid response teams.
2G6. Raise awareness of hull fouling issues.
2G7. Develop voluntary methods, best management practices, and management protocols for hull cleaning.
2G8. Evaluate the feasibility of establishing a quarantine area and an onshore ballast water disposal/treatment facility.
2G9. Evaluate the feasibility of establishing surveillance programs to detect and implement penalties for "polluters".
Strategy 2H: Assess and minimize activity related to planned, authorized introductions of nonnative species into freshwater systems.
2H1. Perform an inter-agency review and assessment of the efficacy versus threats of HDOH's introductions of Poecilids.
2H2. Perform an inter-agency review and assessment of DLNR-DAR's intentional introductions of nonnative species.
2H3. Further research and catalog the history of introductions.
2H4. Explore ways to reduce the amount of unauthorized stocking of nonnative species into aquatic habitats.

OBJECTIVE 2 - PREVENTION:

Minimize the introduction and spread of AIS into and throughout the waters of Hawai‘i.

New introductions of AIS into Hawaiian waters can cause major economic and environmental damage, as well as significantly impact human health and well-being. Throughout the world, prevention (as opposed to control efforts once a population is established) has shown to be the most cost-effective and environmentally sensitive method of managing AIS issues.

As part of the prevention strategies and tasks listed below, a component involving an evaluation of their effectiveness should be integrated into each task or strategy itself. Although measuring the success of minimizing and/or preventing introductions is difficult overall, there are specific metrics that can be developed to determine if a particular technique is working as planned.

STRATEGY 2A. Identify possible vectors and pathways of AIS introductions into and throughout Hawai‘i, and assess the risks and impacts of these.

Issue Addressed: Many AIS vectors and pathways into Hawai‘i are known or have been speculated upon. They include ship ballast water, hull fouling, aquarium trade, aquaculture, and research, among others. These vectors are further detailed in earlier sections of the plan. However, there is a need for a more comprehensive vector assessment to be able to identify actions needed for their effective management.

2A1. Perform an inventory and associated risk assessment of the discharge, overflow systems, and storm/flood containment systems of aquaculture, public aquariums, and research facilities to determine the potential risks of effluents, and propose remedies for re-mediation and monitoring requirements.

(DLNR, EPA, HDOH, HDOA, UH-Sea Grant) YEAR 1

Update: Currently, the level of risk posed by these facilities is not truly known. Though containment procedures must be outlined in the permit process, follow-up efforts are not adequate to ensure containment systems are in place and effective. To address actions to reduce the potential of introductions by these pathways, an accurate assessment of the associated risks must be done. The EPA has acknowledged the importance of this task, but will need additional funding to carry this out.

Methods already exist that are available for such evaluations. For example, the Aquatic Nuisance Species Hazard Analysis Critical Control Point (ANS-HACCP) planning process is considered an effective tool for such a risk assessment of facilities and operations Adapted from the successful HACCP process used by the food industry for years, ANS-HACCP provides a structured approach for developing plans that identify AIS introduction risks and the most effective control points. The U.S. Fish and Wildlife Service has adopted ANS-HACCP as a national tool for use by Federal fish hatcheries and has developed guidance materials and training to facilitate its use by other audiences. Hawai‘i should integrate appropriate measures from ANS-HACCP and other relevant assessment tools when implementing tasks such as 2A1 and in other strategies that relate to pathway risk assessment at specific facilities (e.g., 2D5).

2A2. Assess the impacts of hull fouling and ballast water as mechanisms for the introduction and dispersal of marine AIS throughout Hawai‘i.

(Bishop Museum, AAOTF, DLNR) YEAR 1-2

Update: Researchers at the Bishop Museum are undertaking a study to assess the impact of hull fouling introductions, through a grant by the Hawai‘i Coral Reef Initiative Research Program. This is further detailed in Appendix C. While

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initial work has been done by researchers at the Bishop Museum to assess the impact of ballast water as a pathway, this was preliminary in nature, and additional efforts are warranted to assist in the ballast water prevention program.

2A3. Perform an inventory and associated risk assessment of the mosquito and other insect species arriving by aircraft, vessel, or other means.
(HDOA, HDOH) YEAR 2

New alien mosquito species can be introduced via aircraft and other mechanisms, and are the subject of prevention measures and port monitoring by New Zealand, in an effort to prevent establishment of new disease vectors. The level of risk for insect introductins posed by military, commercial, and private air transport and/or boat traffic is not truly known. Introduction of new aquatic insect species from the Pacific Rim is likely in the absence of targeted prevention and monitoring, potentially leading to transmission of diseases such as malaria, West Nile virus, and yellow fever. Such a program first requires a baseline on risk.

2A4. Further expand upon the pathways list presented in this plan, to create a more comprehensive identification list of the possible pathways and vectors of AIS into and throughout Hawai'i.
(Bishop Museum, Hawai'i Coral Reef Initiative Research Program, HI AIS Advisory Council) YEAR 1-2

Update: Researchers from Bishop Museum, with funding from the Hawai'i Coral Reef Initiative Research Program, will begin this task in Year 1 in conjunction with efforts for task 2A4, to help determine the present and potential mechanisms for the introduction and dispersal of nonnative aquatic species.

2A5. Once a more comprehensive listing of vectors and pathways is identified, perform a risk analysis to identify and assess the potential of current practices to introduce and transport AIS into and throughout Hawaii's waters. This will help to determine how to best target and commit resources.
(Bishop Museum, Hawai'i Coral Reef Initiative Research Program, DLNR, HI AIS Advisory Council, AIS Coordinator) YEAR 1-3

Update: Researchers from Bishop Museum, with funding from the Hawai'i Coral Reef Initiative Research Program, will begin this task in YEAR 1.

STRATEGY 2B: Increase enforcement of existing regulations associated with controlling the transport, propagation, sale, collection, possession, importation, purchase, cultivation, distribution, and introduction of AIS.

2B1. Increase staffing at HDOA to effectively enforce current regulations on prohibited and restricted species. This includes monitoring local vendors and farms to ensure compliance with their permits.
(HDOA) YEAR 2-5

Update: Various regulations currently exist regulating prohibited and restricted species, however there is a lack of personnel within HDOA to effectively enforce these regulations. HDOA has indicated that there is a need for increased resources to adequately address this issue.

2B2. Provide additional training to enable USDA and HDOA inspectors to be able to better identify and subsequently stop unauthorized incoming shipments (including from international and mainland sources) of restricted or prohibited AIS. –Also identified in Education and Outreach
(USDA, HDOA, AIS Coordinator, Bishop Museum, UH) YEAR 2-5

Update: There have been a few initial educational presentations to USDA inspectors for identification of some species, such as the marine alga, *Caulerpa taxifolia* and for terrestrial invasive snails. This training program should be expanded, to focus on larger numbers of AIS. This should also include the development of visual materials, such as flashcards, further detailed in Objective 5: Education and Outreach.

2B3. Ensure that there is adequate staffing and that clear guidelines exist for inspectors /enforcement officers at pre-border, border, and post-border levels for maritime activities.
(DLNR, USCG) YEAR 2

Acronyms:

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CGAPS	Coordinating Group on Alien Pest Species
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HAS	Hawai'i Audubon Society
HDOA	Hawai'i Department of Agriculture
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Comment: If and when the new administrative rules for ballast water management are enacted, it will be critical that there is a clear understanding of these rules and an ability to enforce them. The present State enforcement resources however, are not adequate to address current State resource management needs, and it is not feasible to anticipate that they will be able to effectively enforce additional ballast water regulations. It is critical that dedicated resources, both in funding and staff, to enforce the administrative rules for ballast water and hull fouling be recognized and established. Concurrently, it will be important for the public and the enforcement agency to have a clear understanding of the rules.

2B4. Improve coordination and cooperation between HDOA and USDA on applicable regulations and inspection efforts, to ensure consistency and compatibility

(HDOA, USDA, HI AIS Advisory Council, AIS Coordinator) YEAR 1.

2B5. Continue to enforce procedures and restrictions on nonnative species that are already being imported, and review if further restrictions are appropriate.

(HDOA, DLNR) ONGOING

Comment: HDOA currently carries out this task, recognizing that even once a nonnative species has been introduced and becomes established, there may still be a need for restrictions on further imports and introductions of that same species. This is because when a nonnative species (a host) is introduced, it brings with it only a) subset of the genetic variations of the species itself, and b) a subset of all the species of parasites that can infect it. If additional specimens of that same host are introduced at a later date, they may subsequently a) introduce new genetic strains and increase the genetic diversity of the population, and b) harbor additional parasites that did not infect the original introduction.

2B6. Explore the feasibility of working with the Department of Homeland Security (DHS) Personnel to increase the use of resources available to detect incoming shipments of AIS.

(HI AIS Advisory Council, USDA, Department of Homeland Security, AIS Coordinator) YEAR 3

Update: DHS-Customs and Border Protection (CBP) is responsible for foreign arrivals and inspections of passengers, cargo, aircraft, vessels, other means of conveyance, and mail at nearly 400 Ports of Entry in the United States. Representatives from the agriculture component of the DHS-CBP have expressed a strong interest in cooperating with other agencies and interests, to the extent the agency will allow. Policies and directives are currently being developed as the agency evolves.

2B7. Continue monitoring efforts of effluent and discharge systems, and increase efforts if needed, based on the results from the risk assessment from 2A1, to prevent further introductions and spread of AIS.

(EPA, HDOH, HDOA, UH-Sea Grant) YEAR 1

Update[56]: As part of permit conditions through HDOA, effluent and discharge systems must be such as to not allow introductions into the environment. In addition, as authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In Hawai‘i, the HDOH administers the NPDES through a grant from the EPA, who still provides oversight and writes regulations. It is suggested that for all facilities that have effluent discharge into the ocean, there should be, at a minimum, annual inspections of seawater systems. As a result of these regulations by HDOA, EPA, and HDOH, systems should pose little threat to the natural environment. However with little monitoring and enforcement, this may not necessarily be the case.

2B8. Identify "ecologically sensitive" marine and inland water areas that have little to no AIS (i.e., the waters off the NW Hawaiian Islands, Kaho‘olawe, as well as relatively pristine streams), and identify and implement additional precautionary protocols for those areas.

(USFWS, NOAA, DLNR, HI AIS Advisory Council, Kaho‘olawe Island Reserve Commission, Hawai‘i Natural Heritage Program) ONGOING

Comment: USFWS and DLNR already have some protocols in place for activities in the NW Hawaiian Islands, that get incorporated into the required special use permits. This includes the rinsing of all dive gear in freshwater between usage, and when applicable, hull inspections for barges and other vessels destined for that area. NOAA Fisheries also has put

[56] Taken from the EPA website on the National Pollutant Discharge Elimination System, http://cfpub.epa.gov/npdes/

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protocols into practice to prevent accidental introductions that may be associated with research activities in the NW Hawaiian Islands. It is recommended that a multi-agency assessment be undertaken to identify any gaps that may exist with these and other procedures, including the identification and implementation of suggestions.

STRATEGY 2C: Reduce the ability for unregulated purchases of prohibited and restricted AIS stocks that are still readily obtainable for sale or trade.

Problem addressed: Efforts must be made to minimize the availability of organisms which are listed as restricted and prohibited by State and Federal agencies in both on-island and off-island venues, except as authorized means. This strategy is alluded to in tasks 2B1 and 2B2. However, because of the potential scope of this problem, it is presented as a separate strategy. There are multiple cases of restricted and prohibited stocks being sold, not only in local venues without detection by HDOA and DLNR, but are also easily acquired via mail order and online catalogs. Additionally, some local vendors have expressed concern that because many of these stocks are available through mainland, internet and catalog vendors, local merchants are essentially being penalized financially for following the law.

2C1. Increase the frequency of inspections of local vendors by HDOA and DLNR to insure awareness of prohibited and restricted AIS stocks and compliance with laws.
(HDOA, DLNR) YEAR 2

2C2. Work with US Department of Agriculture, which is funding an employee and the development of a webcrawler to identify online vendors of Federally noxious weeds and regulated plant species.
(AIS Coordinator, USDA, HDOA) YEAR 1

2C3. Develop a program to identify mail order and online vendors who are selling Hawai'i prohibited and restricted stocks and work with these vendors to keep AIS from being imported into Hawai'i.
(HDOA, AIS Coordinator, USDA) YEAR 2

Comment: In many, but not all cases, mainland vendors may be unaware of specific State restricted species. Some states have been proactive in addressing this, and in many catalogs, it is specified that a species is "not available for State X". Hawai'i interests need to work with these vendors to achieve similar results.

STRATEGY 2D: Work with appropriate industry representatives and user groups who may be potential pathways of AIS introductions to ensure awareness of the threats of AIS, and to develop methods to better assist in preventing the introduction and transfer of AIS.

Comment: The Federal Aquatic Nuisance Species Task Force's Committee on Communication, Education, and Outreach is already working with the aquarium industry on task items on a national level similar to 2D1, 2D2, and 2D3 below. (These efforts by the Federal ANS Task Force are being funded by the aquarium industry, USFWS, and NOAA.) When Hawai'i implements these tasks, efforts should be made to link into such activities that are occurring on the national level.

2D1. Work with aquarium, water garden, and other appropriate industries, as well as cultural groups to educate all aquarists, retailers, and consumers of the importance of not releasing unwanted ornamentals into aquatic systems. –This is also referred to in Education, Objective 5
(AIS Coordinator, CGAPS, ISCs, Federal ANS Task Force, DLNR) YEAR 1

Update: An early marketing television advertisement and poster campaign by the Division of Aquatic Resources, focusing on the need to return unwanted fish appeared to be effective; funds and resources need to be identified to re-institute and expand this campaign.

2D2. Work to ensure designated a place(s) on each island where people can dispose of unwanted fish (live or dead that may have eggs) and other aquatic organisms, ensure that these are easily accessible sites, and that people are aware of the location.
(DLNR, HDOA, AIS Coordinator) YEAR 1-2

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Comment: This includes working with aquariums, pet shops, and the Humane Society to encourage industry-wide acceptance of unwanted aquarium species at stores, and to identify ideal humane disposal methods.

Currently many outlets will accept the return of unwanted aquatic organisms. However, in some cases, this puts an additional burden on the businesses as they use up valuable tank space for the storage of these larger animals. Efforts need to be made to work with these businesses to identify a system of return that will work for them.

2D3. Work with the aquaculture industry, aquaculture development programs, and wetland agriculture representatives to ensure that farmers understand the importance of containment systems as well as the threat that escapees may pose to native species and habitats.

(HDOA, HI AIS Advisory Council, UH-SeaGrant, Federal ANS Task Force, CGAPS, AIS Coordinator) YEAR 1

Update: Currently import requests must specify containment procedures. However, it has been reported that some farmers don't truly see this as an important measure. Proactive, voluntary compliance with containment aspects will go far in helping to prevent introductions.

2D4. Work with the aquaculture industry to use only native species for open ocean, cage culture, or ocean-based fishpond aquaculture, as there is a high probability of escape.

(HDOA, CGAPS, DLNR, UH-Sea Grant, Hawai‘i Aquaculture Association) ONGOING

Update: As detailed in earlier sections of this plan, a permit from the Hawai‘i Department of Agriculture is needed for the importation of species. Currently no permits have been granted by the Department of Agriculture for the use of nonnative species in open ocean, cage, or ocean-based culture systems, largely due to the likelihood of escape from such systems.

2D5. Explore the creation of best management practices to reduce the introduction and spread of AIS from potential vector industries, such as the aquarium, nursery, and aquaculture industries.

(HI AIS Advisory Council, HDOA, CGAPS, AIS Coordinator, DLNR, UH-Sea Grant, Hawai‘i Aquaculture Association) YEAR 2

Comment: Best Management Practices have been implemented across the nation addressing AIS issues with various issues. To a large degree they have been shown to be effective in industry compliance. Protocols used elsewhere should be explored and adapted to fit Hawaii's needs.

STRATEGY 2E: Minimize AIS introductions and transfers by researchers and others involved in AIS field activities.

Comment: The Federal Aquatic Nuisance Species Task Force has already developed protocols for research activities. Relevant components of these protocols should be adapted to fit Hawaii's needs, as they relate to tasks 2E1 and 2E2 below. Further, DLNR-DAR already has a research permit process, but the permits are only applicable to “regulated species” in “protected areas”. There may be a need to revise statues to allow for application of these permits on all research to prevent the spread of nonnative species.

2E1. Establish protocols to minimize the spread of AIS into the wild from research, monitoring and control activities, and incorporate this aspect into funding requests.

(HI AIS Advisory Council, DLNR, HCRI-RP, MAG, UH, Bishop Museum) YEAR 1-3

Comment: With the increase in AIS-related activities, there is an increased chance of transferring AIS. For example, many algae species reproduce by fragmentation and can grow into a new plant from a small piece. Fragments can be generated by wave action, currents, herbivory, human trampling, and even removal or “clean-up” activities. To limit the spread of invasive algae from management efforts, protocols are currently being developed for community monitoring and clean-up events. Additionally, preliminary protocols are being employed by researchers at the Bishop Museum and the University of Hawai‘i, such as the surveying of reef sites before harbors to reduce the chance of spread of AIS from infested waters to non-infested waters. However, more attention needs to be paid to this aspect, and protocols addressing this task should be a standard component of all field activities that involve AIS, as well as a required component of grant proposals that address AIS.

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2E2. Establish new and/or utilize existing regulations and protocols for in-water (non lab) based research experiments that could potentially introduce or involve the culture or movement of nonnative species into areas where they do not naturally exist.
(HDOA, DLNR, HCRI-RP, UH) YEAR 1

Update: Representatives from HDOA report that while permits are allowed for lab cultures, the current review process would prohibit using nonnative species for in-ocean research.

STRATEGY 2F. Improve current importation practices to effectively address AIS introductions.

2F1. Perform an interagency review to access the current system regarding regulation of plan imports, including adding known AIS plant species to existing regulation lists under HDOA.
(HDOA, DLNR, HI AIS Advisory Council) YEAR 2

2F2. Continue disease sampling for shipments and stocks of live fish and other species, and assess whether current systems are considered "adequate" to keep contaminated stocks from being distributed via aquaculture, the aquarium trade, and/or government stocking programs.
(HDOA, DLNR, HI AIS Advisory Council, UH-SeaGrant) ONGOING, with Assessment in YEAR 3

Comment: In other states, there are various disease-free certification programs, which are based on sampling of stocks. Hawai'i currently does not have such a statewide program for all species, though a "Disease Diagnosis and Prevention Program" in place with HDOA's Aquaculture Development Program (ADP). Through this, the ADP provides diagnostic services to the aquaculture industry and oversees a voluntary pathogen-free shrimp certification program. SeaGrant extension agents are also regularly in the field, addressing potential disease issues with farmers. An evaluation of the current systems are warranted to determine if they are adequate to prevent the transfer of pathogens and disease species AIS, and to determine what the industry and others define as an "adequate" level.

Marine Specific Prevention Strategies and Tasks

STRATEGY 2G. Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment, and hull fouling pathways (commercial and recreational).

Note: Details of the Ballast Water and Hull Fouling Program, including the Aquatic Alien Organism Task Force (AAOTF), are provided in a separate section of the plan, beginning on page 3-21. The suggested tasks below (except for 2G6) will require additional funding sources. Additionally, in order to be most effective, all tasks will require support from the legislature and associated State agencies.

2G1. Develop administrative rules to minimize the introductions of AIS via ballast water, ballast sediment, and hull fouling.
(DLNR, AAOTF) Ongoing

Update: Chapter 187A-31, Hawai'i Revised Statutes (HRS), titled Alien Aquatic Organisms, gives the Department of Land and Natural Resources (DLNR) the authority to adopt administrative rules, including penalties, to carry out the intent of this law. DLNR, working with the re-established Alien Aquatic Organism Task Force (AAOTF), has developed draft administrative rules to implement a proposed Ballast Water and Hull Fouling Prevention Program for Hawai'i. These administrative rules are ready to begin initial stages of the total process to be approved by the Governor.

2G2. Adequately implement and enforce the administrative rules referred to in task 2G1.
(DLNR, USCG) YEAR 2

Update: Currently, no funding has been identified to implement the first phase of the proposed administrative rules created under the Ballast Water and Hull Fouling Prevention Program. This would include rapid response teams, and the development of a surveillance program to provide surveys of high-risk vessels, as well as additional surveys of vessels on a random basis. Further, enforcement of these rules will likely need to incorporate Federal efforts, such as working with

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the United States Coast Guard (USCG) to be the enforcement for the management programs These implementation and enforcement aspects should be addressed by the State DLNR within Year 1, for implementation of this task within Year 2.

2G3. Continue the efforts of the Ballast Water and Hull Fouling Prevention Program, and associated task force, and initiate measures to have a permanent program with dedicated funding.
(DLNR, AAOTF, USCG, Bishop Museum) YEAR 1

Update: The ballast water and hull fouling program is currently an unfunded mandate, and the present program coordinator's position expires on June 30, 2003. The AAOTF will continue to meet through November 2003 however, under a study by researchers at the Bishop Museum (funded by the Hawai'i Coral Reef Initiative), and will focus on hull fouling concerns and management solutions for hull fouling. If additional funding is not obtained, the future of this program is uncertain. The need for a ballast water coordinator position is also referred to in 1A10.

2G4. Identify and address gaps in the Ballast Water Prevention Program that have not been addressed in the administrative rules.
(DLNR, AAOTF, USCG, AIS Coordinator) YEAR 1-5

Update: Though much effort has been put into the Ballast Water Management Program, gaps remain that need to be addressed for effective management of the issue. These exist in the following areas (the latter two bullet items are being addressed on a national level, and State efforts will need to coordinate with those efforts to prevent unnecessary duplication):

- **Alternative methods for ballast water treatment to be used for interisland barges and other interisland vessels or towed platform traffic.**

  Comment: These cargo barges, which are towed and unmanned, carry ballast water that is sometimes discharged. Ballast water exchange is not reasonable for interisland barges: Because ballast water exchange is conducted outside of the EEZ, this would mean a 400 mile roundtrip voyage to conduct exchanges, which would be approximately 57 hours exclusive of deballast/ballast time[57]. Identification and promotion of alternative methods for addressing ballast on these types of vessels is needed.

- **Development of a risk assessment method/matrix for prioritizing vessels for ballast water management decisions, including boarded inspections.**

  Update: The State is working with the USCG on a ballast water risk assessment matrix. This matrix will "score" each vessel that is bound for Hawai'i and determine which of its three categories a vessel falls: high-risk, medium-risk, and low-risk /no risk. This matrix would assist resource managers in determining which vessels are higher priorities for inspection activities.

- **Develop a web-based ballast water reporting process to increase compliance with the mandatory reporting regulation of the USCG.**

  Update: Currently, the State (DLNR) has met with the U.S. Coast Guard to discuss possibilities for integrating into the U.S. Coast Guard's website, the Hawai'i Integrated Maritime Information System (HIMIS). The HIMIS website will hopefully make reporting easier and, in turn, result in more compliance with the mandatory reporting regulation of the USCG and the State's proposed 48 hr pre-arrival reporting requirement. It is uncertain whether or when this system will be put in place. Concerns by members of the shipping industry have also been raised regarding the effectiveness of HIMIS, and the ease of its use. An initial step to consider would be to secure funding for a demonstration project to research the benefits of the HIMIS system as well as its user-friendliness. Alternate suggestions include a simple email address to which vessels and agents can send the USCG ballast report to.

- **Dissemination of information to the public relating to ballast water issues.**
- **Method for verification of ballast water exchange**
- **Exploration of alternative treatment methods for ballast water exchange.**

[57] D. Hazlehurst (Matson Shipping), personal communication.

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2G5. Form a rapid response team to evaluate the risks and recommend an appropriate course of action once alerted to the pending arrival of a high risk vessel, or notification of an established aquatic nonnative introduction via ballast water or hull fouling.
(DLNR, USCG, AAOTF, USFWS, NOAA) YEAR 1

Comment: This task is taken from recommendations to the Legislature made by the original AAOTF in 1997. Many aspects of this type of team need to be addressed, including funding mechanisms, participants, prioritization of vessels, procedures, as well as safety and insurance aspects for both those inspecting the vessels (including divers) as well as the vessels themselves.

2G6. Raise awareness of hull fouling issues with government, relevant industries (including tourism), recreational sector, local communities (especially those closely associated with coral reefs) and schools.
(Bishop Museum, DLNR, AAOTF, UH-Sea Grant, USCG, AIS Coordinator) YEAR 1

Comment: This task partially taken from recommendations from the Global Invasive Species Programme (GISP). Through the AAOTF, efforts are currently being focus on hull fouling components. This task force is composed of representatives from the maritime industry, aquatic resource managers, and researchers, and will include representation from recreational boaters and others. This is a first step in addressing hull fouling issues, and identifying the direction for future outreach and education efforts.

2G7. Continue to develop voluntary methods, best management practices, and management protocols for hull cleaning of both commercial and private recreational vessels, as well as marine equipment, to minimize the risk of transporting hull fouling organisms into and throughout State marine waters.
(AAOTF, Bishop Museum, DLNR, USCG) YEAR 2

Comment: Taken from recommendations made by the Global Invasive Species Programme (GISP). Many vessel operators ensure clean hulls in order to minimize the energy needed to drive the vessel through the water. The guidelines now in place for commercial vessels are very tightly adhered to, and policed by the USCG, ABS, and similar classification systems worldwide. Additional protocols could include: a) overseas arrivals to not clean their hulls in-water, but rather in controlled areas (designated by the State) such as shipyards, and b) local boaters should also be encouraged to clean their boat out of water, with directives for proper disposal of the hull fouling material. If this not an option, then at a minimum, boaters should refrain from cleaning their hulls over reef areas. A hull fouling working group, likely an extension of the AAOTF, should address these and other aspects relating to best management practices and management protocols, as well as what will be feasible to ask/require from Hawaii's boating community.

2G8. Evaluate the feasibility of establishing a quarantine area and an onshore ballast water disposal/treatment facility.
(DLNR, AAOTF, USGC) YEAR 3

Comment: This task taken from recommendations made to the Legislature by the original AAOTF in 1997, though it is not a key one discussed on page 3-22. This suggestion was made by the original AAOTF in order to prepare for the eventuality that vessels with fouled hulls will arrive into our waters and harbors, and that "ballasted ships will sometimes be unable to exchange ballast enroute to Hawai‘i". Currently, no location has been identified for this facility, though Barber's Point deep draft harbor (Barge Harbor) has been suggested as a good location. This task is described as an "evaluation" because it is still unclear as to whether the logistics and costs of such a facility would be prohibitive or feasible, and studies done in other states, such as Washington,[58] indicate that it may not be a feasible option.

2G9. Evaluate the feasibility of establishing surveillance programs to detect and implement penalties for "polluters" who introduce AIS via fouling.
(AAOTF, DLNR, USCG) YEAR 4

Comment: Taken from recommendations from the Global Invasive Species Programme (GISP). This aspect is one that would need considerable evaluation and input, from numerous stakeholders, researchers and management agencies, both in Hawai‘i and worldwide. Is included here to point out the need to look at numerous types of funding programs, as well as begin to hold those responsible for economic and environmental costs relating to their actions.

[58] S. Smith, personal communication, 2003.

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Inland Water-Specific Prevention Strategies and Tasks

STRATEGY 2H: Assess and minimize activity related to planned, authorized introductions of nonnative species into inland water systems.

Issue Addressed: Planned introductions into inland water systems still are occurring through the State by DLNR and Department of Health. These include the production of channel catfish and rainbow trout for the stocking of public fishing areas at Nu‘uanu (O‘ahu) and Koke‘e (Kaua‘i)[59] and the stocking of poecilids for mosquito control, respectively. Though these species are already in Hawai‘i, there are concerns about the authorized spread into additional waterway locations.

2H1. Perform an inter-agency review and assessment of the efficacy versus threats of HDOH's authorized introductions of Poecilids into native habitats for mosquito control, especially those streams that are still predominately composed of native species

(HI AIS Advisory Council, HDOH, DLNR, UH-HSRC, Bishop Museum) YEAR 1

Comment: The practice of stocking streams, ditches, and other inland waterways with Poecilids (i.e. mosquitofish, swordtail, Mexican molly) to control mosquitoes should be seriously evaluated.[60] Though mosquito control certainly needs to be addressed in Hawai‘i, Poecilids are known to be harmful to native insect and fish species.[61] By writing this plan, it has become clear that this is a contentious issue, with many people voicing concerns about this practice. The use of these fish does appear to be effective for mosquito control in certain situations[62]; however, research also suggests that the use of Poecilids to control mosquitoes is not necessarily an effective mechanism in many cases.

2H2. Perform an inter-agency review and assessment of DLNR-DAR's authorized practice of intentional introductions of nonnative species into aquatic habitats for recreational purposes.

(HI AIS Advisory Council, DLNR, HDOA, UH-HSRC, Bishop Museum) YEAR 1

Comment: This evaluation should relate to both artificial and natural systems. As mentioned in the introduction of the Prevention section, introductions into artificial systems have been shown to be relatively harmless, in terms of AIS. However, it is appropriate to review current procedures regarding this practice, to ensure that we are not deliberately introducing potential AIS. An assessment of the current introduction practices into streams is also warranted, as well as the development of an agency protocol specifying how DLNR-DAR will address this issue in the future.

2H3. Further research and catalog the history of introductions, including accurate identification of stocks, regarding inland water invasive species in Hawai‘i in order to avoid repeating similar problems on other islands. -this task is also referred to in 1A16

(DLNR, AIS Advisory Council, AIS Coordinator, HDOA, UH-SeaGrant) YEAR 2

Comment: Many of the introductions into Hawai‘i have already been documented. This task addresses past introductions that have not been documented. Documentation should proceed using a balance of different agencies and include the personnel involved in past and present introductions and import historical data. All of these elements should be recorded to avoid clouded histories.

2H4. Explore ways to reduce the amount of unauthorized stocking of nonnative species into aquatic habitats.

(DLNR, AIS Coordinator, HDOA, UH-SeaGrant) YEAR 2

Comment: Based on casual conversations with inland water fishing enthusiasts, it appears that the spread of smallmouth bass (*Micropterus dolomieui)* and largemouth bass (*Micropterus salmoides)* in Kauai's streams and reservoirs is due to unauthorized stocking.[63]

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[59] Taken directly from the DLNR-DAR's Anuenue Fisheries Research Center (AFRC) website, www.state.hi.us/dlnr/dar/afrc/index

[60] Timbol et al. 1989 and R. Englund (Bishop Museum), pers. comm. 2003.

[61] Text directly from Timbol et al. 1989

[62] M. Yamamoto (DLNR- DAR), pers.comm. 2003.

[63] Taken directly from Timbol et al. 1989.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	HDOH	Hawai‘i Department of Health
CGAPS	Coordinating Group on Alien Pest Species	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Administration
		TNC	The Nature Conservancy
EPA	Environmental Protection Agency	UH	University of Hawai‘i
HAS	Hawai‘i Audubon Society	USDA	U.S. Department of Agriculture
HDOA	Hawai‘i Department of Agriculture	USFWS	U.S. Fish and Wildlife Service

OBJECTIVE 3- MONITORING AND EARLY DETECTION:

Ensure effective programs that allow for the early detection of new AIS and the monitoring of existing AIS.

Table 4. Summary Table of Strategies and Tasks to Accomplish Objective 3

Strategy 3A: Continue current monitoring efforts to better understand the spatial and temporal distribution of AIS populations, and to detect new incipient populations.
3A1. Continue monitoring efforts at marine sites that have already been inventoried by researchers from the Bishop Museum, as part of their presence and distribution studies.
3A2. Continue monitoring efforts at sites identified in the HCRI grant, *"Ecological Success of Alien/Invasive Algae in Hawai'i"*.
3A3. Participate in NOAA's pilot project for an Early Warning System for Coastal Alien Species to detect new populations of invasive species.
3A4. Continue with current AIS freshwater inventory and monitoring efforts.
Strategy 3B. Identify gaps in current monitoring efforts referred to in Strategy 3A, and improve these efforts and the coordination of efforts among groups to better ensure detection of new or expanding AIS populations.
3B1. Develop a centralized database and associated geographical information system to be accessible by all agencies, groups and organizations engaged in AIS detection and monitoring.
3B2. Obtain funding for Bishop Museum to incorporate its historical stream collections and report findings into a database that is compatible with the current standard DLNR-DAR stream database.
3B3. Assess existing marine monitoring programs and identify areas where expansion of efforts could assist in more effective detection of AIS.
3B4. Based on the results from the assessment in 3B3, implement a standardized, long term marine AIS monitoring program and early warning system that is accepted by the state, to detect new AIS populations and the spread of existing ones.
3B5. Assess existing freshwater monitoring and surveying efforts and make recommendations for a coordinated and integrated approach which would better identify species and sites to focus on, as well as allow for the expansion and integration of current efforts to more effectively detect and monitor AIS.
3B6. Implement appropriate changes identified in the assessment referred to in 3B5.
3B7. Maintain long-term yearly monitoring stations (for all freshwater biota) on at least one pristine stream for each main Hawaiian Island.
3B8. Identify funding to survey, map, and monitor the distributions of introduced freshwater mollusk species.
Strategy 3C: Increase the number of knowledgeable individuals available for increased detection and monitoring efforts.
3C1. Engage those already working in the field to be aware of key invasive species that they may come across.
3C2. Create and train a statewide citizen monitoring network to assist in the detection and monitoring of the distribution of AIS in both marine and freshwater systems.

Acronyms:

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CGAPS	Coordinating Group on Alien Pest Species
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
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HAS	Hawai'i Audubon Society
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
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OBJECTIVE 3- MONITORING AND EARLY DETECTION:

Ensure effective programs that allow for the early detection of new AIS and the monitoring of existing AIS.

A Summary of Marine Monitoring Programs:

Current marine monitoring programs in Hawai‘i are undertaken by a variety of efforts, including programs under Bishop Museum, DLNR, NOAA, USFWS, and UH, among others.

Marine fish (both native and nonnative) are an example of well-documented species in Hawai‘i, largely because of the wealth of experts and extensive formal monitoring programs that already exist. Hawai‘i also has a large pool of active ocean-users across the islands who are knowledgeable of local fish species; this group includes divers, snorkelers, spearfishers, aquarium collectors, volunteer groups, as well as scientists. It is generally agreed that due to the large number of knowledgeable ocean users, in conjunction with expanded formal monitoring efforts, a new marine fish species would likely get noticed rather quickly.

Marine invertebrate and marine algae species pose a different issue. While large scale coral reef monitoring programs do exist, such as the Hawai‘i Coral Reef Assessment and Monitoring Program (CRAMP), they focus primarily on the spatial and temporal patterns of corals and fish. However for other species, such as marine algae or marine invertebrates other than coral, there is currently a lack of a large-scale, ongoing, State-wide monitoring system that would be effective in detecting new AIS populations or monitoring the spread of known populations. Initial studies conducted by the UH-Botany department, in partnership with CRAMP, examined the spatial distribution of algal species, but this was not developed into an extensive monitoring program as of yet. Similarly, many inventory studies have been done by the Bishop Museum and others, focusing on marine invertebrates, but these were part of specific grants, with no long term potential. Consequently, an integrated program of research and monitoring focusing on all aspects of the coral reef, including nonnative algae and non-coral invertebrate populations, is needed.

The Importance of Early Detection

The National Invasive Species Council reports that an important element of its plan—early detection of introductions and quick, coordinated responses—can eradicate or contain invasive species at much lower cost than long-term control, which may be infeasible or prohibitively expensive. In Hawai‘i, early detection of nonnative species before established populations spread beyond the point of introduction, should be considered a vital component of addressing AIS.

There are many programs and efforts currently in place for surveying and monitoring. The purpose of this section is to acknowledge the importance of continuing current programs, but also to identify gaps and areas for improvement of current programs in order to be more effective in detecting new populations of aquatic invasive species, before they become established.

-Adapted directly from an overview of "NOAA's Draft Plan for a National Coastal Marine Alien Species Program". Lead author: D. Turgeon.

A Summary of Inland Water Monitoring Programs

DLNR-DAR has a Statewide program for ongoing stream surveys and monitoring on all the islands, with its objective being to "determine the occurrence, distribution, relative abundance, and impact of nonnative aquatic organisms in Hawaiian streams." [64] Additionally, with support from DLNR and others, many public and private entities are involved in the surveying and monitoring of inland water systems throughout Hawai‘i. This includes Bishop Museum, University of Hawai‘i, and others, as further detailed in Appendices B, C, and D. These efforts

[64] M. Yamamato (DLNR-DAR), personal communication.

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have greatly increased our baseline knowledge of occurrence, distribution, and abundance of nonnative inland water organisms.

However, many of these efforts both by DLNR-DAR and the other entities are one-time surveys, and do not involve long-term monitoring. Further, though these efforts are Statewide, programs are not necessarily coordinated among the agencies or organizations, nor are the results of all the studies available in a centralized location or format.

Much additional surveying and monitoring of inland water systems has also been done by EPA, HDOH, various watershed organizations, and others, focusing on aspects associated water quality and / or native species. These studies greatly add to our knowledge of the inland water systems, but in many cases (especially on the islands other than O‘ahu), introduced species were often overlooked or just briefly addressed.

STRATEGY 3A: Continue current monitoring efforts to better understand the spatial and temporal distribution of AIS populations, and to detect new incipient populations.

Current Marine AIS Monitoring Tasks Related to Strategy 3A

3A1. Continue monitoring efforts at marine sites that have already been inventoried by researchers from the Bishop Museum, as part of their studies on the presence and distribution of AIS.
(DLNR, Bishop Museum, UH) YEAR 2

Comment: As detailed in Appendix C, surveys have been done by the Bishop Museum in conjunction with the Hawai‘i Biological Survey to determine the presence of introduced marine organisms. To detect the presence of new species and increased abundance of previously documented species, these sites should be re-visited on some type of regular basis.

3A2. Continue monitoring efforts at sites identified in the HCRI-RP grant, *“Ecological Success of Alien/Invasive Algae in Hawai‘i*” (detailed in Appendix C) and explore the need to increase the number of sites monitored regularly, especially at sites where nonnative algae was not found.
(MAG, UH) YEAR 1

Update: A follow-up project, “*Alien Algae on Hawaii’s Reef: Distributional Changes and Ecological Responses”,* will re-survey the 81 sites from the 2000-2001 study, plus an additional 9 sites to census the relationship of nonnative algae and herbivores, assess reproductive status of each nonnative algal species, and generate detailed distribution maps. This project will attempt to determine the extent that invasive algae is spreading, as well expand knowledge levels for more effective management of invasive algae in Molokai’s nearshore waters, as well as the waters of Kane‘ohe Bay and Waikiki in O‘ahu. (This study is also referred to in Appendix B).

3A3. Participate in NOAA's pilot project for an Early Warning System for Coastal Alien Species to detect new populations of invasive species.
(NOAA, Bishop Museum, DLNR, TNC) ONGOING

Update: NOAA is currently developing a Marine Invasive Species Early Warning System for Coastal Alien Species, and has designated Hawai‘i to be a pilot State in the project.[65] The Hawaiian Pilot Project is the first in a series of acquisitions of regional data sets. As each regional data node is completed, it will be integrated into a national early warning system, the basis for which is an up-to-date inventory of all native, nonnative, and invasive species known to exist in the coastal waters of US States, Territories, and US-affiliated Islands. The Bishop Museum is developing the baseline list of Hawaiian coastal species.

Current Inland Water AIS Monitoring Tasks Related to Strategy 3A:

3A4. Continue with current AIS inland water inventory and monitoring efforts.
(DLNR, Bishop Museum, UH, USGS, HDOH) ONGOING

[65] This paragraph adapted directly from an overview of "NOAA's Draft Plan for a National Coastal Marine Alien Species Program" and a Powerpoint presentation on the same topic. Lead author: D. Turgeon.

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Comment: There are various ongoing surveying and monitoring efforts, which are further detailed in Appendix B. However, though there is a variety of efforts, almost all are dependent on short-term funding. Further, these surveys are generally limited to selected sites, and do not necessarily represent a complete statewide effort.

STRATEGY 3B. Identify gaps in current monitoring efforts referred to in Strategy 3A, and improve these efforts and the coordination of efforts among groups to better ensure detection of new or expanding AIS populations.

3B1. Develop a centralized database and associated geographical information system to be accessible by all agencies, groups and organizations engaged in AIS detection and monitoring. -This is also referred to in Task 1A15

(UH-Center for Conservation, Research and Training, DLNR) YEAR 2

Update: Mapping is an important step in determining the spatial distribution of AIS. Once effective maps are created, they can be a helpful tool in determining priority sites and assisting in planning strategies. As further detailed in the Overview section, various entities are involved in the mapping of AIS. However as quoted from the Hawai'i Stream Research Center website, there still is a need for an effective, centralized "user-friendly, Internet-based, map-formatted access to the enormous quantity of existing stream data"[66]

3B2. Obtain funding for Bishop Museum to incorporate its historical stream collections (dating back to 1889) and report findings into a database that is compatible with the current standard DLNR-DAR stream database.

(AIS Coordinator, Bishop Museum, DLNR, HI AIS Advisory Council) YEAR 2

Update: The Bishop Museum has a vast amount of information from its programs in conjunction with the Hawai'i Biological Survey. However currently, this information is not incorporated into a system to be easily accessible nor compatible with the DLNR-DAR stream database.

Marine Related Activities Related to Strategy 3B:

A proposed statewide monitoring program may pose some difficulties in its methodology and experimental design, as algae can be very ephemeral, and thus there is a need for both seasonal and year round, as well as long term monitoring. Additionally, because the biology of the various invasive species differs, there is a need to implement appropriate monitoring schedule suitable for the biology of each the species. Also, it is important to note that the distributions of some species of nonnative algae inhabit areas outside of the typical "coral reef" habitat, (i.e., found in deep water and reef flats). As such, this monitoring effort will likely need to extend into areas not typically surveyed. With new coral reef habitat maps now completed (by NOAA) for ca. 80% of all main Hawaiian Islands, there is a baseline set of maps to use to begin discussions and initiate associated the tasks below.

3B3. Assess existing marine monitoring programs and identify areas where expansion of efforts could assist in more effective detection of AIS.

(AIS Coordinator, DLNR, MAG, HI AIS Advisory Council, USFWS, NOAA) YEAR 2-3

3B4. Based on the results from the assessment in 3B3, implement a standardized, long term marine AIS monitoring program and early warning system that is accepted by the State, to detect new AIS populations and the spread of existing ones.

(DLNR, UH, MAG, USFWS, NOAA) YEAR 3

[66] Quote is from the Hawai'i Stream Research Center's webpage, www2.hawaii.edu/hsrc/home/aquaorg.htm

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Comment[67]: There is a need for the development of a consistent protocol that could be used by various researchers on the different islands. Extensive work has been done in Australia and New Zealand focusing on identifying priority sites and implementing an effective early warning monitoring system. Hawai'i can and should build upon this knowledge and work with these countries to create a similar program suitable for Hawaii's waters. All interested agencies should be engaged in the development process from the beginning. The following is a preliminary list of aspects that a monitoring program should include, as suggested by those already involved in marine AIS efforts:

- Focused efforts at centers of dispersal, such as harbors, ports, boat launches, and suspected and known areas of invasions, to allow for early detection;
- Permanent transects on boundary areas to see how specific populations of nonnative algae are spreading;
- Frequent sampling (at least semi-annually) to determine if a species is spreading;
- Accounting for both seasonal time scales (i.e. do algae populations cycle winter/summer) as well as long term scales (from year to year);
- Extension of monitoring efforts into areas not typically surveyed for monitoring of coral reef species;
- Appropriate levels of time and efforts, such as:
  - Intensive efforts at edges of distribution;
  - Intermediate levels of monitoring at select sites within the distribution to monitor the change and impact;
  - Rapid survey methods outside of known distribution areas.
- Incorporation of methods and knowledge from models used for monitoring in Australia and New Zealand.
- The hiring and training of technicians to carry out the monitoring program.

Inland Waters Tasks Related to Strategy 3B:

3B5. Assess existing inland water monitoring and surveying efforts and make recommendations for a coordinated and integrated approach which would better identify species and sites to focus on, as well as allow for the expansion and integration of current efforts to more effectively detect and monitor AIS.

(AIS Advisory Council, DLNR, Bishop Museum, UH, USGS, HDOH) YEAR 2

Comment: As referred to above, various inland water survey and monitoring programs exist, and include work by DLNR-DAR, Bishop Museum, UH-HSRC, and USGS and others. Most of these programs have historically had strong emphasis on native species, and are not integrated with one another at this time. Additionally, there has been little to no focus on coastal areas for the possible disbursement of inland water AIS that can travel via the ocean. Efforts should be made to integrate current programs, as well as identify areas not being monitored to allow for an effective statewide monitoring system for AIS. It is suggested to have a follow-up in Year 3 to evaluate whether programs implemented as a result of the study are effective.

3B6. Implement appropriate changes identified in the assessment referred to in 3B5

(AIS Advisory Council, DLNR, UH, HSRC, Bishop Museum, USGS, HDOH) YEAR 3

3B7. Maintain long-term yearly monitoring stations (for all freshwater biota) on at least one pristine stream for each main Hawaiian Island.

(DLNR, UH, Bishop Museum) YEAR 2

3B8. Identify funding to survey, map, and monitor the distributions of introduced freshwater mollusk species

(UH-Center for Conservation Research and Training, DLNR) YEAR 2

Update: A survey on distributions of apple snails throughout all islands was published in 1995 (data up to 1992), with an update for O'ahu done in 1998. However, continuation of this monitoring as well as for other introduced freshwater snails is done on an ad-hoc basis, as there is not funding specifically for this. Funding mechanisms need to be identified to continue this work in a more formalized manner.

[67] Suggestions for aspects to be included under Monitoring are from researchers currently involved in various monitoring and research efforts for AIS.

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STRATEGY 3C: Increase the number of knowledgeable individuals available for increased detection and monitoring efforts.

3C1. Engage those already working in the field to be aware of key aquatic invasive species that they may come across.

(AIS Coordinator, DLNR, Bishop, UH) YEAR 1

Comment: There are many researchers and others involved in fieldwork that can be effective in identifying new populations or the spread of existing ones. For example, many of those involved in terrestrial resource management efforts could be easily trained to identify and report key inland water invasive plant species.

3C2. Create and train a statewide citizen monitoring network to assist in the detection and monitoring of the distribution of AIS in both marine and inland water systems. To be effective, this network will need to clearly link into an early warning system that incorporates follow-up. –This task is also referred to in Education and Outreach, Objective 5.

(AIS Advisory Council, AIS Coordinator, MAG, DLNR, NOAA, UH-Sea Grant, Reef Check) YEAR 2

Update: Trained volunteers and knowledgeable water users can provide relevant information on the occurrences of new species. Various site-specific efforts are already underway, which incorporate the use of volunteers for monitoring, and these could be expanded to include AIS components. There are multiple elements that would need to be included in the development of a citizen-monitoring network, including the following:

- **Development of a structured training program to educate and train volunteers;**
  Update: Reef Check has been a partner in ongoing nonnative algae cleanup events, and as offered the following to take the lead in structuring a marine AIS training program. With very limited support, they can do quarterly training and monthly ReefChecks; with a supported effort that might include .5 – 1 FTE, weekly events are feasible. ReefWatchers have also begun a training program to integrate algae into their monitoring efforts. In addition, a $20,000 grant has been awarded by Hawai‘i Community Foundation to assist in the development of an Alien Algal Watch program within ReefWatchers.
- **Expansion of current marine monitoring and inland water restoration programs to allow community groups to be more effective in AIS efforts;**
- **Increased use of undergraduate students and interns;**
- **Working with and training divers, spearfishers, aquarium collectors, and other ocean users across the islands on how to identify marine AIS and where to report such species;**
  Comment: Utilizing the expertise of individuals already in the water is a cost-effective way to help detect new species. There are a large number of individuals in the water on a regular basis, many of whom have strong knowledge of existing fish species. Currently, reports of new or unidentified marine fish sightings get reported to the University of Hawai‘i, Bishop Museum, and the Waikiki Aquarium. However, there is no centralized reporting location or information exchange among the various agencies and organizations.

  As part of the study "The Assessment of Nonindigenous Species on Coral Reefs in the Main Hawaiian Islands, with Emphasis on Introduced Invertebrates", researchers will be working with active divers and ReefCheck to educate them on recognizing and reporting suspected nonindigenous marine species, with an emphasis on marine invertebrates.
- **Creation and distribution of education materials with pictures and descriptions of key species;**
- **Creation and maintenance of a website to allow volunteers and water users to report their sightings of AIS;** (This is also referred to in Objective 1 and 4).
- **Development of reporting mechanisms to clearly link this network into an early warning system that incorporates follow-up.**

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OBJECTIVE 4: RAPID RESPONSE, ERADICATION, AND CONTROL:

Establish effective systems for rapid response, eradication, control, and restoration.

Table 5. Summary Table of Strategies and Tasks to Accomplish Objective 4

Strategy 4A. Implement a coordinated system for rapid response efforts to contain newly detected AIS.
4A1. Identify and make it clear among the agencies and organizations involved with resource management who is responsible for which areas and/or species, and what these responsibilities entail. 4A2. Develop a system to allow for centralized and formalized AIS reporting of sightings and response. 4A3. Develop Memoranda of Understanding (MOU) with the appropriate government agencies and appropriate non-government organizations that recognize and assist in the implementation of rapid response protocols. 4A4. Develop emergency response / contingency plans for high priority species and/or locales. 4A5. Explore the establishment and administration of permanent funding to implement emergency response plans. 4A6. Explore the feasibility of using the approach in which some terrestrial monitoring and rapid response is contracted out.
Strategy 4B: Prioritize organisms on which to focus control efforts and develop specific control plans to address these.
4B1. Develop a method to prioritize control actions for both species and sites, on an island by island basis.
Strategy 4C: Integrate knowledge from efforts throughout Hawai‘i, nationally, and internationally when dealing with specific species, and develop appropriate species-specific plans.
4C1. Research and summarize management efforts and effective measures in Hawai‘i and elsewhere regarding specific species. 4C2. Develop species-specific or location-specific action plans, as appropriate.
Strategy 4D: Continue to develop and implement a comprehensive approach to remove and control the spread of nonnative algae AIS by utilizing mechanical removal, native grazers, and the reintroduction of native species.
4D1. Continue and increase the number of ongoing volunteer algae control efforts. 4D2. Establish protocols to prevent the transfer of nonnative algae from clean-up and monitoring events. 4D3. Develop and deploy a mechanical suction system capable of removing large volumes of algal biomass from coral reefs. 4D4. Implement a large-scale volunteer effort, similar those at Waikiki MLCD, for the removal of *Kappaphycus* spp. and *G. salicornia* at Kane‘ohe Bay. 4D5. Explore the feasibility and effectiveness of collecting *G. salicornia* to minimize the fragment pool along beaches. 4D6. Further investigate the use of native grazers, such as urchins, to assist in the control or elimination of invasive algae. 4D7. Explore the need and feasibility of protection for species that are being used as controls for invasive species. 4D8. After removal of nonnative algae, restore native species composition of near shore marine ecosystems by reintroducing native algal species and other native benthos to appropriate areas.
Strategy 4E. Continue to address removal and beach restoration strategies for native and nonnative algae species that are involved in large blooms off the island of Maui.
4E1. Continue and improve efforts for the removal of heavy accumulations of invasive algae. 4E2. Create a master plan for the management of seaweed on the beaches of Kihei, Maui. 4E3. Develop a process for washing collected seaweed from the beaches off Kihei, Maui.
Strategy 4F. Address harbor designs and the availability of artificial substrata to help minimize the ability for the establishment of new invertebrate arrivals, or the spread of current populations.
4F1. Develop an assessment method to assist in evaluating the ramifications from an AIS standpoint when considering placing or constructing any new artificial structures into the water.
Strategy 4G: Explore the feasibility of promoting the harvesting of potentially invasive marine fish species such as ta‘ape and roi.
4G1. Enhance and creatively market ta‘ape by encouraging its consumption in local communities, restaurants, and tourist establishments, as well as on the mainland. 4G2. Develop and possibly subsidize the distribution of affordable ciguatera test kits that would allow a viable fishery for roi.
Strategy 4H: Explore and utilize the various methods available to control priority freshwater AIS.
4H1. Continue and expand volunteer events for the removal of freshwater plant AIS at specific sites. 4H2. Explore the option of using alternative resource pools to be involved with large-scale mechanical removal efforts. 4H3. Continue ongoing chemical treatment methods at existing sites and use these methods to treat new infestations. 4H4. Continue to prudently explore the utilization of ichthyocides for a few selected study sites. 4H5. Continue to prudently explore the utilization of biocontrol options for *Salvinia molesta* and other freshwater plant species.
Strategy 4I. Integrate restoration efforts with control and eradication of freshwater AIS.
4I1. Identify and support existing efforts and community groups that focus on restoration of native habitats. 4I2. Explore the restoration of lowland/coastal native damselfly populations by removing invasive fish and other species and translocating native damselfly larvae and adults to these habitats.
Strategy 4J. Explore the feasibility and advisability of encouraging the harvesting of invasive species other than marine fish for commercial applications.
4J1. Form a working group to evaluate the benefits and risks associated with the marketing and promotion of invasive species.
Strategy 4K. Recognize that degraded habitats may facilitate the decline of native species and/or the proliferation of nonnative species.

OBJECTIVE 4: RESPONSE, ERADICATION, AND CONTROL

Establish effective systems for rapid response, eradication, control, and restoration.

Once AIS are established, complete eradication under most conditions and funding restrictions is not likely to be feasible. In fact, very few cases exist worldwide of complete eradication of established populations of aquatic invasive species. A more realistic approach for most established populations is to use control measures to maintain existing AIS populations at an acceptable level (as determined by the Hawai'i AIS Advisory Council, MAG, DLNR, and the various entities involved with the specific AIS in question), and to prevent their further spread.

Due to the difficulty in controlling and eradicating established populations, a key component of management efforts should be the rapid response to newly detected populations, to prevent their establishment in the first place. Though the term Rapid Response can take on many forms, it can essentially be thought of in the following way: Having surveyed and identified a new invasive species, or a new population of known invasive species, there is a need to control its spread and ideally eradicate the pioneering populations.

Strategy 4A. Implement a coordinated system for rapid response efforts to contain newly detected AIS.

Issue Addressed: With the recent attention given to the population explosion and clean-up costs associated with *Salvinia molesta* at Lake Wilson/Wahiawa Reservoir on O'ahu (see page 5-2 for further details), the question on many people's minds, "how can we prevent this from happening again?". Though all the Objectives outlined in this plan play a critical role in addressing AIS issues in Hawai'i, for problems like that seen with *Salvinia*, a key strategy that could have abated the extent of the problem has to do with rapid response efforts.

Many of the following tasks in this strategy refer to examples seen with the recent control efforts of *Salvinia molesta*; this is done in an attempt to paint a clearer picture of what the strategy and task entails, but should in no way indicate that *Salvinia* is the only species to which rapid response plans and actions are needed.

Lastly, a key component in rapid response efforts is the coordination among Federal, State, and local resources. Many aspects of such coordination are detailed in Objective 1, and will not be repeated here.

The establishment of an interagency advisory council, such as the recently formed Hawai'i Invasive Species Council (HISC), and the proposed HI AIS Advisory Council, will be an important first step in ensuring rapid response, avoiding expensive duplicate efforts, and preventing costly delays caused by agency uncertainty over their jurisdiction.

Rapid Response Plans: Building on Other's Efforts

Numerous examples of rapid response plans exist and/or are currently in development on regional, national and international levels.

For example, there are rapid response plan templates, (e.g., recently developed by the Western Regional Panel) and models (e.g., *Spartina* emergency response plan developed by the State of Oregon) for aquatic invasive species that can be used to facilitate efforts in Hawai'i. Locally, rapid response plans exist addressing some terrestrial species, through the Invasive Species Committees (ISCs) on each island.

Because models and templates are available for use, it is emphasized that the tasks below should be considered only a preliminary listing/outline of tasks that would need to be considered in the development of a full-scale rapid response program. It is highly recommended that available plans and processes be consulted before moving forward in the development of such rapid response plan(s) for AIS in Hawai'i.

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MAG	Marine Algae Group
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TNC	The Nature Conservancy
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4A1. Identify and make it clear among the agencies and organizations involved with resource management who is responsible for which areas and/or species, and what these responsibilities entail.
(HI AIS Advisory Council, Hawai'i Invasive Species Council, DLNR, AIS Coordinator, NOAA, USFWS) YEAR 1

Comment: A lesson learned from the efforts with *Salvinia* clean-up in Lake Wilson on O'ahu is that a clear chain of command is needed, as well as a recognition of what aspects the various agencies are responsible for. On a national level, NOAA also recognizes the importance of this task as a first step; in their National Coastal Marine Alien Species program, they emphasize the need to "identify Federal, regional, State, county, and non-governmental capabilities and resources that could be mobilized to assist in efforts to respond and mitigate impacts from any nonnative species that poses a high risk of becoming invasive" [68].

4A2. Develop a system to allow for centralized and formalized AIS reporting of sightings, verification, and response.
(AIS Coordinator, HI AIS Advisory Council, HDOA, DLNR, Invasive Species Committees (ISCs) YEAR 1

Comment: This would include the ability to make formal requests for investigation of possible nonnative / invasive infestations, with the responsible agencies being required to formally respond to the reporting agency/individual within a certain time period. This system would likely be in the form of a website, as part of the task identified in Objective 1, or a toll free AIS HOTLINE. HDOA currently has a pest hotline; efforts should be made to integrate AIS response capacity into this existing number.

Verification of reports will need to be integrated into this system. This includes a mechanism identifying experts who can make species identification or confirmation of species identification, if needed. Additionally, there will need to be an assessment of whether a newly introduced species is likely to become invasive, which would tie in to risk assessment tasks suggested in Strategy 1C

The importance of responding to a potential invader should not be overlooked. Though this will no doubt likely result in many false calls, the cost of even one AIS that falls through the gaps in current system can be incredibly costly. This was readily seen with *S. molesta* at Lake Wilson, which cost the State over $1 million in control efforts. This species is known to be invasive on a national and international level. It is likely that if a formal request was presented to an AIS Coordinator and subsequently, to the HI AIS Advisory Council, the threat posed by this species would have been recognized much earlier on, with corresponding response efforts also being implemented much earlier on.

4A3. Develop Memoranda of Understanding (MOU) with the appropriate government agencies and appropriate non-government organizations that recognize and assist in the implementation of rapid response protocols.
(AIS Coordinator, All Involved Agencies) YEAR 2

4A4. Develop emergency response/contingency plans for high priority species and/or locales. These plans should include lead agencies, chain of command, specification of appropriate control measures (biological, chemical, and physical), methods to address the pathway of introductions, and ideally regular updates and periodic "drills" to ensure the contingency plans remain up to date and useful for a real incident.
(HI AIS Advisory Council, AIS Coordinator, Hawai'i Invasive Species Council) YEAR 1- 2

Comment: Without previously developed plans, new AIS populations can become established while agencies are developing and agreeing upon appropriate eradication measures.[69] Again, this was seen with Salvinia, where multiple meetings were necessary to try to figure out numerous elements from lead agencies,

[68] From "NOAA's Draft Plan for a National Coastal Marine Alien Species Program", and a Powerpoint presentation on the same topic. Lead author: D. Turgeon.

[69] Directly from the Alaska State ANS Management Plan

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including who had what technology, as well as basic questions, such as who owned the bulldozers and boats needed for the response. Though response plans will not completely eliminate these types of planning meetings, the majority of these tasks can be figured out ahead of time, in a non-emergency situation.

4A5. Explore the establishment and administration of permanent funding to implement emergency response plans.

(HI AIS Advisory Council, Hawai'i Invasive Species Council, AIS Coordinator, DLNR, CGAPS) YEAR 2

Status: Other states, including Washington and Massachusetts, have established an emergency fund that is reserved for the containment/eradication of pioneering infestations of AIS. This emergency funding is made available for immediate control actions that can be taken against new infestations. Hawai'i should explore these examples and implement a comparable funding reserve.

4A6. Explore the feasibility of contracting out to approved private businesses for some of the monitoring and rapid response work.

(HI AIS Advisory Council, AIS Coordinator, DLNR) YEAR 3

Comment: This approach has been used successfully in New Zealand and California

STRATEGY 4B: Prioritize organisms on which to focus control efforts and develop specific control plans to address them.

Issue Addressed: With limited resource capacity, prioritization of control efforts will be a necessary part of effectively addressing AIS issues throughout Hawai'i.

4B1. Develop a method to prioritize control actions for both species and sites, on an island by island basis, according to the threat posed by the species and the expected level of effectiveness of control and/or eradication efforts, among other factors .-This is also referred to in Strategy 1C.

(HI AIS Advisory Council, AIS Coordinator, MAG, DLNR, Invasive Species Committees) YEAR 1

Comment: This task is not only needed for resource managers, but also for volunteer groups. For example, there has been interest from various groups throughout the islands (such as Reef Watchers on the Big Island, and a group of educators and paddlers in the Hawai'i Kai area on O'ahu), in starting control efforts for nonnative marine algae. Before these groups begin their efforts, they have asked for assistance in identifying key sites and or species in which to focus. As a first step to large-scale control efforts, a priority listing of sites and species of where to focus efforts on is needed.

STRATEGY 4C: Integrate knowledge from efforts throughout Hawai'i, nationally, and internationally when dealing with specific species, and develop appropriate species-specific plans in relation to both long term containment and eradication when feasible.

Issue Addressed: Though the islands of Hawai'i are certainly unique in many aspects, many AIS problems found on one island are not unique to that island, or even to the Hawai'i archipelago as a whole. In many cases, long-term control and/or eradication efforts are going on elsewhere in the State, throughout the Pacific, on the mainland, or even internationally which are addressing the same issues that someone in Hawai'i may be trying to manage. Increased attention needs to be put towards learning about ongoing efforts throughout the State and elsewhere, assess if they are relevant, and if so, integrate this knowledge. Integrating knowledge from efforts elsewhere can help to determine whether a particular AIS population in Hawai'i warrants eradication efforts, or if based on available information, it is determined that the population is unlikely to be eradicated, and will instead require a decision about how/if to control its spread.

Further, there are many site-specific efforts throughout the islands involving volunteer efforts, community groups, and small non-profits. In many cases, current available information is not distributed to all these entities involved in hands-on efforts, and those involved may not have the resources available to dedicate a substantial portion of time to researching other current efforts.

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4C1. Research and summarize management efforts and effective measures in Hawai'i and elsewhere regarding specific species, and use this knowledge when developing strategies and plans to address these species.
(AIS Coordinator, HI AIS Advisory Council) YEAR 1

4C2. Using knowledge gained in Task 4C1, develop species-specific or location-specific action plans, as appropriate.
(HI AIS Advisory Council, DLNR, AIS Coordinator, MAG, Invasive Species Committees, CGAPS) YEAR 1

Comment: There is a clear need to develop specific control plans for certain species or certain areas. While the specifics of such action plans are generally not included in the scope of a State AIS Plan such as this one, the State and other associated entities have a responsibility to develop such specific plans, and to work with others who are trying to address AIS issues in Hawai'i. This may include the formation of statewide, working groups as referred to in Objective 1, to allow for the sharing of knowledge when developing such action plans. Species-specific working groups and associated action plans have already shown to be effective in Hawai'i: The Coordinating Group on Alien Pest Species (CGAPS) is heavily involved with various focus groups dealing with specific invasive species, such as the red imported fire ant, miconia, coqui frog, and the brown tree snake, and each island Invasive Species Committee (ISC) develops its own action plan for certain species and areas. In the marine realm, a marine algae working group has been formed (Marine Algae Group and Network – MAGNET) to develop specific action items relating to marine algae species of concern.

Marine Algae Control Strategies

Currently much of the in-water management of algal invasive species has been focused on manual removal by volunteers. While these volunteer events will continue, manual removal alone has shown to be insufficient in scale and scope to address the magnitude of the problem. A large-scale approach to control harmful nonnative algae is needed.

The current distribution of AIS algae blooms in Hawai'i are occurring in relatively discrete areas, and although they are known to be spreading, this somewhat discrete geographical distribution of some nonnative algae offers a hope for control and prevention before these harmful algal blooms spread even further. Though it will no doubt be a difficult process, direct control of these blooms is essential to protecting near-shore coral reef ecosystems and elements of Hawaii's ocean-oriented economy.

STRATEGY 4D: Continue to develop and implement a comprehensive approach to remove and control the spread of nonnative algae AIS by utilizing mechanical removal, native grazers, and the reintroduction of native species.

Background and Update: Research conducted over the past two years suggests a combination of treatments will offer the best potential for large-scale control of harmful macroalgae blooms. An example of this would be mechanical removal via a suction device, followed by complementary control approaches, such as enhancing native grazer populations and direct environmental manipulation, followed by restoration efforts including the seeding of native species. The key tasks are outlined below, and further details on current efforts are presented in Appendix B.

Mechanical Removal for Marine Algae Control

4D1. Continue and increase the number of ongoing volunteer algae control efforts, to have reasonably consistent smaller scale version of what was done at the Waikiki Marine Life Conservation District. - Also listed in Education and Outreach.
(MAG, TNC, UH, DLNR) ONGOING

Update: As detailed earlier in the plan, currently volunteer algae removal events are concentrating on *G. salicornia* at the Marine Life Conservation District (MLCD) in Waikiki. These efforts may be valuable in decreasing the fragment pool

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via removal of the loose mats in order to slow the spread of the species. Various community groups and entities have expressed a desire to start-up such events. In response, TNC and UH are developing protocols for the expansion of such events, and will encourage outer island participation.

4D2. Establish protocols to prevent the transfer of nonnative algae from clean-up and monitoring events. –Also referred to in Task 2E1.
(MAG, TNC, DLNR, UH) YEAR 1

Update: Protocols are currently being developed for community monitoring and clean-up events, to limit the spread of invasive algae from these efforts.

4D3. Develop and deploy a mechanical suction system capable of removing large volumes of algal biomass from coral reefs while minimizing damage to other reef organisms.
(TNC, UH, MAG) YEAR 1

Update: There is currently a protocol being developed addressing site selection, pre-removal community surveys, fabrication of the mechanical suction device, details involved in the mechanical process, as well as impact assessments of the mechanical removal process on the reef community.

4D4. Implement a large-scale volunteer effort, similar those at Waikiki MLCD, for the removal of *Kappaphycus* spp. and *G. salicornia* at Kane'ohe Bay.
(MAG, DLNR, UH, TNC, Hawai'i Institute of Marine Biology, Marine Corps Base Hawai'i, NOAA) YEAR 1

Update: Two preliminary events were held in October of 2002 to remove drifting algal biomass from the reef at Coconut Island in Kane'ohe Bay. Large-scale efforts will continue after the testing and implementing of the mechanical suction device.

4D5. Explore the feasibility and effectiveness of collecting *G. salicornia* to minimize the fragment pool along the beaches of Waikiki MLCD that has come up after south swell, before the high tide re-circulates it back into the water.
(MAG, UH) YEAR 2

Native Grazers for Marine Algae Control:

4D6. Further investigate the use of native grazers, such as urchins, to assist in the control or elimination of invasive algae.
(UH, MAG) ONGOING

4D7. Explore the need and feasibility of protection for species that are being used as controls for invasive species.
(UH, DLNR) YEAR 2

Update: It appears that native urchins being used for the task above may have been harvested from test plots in Kane'ohe Bay. Should these or other native grazers prove successful in being able to control AIS, there may be a need to increase the protection upon these species to prevent their over-harvesting.

Restoration Efforts for Marine Algae Control:

4D8. After removal of nonnative algae, restore native species composition of near shore marine ecosystems by reintroducing native algal species and other native benthos to appropriate areas.
(UH, MAG, Paepae o He'ei'a) YEAR 1

Update: Preliminary protocol is being developed by researchers from UH and is further detailed in the Research Objective section. Traditional Hawaiian planting methods are also being explored by the non-profit group, Paepae o He'ei'a, such as using raffia lei for the seeding of native algal species.

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4D9. Begin the culture and growth of native invertebrates and macro-algae species (to be used for reintroduction) at existing facilities, and explore obtaining additional facilities.
(UH, MAG, DLNR) YEAR 1

STRATEGY 4E. Continue to address removal and restoration strategies for native and nonnative algae species that are involved in large blooms off the island of Maui.

Issue Addressed: The concerns associated with large blooms of marine algae species (both nonnative and native) include invasion and destruction of native coral reef habitats, decrease in property values, and costs associated with removal from the beaches. These concerns are further detailed on in Chapter 2. Also, as introduced in Chapter 3, native species are included in these tasks because it truly is not possible to address the blooms of nonnative algae off of Maui without simultaneously addressing the issues associated with the native blooms.

4E1. Continue and improve efforts for the removal of heavy accumulations of invasive algae, such as *Ulva fasciata* and *Hypnea musciformis*, on Waipuilani Beach, Maui.
(Maui County - Department of Public Works, Waipuilani Beach Association) YEAR 1

Update: The Waipuilani Beach Association contributes $50,000 per year towards the operation of the Beachmaster 2000 machine used to collect and remove algae off the beaches of north Kihei, Maui. An additional special appropriation of $200,000 has been allocated (from a $250K EPA grant to the County of Maui), to assist with the purchase of equipment for the cleanup and removal efforts, as well as to assess the impacts of the different management options.

4E2. Create a master plan for the management of seaweed on the beaches of Kihei, Maui.
(Maui County SeaGrant, Maui County - Department of Public Works) YEAR 1

Update: A master plan for the beaches of north Kihei is currently in development by Maui County Sea Grant, building on its existing workplan developed for the current beach clean-up efforts. The additional guidelines in the Master Plan will be of use to the Maui County Department of Public Works and the Waipuilani Beach Association and its owners to allow for a unified set of guidelines to follow in the beach clean-up efforts, as well as a clear designation of authority. Similar efforts are suggested for the beaches off West Maui. This plan covers invasive species as well as native species that are showing invasive properties.

4E3. Develop a process for further washing of collected seaweed from the beaches off Kihei, Maui to allow for the collection of sand and coral rubble which can be returned to the beach for restoration efforts.
(Maui County SeaGrant, Maui County - Department of Public Works) YEAR 3

Update: Initial discussions have occurred between Maui County Sea Grant, Maui County Department of Public Works and the composting facility collecting the seaweed. This process was to be in the initial EPA proposal from Maui County for current beach cleanup efforts, but the idea was dropped due to budgetary constraints.

Marine Invertebrate Control Strategies

The need for control and eradication measures and on marine invertebrate AIS in Hawai‘i is still being assessed through research being done by scientists from the Bishop Museum and The University of Hawai‘i. The exception may be *C. riisei*, which has already demonstrated strong invasive attributes and a need for control. However, at this point, additional research on the fundamental biology and ecology of the species will likely be needed before an effective management/control strategy can be formulated for any of the marine invertebrate species.

Control efforts for marine invertebrates AIS in Hawai‘i, at least for the near future will largely focus on tasks covered in the sections of Minimizing Transport, Rapid Response, Education, and especially Research. Presented

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here is an additional suggestion that may be valuable in helping to control the establishment and spread of marine invertebrate AIS in Hawai‘i.

Strategy 4F. Address harbor designs and the availability of artificial substrata to help minimize the ability for the establishment of new invertebrate arrivals, or the spread of current populations.

Issue Addressed: The issue of a harbor design's ability to exacerbate or minimize hull fouling and associated settlement by invasive species was discussed by Floerl and Inglis, 2003. The article deals with water movement inside and outside harbors, and how effective design can minimize hull fouling. Though there is likely to be only a minimum of new harbor construction within the islands, it would be worthwhile to evaluate this aspect in the design process. Additionally, researchers' field observations in Hawai‘i suggest that many of the native organisms tend not to prefer artificial substrate, while many of the nonnative invertebrates appear to prefer artificial substrata within low wave-energy environments. It is hypothesized that the more of this kind of habitat that is available, the more likely that potential AIS will expand their populations or the range of their populations.

4F1. Develop an assessment method to assist in evaluating the ramifications from an AIS standpoint when considering placing or constructing any new artificial structures into the water.
(DLNR) YEAR 3-5

Marine Fish Control Strategies

As addressed in Chapter 2, the need for control and/or eradication measures on marine fish AIS in Hawai‘i is still being assessed by researchers and resource managers, as there is currently disagreement between some fishers and researchers as to the level of impact introduced marine fish species (primarily ta‘ape and roi) are having. Among the researchers and resource managers, there is a general consensus that there needs to be a better understanding of whether introduced marine fish are having impacts before control options are discussed and planned. As such, these experts suggest that control and eradication measures for the marine fish species of concern should not be a large focus of this plan at this time. Instead, they suggest that efforts should be focused on tasks covered in the other objectives, especially Prevention, Education, and Research.

However, these researchers and resource managers do agree that a preliminary strategy and associated tasks can be implemented, which focuses on the harvesting of key marine fish species of concern. Should further research suggest evidence that the control and eradication of nonnative marine fish is a necessary and viable option, additional actions for the control of such species will need to be identified in updates of this plan.

STRATEGY 4G: Evaluate promoting the harvesting of potentially invasive marine fish species such as ta‘ape and roi, as a viable control mechanism.

Editor's Note: At this time, the harvesting of key species as a viable control option is only fully supported for marine fish species. There are many aspects and concerns relating to the promoting of harvesting other AIS, which are highlighted in Strategy 4J and on page 3-20.

4G1. Re-investigate the feasibility of increasing the consumption (and subsequently, fishing levels) of ta‘ape with creative and proactive marketing.

(DLNR) YEAR 2

Comment: The nonnative ta‘ape has been implicated in the decline of several more desirable native fish species. Ta'ape is highly preferred of in its native South Pacific range, but is not a preferred food fish in Hawai‘i. In an attempt to explore the feasibility of increasing market demand, DAR conducted a Ta‘ape Market Development Project between

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1985 and 1986. This previous effort should be carefully assessed for its benefits and shortfalls, to determine if development of future promotional programs to encourage the use of ta‘ape will be viable.

4G2. Develop and possibly subsidize the distribution of affordable ciguatera test kits that would allow a viable fishery for roi.
(DLNR) YEAR 2

Update: There is currently a test kit available for approximately $5.00 per sample, which is an improvement over previous years. If control is deemed a necessary option, test kits may help to substantially increase the public's role in the harvesting of certain species such as roi.

Inland Waters Control Strategies

For effective management of inland water AIS on a statewide level, efforts will need to be focused on certain key species. This may be determined on a site by site basis in some cases, but there are also species that should be addressed on a statewide level. The further identification of key priority species in addition to those already identified in Chapter 2, as specified in Strategy 1C, will be integral to an effective statewide control program.

It is also important to emphasize that many inland water systems in Hawai‘i are no longer in their natural state; these include reservoirs and fishing parks such as Wahiawa Reservoir/Lake Wilson, Ho‘omaluhia Reservoir, and Waiakea among others. Many of these reservoir systems are an integral part of a statewide recreational fishing industry that involves authorized stocking of nonnative species by the State. Many of these nonnative species are not considered to be invasive. As such, in these types of waterways, control efforts will not necessarily need to be focused on controlling the species present, but rather on preventing the further spread of these species into natural systems. However, there are also some cases where control of AIS in artificial systems is warranted: examples include Salvinia in Lake Wilson and elodea in Ho‘omaluhia Reservoir. These types of situations will need to be evaluated and managed on a case by case basis.

STRATEGY 4H: Explore and utilize the various methods available (mechanical, chemical, biological) to control priority inland water AIS.

Mechanical Removal:

4H1. Continue and expand volunteer events for the removal of inland water plant AIS at specific sites
(AIS Coordinator, HI AIS Advisory Council, Invasive Species Committees, Ho‘omaluhia Botanical Garden, Kailua Bay Advisory Council, many additional site specific entities) ONGOING

Update: Many efforts are currently underway using volunteers for the hand removal of aquatic invasive plant species, such as mangroves, elodea, pickleweed, and salvinia.

4H2. Explore the option of using alternative resource pools, such as prison labor, to be involved with large-scale mechanical removal efforts.
(AIS Coordinator, HI AIS Advisory Council, DLNR) YEAR 2

Chemical Methods:

4H3. Continue ongoing chemical treatment methods at existing sites and use these methods to treat new infestations.
(DLNR, USFWS, Numerous site-specific entities) ONGOING

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4H4. Continue to prudently explore the utilization of ichthyocides for a few selected study sites. –This is also referred to in Objective 6: Research.
(DLNR, HDOA, USFWS, UH, HDOH) YEAR 1

Updates: Various entities are involved in the exploration of icthyocides for control of inland water AIS, including DLNR-DAR and UH: 1) DLNR-DAR was recently authorized to use the piscicide rotenone, which has been used with success in the past to clear infested anchialine ponds of nonnative species; 2) The University of Hawaii's Hawai'i Stream Research Center is involved with a USFWS study to evaluate the use of Fintrol (antimycin) for chemical control of pest inland water fish. USFWS offers training on the mainland for the use of rotenone and antimycin; there may be a way to get a training session in Hawai'i, but permitting would still need to occur through State Departments such as DLNR-DAR, HDOH, and HDOA.

BioControl Methods:

4H5. Continue to prudently explore the utilization of biocontrol options for *Salvinia molesta* and other key priority inland water plant AIS species, and ensure extensive testing and evaluation measures.
(USDA, HDOA, DLNR) ONGOING

Update: Various research efforts are currently underway for the use of biocontrol agents in the treatment of Salvinia, further detailed in Appendix C.

STRATEGY 4I. Integrate restoration efforts with control and eradication of inland water AIS.

4I1. Identify and support existing efforts and community groups that focus on restoration of native habitats
(HI AIS Advisory Council, AIS Coordinator) YEAR 1

Comment: As detailed in task 1A5, there are many community groups involved with site-based restoration projects. Many of these groups have the focus of restoring the land to reflect native Hawaiian systems, and incorporate the removal of AIS as part of their work.

4I2. Explore the restoration of lowland/coastal native damselfly populations by removing invasive fish and other species from selected aquatic habitats such as anchialine ponds, certain stream habitats, or artificial habitats such as isolated golf course water traps, and then translocating native damselfly larvae and adults to these habitats.
(Bishop Museum, DLNR) YEAR 3

Control Strategies for Both Marine and Inland Water Systems: Exploring Alternatives

STRATEGY 4J. Explore the feasibility and advisability of encouraging the harvesting of invasive species other than marine fish for commercial applications.

Issue addressed: Despite the commercial value and potential applications of some known invasive species, concerns exist as to whether promoting the harvesting of invasive species may in turn encourage the private and illegal cultivation of such species, which could increase the spread of these species into areas where they are not currently present. Some feel that this could exacerbate the pest problem while possibly counteracting any associated benefits. In some cases, there are strong opinions on both sides of this issue, which are further explored using apple snails as an example, under "Examining the idea of 'Pest to Profit': Problem or Solution?", on page 2-24.

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4J1. Form a working group to evaluate the benefits and risks associated with the marketing and promotion of existing or potential invasive species, and devise a set of recommendations and associated tasks for future versions of this plan to address how to move forward with this issue.

(HI AIS Advisory Council, DLNR, UH-Sea Grant, HDOA, HDOH, MAG, AIS Coordinator) YEAR 1-2

Comment: The working group should include resource managers, researchers, farmers, and aquaculture development interests, in order to adequately and effectively address this issue. Efforts should also be made to coordinate with other states that also are addressing this issue. As part of this evaluation, non-biological aspects such as social and ecological factors will also come into play.

STRATEGY 4K. Recognize that degraded habitats may facilitate the decline of native species and/or the proliferation of nonnative species.

Issue Addressed: Through drafting this AIS Management Plan, it has been suggested that the proliferation of certain introduced species may be largely due to degraded environmental conditions. This is further detailed in Chapter 2. Though there is still worldwide debate as to whether intact systems are more resistant to invasions than degraded ones, it does seem clear that changing the environment tends to change the natural balances associated with it. As such, maintaining healthy ecosystems will likely be an important component in addressing AIS in Hawai‘i.

Such ecosystem degradation-based issues are large and complex, and will require attention and efforts beyond the scope of this AIS Management Plan, at least in this first year's version. Therefore, specific tasks are not yet suggested. The exception is that there are two studies that will begin later in 2003 in Maui, to study the root causes of the algae blooms there. These are further detailed in Appendix B. These types of studies will be an important step in linking the proliferation of certain AIS to larger water quality issues.

Though tasks are not specified, this strategy is mentioned here to serve as a reminder that coordination with entities directly involved with water quality, nutrient influx, and run-off issues (such as the U.S. Environmental Protection Agency, Hawai‘i State Department of Health, and various watershed management organizations) will be necessary for the effective long-term management of AIS.

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DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Administration
		TNC	The Nature Conservancy
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HAS	Hawai‘i Audubon Society	USDA	U.S. Department of Agriculture
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OBJECTIVE 5 - EDUCATION AND OUTREACH:

Increase education and outreach efforts to ensure awareness throughout the State on AIS threats and solutions.

Table 6. Summary Table of Strategies and Task to Accomplish Objective 5

Strategy 5A. Increase education and outreach efforts toward those who may be potential sources for AIS introductions.
5A1. Develop and distribute printed material (posters, brochures, articles) for specific industry sectors and user groups. 5A2. Continue and expand public service announcements on a variety of AIS-related topics to be aired at regular intervals 5A3. Promote the value of using native species for trade, purchase, and cultivation within the hobby trades and industries. 5A4. Increase awareness on the direct economic impact of AIS among aquatic industries. 5A5. Develop airport displays to educate travelers on the threats of AIS, current management efforts, and how they can help to minimize the spread of these species. 5A6. Develop and produce and in-flight video highlighting the threats of AIS. 5A7. Develop and produce video highlighting the threats and solutions regarding AIS from ballast water and hull fouling for use by private companies within the maritime industries.
Strategy 5B. Target policy makers and legislative staff for outreach efforts.
5B1. Identify sponsors at the State legislature and county governments who will support policy issues regarding AIS. 5B2. Provide educational briefings on the threats, economic impacts, and solutions to AIS invasions for decision-makers and legislators. 5B3. Keep legislators and decision-makers abreast of the progress of AIS management efforts. 5B4. Encourage community groups to address policy makers regarding their concerns about AIS in Hawai‘i.
Strategy 5C. Increase awareness within the scientific community and natural resource agency staff to support the management of AIS.
5C1. Increase awareness of AIS among the various scientific and natural resource management interests.
Strategy 5D. Develop an education and training program for existing community groups and active ocean users to enable them to assist in early detection and monitoring efforts.
5D1. Work with and train volunteers and active ocean users across the islands in the identification of marine AIS in beach, intertidal and shallow reef areas.
Strategy 5E. Increase AIS awareness and interest for native species within the educational system.
5E1. Work with teachers to develop and give guest presentations on AIS issues at schools, and develop resource packets for teachers to use in the classrooms. 5E3. Further integrate AIS issues into service and education projects that involve students as part of a science class, science club, or for community service credit offered at some schools. 5E4. Work with teachers regarding proper disposal methods for organisms that have been used in the classroom, to ensure that this does not contribute to the release or transfer of AIS. 5E5. Increase outreach and education efforts at universities, through the Marine Option Program (MOP) at each university, to promote AIS research interest among undergraduate students.
Strategy 5F. Raise public awareness, concern, and ultimately, the buy-in on AIS issues for all residents of and visitors to Hawai‘i.
5F1: Continue with and update printed efforts such as posters and brochures focusing on AIS. 5F2. Develop a variety of powerpoint presentations for use in public venues and for casual speaking engagements. 5F3. Increase local television, radio and newspaper media coverage of Hawaii’s AIS issues and programs. 5F4. Incorporate AIS issues into education and outreach programs addressing terrestrial invasive problems. 5F5. Create displays at State parks, on school bulletin boards, in libraries, aquariums, and recreational facilities. 5F6. Create portable presentation boards to show at public events such as, boat shows, conferences, volunteer events, etc. 5F7. Coordinate efforts among UH and Bishop with DLNR-DAR and Sea Grant Educators on neighbor islands and provide materials to incorporate AIS issues into their presentations.
Strategy 5G. Integrate AIS education efforts into local, cultural, and ethnic community efforts.
5G1. Work with native Hawaiian groups and other community groups, to emphasize the threats that AIS pose to native species and traditional practices. 5G2. Work with cultural leaders to ensure that education efforts will be culturally sensitive and translated into the main locally spoken languages, and incorporated into newspapers or newsletters regularly read by individuals in various cultural and ethnic audiences. 5G3. Integrate AIS issues into activities at "culture science centers".
Strategy 5H. Promote clarification of issues and potential misconceptions regarding key taxa of concern, such as ta‘ape and roi.
5H1. Present current status of ongoing research related to ta‘ape and roi.
Strategy 5I. Assess the effectiveness of education and outreach efforts in reaching targeted audiences and changing behavior.
5I1. Develop a method to evaluate what education and outreach efforts will truly be most effective.

OBJECTIVE 5 - EDUCATION AND OUTREACH:

Increase education and outreach efforts to ensure awareness throughout the State on AIS threats and solutions.

Until recently, most of the educational and outreach efforts regarding invasive species in Hawai'i focused on terrestrial species. With the recent *Salvinia molesta* explosion in Lake Wilson on Oahu, many people across the State are now aware that invasive species also include an aquatic component. However, efforts now need to focus on expanding this awareness, to ensure that *Salvinia* is not the only aquatic invasive species gaining attention.

Education and outreach efforts would likely be directly effective in preventing the release of nonnative aquarium species, as many consumers may still be unaware that this could lead to potential problems. Early DLNR-DAR campaigns have focused on this and it is strongly suggested that these campaigns be updated and expanded. Similarly, increased efforts to ensure aquaculturists are more aware of the threats of AIS may help increase voluntary compliance with containment procedures.

It is clear that a multi-sector approach will be needed, and that the promotion of land stewardship and buy-in will be key aspects for an effective educational component. In addition to working with the scientific and natural resources management community, the tasks below include working with local neighborhood groups, civic clubs, local businesses, school groups, divers, snorkelers, and other water users, and policy makers to involve citizens and leaders throughout the State. Such involvement can be extremely powerful, as these people become a voice for increased efforts against AIS.

For many of these strategies and associated tasks, similar efforts are being undertaken in other states, nationally, or internationally. It is emphasized that Hawai'i should link with these existing efforts, and use and adapt relevant tools and methods that have proven to be effective elsewhere. Additionally, in many cases particular mediums (posters, brochures, etc.) are specified, however it is noted that some mediums will not be determined until a needs assessment or similar source of information suggests that a certain medium will have the desired outcome with the target audience. That is, producing various colorful brochures, posters, displays and other items will really only be valuable if they lead to changes in attitudes and behavior.

STRATEGY 5A: Increase education and outreach efforts toward those who may be potential sources for AIS introductions.

5A1. Develop and distribute printed material (posters, brochures, and/or articles) for specific industry sectors and user groups. Target audiences include:

- **pet shops, aquarium dealers, nurseries, and landscapers as well as wholesalers and shippers dealing in aquarium organisms to inform buyers of the dangers of releasing nonnative species into the wild.** (HI AIS Advisory Council, DLNR, AIS Coordinator, Pet Industry, CGAPS) YEAR 1
  Update: Currently, many pet and aquarium stores have been proactive with this task, and have printed up bags with the message of not releasing aquarium fish. Funds need to be identified to help offset these associated costs, and additional mechanisms should be developed to include messages associated with plant material.

Acronyms:

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CGAPS	Coordinating Group on Alien Pest Species
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- **recreational boaters, fishers, and marine tourism boats.** (DLNR) ONGOING
  Update: As part of the EPA grant proposal[70], it has been suggested that a cost-effective way of reaching a wide range of users is through the Harbormasters at State harbors where boats are launched. Through this grant, one-page handouts and posters that focus on these user groups, emphasizing the need for hull, bilge, engine inspections, etc. will be developed for use at harbors.

- **various industries to include AIS items in associated newsletters.** (AIS Coordinator, CGAPS) YEAR 2
  Comment. Examples of this include those circulated among aquarium consumers, on how to care for and dispose of their plants and animals in a way that they do not enter Hawaii's aquatic systems.

5A2. Continue, update, and expand public service announcements on a variety of AIS-related topics to be aired at regular intervals in order to reinforce the message to the general public and to reach new audiences
(DLNR) YEAR 1

Comment: An early public service announcement and poster campaign by the Division of Aquatic Resources, focusing on the need to return unwanted fish, appeared to be effective. Funds and resources need to be identified to update and expand this campaign. Similar campaigns should also be developed for other AIS aspects such as keeping boat hulls clean.

5A3. Promote the value of using native species for trade, purchase, and cultivation within the hobby trades and industries. –This task is also listed in Prevention.
(HI AIS Advisory Council, DLNR, AIS Coordinator, CGAPS) YEAR 2

Comment: It is hoped that increased awareness and use of native species could result in a decreased use of nonnative and potentially invasive AIS. Efforts will need to be taken to ensure that this does not lead to an over- or illegal harvesting of the native species.

5A4. Increase awareness on the direct economic impact of AIS among aquatic industries.
(HI AIS Advisory Council, AIS Coordinator, CGAPS, HISC, HCRI-RP) YEAR 1

Comment: This is fundamental in gaining political and popular support on this issue.

5A5. Develop airport displays to educate travelers on the threats of AIS, current management efforts, and how they can help to minimize the spread of these species.
(DLNR, HDOA, UH) YEAR 1-3

Update: As part of an EPA grant, $3,400 has been designated to help complete this task for the development of airport displays. Though passengers via air travel may not be a significant pathway for the introduction of aquatic species, including aquatic examples with general invasive species information may prove worthwhile. Also, the airport provides a venue to educate many visitors that may otherwise be difficult to reach.

5A6. Develop and produce and in-flight video highlighting the threats of AIS.
(HDOA, DLNR, AIS Coordinator, CGAPS) YEAR 3

Comment: Various airlines show an in-flight video provided by HDOA, which highlights invasive species in Hawai‘i. The videos are terrestrial in focus, but efforts should be made to incorporate an AIS component to this video. In addition, New Zealand has a good in-flight video on introductions that could be used as a model for Hawai‘i.

5A7. Develop and produce video highlighting the threats and solutions regarding AIS from ballast water and hull fouling for use by private companies within the maritime industries.
(DLNR, AIS Coordinator, AAOTF) YEAR 3

[70] Recently, an EPA grant was awarded to a team from DLNR-DAR and the University of Hawai’i to address various outreach and education aspects relating to marine AIS, with a focus on marine algae. This grant is referred to in the relevant tasks simply as "the EPA grant".

Acronyms:

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		USFWS	U.S. Fish and Wildlife Service

STRATEGY 5B. Target policy makers and legislative staff for outreach efforts.

5B1. Identify sponsors at the State legislature and county governments who will support policy issues regarding AIS.
(HI AIS Advisory Council, AIS Coordinators, HAS, TNC, CGAPS) YEAR 1

5B2. Provide educational briefings on the threats, economic impacts, and solutions to AIS invasions for decision-makers and legislators to help them weigh these threats against other legislative imperatives
(HI AIS Advisory Council, DLNR, CGAPS, HAS, TNC) YEAR 1

5B3. Keep legislators and decision-makers abreast of the progress of AIS management efforts by sending and presenting periodic updates to them.
(AIS Coordinator, HAS, DLNR) YEAR 1

5B4. Encourage community groups to address policy makers regarding their concerns about AIS in Hawai‘i.

(HI AIS Advisory Council, AIS Coordinators, HAS, MAG) YEAR 1

STRATEGY 5C: Increase awareness within the scientific community and natural resource agency staff to support the management of AIS.

5C1. Increase awareness of AIS among the various scientific and natural resource management interests, via guest speakers and workshops
(USDA, HDOA, DLNR, AIS Coordinator, Bishop Museum, UH) YEAR 1

Comment: This task has various components, including the following:

- **Conduct specific training and develop field guides for researchers and resource managers who are already in the field for monitoring and other efforts.**
  Comment: There are many researchers in Hawai‘i who may not work on AIS specifically, but who are in the water for monitoring etc. It would be a good use of resources to train them to be aware of the main AIS.

- **Educate resource management and regulatory agencies and their staff regarding dangers of the introduction of parasites.**
  Comment: Many biologists and resource managers working on AIS issues have a very cursory knowledge of parasites. Consequently, they often do not consider parasitic organisms in management and conservation programs even though they can have profound impacts on native flora and fauna.

- **Hold training workshops and develop identification cards with key restricted/prohibited species for use by USDA and HDOA inspectors to help them identify and subsequently stop incoming shipments of these species**. – Also identified in Prevention
  Update: Preliminary training with USDA inspectors has occurred. These types of training need to be ongoing and expanded to focus on the top priority species of concern. It is also suggested that these trainings be more intensive with a certification process eventually included.

STRATEGY 5D. Develop an education and training program for existing community groups and active ocean users to enable them to assist in early detection and monitoring efforts. -

This is also referred to in Objective 3.

Marine Specific Tasks For Strategy 5D:

Acronyms:

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5D1. Work with and train volunteers and active ocean users across the islands in the identification of marine AIS in beach, intertidal and shallow reef areas, and include mechanisms to tie their efforts into a "Citizen's Monitoring Network" for early detection. –Also listed under Objective 3
(AISC, MAG, ReefCheck, ReefCheck, UH, ReefWatchers) YEAR 1

Update: 1) Local awareness is a key line of defense against establishment by invasive species; this technique appears to be effective in terrestrial efforts of early detection, such as identifying incipient ant populations on the Big Island 2) A $20,000 grant has been awarded by HCF to assist in the development of an Alien Algal Watch program within ReefWatchers. Training materials and protocols are currently in development; 3) Reef Check has been a partner in ongoing nonnative algae cleanup events, and has expressed an interest in a more intensive volunteer program focusing on nonnative algae. With very limited support, they can do quarterly training and monthly ReefChecks; with a supported effort that might include .5 – 1 FTE, weekly events are feasible. 4) As part of the EPA grant, efforts will begin to assist in the development of a training program which will include identification of the species involved, and techniques to be used during pilot eradication projects. 5) As part of the study, "The Assessment of Nonindigenous Species on Coral Reefs in the Main Hawaiian Islands, with Emphasis on Introduced Invertebrates", researchers will be working with and holding workshops for active divers and ReefCheck, to educate them on recognizing and reporting suspected nonindigenous marine species, with an emphasis on marine invertebrates.

Specific components of educational aspects for this "citizen's monitoring network" include the following:

- **Develop educational tools for the identification of AIS for volunteer groups that can also be used by dive and snorkel boats.** (DLNR, UH, MAG, ReefWatchers) YEAR 1
  Update: 1) A "Guidebook of Introduced Marine Species of Hawai'i" has already been developed by researchers from the Bishop Museum and the University of Hawai'i, to provide information concerning some of the most common marine nonnative species in the coastal waters of Hawai'i. 2) Identification cards and other training tools are also being developed under various grants, including a Hawai'i Community Foundation grant to ReefWatchers, the EPA grant, an HCRI-RP grant to the Bishop Museum and UH-Zoology, and a second HCRI-RP grant to researchers from the Waikiki Aquarium and UH-Botany. These products will be directly transferable to other groups, such as dive and snorkel operators.

- **Hold workshops geared toward community groups.** (DLNR, UH) YEAR 1
  Update: As described in EPA grant proposal, a series of training workshops will be geared towards community groups tied to Kane'ohe Bay or south Maui, such as canoe paddling clubs, civic groups, fishing clubs, military volunteer groups, and existing marine volunteer groups. These workshops will cover species identification, reef ecology, nonnative algae impacts, as well as monitoring and management concerns.

- **Explore ways to work with existing organizations and groups who may have related interests, and create new ways to tie into their programs**. (AIS Coordinator, MAG, DLNR) YEAR 2
  Suggested ideas include: Creation of a "limu badge" to use with scouts and implementing the "Adopt a Reef" concept: have groups keep a section of the reef clear of invasive species.

- **Implement a pilot project for the eradication of nonnative algae by volunteer groups.** (DLNR, UH) YEAR 2
  Update: As specified in the EPA proposal, this program will include the collection of detailed data on the volume and consistency of the material removed, labor involved, impacts involved, as well as follow-up to document recovery or re-infestation. Control techniques will be developed and tested to develop methods that will effectively remove the invasive algae while minimizing the spread.

- **Increase communication, awareness, and coordination of marine AIS issues with shore fishers, limu pickers, and snorkelers/divers throughout the islands.** This group provides a large labor pool and possibility for community patrol. (DLNR, MAG) YEAR 2

STRATEGY 5E: Increase AIS awareness and interest for native species within the educational system.

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Comment: Oregon, Washington, and California Sea Grant are developing a traveling AIS "education trunk" for West Coast audiences based on a successful version used in the Great Lakes. Adapting relevant materials and activities from this education trunk tool may be valuable for use by teachers and other educators in Hawai'i.

5E1. Work with teachers to develop and give guest presentations on AIS issues at schools, and develop resource packets for teachers to use in the classrooms.
(DLNR, UH, Bishop Museum, AIS Coordinator) ONGOING

Updates: 1) Currently, graduate students from the University of Hawai'i Botany Department, DAR biologists, and the Hanauma Bay Education Program are working with teachers at the Kaiser school complex on the island of O'ahu to develop the knowledge base relevant to marine algae AIS. 2) DAR biologists have developed partnerships with several O'ahu schools. In this capacity, biologists serve as resource people and mentors to students interested in learning about native and nonnative stream animals. Various projects, which are usually initiated by teachers or the students themselves, have been undertaken and completed which focus on AIS issues. 3) Bishop Museum is also involved in guest presentations and AIS activities. However, there is still a need to expand and integrate all these efforts on a statewide level, and could likely be largely accomplished through the use of trained volunteers.

5E2. Develop curricula and materials geared toward use in K-12 public and private schools.
(DLNR, Department of Education, MAG, UH, Bishop Museum). ONGOING

Update: Various efforts are already underway to accomplish this task: 1) Kaiser school complex teachers (on O'ahu) are collaborating with the UH's Colleges of Education, Botany, and Biology on the development of nonnative limu (algae) curricula. This is primarily funded by the Waikiki Aquarium, with support from the USFWS, HCRI-RP, and the Malama I Ka 'Aina grant; and 2) The Bishop Museum is also actively involved in curriculum development.

5E3. Further integrate AIS issues into service and education projects that involve students as part of a science class, science club, or for community service credit offered at some schools
(AIS Coordinator, Various coordinators at site-specific locations) ONGOING

Comment: Various educational efforts are already underway at natural areas, fishponds, and public fishing sites. Efforts should be made to increase AIS aspects into these ongoing efforts, as well as developing new projects to address AIS.

5E4. Work with teachers regarding proper disposal methods for organisms that have been used in the classroom, to ensure that this does not contribute to the release or transfer of AIS.
(MAG, DLNR, Department of Education) YEAR 2

5E5. Increase outreach and education efforts at universities, through the Marine Option Program (MOP) at each university, to promote AIS research interest among undergraduate students.
(AIS Coordinator, UH, MAG) YEAR 1

Update: Representatives from the Marine Option Programs have expressed interest in working closer with those who are involved with Marine AIS issues, to be able to help incorporate this topic into student's projects.

STRATEGY 5F. Raise public awareness, concern, and ultimately, the buy-in on AIS issues for all residents of and visitors to Hawai'i.

5F1: Continue with and update printed efforts such as posters and brochures focusing on AIS.
(MAG, DLNR, HCRI-RP, CGAPS) YEAR 1

Update: A $4,000 USFWS grant was awarded in 2002 to a partnership with UH and TNC for the development and printing of an informational brochure on nonnative/invasive marine algae on Hawaii's reefs. This has been printed and is being distributed to various agencies and the general public. Funding has also been awarded via the EPA grant for the production of additional full color brochures.

5F2. Develop a variety of powerpoint presentations for use in public venues and for casual speaking engagements, and luncheon talks at service clubs, such as Kiwanis, Exchange, etc.
(AIS Coordinator, HI AIS Advisory Council, MAG, DLNR, Bishop Museum, UH) YEAR 1

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Update: Currently, a few individuals from UH, Bishop Museum, DLNR and MAG have given guest presentations to various groups on specific topics relating to AIS issues. However, there is a need for a development of additional presentations, especially ones that can be given to a broad range of audiences. By developing a set of "standardized" presentations, it will allow for a wider range of presenters to speak on the issue.

5F3. Increase local television, radio and newspaper media coverage of Hawaii's AIS issues and programs addressing these issues.
(AIS Coordinator, DLNR, CGAPS) YEAR 1

Update: Various efforts like this have been used in the past, such as Gary Sprinkle with KITV covering AIS topics with representatives from DLNR, Bishop Museum, and UH. These types of efforts need to be continued and increased. In addition, there are various public access shows, like "Mike Sakamoto's Fishing Tales," where information addressing AIS issues would reach a large target audience.

5F4. Incorporate AIS issues into education and outreach programs addressing terrestrial invasive problems.
(CGAPS, AIS Coordinator, Invasive Species Committees, HI AIS Advisory Council, DLNR) YEAR 1

Update: The Coordinating Group on Alien Pest Species (CGAPS) has an extensive public relations and marketing campaign, as well as 1 FTE information officer. Though the campaign is focus largely on terrestrial issues, preliminary integration of AIS issues into CGAPS has begun, and further integration is anticipated.

5F5. Create displays at public venues, such as State parks, on school bulletin boards, in libraries, aquariums, and recreational facilities to improve public awareness of AIS.
(DLNR, UH, AIS Coordinator, CGAPS) YEAR 1

Update: As part of the EPA grant, in early 2004 a team from DLNR-DAR and UH will be developing an interactive outdoor exhibit for use at the Waikiki Aquarium highlighting the issues of invasive algae on coral reefs. Additional displays should be developed for other appropriate venues.

Beyond small tabletop displays, there are few large exhibits on AIS in the United States. Oregon and Washington Sea Grant have recently initiated efforts to develop more substantial AIS exhibits for use in public aquaria and other venues. When developing such large displays in Hawai'i, efforts should be made to coordinate with Oregon and Washington and potentially adapt relevant existing materials.

5F6. Create portable presentation boards to show at public events, such as boat shows, conferences, volunteer events, etc., highlighting the threats of AIS.
(DLNR, AIS Coordinator) YEAR 2

5F7. Coordinate efforts among UH and Bishop with DLNR-DAR and Sea Grant Educators on neighbor islands and provide materials to incorporate AIS issues into their presentations.
(DLNR, UH, UH-SeaGrant, Bishop Museum, MAG) YEAR 1

Update: DAR educators on neighbor islands have indicated an interest in increasing public education of AIS issues, but have also indicated that they need appropriate materials to do so.

STRATEGY 5G: Integrate AIS education efforts into local, cultural, and ethnic community efforts.

5G1. Work with native Hawaiian groups and other community groups, to emphasize the threats that AIS pose to native species and traditional practices. –Also referred to under Objective 1.
(HI AIS Advisory Council, AIS Coordinator, community groups) YEAR 1

5G2. Work with cultural leaders to ensure that education efforts will be culturally sensitive and translated into the main locally spoken languages, and incorporated into newspapers or newsletters regularly read by individuals in various cultural and ethnic audiences.
(AIS Coordinator, CGAPS, All participating agencies and organizations) YEARS 1-5

Acronyms:

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5G3. Integrate AIS issues into activities at "culture science centers".

(UH, AIS Coordinator, HI AIS Advisory Council) Year 2

Update: A UH-College of Education faculty member who is involved in the projects referred to in 5E1 and 5E2, has recently obtained a second 3 year grant, Pikoi Ke Kaula Kualena, to develop up to 6 culture science learning centers associated with schools throughout the islands. This includes the development of two centers on O'ahu, (Kaiser and Kahuku complexes); two on Hawai‘i (Konawaena and one to be determined), and one each on Maui and Kaua‘i. Efforts need to be made by researchers and the HI Advisory Council to ensure incorporation of AIS aspects into these developments.

STRATEGY 5H: Promote clarification of issues and potential misconceptions regarding key taxa of concern, such as ta‘ape and roi.

5H1. Present current status of ongoing research related to ta‘ape and roi through presentations at meetings, other public venues, and existing publications

(DLNR) ONGOING

Update: A researcher and resource manager with DLNR, DAR recently put together a presentation, "Are Ta‘ape and Roi to Blame?". This was done to address the public's concerns regarding the controversy over ta‘ape and roi, as these two species are often blamed for depletion of desirable species due to competition or predation. This presentation gives the latest scientific information on the impacts of ta‘ape and roi, and draws on historical fisheries data and new research information. This presentation has been given at various venues including the West Hawai‘i Fisheries Council, libraries, and schools. It is also being showed numerous times on public television beginning in May of 2002. These efforts should be continued and expanded to include incorporation into fishing publications and other venues.

STRATEGY 5I: Assess the effectiveness of education and outreach efforts in reaching targeted audiences and changing behavior.

Issue Addressed: With limited resources, there is a need to look at what we are doing in terms of education and why. We should be convinced that the education efforts that we engage in will promote fixing the problem. We need to be asking, “Will it change attitudes?" "Will it change behaviors?” and ultimately, "Will it really help?" Currently, there are few attempts made to assess the value of environmental education programs. This will require a dedicated effort.

5I1. Develop a method to evaluate what education and outreach efforts will truly be most effective.

(HI AIS Advisory Council, AIS Coordinator, DLNR, ReefCheck, ReefWatchers) YEAR 2

Comment: This would likely involve working with representatives of disciplines other than the biological sciences. For example, graduate students at the Sociology department at UH are currently working on studies to assess if large-scale national campaigns on social issues are effective. Aspects of these types of assessments would likely be transferable to assessing the impact of educational campaigns and activities regarding AIS.

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OBJECTIVE 6: RESEARCH:

Increase research efforts on key AIS species, associated issues, and economic impacts to allow for more effective management.

Table 7. Summary Table of Strategies and Tasks to Accomplish Objective 6.

Strategy 6A. Increase the knowledge base of AIS in order to develop effective prevention
6A1. Continue and complete current studies regarding AIS in Hawai‘i.
6A2. Further explore additional fundamental basic research topics that will be directly applicable to the management of AIS in Hawai‘i.
Strategy 6B. Increase the level of knowledge regarding economic impacts of AIS.
6B1. Perform economic impact studies on the effects of AIS to Hawai‘i.

Acronyms:

DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	HDOA	Hawai‘i Department of Agriculture
HCRI-RP	Hawai‘i Coral Reef Initiative Research Program	MAG	Marine Algae Group
		UH	University of Hawai‘i

OBJECTIVE 6: RESEARCH:

Increase research efforts on key AIS species, associated issues, and economic impacts to allow for more effective management.

Research is an important component of this plan and is integrated into many of the tasks referred to in previous sections. This section builds on previous sections, focusing on the biological and ecological research activities that will help in other management activities. Increased knowledge of the biology and ecology of invasive species and associated control methods will allow for the most effective management of AIS in Hawai‘i.

Economic research is also highlighted in this section. There is a lack of knowledge on a worldwide scale of the economic impacts of AIS. A small number of studies have begun to assess and document this impact, but additional studies are needed. In many cases, it is the economic impacts that will be the driving force in affecting change in personal and business actions, management, and policy. Industries, cultivators, resource management agencies, and policy makers need to be aware of the economic impacts of AIS.

STRATEGY 6A: Increase the knowledge base of AIS in order to develop effective prevention, control, and overall management programs.

Issue Addressed: There is a need to base prevention, control, and other management efforts for AIS on numerous biological and ecological aspects, including: population dynamics, reproductive biology, and ecological conditions fostering growth. Much of this is not yet fully understood for the AIS in Hawai‘i.

6A1. Continue and complete current studies regarding AIS in Hawai‘i.
(UH, Bishop Museum, DLNR, others) ONGOING

Update: Many studies are currently underway to help us better understand AIS in Hawai‘i. These are detailed in Appendix C, beginning on page C-1

6A2. Further explore additional fundamental basic research topics that will be directly applicable to the management of AIS in Hawai‘i.
(UH, Bishop Museum, MAG, HI AIS Advisory Council, DLNR) Years 1-5

Update: There are many topics relating to AIS that would be valuable to explore further. Specific suggestion and recommendations from the various Focus Area Groups and others involved in the development of this plan are presented in the following pages. In almost all cases, these suggestions do not have associated funding identified, and most are not prioritized, though proposals have been submitted for some topics. Efforts will need to be made to prioritize these suggestions and subsequently obtain funding to carry these research activities out.

Strategy 6B. Increase the level of knowledge regarding economic impacts of AIS.

Issue Addressed: A small number of studies around the world have begun to assess and document the impacts of AIS in economic terms, but additional studies are needed. In many cases, it is the economic affects that will be the driving force in affecting change in personal and business actions, management, and policy.

6B1 Perform economic impact studies on the effects of AIS to Hawai‘i
(HCRI-RP, UH, DLNR, BM) YEARS 2-5

Update: A large scale comprehensive study on the “Economic Valuation of Hawaii’s Coral Reefs”, funded by HCRI-RP, was drafted in 2002. Among other components, this study addressed the economic impact of invasive native algae blooms on Maui’s coastline. Further studies like this are warranted, focusing specifically on the financial impact of AIS. Suggested specific examples include:

- **Research to assess taro yield losses associated with apple snails**

Acronyms:

DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	HDOA	Hawai‘i Department of Agriculture
HCRI-RP	Hawai‘i Coral Reef Initiative Research Program	MAG	Marine Algae Group
		UH	University of Hawai‘i

Comment: Although farmers say their losses are high, there are no numbers to convince legislators or HDOA how serious the problem is economically. HDOA asked for such numbers back in 1990, but no one has come up with the funding to do such a study.

- **Examine and quantify the costs of controlling AIS versus the potential costs of doing nothing.**

Suggested Research Topics Referred to in Task 6A2

Following are suggested research topics that focus on life history, biology, ecology, control methods, and/or impacts of invasive species in Hawai'i. These topics are suggestions only, and do not represent all topics that are relevant to be explored. All topics have come directly from researchers and research managers who have been involved in the development of the plan.

In almost all cases, these suggestions do not have associated funding identified, and most are not prioritized, though proposals have been submitted for some topics. Efforts will need to be made to prioritize these suggestions and subsequently obtain funding to carry these research activities out.

Suggested Marine Algae Research Topics

- **Assess the contribution of nonnative algal species to the diet of the threatened green sea turtle.**
  Update: Turtle diet studies are ongoing at the NOAA Fisheries Honolulu Laboratory. A grant proposal has recently been submitted by NOAA to augment these studies to more fully understand the utilization of nonnative algal species by the sea turtle.

- **Determine if the Mediterranean strain of *Caulerpa taxifolia* exists in Hawaii's reef community.**
  Update: A proposal outlining methods by which to achieve this knowledge has been written by researchers from the University of Hawai'i. This proposal has not been funded.

- **The potential for additional native invertebrate grazers, such as sea hares, to be effective in the control of nonnative algae.**

- **Why are certain reefs (and parts of reef) affected more than similar reefs in the same area?**
  Comment: This is possibly linked to initial coral cover, but this question has not been looked at as of yet.

- **Biological control with bacteria and fungi**
  Update: Preliminary research by researchers with UH-Botany suggests that a pathogen can cause the cell death at holdfasts of *Kappaphycus* spp. If this only affects this species, then collateral impact would be limited.

- **Increased understanding of gene regulation controlling renewed cell division in vegetative basal cells.**
  Update: Manual clearing an area of invasive algae has included the scraping of the biomass down to the basal cells. Preliminary thought has been given to the idea of trying to determine what triggers these cells to go from vegetative state to dividing state, with the long term goal to be able to prevent these cells from dividing.

- **Determine how the invasive alga species are really spreading.**
  Comment: *A. spicifera* spreads via spores, and *H. musciformis* via fragments, but it is unknown if these and other invasive species spread only by these methods.

- **Determine the rates of spread for each invasive algal species**

- **Quantify the relationship between invasive algae and reef building corals; specifically determine the rates at which invasive algae kill coral.**

- **What are the long-term effects of invasive algae on invertebrates, fish, etc?**

- **Incorporate and build into existing research, including the publishing of research being done by graduate students, and accessing data from research done in previous years.**

Acronyms:

DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	HDOA	Hawai'i Department of Agriculture
HCRI-RP	Hawai'i Coral Reef Initiative Research Program	MAG	Marine Algae Group
		UH	University of Hawai'i

Task 6A2: Suggested Research Topics, Continued.

Suggested Marine Invertebrate Research Topics

- **What ecological interactions are going on with established AIS as far as impact on native species.** (i.e. impact assessment)
  Comment: As yet, this information is partial at best and has not been investigated in Hawai'i.
- **Information on how marine invertebrate AIS interact with a suite of native species and how that might vary over time and space.**
- **What are the complete suite of mechanisms for transport, dispersal and establishment?**
- **Knowledge on the population dynamics (long term decadal patterns), reproductive biology, ecological conditions fostering invasive growth.**
- **Basic biological and ecological information on the AIS from their home range and other places where they have invaded, and factors dictating their competitive superiority.**
- **Looking at reefs outside of harbors to see what has escaped.**
- **DNA molecular studies to see a) source; b) how long it's been here; and, c) where it's spread to.**
- **Increase knowledge on the ecological limits of invasive invertebrates.**
  Comment: At this point, this knowledge is probably insufficient to develop a sound prevention strategy specific to any particular marine invertebrate AIS.

Suggested Marine Fish Research Topics

- **Interaction of known nonnative blennies and gobies with native species.**
  Update: It has not been well established whether any of the small cryptic introduced species such as gobies and blennies are invasive in Hawaii's environment. It is known that many of these species are territorial, and initial studies indicate that there is a potential for space and prey competition. Further research should be done on these species to assess the impacts that they may be having.
- **Habitat and nest preferences of gobies and blennies.**
  Comment: This may be a key in helping to control invasive goby and blenny species, as some of these species worldwide have shown to have strong habitat preferences for nonnative environments, including affinities for certain oyster shells, other sessile invertebrates, and fouling communities. If the habitats of these species are known, and it is determined that numbers may need to be controlled, removal of associated nonnative habitats may be a method in which to keep populations down.
- **Trophic and habitat interactions of ta'ape at its mid-zone (120 ft down to 300 ft).**
  Comment: Monitoring has been done at deeper depths (Parrish et al. 2000), and is currently being examined at shallower depths as referenced in Appendix C. There still remains a gap in knowledge for the mid-zone. This will pose difficulties logistically, as this is generally below the recreational diving depths but most submersible work occurs at deeper depths.
- **Interactions of ta'ape with other juvenile snappers as well as juveniles of other species.**
- **Long-term movement patterns for native marine fish species that may interact with nonnative species**.
  Comment: Due to funding limitations, acoustic telemetry studies in Hawai'i to date have been able to focus only on small areas (<1 km2) and limited numbers of species (1-4 per study). Our current understanding of fish habitat use patterns would be greatly enhanced if future research efforts could be larger in geographic and taxonomic scope. Also, technical limitations on the size of transmitters restrict their ability to track large adult individuals of many species. Current suppliers should begin producing smaller transmitters within the next few years. These transmitters should allow researchers to examine more sizes and ages of many species, and examine previously unstudied species.
- **Reproduction and general ecology of nonnative marine fish species**
- **Epidemiology and parasite-vector relationships to better understand interactions of these nonnative species.**
- **Research control methods to be utilized if research indicates that nonnative species of marine fish are impacting native species.**
  Comment: If it turns out that roi, ta'ape, and other species do have an important impact on native species, research on possible control methods will be needed, and this research should be identified in subsequent versions of this plan.

Task 6A2: Suggested Research Topics, Continued.

Suggested Inland Water AIS Topics

Relating to Biology and Ecology Aspects of Inland Water Invasive Macro-Organisms

- **Study the impacts of invasive insect species on native aquatic insects.**
  Comment: Invasive insect species are largely unstudied, but may prove to have significant impacts. For example, introduced caddisfly species are highly invasive and more species are being found on a regular basis. There appears to be a correlation in some areas, with some native species becoming increasingly rare as more caddisfly species become established.

- **Quantitatively document the efficacy of poecilids in controlling mosquitoes in a variety of inland water systems.**
  Comment: This aspect is also referred to in Objective 2.

- **Examine possible competition between native and invasive species for food and other requirements (shelter, spawning sites, etc).**
  Comment: Specific suggestions include investigating the diet of native fish species in streams with and without introduced fish species and evaluating native invertebrate taxa in the diet of introduced fish.

- **Quantitatively examine the impacts of invasive fish species on native invertebrates.**
  Comment: Some species may be known to researchers and resource managers to be invasive in Hawai'i, but there may be a lack of published work to support this. For example, tilapia are known to eliminate most invertebrate species (and thus endangered waterbird food) from wetland areas, and refuge managers periodically must completely dry areas to eliminate tilapia. However, these findings have never been published, and no peer-reviewed studies have yet been published in Hawai'i on the impacts of introduced tilapia.

- **Assess algae composition in streams with and without introduced fish species.**
  Comment: Specifically determine how introduced suckermouth catfish impact algae used by native stream fish species.

- **Develop a risk analysis protocol for nonnative mollusks.**
  Update: R. Cowie (UH) has begun this for the US as a whole, but the project is on hold for lack of funding.

- **Investigate the relationship between native waterbird recovery and introduced aquatic species.**

Relating to Nonnative Viruses, Bacteria, Protistans, etc. that May Cause Diseases in Native Inland Water Organisms

- **Establish if introduced penaied shrimp diseases (IHHN, Whitespot, Taura Syndrome, Bacalourhas, Yellowhead virus, etc.) are in feral penaied shrimp or in the native penaied shrimp, *Penacus marginatus*.**
  Comment: The native and feral penaied shrimp can be associated with brackish water and estuarine systems as well as marine systems.

Relating To More Effective Inland Water AIS Control Measures

- **Design and perform test methods for more effective control of AIS in Hawaiian ecosystems**

- **Develop methodology to differentiate mallard-koloa hybrids from the native koloa.**
  Comment: This is needed to begin the process of removing the hybrids, in an effort to reduce the threat of mallard-koloa hybridization.

Relating to Inland Water BioControl Methods

- **Research the use of ichthyocides for environmental safety and unanticipated potential problems.**

- **Remove invasive fish species with rotenone or other methods from selected reaches of streams and restore native invertebrate populations.**

- **Research the feasibility of anchialine pond restoration on Maui and the Big Island, by using rotenone to remove invasive fish species.**

OBJECTIVE 7 - POLICY:

Ensure State laws and regulations efficiently promote the prevention and control of AIS.

Table 8. Summary Table of Strategies and Tasks to Achieve Objective 7.

Strategy 7A. Review the laws and regulations governing AIS in Hawai'i for gaps and overlaps, compare them to other State and Federal AIS laws, and recommend changes to improve our ability to protect Hawaii's waters from the introduction and spread of AIS.
7A1. Establish a regulatory review subcommittee.
7A2. Conduct a legal review of AIS issues.
7A3. Evaluate and assess the legal boundaries of Hawaii's waters, as they relate to AIS management.
Strategy 7B. Promote legislation and administrative rules that establish or increase the State's authority to control the intentional and unintentional introduction of new species.
7B1. Identify the potential for improved coordination between State agencies as well as necessary new legislation to strengthen Hawaii's statutes aimed at the prevention and control of AIS.
7B2. Provide authority to establish the AIS Advisory Council, as described in task 1A7.
7B3. Provide the DLNR with the authority to establish an Aquatic Invasive Species Rapid Response Program, as detailed in strategy 4A.
7B4. Enact and enforce rules governing the discharge of treated and/or exchanged ballast water.
7B5. Promote legislation (with the participation of relevant agencies and stakeholders), that establishes the authority to inspect, detain and require cleaning of any vehicle, vessel or water based equipment containing or infested with AIS that is traveling in Hawai'i.
Strategy 7C. Obtain dedicated long-term funding from the Hawai'i State Legislature to implement AIS Management Plan tasks and provide the mandatory matching funds that are needed for Federal grants.
7C1. Provide State funding for the AIS Coordinator position as detailed in task 1A8.
7C2. Provide funding for the AIS Advisory Council, as described in task 1A7.
7C3. Provide funding for the Alien Aquatic Organism Task Force (AAOTF) to address ballast water and hull fouling management, as established in HRS § 187A-32.
7C4. Provide funding to the DLNR for the creation of an Aquatic Invasive Species Rapid Response program as described in strategy 4A.
7C5. Provide a mechanism to obtain funding to implement additional tasks referred to in the AIS Management Plan.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force
CGAPS	Coordinating Group on Alien Pest Species
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
EPA	Environmental Protection Agency
HAS	Hawai'i Audubon Society
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
MAG	Marine Algae Group
NOAA	National Oceanic and Atmospheric Administration
TNC	The Nature Conservancy
UH	University of Hawai'i
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

OBJECTIVE 7 - POLICY:[71]

Ensure State laws and regulations efficiently promote the prevention and control of AIS.

AIS law is a new and rapidly evolving field. Hawai‘i State laws must adapt as we improve our knowledge of AIS issues. The regulatory authority and financial support afforded by integrated State and Federal legislation can enable our society to avoid or minimize environmental and economic damage from AIS. Regulatory action is needed to increase the State's authority to control the introduction of new species.

STRATEGY 7A: Review the laws and regulations governing AIS in Hawai‘i for gaps and overlaps, compare them to other State and Federal AIS laws, and recommend changes to improve our ability to protect Hawaii's waters from the introduction and spread of AIS.

7A1. Establish a regulatory review subcommittee.
(DLNR, HDOA, HI AIS Advisory Council, Hawai‘i Invasive Species Council, Hawai‘i Invasive Species Council, CGAPS) YEAR 1

Comment: This subcommittee, to be comprised of representatives from non-governmental organizations, the Department of Land and Natural Resources, and the Department of Agriculture, among others, will emphasize working in a coordinated fashion with existing State, Federal, and international programs. The committee will invite input from all groups affected by any proposed pathway control measures, including representatives of aquaculture, maritime cargo vessels, retail and wholesale aquariums, and other affected groups.

7A2. Conduct a legal review of AIS issues.
(HAS, TNC) ONGOING

Update: Two reviews are currently ongoing: The Hawai‘i Audubon Society's Pacific Fisheries Coalition (PFC) is presently conducting a legal review of current laws governing AIS in Hawai‘i for gaps and overlaps, comparing them to other State and Federal AIS laws, and recommending changes to agencies responsible for regulating AIS. In addition, The Nature Conservancy Asia-Pacific region has hired a contractor to evaluate all invasive programs and policies throughout the region, including Hawai‘i. Both of these are further detailed on page 3-27. The subcommittee in Task 7A1 can use the findings from both of these reviews for its needs.

7A3. Evaluate and assess the legal boundaries of Hawaii's waters, as they relate to AIS management.
(HI AIS Advisory Council, Hawai‘i Invasive Species Council, DLNR, HDOA) YEAR 1

Comment: The boundaries of the State of Hawai‘i include the waters up to 3 miles offshore;[72] beyond that is not considered part of the State. As discussed in Chapter 3 and Appendix H, the statutes that address HDOA import authority require import permits to bring any organisms into the State from outside of Hawai‘i[73]. This poses a unique situation for researchers who are collecting organisms beyond this 3-mile State boundary. As an example, researchers from the Hawai‘i Undersea Research Laboratory (HURL) were recently informed by HDOA that "extremophile" bacteria collected from the submarine volcano, Lo‘ihi, and transported to Oahu would be treated as out-of-state organisms, and subject to HDOA's importation review and permitting process. (Lo‘ihi, which is located off the south coast of the island of Hawai‘i, is outside of the 3-mile boundary defining State waters.) Representatives from HDOA have acknowledged

[71] Thanks to K. Moffie (Pacific Fisheries Coalition) for taking the leadership on authoring the initial drafts of this section and to Scott Smith (Washington Department of Fish and Game) for his valuable input.

[72] The boundaries of State of Hawai‘i are in the constitution, Article XV, section 1. The reference to the 3 miles is in the case notes in that section.

[73] The statutes that refer to PQ authority is 150A (HRS).

Acronyms:

AAOTF	Alien Aquatic Organism Task Force
CGAPS	Coordinating Group on Alien Pest Species
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
EPA	Environmental Protection Agency
HAS	Hawai‘i Audubon Society
HDOA	Hawai‘i Department of Agriculture
HDOH	Hawai‘i Department of Health
MAG	Marine Algae Group
NOAA	National Oceanic and Atmospheric Administration
TNC	The Nature Conservancy
UH	University of Hawai‘i
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

that the 3-mile definition should be addressed for how it relates to out-of-state organisms and the need for the permitting and importation process.

STRATEGY 7B: Promote legislation and administrative rules that establish or increase the State's authority to control the intentional and unintentional introduction of new species.

7B1. Identify the potential for improved coordination between State agencies as well as necessary new legislation to strengthen Hawaii's statutes aimed at the prevention and control of AIS.
(DLNR, HDOA, Regulatory Review Subcommittee, Hawai'i AIS Advisory Council, Hawai'i Invasive Species Council, CGAPS) YEAR 1

Update: The 2003 Hawai'i State Legislature passed Senate Bill 1505, which establishes the temporary Hawai'i Invasive Species Council (HISC) to address the invasive species problem in Hawai'i. The purpose of SB 1505 is to provide statutory authority to the Hawai'i invasive species council to continue its special purpose to foster and organize coordinated approaches among various executive departments, Federal agencies, and international and local initiatives for the prevention and control of invasive species. Governor Linda Lingle signed SB 1505 into law on May 23, 2003.[74]

The 2003 Legislature also adopted House Resolution 123, requesting the DLNR and HDOA to update and report to the legislature in 2004 on their efforts to monitor and restrict the importation of invasive alien aquatic organisms and their efforts to eradicate these organisms.[75]

The 2003 Hawai'i State Legislature adopted Senate Resolution 115, urging the DLNR and HDOA to develop a joint procedure whereby no potentially invasive alien aquatic organisms can be imported into the State without the approval of both the Department of Agriculture and the Department of Land and Natural Resources, and requesting the DLNR and HDOA to report their recommendations, including any necessary proposed legislation, to the 2004 Legislature.[76]

7B2. Provide authority to establish the AIS Advisory Council, as described in Task 1A7.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council) YEAR 1

7B3. Provide the DLNR with the authority to establish an Aquatic Invasive Species Rapid Response Program, as detailed in Strategy 4A.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council) YEAR 1

7B4. Enact and enforce rules governing the discharge of treated and/or exchanged ballast water.
(Hawai'i State Legislature, DLNR, USCG, Hawai'i Invasive Species Council, AAOTF) YEAR 1

Comment: This task is also referred to in Strategy 2G, with additional details regarding the ballast water program presented in Chapter 3, beginning on page 3-21.

7B5. Promote legislation (with the participation of relevant agencies and stakeholders), that establishes the authority to inspect, detain and require cleaning of any vehicle, vessel or water based equipment containing or infested with AIS that is traveling in Hawai'i.
(Hawai'i State Legislature, DLNR, HDOA, Hawai'i Department of Transportation, AAOTF, Hawai'i Invasive Species Council, CGAPS) YEAR 1

[74] Act 85, see Appendix J.
[75] See Appendix J.
[76] See Appendix J.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	HDOH	Hawai'i Department of Health
CGAPS	Coordinating Group on Alien Pest Species	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Administration
		TNC	The Nature Conservancy
EPA	Environmental Protection Agency	UH	University of Hawai'i
HAS	Hawai'i Audubon Society	USDA	U.S. Department of Agriculture
HDOA	Hawai'i Department of Agriculture	USFWS	U.S. Fish and Wildlife Service

STRATEGY 7C: Obtain dedicated long-term funding from the Hawai'i State Legislature to implement AIS Management Plan tasks and provide the mandatory matching funds that are needed for Federal grants.

Comment: The lead implementation entities for all tasks associated with Strategy 7C is the Hawai'i State Legislature and the Department of Land and Natural Resources.

7C1. Provide State funding for the AIS Coordinator position as detailed in task 1A8.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and the HI AIS Advisory Council) YEAR 1

7C2. Provide State funding for the AIS Advisory Council, as described in task 1A7.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and the HI AIS Advisory Council) YEAR 1

7C3. Provide State funding for the Alien Aquatic Organism Task Force (AAOTF) to address ballast water and hull-fouling management, as established in H.R.S. § 187A-32.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and the HI AIS Advisory Council, AAOTF) YEAR 1

Is Permanent Funding Really Needed?

Dedicated permanent funding, to support permanent staff and for funding agency program activities will be a key component in effectively addressing aquatic invasive species issues in Hawai'i.

Though many activities are currently underway throughout the State which address AIS, almost all of these are operating on 'soft' (short-term/grant) monies.

Operating a program on soft money can be very inefficient for the long term. This is because in addition to time and effort expended to working on the program activities, a substantial portion of that time and effort is also commonly spent searching for additional grants to continue the program, writing associated grant proposals, hiring and re-hiring short-term staff, addressing issues that are associated with high staff turnover, and writing and submitting various status reports to comply with grant requirements.

Soft monies have been very effective in funding and implementing research projects; however, when agencies have to operate a long-term program on soft monies, program operations are often compromised. There is a clear need for dedicated permanent funding to address aquatic invasive species issues in the State.

7C4. Provide State funding to the DLNR for the creation of an Aquatic Invasive Species Rapid Response Program as described in Strategy 4A.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and the HI AIS Advisory Council) YEAR 1

7C5. Provide a mechanism (e.g., through user fees, visitor taxes, general funds, etc.) to obtain funding to implement additional tasks referred to in this AIS Management Plan, which include education, control, monitoring, and research.
(Hawai'i State Legislature, DLNR, Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and the HI AIS Advisory Council) YEARS 2-5

Acronyms:

AAOTF	Alien Aquatic Organism Task Force
CGAPS	Coordinating Group on Alien Pest Species
DLNR-DAR	Department of Land and Natural Resources, -Division of Aquatic Resources
EPA	Environmental Protection Agency
HAS	Hawai'i Audubon Society
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
MAG	Marine Algae Group
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CHAPTER 5:
Case Studies

CASE STUDY 1:

THE NEED FOR RAPID RESPONSE

Rapid Response Leads to Eradication of a Potentially Devastating Marine AIS in Australia

The Invasion:[77]

The black-striped mussel, *Mytilopsis (Congeria) sallei,* is native to the western Atlantic coast of Central America and believed to have entered the Pacific after the opening of the Panama Canal in 1914 (Pyne 1999). In late March 1999, this species was observed in Cullen Bay Marina and later in two other marinas and on vessels in Darwin, Australia, at densities up to 26,350/m2 (Willan et al. 2000) by researchers conducting surveys for the Darwin Port Authority in support of a ballast water risk assessment. It is believed that the mussel entered the marina on the hulls of yachts arriving from the Panama Canal in 1998, and a yacht was found with live specimens on its hull in nearby Frances Bay Marina (Pyne 1999).

The Concern:[78]

M. sallei is extremely prolific and fecund, and is closely related and ecologically similar to the zebra mussel (*Dreissena polymorpha)*. It can have similar impacts as the zebra mussel, namely massive fouling of wharves, marinas, seawater systems (e.g. mariculture pumping facilities, vessel ballast and cooling systems) and marine farms. In its preferred habitats, the mussel forms dense monocultures that excludes most other species, leading to a substantial reduction in biodiversity in infected areas as well as extensive economics impacts.

The Response:[79]

Fortunately because of the high tidal exchange, the marinas are isolated from open waters by locked gates, and a rapid response was mounted to eradicate the introduced mussels. This involved the enactment of emergency legislation to permit the use of over 260 tons of liquid sodium hypochlorite and nine tons of copper sulphate, over 280 people including 28 divers, and a cost of over $1.6 million (Pyne 1999). Post eradication surveys found no live *M. sallei* in any marina or Darwin Harbor, but subsequently this species was observed in September 2000 on two Indonesian fishing boats quarantined in Darwin Harbor for illegal fishing (Willan et al. 2000). Both boats left without apparent further infestation of the area, but it is probable that this organism is likely to invade Australian waters unless a means of strict quarantine is devised to prevent its entry on pleasure or fishing vessels.

The Lessons:

Early detection was a key factor in the management of potentially devastating species. Further, this species was identified as part of routine survey of marinas in Darwin, Australia, stressing the need for ongoing monitoring and detection efforts by trained personnel. Upon detection and identification, action was put into place quickly enough and effectively enough to allow for eradication and subsequent prevention of spread to additional areas. In addition, there was a clear commitment to address AIS issues by national and local authorities, and this played a key role in allowing for an effective response effort.

[77] This section is directly excepted from Coles and Eldredge 2002.

[78] This section is directly excerpted from CRIMP (Centre for Research on Introduced Marine Pests) 2001.

[79] This section is directly excepted from Coles and Eldredge 2002.

CASE STUDY 2:

MULTI-AGENCY RESPONSE EFFORT FOR THE CONTROL OF A SITE-SPECIFIC PROBLEM

Perspectives from the DLNR-DAR on the Control of *Salvinia Molesta* in Lake Wilson, O'ahu[80]

The Invasion:

Lake Wilson (also known as Wahiawa Reservoir) is located in central O'ahu. The lake is managed as a public fishing area and has high value in the Wahiawa community.

Salvinia molesta was first noticed in the lake after a previous aquatic plant outbreak (Water Hyacinth) in 1998. Initially, there was no apparent concern for the presence of Salvinia in the lake. During the summer of 2002, Salvinia was noticed to be increasing in the area covered. As of November 2002, 30% of the lake was covered. During the months of November through January, the growth of the Salvinia was explosive. By January, approximately 100% of the lake was covered.

The resources and monitoring of Salvinia throughout this time period was inadequate. Spraying and an attempt at manual removal were not enough to control the outbreak. The cause of the increased growth rate is not fully understood, but is probably related to two main factors. One, the spraying regime was not sufficient to control the growth, and two, increased nutrient loading during the winter months created ideal conditions for optimal plant growth.

Once the lake became covered, the main concern was the depletion of dissolved oxygen. The depletion of oxygen could have resulted in a massive fish kill in the lake. The fish kill would have resulted in a potential public health disaster. The lake is estimated to have 400 to 500 tons of fish biomass. This amount of dead fish in the lake would not only create a health concern, but the clean up of this much dead fish would have been considerable.

The Response:

The problem was attacked using a three-pronged approach. Multiple agencies were involved in the cleanup of Lake Wilson. One of the key elements of this was that each agency had been assigned tasks. This served to accomplish the goals of the project, but did not limit the people working with everyone all the time. The cleanup effort included manual removal of the plant followed by intensive herbicide spraying. Herbicide spraying was the key component. The spraying not only stopped new plant growth, but it also reduced the amount of plant to be removed (by either sinking or shrinkage). The final component was a community support effort. This was important because it involved the Wahiawa community (namely the local fisherman). They participated in hand removal of the plant. The real importance of this component is the long-term effect of their involvement. The local community would not only help lend a hand in the lake's cleanup, but they will also feel vested in the future of the lake. Through this vestment, they will hopefully continue to help manual remove the plant while carrying out their fishing activities.

The process of the lake's cleanup was very successful. The overall process was very efficient with a technique that has not been utilized before. Some experts did not believe that the activities were going to make a difference; however, DLNR was able to avoid a massive fish kill (and did not observe any smaller fish kills related to Salvinia).

One draw back to this process was the expense. This method, although successful, may have not been the most financially efficient method. It might have been more cost effective to conduct the spraying operation before the manual removal. Then manual removal could have been conducted after the spray started to take effect. However, under the scrutiny of time, DLNR felt it could not afford to wait for the spray to take effect. Actions needed to be carried out without hesitation. The agency is planning to buy an aquatic plant harvester and will spray more, to allow for two control methods to be used concurrently.

The Lessons:

Editor's note: The invasion of Lake Wilson by Salvinia points to the need to initiate rapid response efforts when an AIS is in its early stages of infestation.

While there have been various criticisms regarding the operational procedures used to address the issue at Lake Wilson, it is important to note that this was one of the first large-scale, multi-agency control and eradication efforts regarding AIS that we have had to date in Hawai'i, and it was certainly a learning process for many. However, once the issue was made a priority, the problem was effectively addressed, and ultimately Salvinia was considered controlled at the site ahead of schedule. This can be largely attributed to multiple agencies working together.

As a follow-up to their control efforts, DLNR-DAR has developed a long-term management plan for *S. molesta* at Lake Wilson. This includes monitoring, herbicide spraying, water level control, booming, use of an aquatic plant harvester, contingency plans, investigation of biological control, community involvement and education, and the use of memorandums of agreements.

[80] Text for this section was provided upon request by T. Montgomery of the DLNR-DAR, to help highlight the issues and difficulties in trying to control invasive species once they are established

CASE STUDY 3:

THE IMPORTANCE OF COMMUNITY INVOLVEMENT IN ADDRESSING AIS

The Kailua Neighborhood Board addresses *Salvinia Molesta* in Kawainui Marsh, O'ahu[81]

Editor's Note: This text is left in the first person, to better reflect the intent and perspective of the writer and the associated community group.

The Invasion:

Shortly after the news intensified regarding the complete take over of Lake Wilson by the *Salvinia molesta* weed, residents of Kailua began inquiring as to what the "green stuff" was growing in the canals that run adjacent to Kawainui Marsh, on the Kapa'a Quarry Road side. [After consulting experts], it was determined nearly immediately that we also had *Salvinia* growing near the State's largest wetland.

The Response:

The Kailua Neighborhood Board immediately joined with Senator Hogue and others to gather information from the city, State, and Federal agencies about how to quickly eradicate the problem. We quickly learned that all the city, State, and Federal resources were focused on Lake Wilson, and that if we were going to avoid a similar crisis we had to work with the community and address the issue ourselves.

We contacted the media, showed them the problem, and scheduled a community meeting asking the community to help get rid of the *Salvinia*. The response was amazing! Over 100 people showed up to the meeting, agreeing to come and work [to help with removal efforts]. A date was set and we set out to get support from businesses in the community. Everyone we asked stepped forward with supplies and equipment. The response was so great we were able to do work on both the Kapa'a Quarry Road site and also remove water lettuce along the levy on the other side.

The Lesson:

Most importantly, we were able to bring the community together for a common goal, focus on the protection of an incredible community (and State) resource, educate the community about the dangers of alien aquatic species (particularly fish tank plants, which many people never knew could be dangerous if dumped), and that this was a small short term victory in a long term war. When called upon again, the community will be more willing to come and help address the eradication of the invasive plants that threaten this great resource.

[81] This section was provided upon request by K. Bryant of the Kailua Neighborhood Board, to help highlight the importance of community involvement in addressing ANS issues.

CASE STUDY 4:

INDUSTRY'S ROLE: PROACTIVE EFFORTS BY THE AQUACULTURE INDUSTRY

Efforts of NELHA (Natural Energy Laboratory of Hawai'i Authority) to Minimize Introductions and Transfer of AIS[82]

Background:

The Natural Energy Laboratory of Hawai'i Authority (NELHA) is an agency of Hawai'i State government and is administratively attached to the Department of Business, Economic Development & Tourism. NELHA operates the largest technology park in Hawai'i, with 870 acres at Keahole Point, Kailua-Kona, on the Big Island of Hawai'i. The master-permitted ocean science and technology park is tasked with the mission *"to develop and diversify the Hawai'i economy by providing resources and facilities for energy and ocean-related research, education, and commercial activities in an environmentally sound and culturally sensitive manner."* While NELHA is charged with bringing business, research, and education tenants to Kona to utilize its unique complement of natural resources, subtropical environment and community infrastructure, it is also charged with stewardship of the pristine natural resources that make it such an attractive setting. NELHA operates under several master permits, including a master Environmental Impact Statement, two Special Management Area Permits and a Conservation District Use Permit. [NELHA has taken various steps to address the threats that AIS issues pose both to the surrounding environment, as well as to the aquaculture farmers that are their tenants, and these are detailed below-Ed.]

Effluent Management:

Of prime importance is its pristine environment, including Class AA open ocean waters offshore. All seawater disposal is confined to shore-based leach fields, drainage pits, injection wells, and trenches. To prevent escape of nonnative species and any impact to the pristine environmental quality, effluent water is not allowed to be put directly back into the ocean. NELHA recently contracted Planning Solutions, Inc. of Honolulu to complete an analysis of existing seawater return systems to further improve the environmental and economic efficiency of NELHA standards.

Aquatic Species Health Management:

The NELHA Aquatic Species Health Management Program (ASHMP) was created through cooperative efforts of NELHA, its tenants, and the State's Aquaculture Development Program. The goals of the ASHMP are to prevent the introduction of harmful pathogens into the facility and tenant properties from outside sources, establish basic tenant guidelines for the documentation and maintenance of animal health including specific sanitation procedures, and to articulate requirements and guidelines for action and containment in case of a disease event. In addition to compliance with existing permit requirements such as those of the Department of Agriculture and Department of Land and Natural Resources, NELHA tenants must also obtain NELHA approval for introduction of any new species to avoid health management conflicts with other tenants.

Environmental Monitoring:

The NELHA Comprehensive Environmental Monitoring Program (CEMP), ongoing since the 1980's, further protects the environment and pristine offshore oceanic resources by providing regular sampling and analysis of groundwater resources, near shore biota, and oceanic waters, with the goal of maintaining the pristine quality of the unique and valuable natural resources of Keahole Point on which NELHA and its tenants depend. NELHA operates a water quality testing laboratory which regularly reports monitoring results in compliance with regulatory requirements of the Department of Land and Natural Resources, the County Planning Department, the Office of Environmental Quality Control, and the Department of Health.

[82] This section was provided upon request from Barbara Lee, of NELHA, to help highlight the proactive role that industry can take in addressing ANS issues.

CASE STUDY 5:

AIS THREATEN HAWAIIAN CULTURAL RESOURCES

The Kahea Loko Project's Restoration Efforts of Culturally Significant Hawaiian Fishponds (Loko I'a) are Impeded by AIS.[83]

Background:

Historically, the evolution and management of fishponds represented a fundamental shift in how Hawaiians utilized the natural resources of the land and sea to feed themselves. Today, fishponds are on the verge of vanishing, largely due to a change in subsistence to market economy. The introduction of mangroves to the islands in the early 1900's has further contributed greatly to the rapid decline of many coastal and upland fishponds.

The Kahea Loko Project is a three-year program, which began in October 2000. It is a partnership of the Pacific American Foundation (receiver of funds), the Waikalua Loko Fishpond Preservation Society, the Hawai'i Department of Education, The University of Hawai'i Sea Grant program, and the United States Department of Education. It receives its funding from the U.S. Department of Education, Native Hawaiian Education Program. Its focus is to develop culturally relevant curricula for the Hawai'i school system utilizing Hawaiian fishponds as a resource to teach science, social studies and language arts in the 21st century.

The Kahea Loko project made it a goal to link with all other known fishponds, so that knowledge could be shared in revitalization efforts, and in teaching and implementing the curricula for all students and communities statewide. The result of both the revitalization and educational effort has been to increase awareness about the important role that Hawaiian fishponds play in Hawai'i today. These cultural treasures not only represent a link to the knowledge of environmental stewardship, but how it can be applied to critical ecosystems that are in jeopardy.

The Invasion:

Many fishponds throughout the State have been lost or are on the verge of vanishing by the invasive mangroves (*Rhizophora mangle)* and/or other invasive species. Six of the nine key fishpond training sites of Kahea Loko have severe infestations of aquatic invasive species, primarily mangrove, but also pickleweed (*Batis maritima*). These sites include: Alekoko Fishpond (Nawiliwili, Kaua'i), Waikalua Loko Fishpond and He'eia Fishpond (both at Kane'ohe Bay, O'ahu), Ualapu'e Fishpond and Keawanui Fishpond (both at East Moloka'i), and Kaloko, 'Aimakapa Fishpond (Kailua-Kona).

Waikalua Loko fishpond has been the primary training site for the island of O'ahu. Eight years ago, when revitalizing efforts began, the entire pond was surrounded by mangrove that was rapidly encroaching into the middle of the pond. An adjacent existing pond (approx. 2 aces in size) is a living example of a pond totally consumed by this aquatic invasive species.

The Response:

Most of the ponds are being revitalized and managed with community volunteerism and under-funded non-profit organizations. None have had the manpower or resources to totally clean the ponds from the mangrove or pickle weed to date. Kaloko pond in Kona is part of a National Park system, and years ago they were able to secure some funds to remove nearly 90 % of the mangrove using helicopters for transport out of the area. However, most of the ponds have been managed using hand tools and free labor. Efforts to use herbicides (garlon) have been moderately effective, but are considered very expensive and [there is concern that] it could threaten aquatic life.

The Lesson:

Editor's note: Almost all fishpond sites in the State have relied heavily on community workdays and other modes of volunteerism to fight the battle with aquatic invasive species. At many of these sites, due to lack of resources, the community and the fishponds appear to be losing this battle. Increased education, as well as community and political support, including financial support, will be necessary to successfully contain these invasive species in order to truly preserve these culturally important resources.

[83] Text for this section provided by Herb Lee, of the Kahea Loko Project, to help highlight the threat that AIS have on cultural resources, as well as the need for political and financial support to combat such species.

CASE STUDY 6: THE MILITARY'S CONTRIBUTION[84]

Marine Corps Base Hawai'i Addresses Aquatic Invasive Species

Background:

Marine Corps Base Hawai'i (MCBH) has been an early leader in Hawaii's efforts at invasive species control, especially of aquatic invasives in coastal wetland environments at their Mokapu Peninsula, windward O'ahu location. About fifty percent of their total natural resources management efforts address some aspect of the invasive species problem

In addition to being a busy military installation, the 2,951-acre Mokapu peninsula is home to many Federally-protected species. Over 50 different species of waterbirds and shorebirds have been counted here over the past 50 years. Among them are all four of Hawaii's listed endangered waterbirds, but primarily the Ae'o, (Hawaiian Stilt, *Himantopus mexicanus knudseni*). The peninsula's primary waterbird habitat is at the 482-acre Nu'upia Ponds Wildlife Management Area (WMA), an interconnected complex of eight shallow ponds and vegetated mudflats connecting the peninsula to O'ahu. Valuable waterbird habitat is also found at several shoreline marshy areas, golf course drainage ponds, and a constructed retention basin on a new barracks site. MCBH's efforts over the past twenty years [have focused on the] control of several target aquatic invasives which threaten nesting and feeding substrate to the protected species found at Nu'upia Ponds.

The Invasion and Response:

Mangrove (*Rhizophora mangle*):

At Nu'upia Ponds, mangrove became well-established by the mid-1970s and have disrupted historic fishpond walls, encroached on waterbird ground-nesting habitat, clogged waterways, promoted sedimentation, increased algal production, lowered water quality, obstructed floodwater drainage, and decreased food and oxygen available for indigenous aquatic life. Starting in the early 1980s, MCBH environmental staff, Marines and civilian volunteers, and MCBH contractors committed thousands of labor hours and about $2.5M dollars in projects, large and small, which removed 22 acres of invasive mangrove from the WMA by 2001 and completed related baseline and monitoring studies which documented improved native wildlife habitat and water quality (Drigot, 1999). For example, a three-year fieldwork project demonstrated that Hawaiian stilt readily recolonize mangrove-cleared areas for expanded nesting and feeding (Rauzon and Tanino, 1998). Annual total stilt numbers counted in the ponds have more than doubled from 60 to about 130 birds during the same 20 year period (see State waterbird count records). Mangrove removal as well as other invasive species control efforts (e.g., pickleweed (*Batis maritima)* and predator removal) have contributed to these improved numbers (Rauzon and Drigot, 2002). To prevent reinfestation, partnering with volunteers will continue and barricades are in place to discourage mangrove propagules from floating in through pond culverts and becoming reestablished in the mudflats from other areas around Kane'ohe Bay that remain infested.

Pickleweed (*Batis maritima*):

By the mid-1970s, pickleweed mats had almost completely covered open mudflats at Nu'upia Ponds, further threatening primary foraging habitat for many shorebirds and waterbirds. Since the early 1980s, this invasive species is now kept in check through annual "mud ops" maneuvers by Marine's Assault Amphibian Vehicles (AAVs). These 27-ton vehicles are not normally allowed to train in the ponds, due to sensitive biological and archaeological features there. However, with interagency approval, once a year, just before onset of stilt nesting season, AAVs are deliberately deployed in supervised plow-like maneuvers to control pickleweed and shape mudflats to benefit both Stilts and Marines. They break open thick mats of pickleweed, improve stilt nesting and feeding opportunities, eradicate cover for predatory rats, cats, and mongoose, while also giving AAV operators valuable practice in unusual terrain. Their plowing action also creates beneficial checker-board patterned "moat and island" terrain which discourages predators (e.g., alien mongooses, rats, feral cats) from crossing multiple watery barriers to access stilt eggs. These actions also expand access for newly-hatched stilt to water-resident food sources (e.g., flies, larvae, crustaceans). This is critical as Hawaiian stilt chicks must forage for themselves at birth (Drigot 2001).

Expanded MCBH Mangrove/Pickleweed Control Efforts:

Now that MCBH has made sustainable gains in the war against invasive aquatic species at Nu'upia Ponds, the battle is expanding to other geographic areas of these aquatic invasives' infestation under MCBH control. For example, in 2002, a MCBH contractor removed about 131,500 square feet of invasive mangrove vegetation at eight separate locations elsewhere along the shoreline and smaller wetland areas of Mokapu peninsula outside of Nu'upia Ponds, thus eradicating all major infestations on the peninsula (Wil Chee-Planning, Inc. 2002). Gains will be sustained through continual monitoring and regular weeding of any mangrove propagules that float in and become re-established from infestation areas elsewhere around Kane'ohe Bay, outside the borders of MCBH.

Recent efforts to control other Invasive Aquatic Species at MCBH:

MCBH efforts are now expanding to additional geographic areas under their control, both on land and in marine areas.

(continued on next page)

[84] Text and associated references on following page supplied by D. Drigot, Senior Natural Resources Specialist, Marine Corps Base Hawai'i. Text has been edited slightly for inclusion in this plan.

(continued from previous page)

Two special studies were commissioned to assist MCBH in organizing existing information already available on terrestrial and aqueous invasive species threats on MCBH properties, and to assist in recommending further directions that MCBH's integrated natural resources management program might take to address them (SRGII 2002a; SRGII 2002b). One geographic area that was specifically addressed is the 500-yard marine buffer zone around Mokapu Peninsula. The last comprehensive in-water survey in this location was undertaken ten years ago (Henderson 1992). A new survey is being organized at time of this writing for execution in 2004. It involves a newly-funded effort of MCBH environmental managers, with collaborative input from Federal and State partners (e.g., USFWS, NOAA-NMFS, DLNR) to perform an updated marine underwater survey within MCBH's waters in tandem to a similar State survey being undertaken at other spots around Kane'ohe Bay. Based on the combined results of these collaborative efforts, a multi-agency cooperative effort to determine priorities and perform follow-on focused control measures for the most serious invasive species threats identified in the Kane'ohe Bay ecosystem will be a likely result.

Lessons Learned:

Effective and sustainable efforts at aquatic invasive species control in Hawai'i must be multi-species, multi-agency, multi-tasked, and collaborative—involving equally-valuable efforts of public volunteers, military, other government agency, and private parties all working together, in phases, following a shared vision, and similar goals and objectives, while respecting each agency's specific mission priorities. By pooling limited financial, material, labor, and equipment resources and sharing a spirit of cooperation, determination, and commitment, the possibilities for sustainable success are endless.

References on MCBH's Invasive Species Management Efforts:

Drigot, D., 1999. "Mangrove Removal and Related Studies at Marine Corps Base Hawai'i", DoD Legacy Resource Management Program, Tech Note M-3N. In *Technical Notes: Case Studies from the Department of Defense Conservation Program*. Ed. Undersecretary of Defense: Environmental Security Office, Arlington, VA.

Drigot, Diane. 2001. "An ecosystem-based management approach to enhancing endangered waterbird habitat on a military base", In *Evolution, Ecology, Conservation, and Management of Hawaiian Birds: A Vanishing Avifauna*, Studies in Avian Biology No. 22, Cooper Ornithological Society (c/o Western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, CA 93012).

Drigot, D.C., B. A. Wilcox, and K. N. Duin. 2001. "Marine Corps Base Hawai'i Integrated Natural Resources Management Plan and Environmental Assessment (MCBH INRMP/EA) (2001-2006)". Prepared by MCBH Environmental Department and Sustainable Resources Group International Inc. (SRGII), for MCBH, November.

Henderson, Scott. 1992. "A Natural Resources Survey of the Nearshore Waters of Mokapu Peninsula, Kane'ohe Marine Corps Air Station", prepared under contract for MCAS Kaneohe Bay, by Naval Command Control and Ocean Surveillance Center, Environmental Sciences Division, Hawaii Lab.

Rauzon, M. J. and L. Tanino. 1998. "Bird Monitoring During Mangrove Removal at Nu'upia Ponds Wildlife Management Area, Kane'ohe Bay, Marine Corps Base Hawai'i", Prepared by Marine Endeavors. Prepared for Marine Corps Base Hawaii under subcontract to SCS/CRMS, Inc., through US Army Corps of Engineers, Pacific Ocean Division, January.

Rauzon. M. J. and Drigot, D. C. 2002. "Red Mangrove Eradication and Pickleweed Control in a Hawaiian Wetland, Waterbird Responses, and Lessons Learned." In *Turning the Tide: The Eradication of Invasive Species, Proceedings of the International Conference on Eradication of Island Invasives* Ed. C. R. Veitch and M. N. Clout, Occasional Paper of the IUCN Species Survival Commission No. 27, International Union for Conservation of Nature and Natural Resources (IUCN)-The World Conservation Union (Gland, Switzerland and Cambridge, UK).

Sustainable Resources Group International Incorporated (SRGII):

2002a. "Marine Corps Base Hawai'i Invasive Species Management Study", Final Report, prepared for MCBH Environmental Department under contract through Naval Facilities Engineering Service Center, Port Hueneme, CA 93043, December.

2002b. "Marine Corps Base Hawai'i Coral Reef Ecosystem Management Study, Final Report", prepared for MCBH Environmental Department under contract through Naval Facilities Engineering Service Center, Port Hueneme, CA 93043, December.

Wil Chee-Planning, Inc. 2002. "Final Environmental Assessment and Finding of No Significant Impact for Mangrove Removal and Endangered Species Habitat Improvements, Marine Corps Base Hawai'i", for MCBH through contract to US Army Corps of Engineer District, Honolulu, Fort Shafter, Hawaii, August.

CASE STUDY 7: PREVENTION IS THE KEY

The West Nile Prevention Program in Hawai‘i[85]

The Threat of Invasion

Though Hawai‘i has so far been West Nile virus (WNV)-free, the State is at risk.

This virus could be introduced by an infected bird (the virus host) or mosquito (the vector) arriving in Hawai‘i. Modern transportation brought the virus across the Atlantic to New York in 1999, and Hawaii's links to the mainland could be a similar bridge. WNV has sickened thousands in North America, killed nearly 300, and has decimated susceptible wildlife

If established in Hawai‘i, WNV would likely be here to stay, and without a cold winter, mosquitoes would be dangerous year-round. Expensive and long-term mosquito control measures would be required. In addition to persistent human sickness and mortality, domestic animal health would suffer; horses have a high mortality rate from WNV.

Dire losses would be seen in Hawaii's native birds, predicted to be extremely susceptible. Many of the native and rare species could be pushed over the brink to extinction.

The Response

Responding to this threat, a coalition of multiple State and Federal agencies and non-governmental organization was formed in 2001 to reduce the risk of introduction and plan contingencies if WNV were to arrive.

Importation of infected hosts (birds) or vectors (mosquitoes) is the biggest risk. A crucial early action was a State embargo on the mailing of birds to Hawai‘i, supported by the US Postal Service. This allowed a new, stronger quarantine rule to be effective in sharply reducing the risk of an infected bird reaching Hawai‘i. Preventing the transport of infected mosquitoes is much more difficult, but is being assessed.

Arrival of WNV would be detected by the dead bird testing program of the Hawai‘i Department of Health, or by human or veterinary cases reported to the Hawai‘i Department of Agriculture. Background levels of bird viruses are being surveyed by Federal wildlife agencies.

The Bottom Line

Public health measures to cope with WNV are in place in many states, but are expensive to establish and maintain. Some measures can also have unwanted effects on people, streams [and other inland waters] and wildlife. Hawai‘i would have to dedicate scarce resources to this long-term task.

The larger challenge would be to maintain our native ecosystems in the face of a lethal bird disease. The costs would be high, and response time short, if WNV were to arrive. Preventing the arrival of West Nile virus arrival is the key.

[85] Text for this section submitted by Jeff Burgett, West Nile Virus Prevention Group Coordinator, US Fish and Wildlife Service.

CHAPTER 6:
Program Implementation and Evaluation

CHAPTER 6: PROGRAM IMPLEMENTATION AND EVALUATION

PRIORITIES FOR ACTION

Though all tasks identified in this plan are considered important for the effective management of AIS in Hawai‘i, the identification of priority actions is a key step to begin plan implementation.

The formation of an AIS Advisory Council and associated sub-groups (Task 1A7), and the hiring of an Aquatic Invasive Species Coordinator position (Task 1A8), will provide key entities to help determine these priorities, as well as play key roles in task implementation.

However, as an interim step until the Council, its associated sub-groups, and the Coordinator are established, a preliminary delineation of priorities is presented here. It is emphasized that this section should truly be considered a “work in progress”. It is anticipated to be updated not only in future drafts and versions of this plan, but also throughout the year as discussions continue.

General Priorities:

- **Establish a permanent statewide position for an Aquatic Invasive Species Coordinator;**
- **Establish a long-term Aquatic Invasive Species Advisory Council;**
- **Evaluate and decide upon whether AIS issues and ultimate responsibility will fall under the Division of Aquatic Resources, or a newly formed entity;**
- **Develop a system for streamlined reporting of, and rapid response to, newly detected invaders;**
- **Identify and secure additional funding, not only from grants, but also from long-term sources including the Hawai‘i State Legislature;**
- **Develop of a system that allows for risk assessment and a way to prioritize AIS;**
- **Increase knowledge on the biology and ecology of AIS, as well as methods for their control;**
- **Increase documentation and knowledge on the economic and ecological impacts of specific AIS.**

Marine Specific Priorities:

- **Implement and fund the existing Ballast Water and Hull Fouling Prevention Program;**
- **Research to better understand the cause of algal blooms;**
- **Develop a range of control options that are appropriate for the coral reef environment;**
- **Research to better understand and quantify the impacts of ta‘ape and roi;**
- **Assess the distribution and threat of the many nonnative marine invertebrate species that are in our waters;**
- **Examine the ability for control of key invertebrate species like *Carijoa riisea*.**

Inland Water AIS Management Priorities:

- **Increase coordination among inland water researchers, resource managers, and representatives from relevant industries;**
- **Continue and increase education efforts, especially those focusing on unauthorized release of organisms into inland water aquatic systems**.

PROGRAM MONITORING AND EVALUATION

To help in evaluating the effectiveness of this plan, the Steering Committee recommends that a formal evaluation be conducted on the plan itself on a regular basis. Systematic monitoring and evaluation of the implementation and results of tasks put forth in this plan should be considered an integral component of the plan itself.

In addition to an evaluation of efforts and implementation, the objectives, strategies, and tasks will also come under regular review, as this plan is intended to adapt to changing circumstances. It is anticipated that an annual report will be produced by the proposed Hawai‘i AIS Coordinator and the Hawai‘i AIS Advisory Council, which will include recommendations for updating and modifying the relevant management activities.

The Steering Committee for the development of this plan suggests that this evaluation process is conducted at least yearly for the first two years, beginning after an AIS Coordinator is hired. This evaluation process should include public and agency input, as well as a method to track major changes in subsequent documents. It is also suggested that the evaluation report be delivered to key individuals including the Governor, policy makers, and legislative staff; involved agencies and entities including the Federal Aquatic Nuisance Species (ANS) Task Force, the Hawai’i Invasive Species Council (HISC), the Coordinating Group on Alien Pest Species (CGAPS), and the associated Invasive Species Committees (ISCs); industry representatives and other stakeholders; and be made available to the general public.

IMPLEMENTATION TABLE

The implementation table gives budget estimates for each task identified in Chapter 4, predicting out to a 5-year period. Other elements in the implementation table, including the suggested year to begin implementation as well as suggested implementation entities, have also been included directly in the tasks presented in Chapter 4.

The implementation table is included as a separate attachment from the main plan. This was done intentionally, as it is anticipated that the implementation table will get more frequently updated throughout the upcoming year to reflect new funding that becomes dedicated for the various tasks through grants and other funding sources.

State of Hawai‘i Aquatic Invasive Species Management Plan

Appendices

This section provides additional details and descriptions for those species identified in Chapter 2 as being aquatic invasive species in Hawai'i.[1]

MANAGEMENT CLASS 1: LIMITED OR INCIPIENT POPULATIONS

Includes species with known impacts (or potential for impacts) that have limited or incipient populations within State waters.

MARINE ALGAE:

***Dictyota flabellata* (Phaeophyta)**—The brown alga *Dictyota flabellata* was first collected on December 29, 1999 from a floating dock that had been towed to Barber's Point, O'ahu from San Diego, California (Godwin 2001). A number of other nonnative macroalgae, including *Sargassum muticum*, were collected from the same structure but did not persist. A total of three collections have been made on or around the barge since the initial survey in 1999 and on all occasions live samples of *D. flabellata* have been obtained. Samples have also been collected on the shoreline adjacent to the hull of the dry dock, suggesting that *D. flabellata* may be successfully establishing in Hawaiian waters. It is unclear at this point if this species is impacting Hawaii's native marine communities, but efforts should be made to prevent this Northeastern Pacific species from spreading outside of the Barber's Point area.

INLAND WATER PLANTS:

***Typha latifolia* (Common cattail)** – Cattail is an invasive wetland brush which is native to Eurasia, North Africa, and North America. It spreads via wind-blown seeds and a creeping rhizome. This species was first collected on O'ahu in 1979 but is found at several lower elevation marshy sites including the Wailua Canyon on Kaua'i, Salt Lake and Pearl Harbor on O'ahu. If left unchecked, this plant can form dense, monotypic stands, effectively eliminating all open water in shallow water habitats. These already scarce habitats are critical to the survival of some native species, such as the endangered Hawaiian Stilt. It is also a serious pest to the taro industry, which relies on shallow water ponds for cultivation. The USFWS had appropriated funds to the Sea Grant and to the Kaua'i Invasive Species Committee (KISC) in FY03 to treat known populations and survey the common cattail on Kaua'i. KISC is currently working to control known populations using foliar sprayed Rodeo (now called Aquamaster) mixed with a non-ionic surfactant, and applied with a drizzle sprayer.

MANAGEMENT CLASS 2: ESTABLISHED, POTENTIAL FOR IMPACT, SOME CONTROL TECHNIQUES AVAILABLE

Includes species present and established in Hawai'i with known impacts (or potential for impact), that may be mitigated or controlled with appropriate management techniques. This category includes species that are approved for import and managed under other regulations for commercial or recreational purposes, but may still have known or potential impacts on native species, ecosystems, or the human use of these ecosytems.

MARINE ALGAE:

***Kappaphycus spp.* (Rhodophyta, red algae)**–*Kappaphycus alvarezii, K. striatum* and *Eucheuma denticulatum* were all introduced to O'ahu (Kane'ohe Bay and Honolulu Harbor) from the Philippines in the 1970's for open reef research experiments. It is still unclear what the actual degree of success is for each of these species because of the high morphological plasticity that exists between all of them. It appears that *Kappaphycus* has become highly successful in Kane'ohe Bay and has spread to numerous reefs since its initial introduction to Coconut Island; two samples have recently been collected outside of the bay (in the Ka'a'awa area). It seems likely that at least two taxonomic entities have become successful in Kane'ohe but without sexually mature samples, identification is not possible. Nevertheless, *Kappaphycus* generally forms large, three-dimensional mats similar to *Gracilaria salicornia* although the individual branches of *Kappaphycus* are much thicker (up to 2 cm in diameter), branching is irregular and numerous spines are present along each of the branches. Thallus color ranges from a light tan to dark magenta and sometimes green. Reproduction is primarily through vegetative propagation or fragmentation. *Kappaphycus* has become the single most dominant species at a number of reefs in Kane'ohe Bay and is frequently observed growing over and severely shading and killing reef building corals. Evidence suggests that *Kappaphycus* has significantly altered benthic community structure and species diversity in Kane'ohe. This species is not listed on the Hawai'i Department of Agriculture (HDOA) importation lists, and is therefore restricted for entry into Hawai'i until further review and approval by the Board of Agriculture.

***Gracilaria salicornia* (Rhodophyta, red algae)**—*G. salicornia* has been present on the Big Island of Hawai'i (in the Hilo area, inside and outside of the break wall and in Kapoho Bay) for several decades and the origin of these populations is unknown. *G. salicornia* was intentionally transported from Hawai'i to O'ahu in the 1970's (Kane'ohe Bay and Waikiki) and later to Moloka'i (near Pukoo) for open reef research experiments. Samples were planted in open reef cultures at all of these locations. Today, *G. salicornia* has spread throughout much of Waikiki. While the population isn't entirely continuous, it can be found in an extensive distribution range on O'ahu, from Kane'ohe to Ala Moana Beach Park (sites of particular abundance are: Kualoa Beach park, throughout Kane'ohe Bay, Alan Davis/Queen's Beach, Hawai'i Kai and Waikiki) (see figure A-1), and reports suggest that it is now common on much of

[1]Species descriptions were researched and compiled by the following individuals: for marine algae—J.E. Smith (University of Hawai'i), with additional input from C. Hunter (University of Hawai'i); for marine invertebrates—S. Godwin and L. Eldredge (both of the Bishop Museum); for freshwater species—M. Yamamoto (DLNR-Division of Aquatic Resouces), for freshwater insects - R. Englund (Bishop Museum); for freshwater invertebrates—R. Cowie (University of Hawai'i) for brackish water plants—M. Wilkinson (DLNR-Division of Forestry and Wildlife) .

Molokai's south shore (from Kamalo to Kaunakakai). Though the rate of spread for *G. salicornia* on O'ahu or Moloka'i is not known, based on surveys conducted in 2000 and 2003, it appears that the alga is still spreading. Though there have been suggestions from the public and from aquaculture farmers that this alga only blooms in areas subjected to high nutrient input, there is no data as of yet to support this statement from a scientific standpoint. While nutrients may likely play a key role in the associated blooms, most researchers feel that given the extensive distribution of the alga, nutrients are not the sole driver of *G. salicornia* abundance.

G. salicornia varies in color from a bright yellow at the tips to orange or green and then even brown at the base. This species is cylindrical (0.5 cm in diameter) and dichotomously branched with constrictions at the base of each dichotomy. In Hawai'i it generally grows in three-dimensional mats that are tightly adhered to hard substrata and can be up to 25-40 cm in thickness. In more calm environments it can also grow in an upright and more openly branching form. Reproduction is primarily through vegetative propagation (fragmentation).

G. salicornia can be particularly disruptive in some habitats because of its three-dimensional growth form which seems to allow it to simply grow over other benthic organisms (native algae and invertebrates). At several locations on O'ahu (Figure A-1) and various locations on Moloka'i, this alga has become an ecological dominant and can frequently be seen overgrowing or growing over live reef building corals. Evidence suggests that *G. salicorni*a has significantly altered benthic community structure and species diversity in Waikiki. *G. salicornia* is also grown commercially in Hawai'i on at least two operations. Because of its commercial value in conjunction with its ability for massive destruction of native reef species, resource managers, researchers, and aquaculturists will need to work together to adequately manage this species in the long-term. This species is restricted for import (part B) under permit for research, lab study, and/or cultivation.

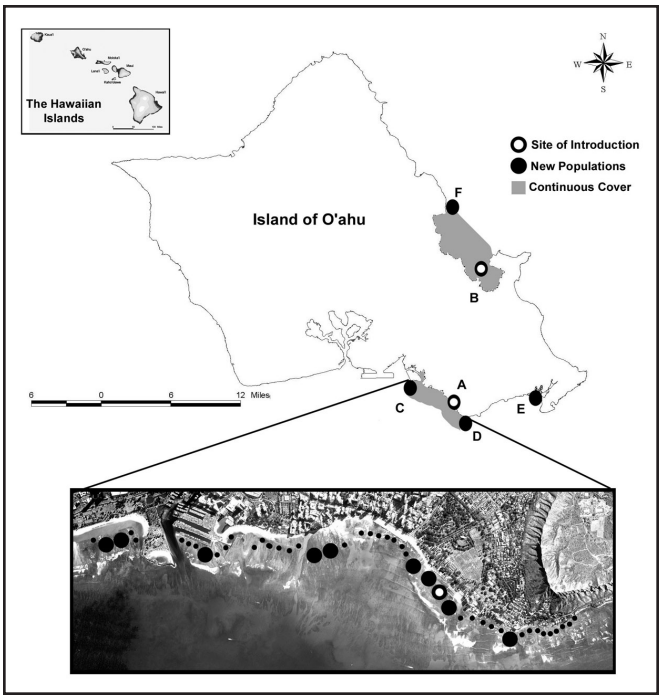

Figure A-1. Distribution of *G. salicornia* and on the island of O'ahu as of 01/03. Black dots with white centers indicate the original sites of introduction, whereas solid black dots represent new populations. The shaded gray areas on the O'ahu map represent areas where *G. salicornia* is common throughout. Sites are indicated by letters as follows: A-Waikiki Natatorium, B-Hawai'i Institute of Marine Biology (HIMB), C-Ala Moana Beach Park, D-Diamond Head, E-Hawai'i Kai, F-Kualoa Beach Park. The lower photograph shows detail of the Waikiki area, where large dots indicate continuous coverage (less than 5 m between adjacent patches) and small dots indicate smaller isolated patches (5–20 m between patches). *Source:* Smith et al. in press.

MARINE INVERTEBRATES:

***Scylla serrata* (Samoan crab)**—Though there is little scientific information on this species' impact as a competitor with Hawaiian organisms, it is a generalist predator that is considered a pest in Hawaiian fishponds.

INLAND WATER PLANTS:

***Salvinia molesta* (Kariba weed)**—*Salvinia molesta*, also known as the giant salvinia or kariba weed, is considered by some to be the worst aquatic weed in the world. It is native to southeastern Brazil, and has become a problem everywhere in the tropics and subtropics where it has been introduced. These plants multiply and spread asexually through budding. Under optimal conditions, vegetative propagation can be very rapid, with the plant capable of doubling in size in only a few days. Through fragmentation (only a pair of leaves is needed for a new colony) and rapid vegetative growth, *Salvinia molesta* can quickly cover the surface of lakes and slow-flowing rivers with mats more than two feet thick.

***Eichhornia crassipes* (Water hyacinth)—**If *Salvinia molesta* is the worst aquatic weed in the world, the water hyacinth ranks a close second. Native to South America, the water hyacinth has been in Hawai'i for many years. Water hyacinth reproduces vegetatively by short runner stems that radiate from the base of the plant to form daughter plants. It can also reproduce by seed.

***Pistia stratioides* (Water lettuce)**—This floating plant, native to South America, is considered to be one of the worst weeds in the subtropical and tropical regions of the world. In Hawai'i it was apparently brought in from Los Angeles, California in 1932 and is widely available as a pond ornamental. Under optimal environmental conditions, water lettuce can double its population size in less than three weeks. Seed production makes this plant resilient to adverse environmental conditions such as drought. Water lettuce populations often form large expanses of dense, impenetrable floating mats, limiting boat traffic, recreation, flood control, and wildlife use. In Hawai'i this plant can be found on Kaua'i, O'ahu, Moloka'i, and Maui but the popularity of this species for pond landscaping makes it likely that it is also found on the Big Island as well. The plant is not being controlled but SB 1505, signed in May 2003 adds this species to the State Noxious Weed list.

***Egeria densa* (Elodea or Anacharis)**—Elodea is a popular aquarium plant. Under the right conditions this plant can be highly invasive. New colonies can quickly become established by the rooting

and re-growth of plant fragments. At the Ho‘omaluhia Botanical Garden on O‘ahu, this plant essentially filled a 32-acre reservoir within a year. Eradication of *Egeria densa* is made more difficult because it is strongly rooted. If the entire plant is not removed, regrowth will quickly occur.

***Rhizophora mangle* (Mangroves)**[2]—Mangroves were imported to the Hawaiian Islands by the America Sugar Company in 1902 to hold soil in mudflats on Moloka‘i. Their current range includes Kaua‘i, O‘ahu, Moloka‘i, Lana‘i and Hawai‘i. Although they are a vital part of other ecosystems throughout the Pacific, in Hawai‘i they replace the open coastal habitats with dense stands of trees that make the habitat unsuitable for native water birds. These trees also cover and degrade the walls of historic fishponds. At this time, only local control has been attempted. Cutting young trees below the water line and pulling seedlings is effective. Dense infestations of trees can be controlled using Garlon 4 basal treatment.

***Batis maritima* (Pickleweed)**—This species was first collected in 1859 on Sand Island, O‘ahu and is now abundant along coastal areas on all of the main islands. It tolerates both moist soil and shallow water. Native to tropical and subtropical America and the Galapagos Islands, it covers mudflats that provide foraging habitat for endangered native water birds. Pickleweed also provides cover for cats, mongoose, and rats which prey on these birds. This species is being controlled at various sites throughout Hawai‘i including Nu‘upia Ponds at Marine Corps Base Hawai‘i on O‘ahu as well as at Kealia Pond National Wildlife Refuge in Maui. The Marines conduct annual training with 27-ton Amphibious Assault Vehicles which create open mudflat areas for Stilts by crushing the plants. Other effective control methods remove much of the standing material then scorch the remaining material.

INLAND WATER INVERTEBRATES:

***Pomacea species* (Apple snails)**—Commonly referred to as apple snails, this genus contains a number of closely related species that look very similar. At least three species can be found in the wild: *Pomacea bridgesi, P. canaliculata and Pila conica.* Most researchers and resource managers consider *P. canaliculata* to be the most destructive of the three species, but some aquaculturists have expressed disagreement with this statement. *Pomacea canaliculata* can be distinguished from the other two species by the deep groove between the whorls of its shell. This species is considered to be problematic in some natural and agricultural wetlands, most notably the taro fields, which play an important role in Hawaiian culture. Aquaculturists, resource managers, and researchers seem to generally agree that it is important to keep this and other nonnative snail species out of stream and wetland systems where they currently do not occur. However, some aquaculturists also feel that this species has considerable potential for culturing, and it is currently being cultured at sites approved by HDOA. Due to the different viewpoints regarding *P. canaliculata*, management efforts will not be a clear or simple path, but control of the spread of this species in the wild certainly warrants attention. (Management aspects relating to this species are further detailed in “Taking a Closer Look: Examining the Idea of Pest to Profit” in Chapter 2.)

INLAND WATER FISH:

***Micropterus dolomieui* (Smallmouth bass)**—The smallmouth bass was introduced by the Hawai‘i Division of Fish and Game (which is now the Department of Land and Natural Resources) in 1953 to improve freshwater fishing in selected reservoirs and streams. However, possibly in efforts to establish new fishing areas in recent years, this species has spread beyond the streams and reservoirs in which it was originally stocked. This is a result of unauthorized movements to other freshwater systems. The smallmouth bass is an aggressive, highly predatory species that feeds on a wide variety of aquatic life and poses a significant threat to native stream animals. It is imperative to educate anglers not to transport this (and other) species to new areas.

***Hemichromis elongatus* (Jewel cichlid)**—The jewel cichlid is an ornamental species from West Africa. Originally brought in for the aquarium trade, it has become established in several O‘ahu streams and reservoirs. Like the smallmouth bass, the jewel cichlid is a voracious predator and poses a significant threat to our native stream animals.

Tilapia spp. —About ten species of tilapia are presently established in Hawaiian waters. Several of these species were intentionally released by government agencies, but there are additional species observed in freshwater systems that were not part of these intentional releases. In the wild, these fishes are likely to compete with our native stream animals for food and space. At this point, it is generally agreed upon that not much can be done about established populations on a statewide level, but site-specific control is feasible. Efforts have, therefore, been focused on limiting the spread of tilapia species within the state and minimizing new species introductions. Many supermarkets in Hawai‘i sell tilapia and it is one of the more heavily aquacultured food fishes in the United States. The Hawai‘i aquaculture industry is also heavily dependent on tilapia for commercial production, and has worked cooperatively with HDOA and DLNR to limit the spread of tilapia and the diseases they carry in Hawaiian waters. Any requests by the aquaculture industry (or other entities) for the introduction of additional tilapia species are required to go through the existing HDOA permit process for the importation of new species.

***Clarias fuscus* (Chinese catfish, puntat, paltat)**—The Chinese catfish, also known as the puntat, or paltat, is believed to have accompanied the early Asian immigrants to Hawai‘i during the 1800’s. Although the puntat is valued for food, recreational fishing, and as an important aquacultured species, it is a nocturnal predator that is reported to feed on worms, snails, insects, crustaceans, and small fishes, and could impact native stream animals. It is, therefore, important to keep this species out of stream systems where they currently do not occur.

***Hypostomus c.f. watwata* (Armored catfish)**—Three species of armored catfishes can currently be found in several streams and reservoirs on O‘ahu and Maui. All three species can be traced to the aquarium trade. Although they are herbivores and do not prey on native stream animals, armored catfishes compete for food and space. They also contribute to erosion and sedimentation by burrowing into the banks of streams and reservoirs.

[2]Text for Descriptions for mangroves and pickleweed taken from the Draft Invasive Species Management Study—Marine Corps Base Hawai‘i, and edited for this document by M. Wilkinson–DLNR.

***Poecilids* (Topminnows)**—A number of species of topminnows have been widely distributed throughout freshwater streams and reservoirs in Hawai‘i for mosquito control, and to serve as bait and forage species. Although they have served this purpose well, recent research suggests that these fishes also serve as vectors for a number of parasites and diseases, which infect our native o‘opu. There are still a few remote streams and drainage systems which are free of topminnows. It is important that we keep them that way.

***Trachemys scripta elegans, Pelodiscus sinensis and Palea steindachneri* (Freshwater turtles)**—Three species of freshwater turtles are established in several wetland areas, reservoirs and streams. The red-eared pond slider, *Trachemys scripta elegans*, is an aquarium escapee, while the two species of softshell turtles, *Pelodiscus sinensis* and *Palea steindachneri*, are believed to have accompanied early Asian immigrants to Hawai‘i during the 1800’s. All three species feed on fish and crustaceans and are, therefore, considered threats to native stream species.

INLAND WATER BIRDS[3]

***Anas platyrhynchos* (Mallard, feral)**—In the late 1800s, Mallards were introduced to the Hawaiian Islands for sport and food. Today feral Mallards are established on all the main islands except Kaho‘olawe and Lana‘i. Ongoing sources of feral Mallards include flocks sustained in urban and hotel ponds, farm ducks, and pets that disperse or are released into the wild. The principal threat to recovery of endangered Hawaiian Duck, or Koloa, (*A. wyvilliana*) is displacement by and hybridization with feral Mallards. The interbreeding of the 2 species has resulted in a hybrid swarm on Oahu and Maui. Hybrids have also recently been documented on Kaua‘i and Hawai‘i. Subsequently, **Koloa x Mallard hybrids (*A. wyvilliana x A. platyrhynchos*)** compound problems of competition and genetic dilution. Loss of genetically-pure Koloa is imminent if feral Mallards are not controlled in the immediate future. Interspecific competition for forage and nesting sites has also been incidentally observed between feral Mallards/Mallard hybrids and other native Hawaiian waterbirds. Migratory Mallards are rare in the Hawaiian Islands and feral Mallards in Hawai‘i are believed to be descendants of domestic ducks. The state feral Mallard population is unknown; however, Mallard/Mallard hybrid counts on Oahu have increased by 7-fold over the past 15 years. Although *A. platyrhynchos* is listed as import-restricted by HDOA, Mallards can enter the state by mail, and continue to be sold instate for farming, pets, and display.

***Bulbulcus ibis* (Cattle Egret)**—Cattle Egrets were introduced to Hawai‘i from Florida in 1959. The release was sponsored by local ranchers and the Hawaii State Board of Agriculture to control pasture insects. Nearly 150 birds were released on all the main islands except Kaho‘olawe. After 1 year, successful breeding was recorded on O‘ahu where egrets were quick to establish. On Kaua‘i, egret numbers remained low until 1975, when the population exploded. By 1980 Kaua‘i had a population of at least 6,800 egrets, and by the mid to late 80s rookeries were documented on all release islands. Cattle Egrets are opportunistic feeders. In addition to pest insects, egrets consume a variety of invertebrates (nonnative and native), and small vertebrates such as fish, skinks, frogs, and Hawaiian waterbird and seabird chicks. Cattle Egrets are the subject of localized control at wildlife sanctuaries to protect endangered species, and at airports to avert bird strikes.

MANAGEMENT CLASS 3: ESTABLISHED, BUT NO KNOWN EFFECTIVE CONTROL TECHNIQUES

Includes species present and established in Hawai‘i, with known impacts (or potential for impact), but with no known available effective or appropriate effective management techniques.

MARINE ALGAE:

***Acanthophora spicifera* (Rhodophyta, red algae)**—*A. spicifera* was introduced to Pearl Harbor and/or Waikiki in the early 1950’s. It was identified in the hull fouling community on a barge that arrived in Hawai‘i from Guam and shortly after it had become established throughout most of the nearshore waters of the main Hawaiian Islands (except for Hawai‘i and Kaho‘olawe). Currently it is found on all of the main Hawaiian Islands and is a common component of intertidal environments throughout the state (excluding the Northwest Hawaiian Islands). Plants generally attach to hard substrata with a discoid holdfast, branching is irregular (diameter 2–3 mm wide) and side branches contain numerous small spines. The plants are usually tan to dark brown in color. Reproduction is both vegetative propagation and spore production. *A. spicifera* is the most widespread alien alga in Hawai‘i. Competition between *A. spicifera* and native algae and invertebrates is likely but impacts on community structure and diversity have not yet been extensively quantified. This species is not listed on the HDOA importation lists, and is therefore restricted for entry into Hawai‘i until further review and approval by the Board of Agriculture.

***Hypnea musciformis* (Rhodophyta, red algae)**—*H. musciformis* was introduced to Kane‘ohe Bay from Florida in 1974 for open reef research experiments. By the early 1980’s it had spread throughout much of O‘ahu’s intertidal and by the late 1980’s large windrows of *H. musciformis* were washing up on the beaches of west Maui. This species has now been collected from all of the main Hawaiian Islands except from Hawai‘i and Kaho‘olawe and samples have been collected from lobster traps in deep water off of Maro Reef and Necker Island in the Northwestern Hawaiian Islands. The plants are cylindrical with numerous small proliferations or elongate spines covering the axes. The tips of main branches end with somewhat large or inflated “hooks” that are used to attach onto other algae. The color is usually dark magenta to tan. Reproduction is through both vegetative propagation and spore production. *H. musciformis* is most common on the island of Maui where it is considered an invasive species. Up to 20,000 lbs. of drift algae often wash up onto the beaches in Kihei and eventually rots, exuding an extremely foul odor and an unpleasant beach setting. A recent economic study determined that in Kihei alone, these *H. musciformis* blooms are causing losses of over 20 million dollars per year to Maui’s economy. Aside from obvious economic impacts, it is likely that *H. musciformis* is impacting the benthic

[3]Descriptions for waterbirds supplied by K. Uyehara.

community structure and diversity, but this remains to be quantified. This species is not listed on the HDOA importation lists, and is therefore restricted for entry into Hawai‘i until further review and approval by the Board of Agriculture.

MARINE INVERTEBRATES:

Carijoa riisei **(Snowflake Coral)**[4]—*Carijoa riisei* is an octocoral originally described as *Telesto rusei*, and later revised to *Telesto riisei*. It was first reported in Hawai‘i in 1972 at Pearl Harbor. It was likely transported by either hull fouling or as an opportunistic organism associated with shipments for the aquarium industry. *C. riisei* was originally reported to be common in harbor fouling communities, but by 1979 it was also noted at eight sites on coral reefs around O‘ahu. By the 1990’s, it was reported to exist throughout the main Hawaiian Islands, from Kaua‘i to Hawai‘i. Available information suggests that *C. riisei* has spread well beyond Hawai‘i into the Indo-Pacific, and that it may have occurred in other Pacific areas before it was first observed in Hawai‘i. Up until recently, *C. riisei* appeared to be a relatively benign introduction that had been present at the 10-30m depth range, thought to be occupying previously underutilized habitat and producing no recognized negative impacts on the overall reef community. However, observations in 2001 have elevated its invasive status, as a large-scale survey of the Maui Black Coral Bed revealed that *C. riisei* have virtually exploded in abundance at many stations at depths between 75-100m. This depth represents the lower limits of the black corals *Antipathes dichotoma* and *A. grandis*, the two species that make up 100% of the commercial harvest of black coral collected annually from the Maui Bed. This fishery produces over $30 million in annual retail sales of precious coral jewelry (Grigg 2001). The 2001 survey showed that up to 90% of the black coral colonies of both species that occur in this zone are dead, having been overgrown by *C. riisei.* Though the black corals that occur in this depth range are too deep to be harvested by traditional methods, this segment of the population is important as a source of larvae for reseeding the shallower portions of the population that are subject to harvest, and *C. riisei* is now considered the most invasive marine invertebrate on Hawaiian reefs. The family Clavulariidae, which includes this octocoral species, is restricted for import and possession under permit for research by government agencies and universities, or for exhibition in a government-affiliated aquarium. The spread of this species can be limited by focusing on dispersal mechanisms associated with the maritime industry and black coral harvesting activities.

Chthamalus proteus **(Caribbean Barnacle)**[5]—This small barnacle lives in the high intertidal zone and is native to the Caribbean, Gulf of Mexico, and Brazil. *C. proteus* is thought to have arrived in Hawai‘i sometime after 1972, as it was not reported in comprehensive barnacle surveys done on O‘ahu in 1972–1973. Its mode of introduction was either vessel hull fouling or ballast water. It is now the most abundant organism in the upper intertidal areas in many harbors and bays throughout the main Hawaiian Islands, and it occurs as far west as Midway and Guam. In Hawai‘i, *C. proteus* reaches some of its highest abundances on artificial substrate, such as seawalls and pier pilings. It can likely cause negative impacts on native species in habitats in which it has become established, though these may be subtle and remain largely untested. However, *C. proteus* is likely to have been responsible for almost completely displacing another invasive barnacle, *Balanus amphitrite,* in some areas where they co-occur. Its likelihood of establishment to other non-invaded islands and harbors within the state can be minimized through the management of hull fouling on vessels operating in these locations. This species is prohibited for entry into Hawai‘i through intentional importation.

Gonodactylus falcatus **(Philippine mantis shrimp)**—The first reported sighting of this stomatopod was in Kāne‘ohe Bay in 1954 in dead coral rubble. It has been suggested that this species was introduced to O‘ahu with concrete barges towed from the Philippines and the South China Sea following World War II. Stomatopods have separate sexes; fertilized eggs are carried by the female until hatching. The free-swimming planktonic larvae undergo several stages of development before settling in shallow water. These crustaceans are generally carnivores, using their powerful claws to snap at prey. As an aggressive species, this one has been shown to drive out the native stomatopod *Pseudosquilla ciliata* and has almost completely replaced it in the coral heads of the shallow reefs of O‘ahu. Although this species has undergone considerable name changes (*Gonodactyleus falcatus, G. aloha, G. mutatus*), and its status as an introduced species in Hawai‘i has been debated, it has been resolved that it is an introduced species to Hawai‘i under this genus name. Intentional importation of this species is prohibited.

MARINE FISH:

Valamugil engeli **(Australian mullet)—**The primary concern with *Valamugil engeli* is competition with native mullet, *Mugil cephalus*. The juveniles have different habitats, as Australian mullet juveniles prefer high salinity while native mullet juveniles prefer less saline environments. However, the adults of both species share the same habitats. To help mitigate the impact on native mullet, there is a stock enhancement program for native mullet in Hilo, run by DLNR-DAR.

INLAND WATER INVERTEBRATES:

Macrobrachium lar **(Tahitian prawn)**—The Tahitian prawn was introduced to Hawai‘i in 1956 by the Hawai‘i Division of Fish and Game. A total of 340 prawns were brought in, 94 of which were released in Pelekunu Stream on Moloka‘i. In 1957, an additional 27 prawns were released in Nu‘uanu Stream on O‘ahu. By 1969, the Tahitian prawn had spread to more than 42 streams on all the islands. The Tahitian prawn demonstrates the special threat posed by amphidromous alien species. Like our native stream animals, the larvae of amphidromous alien species spend several months developing in the ocean. This facilitates the spread of these species between streams and between islands.

Neocaridina denticulata sinensis **(Grass Shrimp)—**Grass shrimp are already well established on O‘ahu, and can successfully outcompete the native Hawaiian shrimp, *Atyoida bisulcata*, for food and habitat. It is unclear when the grass shrimp was first introduced and where the original stock came from. The appearance of this shrimp in our streams seemed to coincide with the sale of this species as “feeder shrimp” in the early 1990’s. It is important to prevent this shrimp from spreading, particularly to the pristine streams located on the neighbor islands.

[4]Much of the following text for *C. riisei* taken from Coles and Eldredge 2001a and Grigg 2003.

[5]Text for C. proteus from C. Zabin (University of Hawai‘i).

***Corbicula fluminea* (Asiatic Clam)—**The Asiatic clam is a highly invasive species. These clams are hermaphrodites and a single individual is capable of establishing a new population. The first observation of this clam in Hawai‘i was made close to thirty years ago. A popular food item in the Asian community, this species has been deliberately spread to many streams and reservoirs on Hawai‘i, Maui, Kaua‘i and O‘ahu. Juvenile clams have been responsible for clogging irrigation lines, and the broken shells of adult clams pose a hazard to farmers walking barefoot in taro lo‘i.

***Myzobdella lugubris* (Leech)**—Hawai‘i has no native freshwater leeches. *Myzobdella lugubris* is the most commonly occurring introduced leech found on native freshwater fishes in Hawai‘i. It was brought in and spread via introduced topminnows and possibly also via other aquarium releases. This leech is absent in streams lacking introduced fish species, but where present, leech outbreaks can decimate native stream fishes and crustaceans.

***Trichoptera* (Caddisflies)—**Caddisflies are not native to Hawai‘i, but they now comprise the majority of the insect biomass in many Hawaiian streams, and are considered to have detrimental effects on native aquatic insects. At least four species are well established here: *Cheumatopsyche analis, Hydroptila potosina, Hydroptila icona,* and *Oxyethria maya.*

***Culicidae* (Mosquitoes)**—No native species in the Culicidae family are found in Hawai‘i, and although several harmful species are already established, any new species (or new strains) in this family should be excluded from becoming established. This group of aquatic insects has the greatest potential to harm human health of any other group of invasive species. Culicidae species are vectors for malaria, yellow fever, dengue fever, avian malaria, West Nile virus, and others. Mosquito species already established or collected in Hawai‘i include *Aedes aegypti, Aedes albopictus, Aedes nocturnus, Culex quinquefasciatus*, and *Wyeomyia mitchelli.*

INLAND WATER REPTILES AND AMPHIBIANS:

***Bufo marinus, Rana catesbeiana, and Rana rugosa* (Toad and Frogs)—**Harmful established Hawaiian species include the giant marine toad (*Bufo marinus*), the bullfrog (*Rana catesbeiana*), and the wrinkled frog (*Rana rugosa*). The predatory effects of these amphibians have been well documented, with bullfrogs consuming endangered Hawaiian waterbird chicks, and freshwater aquaculture crops, among other impacts. Bullfrogs have also been implicated as vectors for leptospirosis, and thus pose a threat to human health.

MANAGEMENT CLASS 4: ESTABLISHED; IMPACTS UNCLEAR

Includes species that may have the potential to cause impacts, but current knowledge is insufficient to determine if control actions are warranted.

MARINE ALGAE:

***Avrainvillea amadelpha* (Chlorophyta-Green Alga)**—*A. amadelpha* was first collected off of Koko Head and Kahe Point on the island of O‘ahu after 1981. At the time that it was first collected there were no clear vectors of transport and so determination of “nonnative” status was not possible. But because of its apparent sudden appearance and high abundance on the reef flats on O‘ahu’s south shore over the next decade it seemed to be a likely introduction. This species is native to the Northwest Pacific, Southwest Pacific and Indian Oceans. In Hawai‘i, *A. amadelpha* can now be found in abundance on the shallow reef flats in Hawai‘i Kai and Kahala on O‘ahu’s south shore. Samples have also been collected from deeper water (10 m) at Koko Head and Kahe Point, from a shallow reef in Hoai Bay on Kauai’s south shore and recent photographs from submersible dives show populations at 90 m depth off of Ewa Beach, O‘ahu. Because of the dynamic distribution of this species it is difficult at this time to make any conclusions about its status as a nonnative or a native species. It is possible that *A. amadelpha* is a natural component of the deep-water community in Hawai‘i and is now emerging in shallow water. Plants consist of a spongy basal or holdfast region that often anchors the plant in soft sediment environments, although specimens have also been found growing on hard substrata. The upright portions of the plants consist of paddle-like regions with a short stalk ending in a broad fan shape. The fans are also somewhat spongy and are flattened. The plants are usually dark to olive green and can be epiphitized by other, smaller algae. The primary concern regarding *A. amadelpha* is the possibility that this species may be invading Hawaii’s highly unique seagrass habitats. Clearly, much more research is needed to determine depth distribution and potential impacts and interactions that this possible invader may be having in Hawaii’s marine ecosystems. This species is not listed on the HDOA importation lists, and is therefore restricted for entry into Hawai‘i until further review and approval by the Board of Agriculture

MARINE INVERTEBRATES:

***Mycale armata* (Orange Sponge)—**This species can be found on O‘ahu and Maui in shallow water fouling communities and patch reefs. Vessel hull fouling is the likely mode of introduction for this species, which shows invasive characteristics on patch reef habitats through overgrowth of corals. All sponge species are prohibited from being intentionally brought into Hawai‘i. This and the control of the spread of this species through vessel hull fouling and other transport means are the only management efforts that are in place.

***Sigmadocia caerulea* (Blue Caribbean Sponge)**—Pier pilings, floating docks and other altered habitats are the areas where this species has become establishment on O‘ahu and Kaua‘i. This species was likely introduced through vessel hull fouling from its native range in the Caribbean. Its impact is unstudied but likely effects native bottom communities through competition for space. All sponge species are prohibited from being intentionally brought into Hawai‘i. The prohibition against intentional import and efforts to control the spread through anthropogenic vectors are the only management efforts in place.

***Pennaria distica* (Christmas tree hydroid)**—This common fouling hydroid was most likely introduced through ship fouling. The earliest record of this species in Hawaiian waters was in Pearl

Harbor in 1929. However, there is speculation that it has been present in Hawaiian waters for a much longer period of time, since sightings have been reported from warm waters worldwide. Colonies attach to artificial and natural hard substrates where there is some water movement. *P. distica* is a very common fouling organisms in harbors throughout the main Hawaiian islands, and is commonly found on reefs, usually in more protected areas or in cracks and crevices. The species has been recently reported at Laysan Island, Lisianski Island, Pearl and Hermes Reef, French Frigate Shoals and Midway. Polyps can reproduce asexually by budding and the medusa bud off singly from the body just above the proximal tentacles. The mature medusae are similar in both sexes. The hydroid is a carnivore, using the stinging cells on its tentacles to capture small plankton that drift by on currents. The ecological impacts are unstudied, but some competition for space with other invertebrates is likely. Additionally, this hydroid will sting humans, causing a mild irritation. This species is prohibited for entry into Hawai‘i.

***Amathia distans* (Bushy bryozoan)**—First reported in Kane‘ohe Bay from collections made in 1935, this bushy bryozoan is now a well established fouling species, reported throughout the main Hawaiian Islands. It was also one of the few introduced species found at Midway during collections in 1998. The species’ native range is the Caribbean but is now reported in warm-water areas throughout the world where it was unintentionally introduced either through fouling or as larvae in ballast water. Each bryozoan colony begins from a single sexually produced primary zooid. This form undergoes asexual budding to produce an upright bushy colony. This bryozoan is a suspension feeder. It has a retractable U-shaped crown of tentacles that bear cilia that create a current, bringing food toward the animal. The ecological impacts are unstudied; if it becomes established in protected coastal areas it has the potential to overgrow coral reefs. The control of the dispersal of this species and the prohibited entry status are the management options at this time.

***Schizoporella errata* (Branching bryozoan)**—This is a common fouling species found throughout the main Hawaiian Islands and at Midway. Its native range is the Mediterranean region, but it is now known from around the world. This species was most likely unintentionally introduced through hull fouling. Each colony begins from a single sexually produced primary zooids. This form undergoes asexual budding to produce its characteristic, typically dark brick red with orange red margins, calcified encrusting appearance. This bryozoan is a suspension feeder. Particles are moved to the mouth by cilia on the U-shaped crown of tentacles. The ecological impacts are unstudied, some competition for space may exist. Bryozoans not native to Hawai‘i are prohibited from being brought in intentionally. This restriction combined with the control of dispersal are the only management actions available at present.

***Didemnum candidum* (White didemnid)**—This white or gray encrusting ascidian is common in the main Hawaiian Islands. Its native range is not known, but it is now found throughout the world in warm waters. The species was probably introduced through hull fouling. It is a hermaphrodite with a simple reproductive system; small “tadpole” larvae are release from the parent colony and settle and metamorphose on an appropriate substrate. Ascidians are suspension feeders that use a mucous net to filter plankton from the water. This species name has been applied to large number of ascidians with similar appearance; the species being one of the most widely recorded species in the world. The ecological impacts are unstudied in Hawai‘i, but observations suggest some competition for space with other shallow water species in harbors and embayments. Intentional importation of this species is prohibited.

MARINE FISH:

***Lutjanus kasmira* (ta‘ape, blueline snapper)**[6]—This fish was intentionally introduced by the State in 1955 from the Marquesas and Moorea to increase fishing stocks. From some 3200 individuals introduced to the island of O‘ahu, the population has multiplied dramatically and expanded its range widely. It is now reported to have colonized the full length of the Hawaiian archipelago, including the Northwestern Hawaiian Islands. Though successful as an introduction, ta‘ape have not been well accepted into the local diet and remain a very abundant and under-exploited resource. Some fishers are concerned that this species may prey upon or out-compete desirable fish species for habitat and food resources, and that the ta‘ape compete so aggressively for fishing gear (e.g. baited hooks, traps) that catches of desirable native species are reduced. However conclusive evidence is lacking that suggests biologically or ecologically significant impacts on resident species by ta‘ape, and preliminary studies suggest this is not the case. As such there is some debate and disagreement among the scientists and the fishers as to whether ta‘ape pose a threat to the native species.

***Cephalopholis argus* (Roi)**[7]—This piscivorous species was introduced on O‘ahu and Hawai‘i island from French Polynesia (Moorea, Society Islands) by the State in 1956 to serve as a food-fish. Roi has since spread widely in the main Hawaiian Islands, is very prevalent on the Kona Coast, and has been observed at French Frigate Shoals in the leeward chain. Unfortunately, the roi in Hawai‘i have been found to have a high incidence of ciguatoxin, which is toxic to humans upon consumption. As a result, a roi fishery never succeeded. The full impact of roi upon native species is currently unknown, but aquarium collectors, dive tour operators, spearfisherman and others have claimed that the impact of roi is strong upon the reef-fish community and blame roi for declines in the populations that they target. However, little research has been done on roi, so science-based assessments are currently not possible. It still remains to be determined whether roi predation in Hawai‘i impacts the abundance of native reef fish species, and if so, to what extent. In its native habitats, roi commonly feeds on fish families that are targeted by Hawaiian aquarium fish collectors (e.g., Hobson 1974, Randall and Brock 1960). As this species is abundant on reefs in Kona and elsewhere, assessing the influence of this alien species on native fish species is of high importance.

***Lutjanus fulvus* (To‘au)**—Though introduced around the same time as ta‘ape and roi (from Moorea in 1956), this species does not seem to be as prevalent as the aforementioned species. It has been suggested that this may be due to to‘au being a more preferred food fish than ta‘ape and roi, yielding better market prices, and are therefore more exploited to meet the demand. Juveniles appear to prefer marginal brackish waters. To‘au has been observed throughout the main Hawaiian islands and into the Leeward chain, at Nihoa and French Frigate Shoals. Due to the relatively low abundance, this species is not currently considered a big concern.

[6]Species description taken directly from Oda and Parrish 1981; Staples and Cowie 2001; Parrish and Holland 2000; and Friedlander et al. 2002.

[7]Species description from Birkeland et al. 2002, and from Friedlander, pers. comm.

However, due to the many biological similarities it has with ta‘ape, it may be worthwhile to monitor its abundance and spread.

Herklotsichthys quadrimaculatus **(Goldspot herring)**[8] – Considered an accidental introduction, this species suddenly proliferated throughout nearshore O‘ahu in 1976, perhaps at the expense of a Hawaiian endemic, the iao, *Atherinomorus insularum.* Interestingly, even though iao and herring are both forage fishes, adult herring prey on larval-juvenile iao (Williams and Clarke 1983). It is not known whether the gold spot herring has had an impact on other resident species such as the nehu, *Encrasicholina purpurea,* another Hawaiian endemic.

Omobranchus rotundiceps obliquus, Omobranchus ferox, and Parablennius thysanius **(Small Cryptic Fishes)**[9]—Small fishes tend to be overlooked and ignored in many studies; it is harder to identify and estimate abundance of these smaller fishes, and many sampling techniques are biased against them. Because of this, small invaders may not be noticed, or may be ignored as insignificant until they have become extremely successful in the invaded community (Baltz, 1991). Further, in many communities, the effects of these fish upon the ecosystem are unknown because the native community of small cryptic fishes is also largely unstudied.

Three introduced blennies have been documented around O‘ahu: 1) The mangrove blenny *Omobranchus rotundiceps obliquus,* documented in 1955 (Strasburg, 1956), is found throughout O‘ahu; 2) The tasseled blenny, *Parablennius thysanius,* documented in 1991 (Springer, 1991), remains confined to South Kane‘ohe Bay, O‘ahu and 3) The fang blenny, *Omobranchus ferox,* documented in 2000 (Englund and Baumgartner, 2000), has begun to spread from Halawa estuary in O‘ahu throughout the Honolulu Harbor area. As may be expected, the effects of these fish on native populations are unclear. Population size of *O.r.obliquus* has been negatively correlated with population size of the native goby *Eviota susanae*, although the underlying reason for this relationship is uncertain. Additionally, the examination of stomach contents has indicated potential dietary overlap between *P. thysanius* and *E. susanae*, as both species primarily consume small crustaceans. However, the species composition of the diet may not be identical because the taxonomic level of examination was relatively high. These preliminary studies suggest that effects may be present, and that these introduced cryptic species may in fact be considered invasive species when more information is known.

INLAND WATER FISH:

Misgurnus anguillicaudatus **(Dojo, Weather loach, Japanese weatherfish)**—The dojo was one of the fishes brought in by Asian immigrants during the 1800s, as a food fish. In Hawai‘i, dojo can be found on O‘ahu, Kaua‘i, Maui, and Hawai‘i. The dojo feeds on worms, small crustaceans, insects, insect larvae, and other small aquatic animals found on the stream bottom.

INLAND WATER BIRDS

Anas platyrhynchos domesticus **(Mallard breeds, feral, e.g., Khaki Campbells, Indian Runners, Pekin)**—Most domestic ducks in the United States used for farming, pets, and/or display are either Muscovy (*Cairina moschata domesticus*) or Mallard derivatives, and come in a wide variety colors, shapes, sizes, and dispositions. Domestic Mallard breeds can enter the wild and pose threats to native waterbirds, where habitats overlap, as seen with feral Mallards (see Management Class 2). Though hybridization with Koloa is unlikely, aggression between domestic Mallard breeds and Koloa has raised concerns. In addition, domestic ducks can be vectors of disease potentially harmful to wild bird populations and humans. Although *A. platyrhynchos* is listed as import-restricted by HDOA, Mallards breeds can enter the state by mail, and continue to be sold instate for farming, pets, and display. There is a need to identify a lead agency to address nuisance or feral waterfowl issues within the state.

Potential AIS—Not Yet Established In Hawai‘i:

This category includes a list of species or species groups of concern that have the potential for introduction to Hawai‘i. Concern for these species are based on the invasive characteristics displayed by these species in areas with similar environmental conditions, and those species with viable pathways for introduction into Hawai‘i. Many of the examples on this list are allowed to be imported by various commercial activities, but are governed by Hawai‘i Department of Agriculture (HDOA) restrictions. This list is meant to provide a basis for discussion regarding the management of prohibited and conditionally permitted organisms in terms of their accidental or intentional release into the Hawaii’s environment.

POTENTIAL MARINE AIS

MARINE ALGAE:

Caulerpa taxifolia **Mediterranean Strain (Chlorophyta, green algae)—***C. taxifolia* is a native member of Hawaii’s marine flora and is found in occasional, small patches throughout the state. While the Mediterranean strain of *C. taxifolia* has become highly invasive in Europe, Australia and California, the Hawaiian populations have never exhibited invasive characteristics, and may prove harmless. The Mediterranean strain of *C. taxifolia* was accidentally released into the previously mentioned three locations and now covers the bottom for miles of coastline off France, Italy, Greece, Monaco and Croatia, overgrowing native plants and animals at an average rate of expansion of 50 kilometers per year (Vroom and Smith 2001). A recent study published in 2000 suggests that Hawaiian *C. taxifolia* shares the same genetic make-up as the invasive Mediterranean strain, but it is still unclear whether the two strains are indeed the same, as samples that were supplied from Hawai‘i were taken from an aquarium and not from the reef itself. As such, the origin of these samples remains unknown and could have originated from outside of the state. As the Mediterranean strain has caused extensive ecological and economic damage

[8]Species description is directly from DeMartini et al. 1999

[9]Species description supplied from E. Baumgartner, (University of Hawai‘i).

(clean-up efforts in California have already exceed $2M), there is a clear need to identify whether the Mediterranean strain exists in Hawai'i. Because *C. taxifolia* is known to exhibit invasive tendencies, movement of this species in and out of the state should be treated with caution. The listing of this species is not meant to take attention away from those species that are already here and have demonstrated their ability for large-scale negative impacts. Rather, this species is noted to emphasize that we do not yet know if it is a species of concern for Hawai'i, and should not be dismissed as of yet.

MARINE INVERTEBRATES:

***Musculista senhousia* (Asian mussel)—**This is an opportunistic species that can survive on hard or soft substrate that is native to lagoons and estuaries of the Western Pacific. The Asian mussel is a successful invader along the West Coast of the United States, the Mediterranean Sea and the Adriatic Sea. In some areas it has formed very large mats across shallow sheltered seabeds, with densities reaching 3,300 individuals per square meter. Such occurrences can significantly alter the local biota and substrate by competition for food and space. A likely transport for this species is maritime commerce activities.

***Mytilopsis sallei* (Black striped mussel)**—This native of Central America and the Caribbean, has invaded India, Taiwan, Japan, and more recently Australia's Northern Territory. It was probably introduced to Australia via hull fouling or internal water systems of commercial or recreational vessels. Individuals are sexually mature year round in the brackish waters of its native range. Outside its native range it prefers disturbed environments and spawns twice a year. Confusion in the literature might indicate that there is more than one species involved. The impact of the black striped mussel is similar to that of the zebra mussel in North America. Impacts include massive fouling of wharves, marinas, marine farms, and other seawater systems, such as ballast and cooling systems. The mussel can form monocultures that exclude other species, leading to a distinct decrease in biodiversity. The black striped mussel invaded four sheltered marinas in the Northern Territory of Australia in March 1999, reaching densities of nearly 24,000 per meter squared. Through a massive effort, costing several million dollars, the mussels were eradicated.

***Carcinus maenus* (Green crab)—**A native of the European Atlantic coast, the green crab was first recorded in North America in 1817. It dispersed along the West coast and appeared in San Francisco Bay in 1989, moving along the coast to British Columbia. The species is also found in Australia, Japan and South Africa. It appears that the maritime industry has been the pathway for most of its dispersal, since the species is most often found in harbor areas. Both sexes are a greenish color, but males and juveniles have a yellowish underside while adult females are a reddish orange underneath. The crab is a voracious predator, feeding upon some algae but takes a range of crustaceans, barnacles, and mollusks as well. This species has the potential of changing community structures and altering ecosystems. A single male specimen of this species was collected in Hawai'i in 1873 (the identification of this specimen has been verified). This was probably a waif that arrived on a ship hull. No other specimens have been reported in the Hawaiian Islands.

***Eriocheir sinensis* (Chinese mitten crab)—**This species is native to the northern China coasts. Taken to Europe probably in ballast water, it has spread through Germany and most of the continental regions and has recently been reported in England. In 1992 it was sighted in San Francisco Bay (thought to have been intentionally released) and individuals have been reported in Lake Erie. Sightings have also been reported along the Louisiana coast. This species can be recognized by its conspicuous furry "mittens" on each claw. Normal habitats for adults are the bottoms and banks of freshwater rivers and estuaries. As sexual maturity approaches, mitten crabs begin migrating toward coastal waters where spawning occurs. Their main source of food is submerged plants. Mitten crabs are proficient at burrowing and can weaken earthen retaining walls and collapse river banks. In the Far East they are one of the intermediate hosts of lung flukes.

***Potamocorbula amurensis* (Asian clam)[10]—**native to Japan, China and Korea, in tropical to cold temperate waters. It has been introduced into California, probably when larval forms were present in jettisoned ballast water. Large populations have become established in San Francisco Bay and are having a significant impact on the aquatic environment. This single species now forms a carpet over the floor of San Francisco Bay and estuary, displacing the former benthic community and causing sediment disturbance. It feeds at multiple levels in the food chain, consuming bacterioplankton, phytoplankton, and zooplankton (copepods), with the potential to substantially reduce copepod populations by depleting the copepods' phytoplankton food source and by direct predation. The Asian clam is found living on mud, sand, peat and clay substrates in the subtidal zone. It is tolerant of a wide range of salinity – from 1% to 33% salinity. In combination with its ability to flourish in tropical to cold temperate waters and survive in polluted environments, this salinity-tolerant bivalve has a distinct advantage in invading a variety of geographic areas and habitats.

***Potamopyrgus antipodarum* (New Zealand mudsnail)[11,12]**—native to a wide range of freshwater habitats throughout New Zealand. It has been introduced into Australia, Europe and the United States—waters of Montana, Wyoming, Arizona, California, Idaho, Utah, and in Lake Ontario. The New Zealand mudsnail is a parthenogenic livebearer with high reproductive potential. Populations of this mudsnail often reach densities greater than 100,000/m2 in suitable habitat and has been reported to approach densities as high as 750,000/m2. Frequently, they will comprise over 95% of the invertebrate biomass in a river, thus choking out native species.

***Cnidarians* (jellyfish, sea anemones and corals)**—Cnidarians as a whole, contain species that have demonstrated the ability to act invasively in habitats that are both characteristic of and similar to their home ranges, once they have become established. Most are commonly shipped throughout the world legally and illegally for the aquarium industry. The majority are either prohibited or restricted from being brought into Hawai'i intentionally.

[10]Taken directly from: Cohen and Carlton 1995 and from Australian Department of Fisheries 2000.

[11]Taken directly from: USGS Florida Integrated Science Center—Gainesville, http://www.fcsc.usgs.gov/Nonindigenous_Species/New_Zealand_Mudsnail/new_zealand_mudsnail.html.

[12]Taken directly from: Montana State University—Bozeman, Department of Ecology, "New Zealand Mudsnails in the Western USA", April 2003. http://www.esg.montana.edu/aim/mollusca/nzms/id.html.

- **Scyphozoa** (Jellyfish)

  From an ecological standpoint any scyphozoan species introduced to Hawai‘i could become locally dominant and act negatively on planktonic stages of important fish and invertebrate species. Also, nonnative species with painful or deadly stings that invade areas used for water recreation have direct impact on humans.

- **Anthozoa**

  1) Octocorallia

  This group includes blue corals, soft corals, sea fans and sea pens. Octocorallia are not well represented in the shallow water coral reef habitats of Hawai‘i. Negative impacts on coral reef communities in coastal areas could occur through competition for space and food resources.

  2) Hexacorallia

  Includes the anemones, hard coral, black coral, corallimorpharians (false corals), and zoanthids (rubber corals). This group is well represented in Hawai‘i except for the corallimorpharians. The potential effect of the introduction and establishment of a nonnative species from this group would be the same as for the Octacorallia.

- **Hydrozoa**

  Includes the hydroids, milleporines (fire corals) and stylasterine (lace corals). The hydroid *Eudendrium* species has demonstrated invasive characteristics in coral reef areas in which it has been inadvertently introduced. Physical contact with fire corals and some hydroid species can produce skin irritations that can be serious in some individuals. There are no native stylasterine corals described in Hawai‘i. This group could be a competitor for space with native Hydrozoa.

POTENTIAL INLAND WATER AIS

FISH:

Piranha—Piranhas are schooling, opportunistic carnivores. In terms of inland water nonnative fishes, the group of fishes collectively referred to as piranhas represent the worst case scenario. Although members of this group are prohibited from entry into Hawai‘i, fishes do get smuggled in. One, possibly two, live specimens were recovered from the Wahiawa Reservoir on O‘ahu several years ago. A number of specimens were also turned in by fish hobbyists under an amnesty program implemented by the Department of Agriculture. Continued vigilance and public education are the best preventative measures.

Anguilla sp. **(Freshwater eels)—**Freshwater eels of the genus *Anguilla* pose a significant threat to our freshwater ecosystems. They are nocturnal predators, which will feed on native o‘opu, ‘opae and shellfish. A specimen of *Anguilla marmorata* was recently recovered from a stream on Maui. Although there is a possibility that this individual drifted to Hawai‘i on its own as a larvae, it is also possible that the eel was smuggled in.

INVERTEBRATES:

Placobdelloides bdellae **(Leech)—**These leeches attach to humans and are a vector for human disease. They have been collected from aquatic plant containers on both Kaua‘i and O‘ahu, but fortunately, have not yet been found in the wild. Every effort must be made to prevent this leech species from becoming established because of its potential to transmit human disease.

Ceratopogonidae and Simuliidae **(Nono Flies)**—Nono flies are native to the Marquesas Islands of French Polynesia, which are the nearest Pacific Island group to Hawai‘i with flowing streams. Nono flies are also in the Cook Islands, an area that Hawai‘i currently has direct flights with twice a week. The bite often gives an immediate needle-like pain, and is followed by itching and burning sensations. Raised welts last from 2–3 weeks. Nono flies are not presently in Hawai‘i, but their establishment would likely significantly negatively affect tourism. If a Nono population became established in Hawai‘i, severe emergency actions would have to be taken to stop its spread.

Marisa cornuarietis **(Giant ramshorn snail)—**This is another ampullariid (apple snail). Though sold by some petshops (not necessarily in Hawai‘i), this species has been shown to be able to do serious damage to wetland plants where it has been introduced on the mainland.

Dreissena polymorpha (**Zebra mussel)**—The impacts of this species are known throughout North America and in many parts of the world, and include clogging of cooling systems of industrial installations, power plants, and of irrigation systems, as well as displacement of native species, and massive decline in fisheries. Currently, there is debate as to whether this species could survive in Hawaii's climate. However, if it could, it would likely take over many freshwater habitats and cause massive economic and ecological destruction.

Limnoperna fortunei **(Golden mussel)**—This species is rapidly advancing through South America and creating similar impacts and devastation as the zebra mussel is having in North America. This species may be more tolerant of our warm climate than the zebra mussel.

Xenopus laevis **(African clawed frog)—**Several species of harmful invasive frogs such as the African clawed frog (*Xenopus laevis*) are common in the pet trade, and are extremely aggressive predators with potentially severe impacts on native aquatic fauna.

Other Species Referred to In this Plan

SNAKES

***Boiga irregularis* (Brown tree snake)—**The brown tree snake (BTS) is a terrestrial species. However, because both Federal legislation addressing funding, and the interdiction and control of the brown tree snake is part of the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990, the species is noted here. In Guam, brown tree snakes have caused the extinction of numerous bird and lizard species, caused power outages, damaged agricultural interests, envenomed children, and consumed pets.[13] The threat of the brown tree snake's dispersal to other islands (including Hawai'i) is significant. Due to the threat posed to Hawai'i, brown tree snake control and interdiction efforts have been formally addressed, beginning with the Federal ANS Task Force-approved "Brown Tree Snake Control Plan", produced in 1996. Two subsequent reports in 1998 and 1999 have supplemented the Control Plan. In April 2003, a three day meeting was held on O'ahu for the Brown Tree Snake Control Technical Committee, which consists of representatives from the territorial, State and Federal signatories of an MOU dealing with BTS control as well as members of the Federally mandated Brown Tree Snake Control Committee. The purpose of the meeting was for discussion of inter- and intra-agency and government commitment, cooperation and collaboration associated with BTS management (interdiction and control) and research.

Because the brown tree snake is a terrestrial species in biological terms, combined with the fact that control and interdiction efforts are being dealt with specifically in other plans, the brown tree snake will not be addressed further in this document.

NATIVE MARINE ALGAE SPECIES WITH INVASIVE PROPERTIES

Editor's Note: As detailed earlier in the plan, there are native algal species which are causing great concerns, both economically and ecologically, due to their ability to form massive blooms. Though these species are not technically "AIS" because they are native, it was felt strongly by resource managers, researchers, policy makers, and private citizens that the following three species are worthy of being noted, as efforts and resources are being dedicated to address their blooms, in conjunction with the blooms of nonnative species.

***Cladophora sericea* (Chlorophyta, green algae)**—*C. sericea* is considered to be a native species in the Hawaiian Islands. It forms blooms episodically on Maui's west coast, primarily in the summer months in the Ka'anapali area from shore to over 30 m depth. It is frequently seen drifting or growing on top of other algae, coral and specifically the green alga *Halimeda incrassata*. Blooms of *C. sericea* have been occurring for at least the past two decades but do not occur every year and are at this point unpredictable. The blooms can persist throughout the months of April to August and can span several miles of coastline. The plants consist of extremely fine and highly branched filaments that tangle together forming large clumps of bright green wisps. This species has also been known to cause economic problems on Maui in the Ka'anapali area, as rotting algae on the beaches and extensive amounts of algae drifting in the nearshore environment prevent people from enjoying ocean related activities. Because of the ephemeral nature of this species, research has been extremely difficult to conduct. Therefore, the impacts that *C. sericea* has on reef community dynamics during a bloom have not yet been determined. This species is not listed on the HDOA importation lists, and is therefore restricted for entry into Hawai'i until further review and approval by the Board of Agriculture.

***Ulva fasciata* (Chlorophyta, green algae)**—*U. fasciata* or limu palahalaha is a native green alga otherwise known as sea lettuce. It is commonly found in rocky, boulder or basalt habitats throughout the state, especially in areas where nitrogen input is high. *U. fasciata*, though native, shows invasive-like properties on the island of Maui, specifically in the Kahului and Kihei areas where it often co-occurs and blooms with the nonnative red alga *Hypnea musciformis*. *Ulva* attaches to hard substrata with a single holdfast and the plants are essentially thin and often transparent bright green sheets that can grow in small rosettes or can be long and ribbon-like. The genus *Ulva* is known throughout the world for blooming under high nutrient or "eutrophic" conditions. This species is not listed on the HDOA importation lists, and is therefore restricted for entry into Hawai'i until further review and approval by the Board of Agriculture.

***Dictyosphaeria cavernosa* (Chlorophyta, green algae)**—*D. cavernosa* is a native green alga otherwise known as the "bubble algae". It is a common component of algal communities throughout the state but is most abundant in Kane'ohe Bay. In the early 1970's three urban sewage outfalls were placed within the basin of the bay and shortly thereafter, *D. cavernosa* became extremely abundant. The alga frequently overgrew corals and became by far the most abundant alga in the bay. The sewage pipes were later diverted and eventually *D. cavernosa* populations began to decline. Now, three decades later, *D. cavernosa* is still incredibly abundant in the bay where it is frequently seen interacting with coral. *D. cavernosa* is made up of a single sheet of cells that folds several times forming chambers or caverns. The individual cells are quite large and are visible with the naked eye. These plants commonly grow in crevices between corals. The impacts that this species has had on diversity and coral cover within the bay have not recently been quantified. *D. cavernosa* is restricted for import under permit for research, lab study, and/or cultivation.

[13]Taken directly from US Department of the Interior, 1999.

This appendix details some of the AIS activities referred to elsewhere in the plan. It is not intended to be a complete listing of every AIS activity in the state.

Details on Current Activities: *Marine Algae*

Presented here is a summary of some of key efforts identified for the large-scale control of nonnative algae in the waters of Hawai‘i. These efforts are part of the Alien Algae Control Program, which is a suite of activities designed to control the spread of nonnative algae and attempt to shift the competitive advantages back to native coral reef species and associated systems. These efforts are instigated and overseen by individuals at the University of Hawai‘i at Manoa—Botany and Zoology Departments, the Waikiki Aquarium, and The Nature Conservancy, with much support and input from the other members of the Marine Algae Group, as detailed in Chapter 3.

Also presented are key efforts identified for the management of native species that have the same impacts of AIS, due to their tendency to produce large blooms. Many of the same individuals in the Alien Algae Control Program are also involved in these efforts, with additional participation from the EPA, Maui County, and Maui residents.

“‘A‘ohe Limu‘e—No Alien Algae” volunteer-based nonnative algae removal efforts

The main objectives of these removal events are to actively combat the spread of nonnative algae and to promote awareness in our local community of this serious threat to our coral reefs. Six of these events have been held so far at the Waikiki Marine Life Conservation District (MLCD), and each event has been attended by between 75 and 120 volunteers. Collectively these events have removed over 25 tons of the nonnative algae, *Gracilaria salicornia*.

It is hoped that these events will provide direct positive benefits to the coral reef ecosystem of the collection area by removing algal biomass. In addition, these events have also raised public awareness and media attention to the issue of harmful algal blooms in Hawai‘i. These removal efforts have been covered on all major television channels and attracted front-page articles in Hawaii’s largest newspapers, as well as directly involved the public in efforts to combat invasive algae.

Development and deployment of a mechanical suction system capable of removing large volumes of algal biomass from coral reefs.

Studies conducted on effectiveness and impacts of alga removal and control to date have been small-scale (meter to sub-meter), and need to be scaled up to be more ecologically relevant. There is a strong interest to develop and fully implement a mechanism by which control of harmful macro-algal blooms happens on a much larger scale. A mechanized suction device has been purchased that uses a venturi system, which contains no fans or blades. The advantages of this system is that other marine life and native algae can pass through it unharmed and be returned to the marine environment. The protocol for algae removal using this device is still in the planning stages, but it is anticipated that a team of five technicians will be involved in the operation. It has been estimated that the device is capable of removing up to ten tons of nonnative algae in two hours with the team of five; this is orders of magnitude more algae removal capacity than “by hand” removal methods. Removal with this suction system will be accompanied by thorough biological monitoring to understand the benefits and impacts of these techniques.

Exploration of the use of native grazers to assist in the control or elimination of invasive algae.

Initial small-scale experiments, combining both manual removal and increasing the levels of native sea urchin grazers, *Tripneustes gratilla*, have shown success in reducing algal biomass by slowing the rate of algal regrowth. In addition, preliminary studies indicate that *T. gratilla*, in contrast to the native fish tested, prefers many nonnative algae species, including *G. salicornia* and *Kappaphycus* spp., over native species (J. Stimson and E. Conklin, unpublished data). These preliminary results suggest that these native sea urchins may prove an effective tool, in combination with mechanical removal, for long-term management efforts to control regrowth and biomass of invasive algae species. However, further controlled study is needed to determine if the use of urchins is practical and ecologically sound.

It should be noted that urchins are not very mobile and as a result, if any negative impacts on study plots are observed, researchers can remove the urchins. Also, since the number of urchins used will be representative of near natural densities of urchins on healthy reef, there is minimal concern about potential for population explosions. Finally, it is emphasized that the urchins to be used are native to Hawai‘i.

Repopulation of native algal species. [1, 2]

Habitat restoration efforts are an integral part of land-based management efforts, but little attempts have been made applying such principles to marine situations. Replanting cleared areas with appropriate juvenile or sub-adult native algae may be an important tool to shift competitive advantages towards restoration of native communities. Before large-scale efforts can begin, research is needed to 1) identify and characterize native algal and coral species that will grow with typical hydrodynamic flow regimes found in targeted reef regions, and to 2) identify optimal outplanting techniques for identified native species. However, before this research is carried out, localized direct restoration efforts will still likely be beneficial to the marine environment by increasing the survival of native algae and possibly preventing the encroachment by invasive species. Efforts of this nature are currently being planned by researchers from University of Hawai'i and community groups, such as Paepae o He'ei'a and others.

Removal, Control, and Research of both Invasive and Native Algae Blooms off Maui.

Maui County Department of Public Works and Environmental Management (DPWEM) has jurisdiction over the removal of algae off the beaches under HCR 405. This includes both native and nonnative species. Researchers from the University of Hawai'i are also leading efforts to better understand the causes behind these blooms. This work in Maui is occurring in two areas of the island:

Research and Management in South and Central Maui: [3,4]

DPWEM spends $60,000 per year for the removal of seaweed off Kahului harbor. In addition, the county is working in a cooperative partnership study with the EPA in a $250,000 grant to collect, remove, and compost invasive algae in the north Kihei area. $50,000 of this grant will go to UH researchers, to study the underlying causes of the profuse blooms of the nonnative alga, *Hypnea musciformis*, and the native alga, *Ulva fasciata,* and to determine possible means by which this growth may be reduced. As part of this total grant, there are six main components:

1) Establish a method of algal collection that will minimize the amount of beach sand removed;
2) Contain and remove the algae from the beach system so that nutrients from the decaying seaweed do not return to the nearshore water;
3) Find a beneficial use for the disposed algae;
4) Determine the type and source of nutrients contributing to algae growth in north Kihei;
5) Determine if there are any actions that could be taken to reduce the growth;
6) Restoration of the damaged beach and dune system, while reestablishing an attractive usable waterfront environment.

Research and Management in West Maui: [5,6]

From 1993-1997, special appropriations were received from NOAA and EPA for the determination of the causes and links between land-based nutrients and the algal blooms off west Maui. The initial thrust of this work was to document and determine causes of the extensive blooms of the native green alga, *C. sericea*. However, during the period of study there was a lack of these major blooms. As such, though much information was generated on nutrient loading from different terrestrial sources, detection of nutrients in the near-shore environment, physical oceanographic processes, and the distribution of these algae, the direct link of algal growth to nutrient sources remained largely unstudied. Efforts during this study period (when there was a lack of substantial blooms) turned to focus on watershed management, to bring the community together in an effort to reduce sediment and nutrient loads. As a result, the West Maui Watershed Project, a community-based environmental management effort, has helped to cut nitrogen loads to sewage injection wells, promoted recycling of wastewater and erosion control practices, and encouraged the development of desilting basin to trap sediment before it reaches the ocean. During this study period, there was also a strong focus on invasive algae cleanup programs. Such efforts included a "bounty program" where youth groups were subsidized for each bag of algae collected, as well a $75,000 award for a "Best Business Plan" contest focusing on sustainable methods to harvest the algae.

A second large-scale, multi-year research study has been funded by EPA, and is slated to begin in 2004. Research efforts will still focus primarily on the native *C. sericea*, but the study design and experimental protocols will be easily transferable to other bloom-forming algal species, including nonnative and invasive species. By assembling a team of researchers from a variety of disciplines (geology, geophysics, hydrology, chemistry, biology, ecology, phycology, and physiology) as well as State of Hawai'i resource managers, while utilizing innovative technologies, we have perhaps for the first time the resources needed to address this difficult issue.

[1]Adapted and excerpts taken directly from Atkinson et al. 2003b (proposal to NOAA).

[2]Excepts taken directly from a Shultz, K. 2003 (permit application).

[3]Excerpts taken directly from Norcross, Z. 2002 (grant proposal and workplan).

[4]Norcross, Z. and Parsons, R., personal communication 2003.

[5]Information gathered during phone conversations with Wendy Wiltse, EPA and Celia Smith, UH-Botany. April, 2003.

[6]Adapted and excerpts taken directly from Smith et al. 2002 (grant proposal submitted to EPA)..

Details on Current Activities: *Marine Invertebrates and Fish*

The bulk of efforts regarding marine invertebrate and fish AIS species are researched based, and are further detailed in Appendix C.

Details on Current Activities: *Inland Waters*

SURVEYING AND MONITORING

Various stream and other inland water surveying programs exist throughout the state. The programs highlighted here contain aspects or components relating specifically to AIS. (This list is not complete, and it is hoped that additional agencies and individuals involved in inland water AIS monitoring will submit descriptions of their projects if they are not already identified).

Surveying and Monitoring Activities by the DLNR-DAR, Bishop Museum/Hawai'i Biological Survey and Partners

- State-Wide Invertebrate Surveys: DLNR-DAR has a program to manage and control nonnative aquatic organisms in Hawaiian freshwater ecosystems. Its monitoring program objective is for the determination of the occurrence, distribution, relative abundance and impact of nonnative aquatic organisms in Hawaiian streams. Ongoing stream surveys on all the islands provide information on the occurrence, distribution and abundance of nonnative freshwater organisms in Hawai'i. Diet studies along with research conducted on parasites brought in by nonnative aquatic species have provided some insight on the impacts these nonnative species are having on native stream animals.
- In coordination with DLNR-DAR, the Hawai'i Biological Survey of the Bishop Museum is conducting surveys of aquatic invertebrates in a selected variety of aquatic habitats. All results are posted as freely available pdf downloads at http://hbs.bishopmuseum.org/hbs.pubs.html. The Bishop Museum is currently working on obtaining funding to incorporate data from over 100 years of aquatic surveys into a database that will be compatible with the current HDAR stream database. When completed, this will also be available for public use on the Bishop Museum website. (DLNR-DAR, Bishop Museum)
- Rare Native and New Alien Species Surveys: In conjunction with HDAR fish and algae surveys, Bishop Museum staff are conducting surveys at selected sites throughout the state of rare native species and searching for new species of invasive aquatic insects. Information gained from the surveys will provide a database, collections, and reports of both native and introduced aquatic insects. (Bishop Museum, DLNR-DAR)
- Biodiversity Investigations of Hawaiian Stream Algae: Survey efforts of Hawaiian stream algae have been ongoing since early 2001. DLNR-DAR, Bishop Mueum, and UH, are conducting the surveys under a variety of different projects, and aim to catalogue the diversity of freshwater algae in Hawai'i. Establishment of a species list for Hawaiian stream algae will allow for detection of future introductions. Collections obtained through these surveys will also be used for the determination of native versus nonnative species, through examination of pristine versus impacted areas, and molecular comparisons. (DLNR-DAR, UH, Bishop Museum)
- Long-term Monitoring of Pelekunu Stream, Moloka'i: Since 1991, Pelekunu Stream on Moloka'i has been periodically monitored by Bishop Museum staff, in cooperation with The Nature Conservancy Moloka'i, for native and introduced aquatic insects. This stream is one of the last free-flowing, pristine streams in Hawai'i and of utmost conservation importance. (TNC, Bishop Museum)
- Waipi'o Valley Hi'ilawe/Lalakea Stream Study: This three-year study will assess the impacts of stream flow restoration on native and introduced species. Parasite load and habitat use of invasive freshwater fish species will be analyzed, along with predation impacts on native species by invasive fish. (Bishop Museum)
- Surveys of Streams Impacted by the Waiahole Ditch: Streams in windward O'ahu which are diverted by the Waiahole Ditch are being surveyed for introduced and native aquatic insect taxa. This research is in conjunction with the HDAR fish and algae surveys. (Bishop Museum, DLNR-DAR)
- Invasive Species Surveys of French Polynesian Streams: Because Tahiti and other French Polynesian islands are potential sources of invasive aquatic insects and associated diseases to Hawai'i (French Polynesia was a source of the 2002 mosquito-borne dengue fever outbreak), surveys for invasive and native species in the French Polynesian archipelago have been conducted since 1999. (Bishop Museum)

Surveying and Monitoring Activities by UH Hawai'i Stream Research Center:

- Establishment of an ecological stream research station with the state Department of Land and Natural Resources and Limahuli Gardens, an affiliate of the National Tropical Botanical Garden on Kaua'i, for the state's first long-term study of a Hawaiian stream ecosystem.
- Refining technologies and the use of volunteers for monitoring of Hawaiian Streams. Under a Federal grant with the cooperation of landowner Kamehameha Schools and U.S. Fish and Wildlife Service, the Hawai'i Stream Research Center is involved in a three-year cooperative research project with

Limahuli Gardens. In this project, the Hawai‘i Stream Research Center is 1) refining technologies for monitoring ecological components of Hawaiian streams, and 2) developing a model community-based stream monitoring program.

- Apple snails in the Hawaiian Islands: Currently the spread of these snails around the state are tracked to a limited extent, as there is no funding specifically for this. A survey was published in 1995 (data up to 1992) for all islands. An update survey was undertaken in 1998 for O‘ahu and published in 1999. (UH, Bishop Museum)
- General Freshwater Snails: Tracking of the introduction and spread of nonnative snails on an ad hoc basis. (UH, Bishop Museum)

Additional Surveying and Monitoring Programs of Freshwater Systems by Other Entities:

A variety of additional programs exist which monitor Hawaii's freshwater systems. These programs have a heavy focus on water quality, though their programs may also include aspects relating to AIS monitoring.

- **USGS's National Water-Quality Assessment (NAWQA) Program[7]:** In 1991, the U.S. Geological Survey initiated the National Water-Quality Assessment (NAWQA) Program to assess the status and trends in the quality of freshwater streams and aquifers, and to provide a sound understanding of the natural and human factors that affect the quality of these resources. Beginning in October 1998, and continuing for a period of 3 years, the NAWQA Program investigated the quality of water resources on the island of O‘ahu. As part of this NAWQA study, invertebrate and habitat data were collected at ten sites in 1999. This is the most extensive and comprehensive study of this type undertaken in Hawai‘i to date, and included both native and nonnative species. The fieldwork component of this study is largely completed, however the data analysis is still being undertaken.
- **Kane‘ohe Stream Project.** This project is overseen by private sector consultants, AECOS Inc. and Oceanit Laboratories Inc. The purposes of the Kane‘ohe Stream Project are to enhance community appreciation of Kane‘ohe Stream and the quality of the water discharged into Kane‘ohe Bay, and improve habitat in the stream for native aquatic fauna. This effort is tied to studies to understand influences of land uses on water quality in this windward O‘ahu, perennial stream system (State ID No. 3-2-10) that flows into south Kane‘ohe Bay. This effort supplements the Department of Health *Total Maximum Daily Load, Kane‘ohe Stream* program. More information can be found at http://www.aecos.com/KOOLAU/KaneoheStrTMDL.html
- **Environmental Protection Agency (EPA) and Hawai‘i Department of Health (HDOH).** These two agencies work together in the statewide monitoring of water quality within Hawaii's streams and other freshwater systems.

Associated Inland Water Databases

DAR Stream Database
The Division of Aquatic Resources has developed and is maintaining a large information storage/retrieval system involving freshwater stream and estuary biological resources throughout the State. A background compilation of all prior information about such resources has been completed in the Hawai‘i Stream Assessment (HAS) report, which provides the core database for this system. This system is a Stream Biological Database which contains the biological portion of the HAS and is expanded to include updated information. This has been modified from the original format to provide a qualitative database providing descriptive biological information on individual streams.

Hawai‘i Watersheds[8]
This database is primarily an educational database, heavily focused on freshwater aspects (both nonnative and native). Users can look at photos, review existing records, and submit records of their sightings. This project is partially funded by the Hawai‘i Department of Education, the United States Environmental Protection Agency, and the Hawai‘i Department of Health, and contributions have also been made by the Hawai‘i Department of Land and Natural Resources. The purpose of this project is to have students, teachers and professional researchers who live in Hawaii's watershed areas develop and test hypotheses to understand the impacts of human behavior and natural events on its ecology. It can be accessed at http://www.hawaii.edu/environment/

Hawai‘i Stream Research Center's Aquatic Gap Project
The Hawai‘i Stream Research Center, with funding from USGS, is expanding and refining its PC ARC-Info based Geographical Information System (GIS) and Internet website, centralized within the UH Center for Conservation Research and Training. Their long-range goal is to provide for user-friendly, Internet-based, map-formatted access by resource managers to the enormous quantity of existing stream data.

[7]Text taken directly from the USGS websites http://hi.water.usgs.gov/projects/project_invert.htm and http://hi.water.usgs.gov/nawqa/index.html as well as personal communication with S. Anthony, USGS.

[8]Text taken from http://www.hawaii.edu/environment/

This appendix details many of the current research activities in the state relating to AIS. It is not meant to be a complete listing of every AIS research project currently underway.

Current Inland Water Research

1. Engage in the identification of native versus nonnative freshwater algae species. (UH, DLNR-DAR)

UPDATE: Incorporating several kinds of studies will be necessary for this goal, including: 1) surveying pristine areas that have likely been minimally impacted by recent introductions; and, 2) using molecular biological tools to compare Hawaiian stream algae to those from potential colonization sources. This work has only recently begun. Allison Sherwood (UH/DAR) is beginning some molecular studies involving Hawaiian stream algae, and has been making field collections for the past several years.

2. Better understand the factors driving abundance changes in stream algal communities in Hawai'i. (DLNR-DAR, UH)

UPDATE: This work is currently being funded by DAR, and will be ongoing for a period of 13 months. The study examines stream transects on a bi-monthly basis and will identify correlations between changes in algal abundance/community composition and various physical and chemical characteristics of the streams. Later identification of native versus nonnative species will allow this data to be re-examined to determine if patterns differ for the two groups.

3. Assess the impacts of stream flow on native and introduced species. (Bishop Museum, DLNR-DAR)

UPDATE: 1) A current three-year study in Waipi'o Valley Hi'ilawe/Lalakea Stream is being conducted by R. Englund and other researchers at the Bishop Museum to assess the impacts of stream flow restoration on native and introduced species. Parasite load and habitat use of invasive freshwater fish species will be analyzed, along with predation impacts on native species by invasive fish. 2) Surveys of streams impacted by the Waiahole Ditch are also being conducted by researchers from Bishop Museum. These streams on windward O'ahu, which are diverted by the Waiahole Ditch, are being surveyed for introduced and native aquatic insect taxa. This research is in conjunction with the DAR fish and algae surveys.

4. Research into the potential for translocating native species affected by AIS. (Bishop Museum, USFWS)

UPDATE: R. Englund and other researchers at Bishop Museum are currently conducting a "Tripler Damselfly Project". With U.S. Fish & Wildlife Service funding, long-term monitoring and the potential translocation of the rarest population of native damselflies in the Hawaiian Islands has been taking place at the Tripler Army Medical Center since 1994. Because invasive fish species have caused the extinction of this species throughout O'ahu, the native *Megalagrion xanthomelas* damselfly is now found in only 100 meters of stream habitat. Efforts to save this damselfly species from extinction include finding suitable aquatic habitats lacking invasive fish species, and then translocating individuals from the Tripler Stream to the new aquatic habitat. Restoration is currently being hampered as this damselfly is a lowland species, and all known O'ahu lowland aquatic habitats (other than the Tripler Stream) contain invasive fish species.

5. Continue to research nonnative viruses, bacteria, protistans, etc. that may cause diseases in native fish. (DLNR-DAR, SE Louisiana University)

UPDATE: W. Font, at SE Louisiana University has been actively involved with the research of freshwater parasites for over 10 years, through funding by the DLNR-DAR. As a result of his work, we are just beginning to understand the importance of nonnative helminth parasites with regard to the conservation of native Hawaiian stream fishes. A long-term goal for Hawaii's universities and governmental agencies should be to actively recruit and employ parasitologists and other aquatic disease specialists.

6. Continue with research on apple snail systematics. (UH-CCRT, USDA)

UPDATE: Funded by USDA, R. Cowie from UH - CCRT is investigating the systematics of the *Pomacea canaliculata* group of species, and addressing the specific identity

[1]When descriptions are presented, they have been excerpted either directly from the proposals, published work, postings on associated websites, and/or from personal communication with the author.

ACRONYMS:

Bishop	Bishop Museum
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources
EPA	Environmental Protection Agency
HCRI-RP	Hawai'i Coral Reef Initiative Research Program
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
TNC	The Nature Conservancy
UH	University of Hawai'i
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

of the pest species both in Hawai'i and in Southeast Asia, using molecular techniques.

7. Research host specificity testing for biocontrol of Giant Salvinia. (DLNR-DAR, HDOH, USDA)

UPDATE: 1) In cooperation with the Hawai'i Department of Agriculture, the DAR is in the process of evaluating the Salvinia weevil, *Cyrtobagous salvinae* for the biocontrol of *Salvinia molesta* in Hawai'i. The work will involve testing of the Salvinia weevil against a number of native and nonnative plants to determine how selective the feeding habits of the weevil are, and if the weevil can complete its life cycle in plants other than the target species. 2) USDA-APHIS-PPQ is also assisting with the testing of biological control for *C. salvinae* for use in Hawai'i.

Current and Planned Marine Research: *Algae*

Some of the research activities decribed below are also included in Appendix B.

1. Better identify boundary areas of invasive algae blooms. (UH)

UPDATE: An HCRI-RP sponsored grant, "Alien algae on Hawaiian reefs: distributional changes and ecological responses", led by researchers at UH Manoa will re-survey the 89 sites previously surveyed in 2000-2001. This study will generate detailed distribution maps to assist in determining the extent that invasive algae is spreading.

2. Further investigate the use of native grazers to assist in the control or elimination of invasive algae, to determine both effectiveness and impacts upon the reef ecosystem. (UH)

UPDATE: Research has recently begun under the UH Manoa Zoology, funded by HCRI-RP, to examine the habitat utilization patterns of these native urchins and the most effective means of limiting their dispersal out of stocking areas. Protocols for an additional study, involving researchers from UH Manoa which will build upon preliminary results from this HCRI-RP study are currently being developed.

3. Identify short and long term impacts of a mechanical suction system on the native benthic community. (UH, TNC)

UPDATE: This study will focus on assessing direct impacts of benthic algae removal on the reef community. Protocols include quantifying the species, number, and biomass of non-target organisms removed with the invasive algae, assessment of coral breakage and scars, and the monitoring of changes in community structure due to algal removal.

4. Understand the root cause of Hawaii's algal blooms from *Cladophora sericea* and *Hypnea musciformis*, and *Ulva fasciata.* (UH, HDOH, DLNR-DAR, USGS)

UPDATE: 1) $1.2 million was appropriated between 1993-1997 to determine the causes of the *C. sericea* blooms, but the cause was never determined because blooms did not occur during the time of study. 2) A second small study was funded with $10,000 from Sea Grant in 2001 to readdress this issue. Results from that preliminary study will be integrated into a 3) four-year EPA grant for $1.2 million that has been awarded to a inter-disciplinary team led by researchers with UH Manoa Botany Department, to understand the root causes of harmful blooms of *C. sericea*. This work is anticipated to begin in 2004. 4) An additional grant for $50,000 was awarded in 2003 to researchers of UH Manoa Botany Department from Maui County and the EPA for additional research on the causes of the blooms of *H. musciformis* and *U. fasciata* off of Kihei.

5. Assess the impacts of management options for the algae blooms off the beaches of Kihei, Maui County. (Maui County, EPA, UH)

UPDATE: Maui County is conducting an experimental study under a $250K grant from the Environmental Protection Agency, for the removal of the heavy accumulations of algae (both native and nonnative) on the beaches of north Kihei. The purpose of this study is six-fold: 1) establish a method of algal collection that will minimize the amount of beach sand removed, 2) contain and remove the algae from the beach system so that nutrients from the decaying seaweed do not return to the near-

ACRONYMS:

Bishop	Bishop Museum
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources
EPA	Environmental Protection Agency
HCRI-RP	Hawai'i Coral Reef Initiative Research Program
HDOA	Hawai'i Department of Agriculture
HDOH	Hawai'i Department of Health
TNC	The Nature Conservancy
UH	University of Hawai'i
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

shore water, 3) find a beneficial use for the disposed algae; 4) determine the type and source of nutrients contributing to algae growth in north Kihei, 5) determine if there are any actions that could be taken to reduce the growth, and 6) restoration of the damaged beach and dune system while reestablishing an attractive usable waterfront environment.

6. Assist in the understanding of how to most effectively repopulate native algae and other native benthos into their former habitats. (UH)

UPDATE: Preliminary protocol is being developed, focusing on the needs and methods for the determination of algae species to be planted, various reintroduction techniques, and optimal site locations for replanting.

7. Further examine the potential for additional complementary control approaches, such as changes in salinity, temperature, and herbicides, to be effective in the control of nonnative algae without causing further ecological damage to the coral reef. (UH)

UPDATE: Research is currently being funded under HCRI to look at these alternative approaches, and researchers have performed in situ experiments with exposures to a range of temperatures, salinity, and herbicides. Though all were effective, collateral impacts to native species may prevent their use in most reef settings.

Current Marine Research: *Fish*

ROI-SPECIFIC:

Within the fishing community, there is some concern that the nonnative roi are competing with the fishers and collectors for reef fishes by preying upon juveniles and affecting the recruitment of the reef fishes. Quantitative determination of the actual impact of predation or affect on recruitment of other fish species by roi is of major economic importance to the state because of the potential negative effect on the abundance of small reef fishes in Hawai‘i. Additionally, since Ciguatera toxicity is the main obstacle preventing the harvesting of roi, it is important to better determine the relationship between roi and Ciguatera.

1. Examine what impact roi has on native fish populations, and what species in particular may be impacted. (UH, DLNR-DAR) ONGOING

UPDATE: A study, *Feeding Biology of the Introduced Fish Roi (Cephalopholis argus) and its Impact on Hawaiian Coral Reef-Fishes and Fisheries*, is currently in its initial stage and is scheduled to be completed before August 2004. It is known from other locations that the diet of roi is almost entirely composed of other fishes; however, knowledge about prey composition of roi in Hawai‘i is scarce and will be analyzed in this study. Furthermore, the impact of roi on native fishes is a matter of how the rate of consumption of smaller fishes by roi compares to the rate of recruitment by the smaller fishes. By determining rates of predation and rates of digestion by roi, it will be possible for the first time to evaluate the impact of roi on nearshore reef ecosystems in Hawai‘i. This will assist resource managers in the decision of whether or not roi should be taken into account in future management efforts. Researchers from the University of Hawai‘i, Zoology department and the Hawai‘i Cooperative Fishery Research Unit, and the Department of Land and Natural Resources, Division of Aquatic Resources, are jointly conducting this study. At this point, only a small portion of this study is funded through a grant from the University of Hawai‘i. Additional funding needs to be secured to close the critical gaps in knowledge that the study addresses.

A second untitled study, focusing on *Using removal experiments to determine the affect that Roi (Cephalopholis argus) may have on recruitment of other fish species*, will also be undertaken by a graduate student at University of Hawai‘i. Controlled experiments are necessary to effectively clarify this issue. Roi will be removed from sites on the Kona Coast of the Island of Hawai‘i, as well as sites off O‘ahu, and the recruitment of reef fish, such as butterfly fishes, yellow tang, and other acanthurids, will be monitored at these sites.

ACRONYMS:

Bishop	Bishop Museum
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources
EPA	Environmental Protection Agency
HCRI-RP	Hawai‘i Coral Reef Initiative Research Program
HDOA	Hawai‘i Department of Agriculture
HDOH	Hawai‘i Department of Health
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UH	University of Hawai‘i
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USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

2. Better understand the principles of Ciguatera accumulation and dynamics in roi. (UH, DLNR-DAR) YEAR 1

UPDATE: As a key impediment to increased fishing pressure on roi is its link with Ciguatera, there is a need to understand what regulates Ciguatera levels in roi. The association of Ciguatera with roi will be studied in the roi study referred to above, and results of this study may assist in the development of a viable roi fishery.

TA‘APE SPECIFIC:

Because of ta‘ape’s spectacular population growth and uncertain status in the marine community, investigations into their ecology and interrelationships with other shallow-water reef fishes are timely and relevant to the interests of resource managers and marine ecologists in general[2]. Previous ta‘ape studies have not fully examined the potential for interactions of ta‘ape with young stages of the native snappers or with native species in shallow-water coastal habitats. These aspects of shallow-water interactions, both in terms of habitat use patterns and trophic interactions, have begun to be addressed in current studies, and are detailed below.

3. Identify the habitat use patterns of ta‘ape in shallow water environments. (UH) ONGOING.

UPDATE: A study, *Analysis of habitat use and movement patterns of native and alien demersal fisheries species*, is currently underway to study the spatio-temporal aspect of the interactions between the ta‘ape (*L. kasmira)* and a number native goatfish (Mullidae family). This study is being funded by Sea Grant, and being carried out by researchers from the University of Hawaii’s Hawai‘i Cooperative Fishery Unit and the Hawai‘i Institute of Marine Biology. The overall goal is to obtain and interpret information on the habitats used, movement patterns, and behavior of some key demersal fishery species in terms of interactions between them, and probable effects of these interactions. This information will provide the State information on these resource species and their habitats that will assist in managing present populations and developing additional management practices.

4. Examine trophic interactions of ta‘ape in shallow water environments. (UH, DLNR-DAR). ONGOING

UPDATE: A study, *“Feeding interactions of the introduced blue-line snapper with important native fishery species in Hawaiian coral reef habitats,”* supported by NOAA Coral Conservation Funds administered by DLNR-DAR is currently being carried out by researchers at the Hawai‘i Cooperative Fishery Research Unit at the University of Hawai‘i. This study will address: 1) predation by the introduced ta‘ape on important native species or vice versa; and, 2) feeding similarity by ta‘ape and native species in close proximity on a common diet, that can result in food competition that reduces nutrition for the competitors. The overall goal is to definitively describe the species interactions and forage preferences of ta‘ape.

ROI AND TA‘APE SPECIFIC:

5. Compare the genetic and life history differences between roi and ta‘ape in Hawai‘i with these species in their source locations in native habitats in Moorea and the Marquesa Islands. (This work is being done by researchers outside of Hawai‘i; through the Smithsonian Tropical Research Institute and James Cook University) YEAR 1

UPDATE: Nearly half a century has passed since roi and ta‘ape have been released in the Hawaiian Islands, a new environment where there were no others of their genus. They spread rapidly. Do they grow faster and reproduce earlier than in their native region because of competitive release? Have they evolved over this half century? Moorea is at a latitude comparable to Hawai‘i while the Marquesas are more tropical; did one group prevail? Ross Robertson (Smithsonian Tropical Research Institute, Panama) and Howard Choat (James Cook University, Australia) received a National Geographics grant to take tissue samples and otoliths from ta‘ape and roi in Hawai‘i, Moorea and Marquesas to compare the genetics and life-history characteristics of these introduced species with the populations from which they originated.

[2]Taken directly from Parrish and Holland 2001.

ACRONYMS:

Bishop	Bishop Museum
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources
EPA	Environmental Protection Agency
HCRI-RP	Hawai‘i Coral Reef Initiative Research Program
HDOA	Hawai‘i Department of Agriculture
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Current Marine Research: *Invertebrates*[3]

1. "Nonindigenous Marine Species Introductions in the Harbors of Nawiliwili and Port Allen, Kaua'i, Kaunakakai, Moloka'i; Kahalui, Maui; Hilo and Kawaihae, Hawai'i". (Bishop Museum) ONGOING

This study, funded by the Hawai'i Community Foundation and the US Fish and Wildlife Service, will focus on harbors on islands in the Main Hawaiian Islands, other than O'ahu, to determine whether nonnative species occur in similar frequency, and whether they represent a significant source of competition for native species. This information is critical for determining the extent of invasions throughout the Main Hawaiian Islands, and what management and possible prevention controls, if any, should be taken. Specifics of this study include:

- Conducting the first comprehensive surveys of the marine macroinvertebrates, algae, and fishes in the harbors of Nawiliwili and Port Allen, Kaua'i; Kaunakakai, Moloka'i; Kahalui and Ma'alaea, Maui; and Hilo and Kawaihae, Hawai'i.
- Compare findings with any biological information available from previous studies at the sites and from comparable studies at harbors and coral reefs conducted elsewhere in Hawai'i.
- Combine these data into a relational database and compare survey findings with previous records of introduced and cryptogenic species to detect presence of both previous and new introductions of nonnative marine species
- Evaluate the findings in terms of the extent of invasions and impact of nonnative marine species, and make recommendations regarding the need for management and control.

2. "The Assessment of Hull Fouling as a Mechanism for the Introduction and Dispersal of Marine Alien Species in the Main Hawaiian Islands". (Bishop Museum) ONGOING

This study is funded by the Hawai'i Coral Reef Initiative Research Progam and being carried out by researchers from the Bishop Museum. The goals and objectives of this current project deal with both a field component as well as collaborating with an assembled group of stakeholders (as part of the Alien Aquatic Organism Task Force, detailed in Chapter 3) concerned with formulating management decisions and proposed solutions. The field component will survey the potential mechanisms for introducing marine nonnative species through hull fouling, and will include:

- SCUBA surveys of overseas and interisland barges operating within Hawai'i, motor yachts and sailboats arriving from overseas destinations, and fishing boats.
- Dry dock surveys of vessels being serviced, including commercial barges, foreign fishing boats, other commercial vessels, research vessels, and U.S. Coast Guard vessels.
- Surveying of biofouling waste disposal practices for commercial hull cleaning facilities
- Compilation of arrival patterns and vessel operation dynamics for commercial barges, foreign fishing boats, and motor yachts and sailboats.

3. "Assessment of Nonindigenous Species on Coral Reefs in the Main Hawaiian Islands, with Emphasis on Introduced Invertebrates". (Bishop Museum) ONGOING

This study is being funded by the Hawai'i Coral Reef Initiative Research Progam and being carried out by researchers from the Bishop Museum has the following goals and objectives:

- Conduct assessment surveys for presence, relative abundance, and impacts of nonnative species on native reef organisms.
- Compare results with findings from studies in the principal harbors of these islands, and evaluate the potential impact that nonnative species from the harbors have had on the surveyed reef .
- Present summaries of findings on a web site and at public workshops that will be part of an ongoing outreach program with the purpose of alerting reef scientists, managers, and the general public about nonindigenous marine species invasions.
- Evaluate the potential long term impacts of any nonnative species found on the coral reef systems they have invaded, and assess the economic and environmental

[3]Text for many of the following descriptions has been excerpted directly from the associated proposals.

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cost-benefits of alternative methods of control and/or eradication.

4. "Impact of an Invasive Invertebrate Alien Species (*Carijoa riisei*) on Coral Reef Ecology in Hawai'i" (UH) ONGOING

This research is being conducted by researchers at the University of Hawai'i and is being funded by Sea Grant. The objectives for the study are as follows:

- Document patterns of distribution and abundance of *Carijoa riisei* in the main Hawaiian Islands
- Investigate the taxonomic relation of *Carijoa riisei* in Hawai'i to populations in the Western Atlantic and Indo-West Pacific.
- Study the overall ecology of *Carijoa riisei*, particularly rates of recruitment and patterns of growth, and the ability or not, of *Carijoa riisei* to reproduce asexually by successful fragmentation. Identify the feeding behavior of *Carijoa riisei* and determine if natural predators exist in Hawai'i. If so, determine their efficiency in controlling the abundance of *Carijoa riisei*.
- Further evaluate the impacts of *Carijoa riisei* on black coral populations in Hawai'i, and the hypothesis that deep black coral populations are an important source of larvae that supports recruitment and serves to sustain commercial harvest levels at shallower depths. Also evaluate the impacts of *Carijoa riisei* on other deep-water benthic communities and deep-water bottom fish.

5. "Community Effects of the Caribbean Barnacle *Chthamalus proteus* in Hawai'i" (UH) ONGOING

This dissertation study has received support from a National Science Foundation Graduate Research Fellowship, a National Science Foundation GK-12 Fellowship, and grants from U.S. Sea Grant and the Edmondson Research Fund. It is being carried out by a doctoral candidate at the University of Hawai'i and addresses four basic questions about *Chthamalus proteus*. These are presented below, along with results from preliminary observations and analysis:

- ***Does the ecology and biology of C. proteus in Hawai'i differ from that in its native range?***

  C. proteus does not appear to have undergone any changes in habitat usage, body size or reproductive effort in its invaded range.
- ***Is competition with other intertidal organisms limiting the range of C. proteus in Hawai'i?***

  Competition with other intertidal organisms does not appear to be an important factor in limiting this invasion, however there is evidence that *C. proteus* competitively excludes another abundant barnacle, *Balanus amphitrite*. Other factors, such as larval limitation and wave action, may be more important in this invasion.
- ***Is C. proteus competing for space with the native barnacle Nesochthamalus intertextus or the native pulmonate limpet Siphonaria normalis?***

  C. proteus does not appear to compete for space with the native barnacle, at least in the densities in which it now occurs. Experiments with the limpet are ongoing; but there are indications of competition at a site where the limpet occurs in high densities.
- ***Does C. proteus influence the community composition of other sessile invertebrates in the intertidal zone?***

  Communities of sessile invertebrates in Kane'ohe Bay that develop in the presence of *C. proteus* appear to be different from those without. This is still being evaluated with the use of settlement plates to be followed by community analysis

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This section is presented to increase awareness of efforts that have already been undertaken in addressing AIS issues in Hawai'i. This list is considered to be a work in progress, and all researchers who have been involved in research on AIS issues are encouraged to submit a description of their work to be included in future drafts of this Hawai'i AIS Management Plan.

Marine AIS Issues

Relating to General Marine AIS

1) **Presence and distribution of introduced marine organisms** (Coles et al. 1997, 1998, 1999a, 1999b, 2001a, 2001b; DeFelice et al. 1998, 2002)

   Extensive surveys have been conducted by researchers from the Bishop Museum to determine the presence and impact of introduced marine organisms. The focus of these studies were marine invertebrates, but also included marine algae and reef fishes. On O'ahu, these surveys have occurred in Pearl Harbor, Honolulu Harbor, and other O'ahu south and west shore commercial harbors, as well as Kane'ohe Bay, Waikiki, and waters off Hawai'i Kai (Kuapa Ponds). Additional survey sites included Kaho'olawe Island (Coles et al. 1997, 1998, 1999a, 1999b, 2002a, 2002b), Midway Atoll (DeFelice et al. 1998), and French Frigate Shoals (DeFelice et al. 2002), the latter of the two locations being within the Northwestern Hawaiian Islands. These studies have greatly increased our knowledge on marine nonnative species in the Hawaiian Islands, and have provided comparison with other areas impacted by species introductions.

2) **Hawaiian Marine Bioinvasions: A Preliminary Assessment** (Eldredge and Carlton 2002)

3) **Nonindigenous Species Introductions on Coral Reefs: A Need for Information.** (Coles and Eldredge 2002)

Relating to Marine AIS Pathways

1) **South O'ahu Marine Invasion Shipping Study** (Godwin and Eldredge 2001).

   This study prepared for DLNR-DAR focused on the analysis of the anthropogenic transport mechanisms associated with maritime shipping (ballast water, ballast sediments and hull fouling).

Relating To Marine Algae AIS

A variety of work has been done relating to the distribution, ecology, and management of marine algae AIS in Hawai'i. (Russell 1987, 1992, Russell and Balazs 1993, Rodgers and Cox 1999, Woo 2000, Stimson et al. 2001, Smith et al. 2002, Smith et al in press). In addition, two recent projects focusing on marine algae AIS are described below. Further information on these two projects is contained in the associated websites, and several publications are planned to come out of these two projects:

- **"Macroalgal Ecology and Taxonomic Assessment for HCRI-RP sites"** (Principal Investigators Abbot I.A. and C.M. Smith, with Smith, J. and R. Okano)

  http://www.botany.hawaii.edu/GradStud/smith/CRAMP/TEAM-homepage.htm

  Funded by Hawai'i Coral Reef Initiative-Research Program (HCRI-RP) and led by a team of scientists from the University of Hawai'i at Manoa Botany Department in 2001, this was the first systematic effort to collect and catalog the diversity of algal species in Hawai'i. Over 1200 specimens were collected from 33 sites throughout the Islands. 791 species were identified, although 200 are tentative and require further study. Twenty-eight species not previously seen in Hawai'i were documented. Results can be accessed at website of The Taxonomy and Ecology of Algal Macrophytes (TEAM). TEAM was initiated in the spring of 2001 and is sponsored by the HCRI-RP. The primary purpose of this research program (TEAM) is to provide taxonomic and ecological algal expertise for the Coral Reef Monitoring and Assessment Program (CRAMP).

- **"Ecological Success of Alien / Invasive Algae in Hawai'i"** (Principle Investigators Hunter, C.L., and C.M. Smith, with Smith, J. and E. Conklin)

  http://www.botany.hawaii.edu/GradStud/smith/websites/ALIEN-HOME.htm

  This study, also funded by HCRI-RP and led by researchers from the University of Hawaii's Waikiki Aquarium and Botany and Zoology departments, surveyed 81 sites throughout the main Hawaiian Islands in 2000–2001. Results of this study were used to document and map the distributions of the nonnative species of marine algae in Hawai'i, to document any locations which seem to be impacted by invasive algae, to identify the growth parameters of these algal species under a variety of nutrient (nitrogen and phosphorus) regimes, and to determine if there are any predators/herbivores that would consume these plants in the field.

[1]When descriptions are presented, they have been excerpted either directly from the proposals, published work, postings on associated websites, and/or from personal communication with the author.

Relating to Marine Fish AIS

FOCUSING ON TA‘APE:

1) **“Ecology of Commercial Snappers and Groupers Introduced to Hawaiian Reefs”** (Oda and Parrish 1981). This was a preliminary study on the diet and habitat ecology of the ta‘ape and a native soldierfish (menpachi) in waters to about 30 m deep. This study of the taape’s ecology and interactions with native species, centered about feeding relationships focused on feeding and habitat utilization of the ta‘ape, and sought to explain its effects on the local inshore fishery.

2) **“Ta‘ape Market Development Project”** (Kushima 1989)
In 1985, DLNR-DAR undertook a market development project to determine whether or not the market for ta‘ape could be expanded by increasing consumer awareness.

3) **“Interactions of Nonindigenous Blueline Snapper (Ta‘ape) with Native Fishery Species”** (Parrish et. al. 2000). Funded by DLNR-DAR, and carried out by researchers from the University of Hawaii’s Hawai‘i Cooperative Fishery Research Unit, this study examined fishery, habitat, and trophic interactions between the ta‘ape and several species of native deep-water lutjanid snappers in the subfamily Etelinae that support the valuable Hawaiian deep-water bottom fishery. The goals of this study were to assess the magnitude of predation by ta‘ape on important native eteline snappers (and vice versa), the potential for competition for food resources, and the potential for competition for important habitat. Results from this large-scale 3 year study suggest that introduced ta‘ape shows little if any aggression toward native snappers, generally does not share the same depth and feeding habitat with most native species, overlaps little in diet, and is not a frequent predator on or prey of the natives. Overall, the study did not find evidence of strong negative effects of ta‘ape on adults of native fishery species in these habitats.

4) **“Ecology of the Introduced Snapper *Lutjanus kasmira* in the reef fish assemblage of a Hawaiian Bay”** (Friedlander et al. 2002).
This study looked at the adaptations of the ta‘ape to the benthic communities in a shallow bay off the island of Kaua‘i. Among other findings, the study showed 1) a dominance of benthic invertebrates (shrimp and crab) in gut contents, as well as small sand-dwelling fish; 2) no demonstrable predation by ta‘ape on native fishery species or vice-versa, and 3) no suggestion of a strong common dependence on limited resources such as space, shelter, food, or foraging grounds with other native species.[2]

FOCUSING ON ROI:

5) **Preliminary Gut Sampling of Roi[3]**
DLNR-DAR conducted preliminary sampling of roi in 1999 and 2002 in Kukio Bay, Big Island to address potential threats by roi in the light of management of the aquarium fish industry and the main Hawaiian reefs in general. Ciguatera abundance in roi and feeding biology were key questions. These studies showed 64% of individuals contained ciguatera, and that there was not a correlation of ciguatera with size of individuals in Kukio Bay. 73% of gut samples were empty; this low number allowed only limited prey composition analysis, and no conclusion could be made about whether prey preference could be responsible for ciguatera accumulation in certain roi individuals.

6) **DLNR-DAR Monitoring Studies[4]**
DLNR-DAR has examined transect data of 23 sites in West Hawai‘i over a 3-year period and this data suggests that there is no relationship between roi abundance and the numbers of fish species or individuals. In contrast to what would be expected if roi were “eating everything”, the numbers of other fish-eating predators was positively related to roi abundance. That is to say that where there were lots of roi, there were also lots of other piscivores.

Inland Water AIS Issues

Relating to General Inland Water AIS

1) **“Biodiversity of freshwater and estuarine communities in lower Pearl Harbor, O‘ahu, Hawai‘i with observations on introduced species**” (Englund et al. 2000b). This technical report provides extensive habitat descriptions and species lists of native and introduced freshwater and
estuarine species found during Bishop Museum surveys of Pearl Harbor.

2) **“Nonindigenous freshwater and estuarine species introductions and their potential to affect sportfishing in the lower stream and estuarine regions of the south and west shores of O‘ahu, Hawai‘i”** (Englund et al. 2000a). Surveys of all south shore O‘ahu estuarine and lower stream mouth areas (exclusive of Pearl Harbor) are compiled in this report, with a list of native and introduced taxa found within each surveyed area.

[2]Findings taken from Powerpoint presentation by Walsh, W.J. 2003.
[3]This description taken from Birkeland et al. 2002.
[4]Findings taken from Powerpoint presentation by Walsh, W.J. 2003.

3) **Hawaii's Native and Exotic Freshwater Animals.** (Yamamoto and Tagawa 2000)
   This book describes the native and nonnative freshwater animals found in Hawaii's streams and reservoirs.
4) **"The loss of native biodiversity and continuing non-indigenous species introductions in freshwater, estuarine, and wetland communities of Pearl Harbor, O'ahu, Hawaiian Islands"** (Englund 2002).
   This paper resulted from intensive surveys of Pearl Harbor springs and stream mouth areas. It provides a description of the decline in native aquatic insects resulting mainly from aquatic species introductions, and investigates the pathways of invasions of introduced species. The Pearl Harbor area retains some surprisingly good aquatic habitats, especially in the extensive spring complex that is one of the largest spring areas in the tropical Pacific. Although these habitats often have excellent water quality, all are severely biologically degraded because of the many invasive species that have been purposefully or sometimes accidentally introduced into them.

Relating to Inland Water Invertebrate AIS

CRUSTACEANS:

1) **"The occurrence and description of Neocaridina denticulata sinensis (Kemp, 1918) (Crustacea: Decapoda: Atyidae), a new introduction to the Hawaiian Islands"** (Englund and Cai 1999).
   The introduced grass shrimp (*Neocaridina denticulata sinensis*) is an extremely aggressive invasive shrimp species that out competes the highly desired native shrimp *Atyoida bisulcata*. This paper provided evidence that aquarium stores were the source of this invasive species into O'ahu streams.
2) **Crustaceans. In: Hawaii's Invasive species. A guide to invasive plants and animals in the Hawaiian Islands** (Eldredge and Englund 2001a).
   This book chapter reviews the impacts of invasive freshwater crustacean species on the native Hawaiian stream fauna, and describes how these species have negative impacts on Hawaiian culture by impacting taro lo'i.

AQUATIC INSECTS:

1) **"Long-term monitoring of one the most restricted insect populations in the United States, Megalagrion xanthomelas (Selys-Longchamps), at Tripler Army Medical Center, O'ahu, Hawai'i** (Zygoptera: Coenagrionidae)" (Englund 2001).
   Three-years of monitoring this very rare native damselfly species are discussed in this paper. The native *Megalagrion xanthomelas* is almost extinct due to predation from invasive fish species, and exists now only in 100 meters of stream.
2) **"Report on long-term aquatic insect monitoring in 2002 by Hawai'i Biological Survey, Bishop Museum in Pelekunu Valley, Moloka'i, Hawai'i"** (Englund and Arakaki 2003).
   Since 1991, Pelekunu Stream on Molokai has been periodically monitored by Bishop Museum staff in cooperation with The Nature Conservancy Moloka'i, for native and introduced aquatic insects. Long-term monitoring trends indicate native freshwater insect species, such as two threatened species of *Megalagrion* damselflies, and several rare species of dolichopodid flies, continue to maintain healthy populations despite their extinction in most other Hawaiian stream habitats. The continuing lack of invasive fish and amphibian species in Pelekunu Stream is the primary reason for the continued maintenance of extremely high freshwater biodiversity in this system. This stream is one of the last free-flowing, pristine streams in Hawai'i and of utmost conservation importance.
3) **"A reassessment and new State records of Trichoptera occurring in Hawai'i with discussion on origins and potential ecological impacts"** (Flint, Englund, and Kumashiro, 2003).
   Invasive aquatic insects have received little attention in Hawai'i due to their generally small size and often innocuous nature. This paper documents the geographic source area and the fast spread of a highly invasive aquatic insect species. Ecological impacts to endemic aquatic insect species are also postulated.

APPLE SNAILS AND OTHER FRESHWATER MOLLUSKS:

A variety of efforts (Cowie 1995, 1996 1997, 1998, 1999 2001, 2002; Lach and Cowie 1999; Lach et al. 2001) have been undertaken to examine the introduction, distribution, ecology, and impacts of nonnative freshwater mollusks in Hawai'i.

OTHER FRESHWATER INVERTEBRATE AIS:

1) **Other invertebrates.** ***In: Hawaii's Invasive Species. A guide to invasive plants and animals in the Hawaiian Islands*** (Eldredge and Englund 2001b).
   This book chapter reviews the impacts of freshwater leeches on the native Hawaiian stream fauna, and describes how introduced aquarium fish had the unintended consequence of bringing in unwanted leech parasites that decimate native fish species.

Relating to Inland Water Fish AIS

1) **"The impacts of introduced poeciliid fish and Odonata on endemic *Megalagrion* (Odonata) damselflies of O'ahu Island, Hawai'i"** (Englund 1999).

   Native damselflies are large and beautiful stream invertebrates that are currently highly threatened in the Hawaiian Islands. This paper documents a link between the spread of invasive poeciliid fish (mosquitofish, guppies, and mollies) introduced into Hawai'i in 1905, and the decline of all native freshwater damselfly species.

2) **"Preliminary identification and current distributions of two suckermouth armored catfishes (Loricariidae) introduced to O'ahu streams"** (Sabaj and Englund 1999).

   Current distributions and identifications of two highly invasive fish species were documented in this paper. These heavily armored fish are herbivores and undoubtedly consume the same food resource used by native stream fish species. Densities and biomass of armored catfish have reached exceedingly high levels in areas such as Manoa Stream, such that native fish species are virtually absent from this stream.

3) **"Alien rainbow trout (*Oncorhynchus mykis*) (Salmoniformes: Salmonidae) diet in Hawaiian Streams"** (Kido, Heacock, and Asquith 1999).

   The diet of the rainbow trout intoduced by the State of Hawai'i into streams of the Waimea River on Kaua'i were examined in this study through gut content analysis. In Wai'alae Stream, rainbow trout were found to be opportunistic general predators efficient at feeding on invertebrate drift. Native aquatic species, particulary dragonfly (*Anax strennus*) and damselfly (*Megalagrion heterogamias*) niads, lymnaeid snails (*Erinna aulacospira*) and atyid shrimp (*Atyoida bisculcata*), were determined to be major foods for nonnative trout. Terrestrial invertebrates (primarily arthropods), however, provided a substantial (albeit unpredictable) additional food supply. Based on results of this study, the authors cautioned that large numbers of rainbow trout indiscriminately released into lower- to middle-elevation reaches of Hawaiian streams could do substantial damage to populations of native aquatic species through predation, competition, and/or habitat alteration.

   Editor's note: see alternate findings in study (5) below.

4) **"The Fang-Toothed Blenny *Omobranchus ferox* (Herre, 1927) from Pearl Harbor, O'ahu, a probable unintentional introduction to the Hawaiian Islands"** (Englund and Baumgartner 2000). This paper documents the finding of a new and potentially harmful invasive fish species to the Hawaiian Islands. The highly aggressive fang-toothed blenny can live in pure freshwater, and has the potential to outcompete other native benthic estuarine fish species as well.

5) **"Evaluating the effects of introduced rainbow trout (*Oncorhynchus mykiss*) on native stream insects on Kaua'i Island, Hawai'i"** (Englund and Polhemus 2001).

   Streams with and without rainbow trout in the nearly pristine Alakai plateau of Kaua'i were examined for this introduced species' impacts. Rainbow trout were not found to be invasive, and reproduced naturally in a very limited portion of a few high-elevation sections of Kaua'i streams. Findings of a limited range of trout, along with a lack of statistical differences in the rare native aquatic insect species composition between streams containing and lacking trout, provided the conclusion that trout were not impacting the native aquatic fauna of Kaua'i streams. It was concluded because trout are not invasive, they had no measurable impact on native Hawaiian stream fauna.

   Editor's note: see alternate findings in study (3) below.

6) **Fishes. *In: Hawaii's Invasive Species. A guide to invasive plants and animals in the Hawaiian Islands*** (Englund and Eldredge 2001).

   This book chapter reviews the impacts of invasive fish species on the native Hawaiian stream fauna. It highlights the most invasive species and documents their known and postulated negative impacts.

   Editor's note: In addition to the studies referred to above, numerous stream and other inland waterway monitoring efforts have been undertaken across the State. Though the majority of those efforts were not specifically focussed on AIS aspects, many of the studies did include observation and subsequent discussion on AIS.

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**though not directly involved in the drafting of the plan, these individuals were kept updated on the development process.*

Alien Aquatic Organism Task Force (AAOTF) Members

(The AAOTF was formed before the beginning of the development of this plan, to address ballast water and hull fouling issues, as further detailed in Chapter 3.

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Review and Comment Period

A draft version of the State of Hawai‘i Aquatic Invasive Species Management Plan was available for a 3-week public review and comment period, beginning July 2, 2003 and continuing through July 23, 2003. Comments submitted after the official period were still accepted through August 15th, 2003.

Notice of the public comment period was sent to all individuals involved with the drafting of this plan, including industry and affiliate members. In addition, a notice was posted on various list-servers, including the internationally subscribed to Aliens-L, as well as the statewide subscribed to CGAPS-L and AllISCS-L. A notice was also forwarded to the “Hawai‘i Coral Reef Community” mailing list that is maintained by the Department of Land and Natural Resources, Division of Aquatic Resources.

Press releases were issued to all local newspapers, and associated articles ran in the *Maui News* and the *Honolulu Weekly*.

Public information meetings (in addition to the public scoping meetings detailed in the following pages) were held on Kaua‘i, Moloka‘i, Lana‘i, and in Kona on the island of Hawai‘i. These meeting dates were advertised via paid and public notices in the local papers, and emails with the dates were sent out directly to numerous individuals, as well as to the major aquaculture development entities.

The Federal Aquatic Nuisance Species Task Force also had 1-month period for preliminary review of the draft version of the plan.

All comments received during the comment period were reviewed, and many changes and suggestions have been incorporated. All comments are available for further review as part of a separate attachment from this plan. Comments from initial public scoping meetings on Maui, Hawai‘i, and O‘ahu are included below.

Comments from the Maui Scoping Meeting—April 2003[1]

This meeting was held on April 14, 2003 in Kihei, Maui, and was geared toward those who would likely be involved in management solutions for AIS issues on Maui. The meeting aimed to a) ensure awareness of the development of the AIS Management Plan for Hawai‘i; b) facilitate understanding of the threats and extent of aquatic invasive species throughout Hawai‘i; and, c) solicit feedback on AIS concerns and suggestions for AIS management. Twelve people attended the meeting, representing the dive community, resource managers, educators, state and county agencies, as well as private citizens affected by algae blooms.

Miki Lee of Leeway Enterprises facilitated the meeting. An overview of the AIS Management Plan was given by Andi Shluker of The Nature Conservancy. Jennifer Smith of the University of Hawai‘i Botany Department gave a presentation on marine AIS issues, with an emphasis on marine algae AIS and native algal species that have invasive properties. A presentation on current and expected research of algae blooms off Maui’s reefs was also given by Jennifer Smith. A draft version of the plan’s strategies and tasks for addressing marine algae AIS was presented. Participants were then asked for their suggestions of additional tasks to be included in the plan. A summary of the specific comments made by participants is listed below. These comments have not been edited, and all comments from the meeting are included.[2]

OBJECTIVE 1: Coordination

- Use “neighbor islands” instead of “outer islands”.
- Need coordinated information release and cooperation responding questions.
- Get support for SB1505 and HB900 (for the Hawai‘i Invasive Species Council).
- Identify point persons / agencies for neighbor islands.
- Actual management must be linked by players in specific geographic areas. Don’t include too many outside agencies for specific area management- look at partnerships.
- Host a “Status of the Invasion” workshop or “Progress Reports” for each island annually to share information between and within the islands.
- Increase knowledge and coordination between scientists, resource managers, and introduction and control agencies (i.e, HDOA).

OBJECTIVE 2: Prevention

- Water quality data should be made public-cumulative impacts from development not being monitored.
- Nutrients are not being reduced, hence algae impacts continue to spread.
- Have the state designate “ecologically sensitive” marine areas, i.e, areas with little to no invasive algaes (i.e, Kaho‘olawe); these areas may get more regulatory protection regarding inter-island boat travel; research vessels should get hull checked before entering these areas.
- Vessel discharge enforcement.
- Watershed education to reduce nutrient sources and drainage runoff.
- Suggestions to reduce algal introductions into other dive areas.

[1]Many thanks to Holly Crosson (UC-Davis’s Aquatic Invasive Species Management Plan Coordinator) for her ideas and suggestions on the process of putting together a stakeholders’ meeting, including aspects relating to the format of the meeting itself as well as this summary.

[2]The term "nuisance" is referred to in these comments, as this meeting occurred when this plan was termed the Aquatic Nuisance Species Management Plan. For the Maui comments, "nuisance algae" refers to both native and nonnative algae species.

- DobAR should require "clean hull" check from DoCARE or DAR before vessel gets HA#, repeat hull inspections every few years. DAR should keep records of invasives found on such hulls.
- Concentrate outreach to golf courses re: BMPs for fertilizer applications.

OBJECTIVE 3: Early Detection, Rapid Response and Monitoring, and Restoration

- Comprehensive water monitoring stations at selected locations.
- Increase monitoring sites for ongoing monitoring such as CRAMP so can increase funding.

OBJECTIVE 4: Control, Eradication, and Restoration

- Establish groups such as the "limu pickers" or "save native limu" of divers on each island to conduct regular clean-up dives like beach or reef clean-ups. Standardize program within state-learn form the Oahu effort and transplant to outer islands.
- Encourage homeowner composting of algae; do a "how to compost algae" flyer.
- Check out Sea Grant's educational aquaculture facilities for urchin production possibilities.
- Raise and introduce native herbivores that will feed on nuisance algae.
- Construct traps along shoreline to collect seaweed and pump it from the water before it hits beaches.
- Develop cost effective dredging system, either pump or mechanical, to remove nuisance algae from the water.
- Develop rinsing and sand separating equipment for efforts with removal of nuisance algae off the beaches.
- "Appropriation of $250K has been secured" (not $200K). However $50k of this has been spent on research leaving only $200k- maybe that's why you have $200K.
- Change to "on Waipuilani Beach" from "Maui's Beaches".
- Seaweed sucker machine would be best for Kahului Harbor.

OBJECTIVE 5: Education and Outreach

- Need to work with limu pickers, fisherman, and divers.
- Train all UH Research divers in in-field identification of the top 5 invasive algaes.
- Work with Reef Check to include the top 5 invasive in their check-list in their Reef Check packets.
- Increase participation in REEF fish counts for nuisance species.
- Coordinate with Maui Invasive Species Council (MISC), which is currently the most effective education /outreach group on Maui.
- Work with Ka Hea Loko on Maui, an education group for 4th-12th graders with DOE with emphasis on fish ponds. (Director Herbert Lee in O'ahu).
- Aggressively seek educational support and even funding from commercial snorkel and dive operators.
- Provide information for news and public education (basic information on biology, problems).
- Set up a lab to study seaweed at Maui Community College; visiting scientists could also use it.
- Coordinate with the Maui Coral Reef Network (bring Jen and Andi to a meeting).
- Jen Smith's slide show should be widely distributed for education and awareness.
- Develop curricula and educational materials (i.e., videos, etc) to help teachers teach this subject.
- Students at MOP were struggling with the identification of specific MOP projects. We thought of seaweed, but as a geologist, didn't know enough about the issues to recommend a study. This would be a great idea- if projects could be identified, I'd be happy to act as and advisor.
- Add: Provide materials to DAR outreach to help increase the public education of AIS issues.

OBJECTIVE 6: Research

- Establish a permanent research facility on Maui with staff.
- Ultimately, specific research to identify causes of nutrient-loading will assist with prevention for algae AIS.
- What about fish as biocontrols for alien algae?
- Nutrient studies of ground water adjacent to high algae growth areas.
- Is heavy fishing pressure on herbivore increasing algae blooms? If so, can we help control algal blooms with fishing regulations?
- 6A2- What factors are influencing the current distribution and abundance of these native urchins? Why aren't they naturally increasing in abundance in response to increased food?
- Study urchin blooms in the Galapagos for decreased impacts of this biocontrol option.

Additional Comments Regarding Regulation:

- Identify sponsors at state legislature and county governments.
- Link aquatic nuisance species prevention legislation to terrestrial invasive species prevention legislation to benefit from the political momentum in that area.
- AIS should be included in the permit process for all ships or boating.
- Increased regulation mandating reclaimed water usage (versus injection wells) and retrofitting cesspools in coastal areas.
- Regulate/inspect vessels permitted to enter previously designated "ecologically sensitive areas", i.e, those areas with little to no invasive species/invasive algae (i.e., Kaho'olawe to prevent introductions…) See Florida's no entry ecological reserve.
- Develop a regulation that prevents fallow agricultural lands from being fallow, i.e, they must be planted with at least ground cover or native grasses.

Comments from the Freshwater Invasive Species Scoping Meeting, Hilo—April 2003[3]

The US Fish and Wildlife Service on the island of Hawai'i (Big Island) took the lead in organizing this meeting to bring various interests on the Big Island together regarding the management of freshwater invasive species. This meeting was partly in response to earlier correspondence among resource managers and aquaculture farmers regarding specific Big Island problematic freshwater/anchialine species. The meeting was attended by representatives of US Fish and Wildlife, Big Island Invasive Species Committee (BIISC), Department of Land and Natural Resources' Division of Aquatic Resources (DLNR-DAR), University of Hawaii's Sea Grant Aquaculture Extension, Pacific Aquaculture and Coastal Resources Center (PACRC), the Big Island Water Garden Club, and The Nature Conservancy.

The original purpose of this meeting was to address specific invasive/nuisance species that were affecting the Big Island, and there was some preliminary discussion on this. However, it was decided by the group that a better use of time would be to move away from focusing on specific species, and instead share information and perspectives regarding actions that could be taken to address the wide range of issues associated with freshwater invasive/nuisance species. The remainder of the meeting was used to gather input from the group regarding specific suggestions and questions relating to Hawaii's AIS Management Plan.

The following is a listing of specific suggestions made by attendees regarding actions that should be considered for the management of aquatic invasive species. Please note that these comments are taken directly as written by the participants, and all of the suggestions have been included. As such, there are some overlapping ideas.

SPECIFIC SUGGESTIONS GIVEN BY INDIVIDUALS:

OBJECTIVE 1: Coordination

- Learn how to work with communities by taking a grass roots approach.
- Assemble a Big Island ANS Working Group [BIANSWG] that can act as an advisory board to permitting agencies.
- Create and maintain island-specific working groups.
- Invite diverse interests to join working groups – include commercial aquaculturists.
- BI ANS Working Group should have representation from aquaculture industry, aquarium society, Big Island Water Garden Club (Kona side too), DLNR, DAR, and Conservation council.
- Create a list server for members of BIANSWG.
- Output of BIANSWG should be strategic action plan for ANS control.

OBJECTIVE 2: Prevention of spread

- Work with partners to ensure enforcement and mitigate costs of enforcement.
- Require permits for importing, cultivating, and disposing of ANS.
- Conduct regular inspection of culture, farm sites.
- Enforcement of permit conditions for imported aquaculture species should be reasonable and attentive.
- Assess penalties for releases of ANS.
- Perform continual monitoring of natural environments.
- Establish an amnesty turn in location for ANS for all of Hawaii's residents.
- Make a certification program for nurseries/suppliers that do not carry ANS.
- Give monetary assistance to farmers and businesses to prevent escapes into native habitat.

OBJECTIVE 3: Early Detection, Rapid Response and Monitoring, and Restoration

- Install a public "hotline" for reporting ANS.
- Get industry representatives to watch for and report ANS or potential ANS.
- Record observations on species spread.
- Think about what we want to recognize – prioritize ANS and potential ANS.

OBJECTIVE 4: Control, Eradication, and Restoration

- Select only readily controllable cases of ANS , and consider other ANS cases for lower level management focus.
- Identify non-impacted ecosystems and act to preserve them – balance this against control of existing ANS.
- Make and keep a distinction between nuisance species in natural environment versus culture systems.
- Make a manual of control and identification methods available on the web.
- Increase awareness of Hawaii's ANS issues among catalog sources of plants/fish/etc. and provide lists of species that should not be shipped to Hawai'i.
- Improve coordination of the DOA to educate inspectors on approved species so that the process is not so inconvenient that people will "hide" plants and bring them into the state illegally.
- Use biological control with highly feed specific predators.
- Use pest-specific chemical control.

OBJECTIVE 5: Education and Outreach

- Do more PSA's like the DAR one on aquarium releases like the one by Yamamoto.
- Get the "don't dump aquariums" message out, and continue it.
- Create flyers, newspaper articles, TV spots, on the present critical issue or future disaster.

[3]The term ANS is used in these comments, as this plan originally started development as the Aquatic Nuisance Species Management Plan. Later, the word Nuisance was replaced by the word "Invasive", to more accurately reflect currently terminology.

Compelling statements, i.e. if "action x" is not taken, dire consequences result; strong argument

- Follow along with the terrestrial movement.
- Send the working group on a field trip, led by experts, to natural areas that have been impacted by ANS.
- Educate public about distinctions between species versus ecosystems – important message is that we want to preserve the ecosystem.
- Convey a balanced message about conservation– no harm to: Resources, Business development, Other values.
- Utilize a spokesperson to address relevant groups.
- Hold workshops and/or presentations.
- Create posters and/or displays at agriculture/aquaculture and public shows.

Additional comments regarding Rules/Regulations/Policy

- Make no unfunded mandates.
- Re: Aquaculture species importation
  1. review/clean up state lists – many things aren't listed,
  2. make new species easy to list as permitted,
  3. make individual use – permits strict and enforce them.
- Require observational, empirical support for naming species as ANS.

Comments from the Industry and Stakeholder Meeting, O'ahu—April 2003[4]

This meeting was held on April 25, 2003 in Honolulu, Hawai'i. The primary purpose of the meeting were to solicit questions, concerns, and suggestions from stakeholders on the development of Hawaii's AIS Management Plan. Invitations were sent to over 300 individuals via email and post, representing numerous industries and organizations. This included seafood marketers and producers, environmental groups, shipping and maritime industry, aquarium suppliers, pet stores, plant nurseries, divers, snorkelers, hotel tourism associations, and economic development councils. Additional invitations were sent to six key industry development groups - HDOA's Aquaculture Development Program, Hawai'i Aquaculture Association, Pacific Aquaculture and Coastal Resource Center, Hawai'i Sea Grant Aquaculture Program, the Center for Tropical and Subtropical Aquaculture, and Hawai'i Ocean Safety Team, with requests to extend the invitation to their members and affiliates.

Twenty-one people attended the meeting, representing dive operators, aquaculture farmers, marine researchers aquarium suppliers, shipping and maritime, recreational boaters, and the nursery industry. There was additional attendance by members of the AIS Steering Committee, with representation of various agencies including Hawaii's Department of Land and Natural Resources' Division of Aquatic Resources (DLNR-DAR), Bishop Museum, and the Hawai'i Department of Agriculture.

Miki Lee of Leeway Enterprises facilitated the meeting, and began by welcoming the group, introducing attendees, reviewing the meeting purpose, and summarizing the agenda. An overview of the AIS Plan was given by Andi Shluker of The Nature Conservancy. Presentations on AIS issues were given by Scott Godwin of the Bishop Museum and Mike Yamamoto of DLNR-DAR, discussing marine AIS issues and freshwater AIS issues, respectively. Athline Clark of DLNR-DAR discussed the Plan from the perspective of that state agency. Industry representatives Brad Rimmel of Sause Brothers Ocean Towing and Matt Zimmerman of Island Divers talked about the importance of industry participation in the development of the State of Hawai'i AIS Management Plan. Ken Matsui of the aquarium industry discussed education efforts that his industry has participated in, and shared examples of aquarium fish bags printed with guidelines for safe disposal of unwanted aquarium fish. Robin Bond of the Hawai'i Ocean Safety Team gave examples of the codes of conduct used by his organization. Andi Shluker shared the Pennsylvania Landscape and Nursery Association's Codes of Conduct, to show examples of how other states address invasive species. The remainder of the meeting was spent soliciting feedback from stakeholders. The feedback sessions were geared toward: 1) specific questions and concerns about AIS issues and/or AIS management; 2) specific suggestions for the management of AIS issues related to coordination, prevention of AIS entering Hawai'i and spreading throughout the islands, education and outreach, detection and control, and regulations and rules; and, 3) the elements of an effective plan. A summary of specific comments made by stakeholders is listed below. These comments are not edited, and all comments made have been included.

Coordination—

- Creation of a specific alien species division within DLNR that has focus on FW and SW environments.
- Trying to handle all types of ANS in one group is cumbersome. Break up into sub-groups to identify and work on the various major types of ANS (marine vessels, plants, fish, etc.)
- Funding targeting enforcement and response.
- Work with growers of aquatic plants to determine nuisance or beneficial aquatic plant.
- Continue to improve cooperative efforts between DLNR and DOA.
- Hire permanent people to do the job (with funding).

[4]Many thanks to Holly Crosson (UC-Davis's Aquatic Invasive Species Management Plan Coordinator) for her ideas and suggestions on the process of putting together a stakeholders' meeting, including aspects relating to the format of the meeting itself as well as this summary.

- Re: snail farming—
  - ◊ 200 yds. from any open waterways (streams, ponds, etc.).
  - ◊ farming of snails should be done in closed, recirculating systems.
  - ◊ state should allow and pay for snail growers to police themselves and monitored by an individual with some powers by the state.

Prevention—

- Aquaculture industry should make a greater effort to work with native species rather than "known" or already developed species from outside of the state.
- Have marine biologists come up with procedure to prevent divers from introducing MIS..
- Introduce non-invasive water plants to fresh bodies of water to reduce amount of excess nitrates in water. This will reduce food for fast growing nuisance plants.
- Inspection of all live plants and animals coming to Hawai'i (already done by DOA?).
- Quarantine plants we know little about to determine if a threat to Hawai'i.
- Review procedure for approving request for introduction.
  - ◊ Should not be introduced unless there is "good reason" – good argument for introduction.
- Add to list of nuisance plants if nuisance or place on o.k. list.
- Develop a center of expertise (at UH?) to help assess the potential of newly proposed imported species to become invasive, based on all available information.
- Do more studies of freshwater lakes by water sample to determine nitrate levels and implement program to balance ecosystem.
- Investigate "bad introductions" (i.e. sea wasp) – research its biology to determine if it is possible for it to be accidentally introduced to Hawai'i and then post red flags to people and organizations where potential pathways are.
- Develop a more precise definition of nonnative species, such as those not found within the 200 mile EEZ.
- Put more resources toward the largest source of introductions – hull fouling.
- Obtain congressional support and authority to prevent the illegal introduction of aquatic organisms through priority or first class mail, freight forwarders and other transport mechanisms.
- Post more signs discouraging the release of fish and aquarium plants into park lakes.

Detection and Control—Suggestions

- Need to have dedicated group to be "rapid response team", develop plans, and define duties and lines of authority.
- Secure funding for quick response activity.
- Funded monitoring program involving experts for FW and SW environments. Program run by state.
- Place funds into study and monitoring of biota.
- Initiate or expand monitoring programs (nutrients, temperature, etc.) in marine areas in order to correlate "invasions" with changes in environmental conditions.
- Continue and expand support for baseline biodiversity studies, using detections and control of invasive species as a justification for funding.
- Ban sale of live snails.

Education and Outreach—Suggestions

- Brochures.
  - ◊ Fund/create informational brochures for people who may unintentionally introduce ANS (i.e. divers, pet owners, boat operators)
  - ◊ Distribute brochures to stakeholders and resource managers
- Education through trade magazines, newsletters, associations, etc.
- Distribute web-based information to stakeholders and resource managers.
- Outline specific guidelines for stakeholders.
- Better PSAs targeting the various sources of ANS (i.e. freshwater fish, snails, etc.).
- Continue support of and funding for public awareness and education on invasive species on a continuous basis.
- Some public awareness programs have already been effective, but the people working or dealing with aquatic environments need to be updated on a regular basis to reinforce policy.
- Get the word out to the public—hotels, dive operators, dive clubs, fishermen, etc. If they see anything they have never seen – document (what did it look like)—pictures—include date, where seen, depth
- Need to have an office to call and we need to have that office field the concern to appropriate person
- Plan for teaching modules in public school system.
- Produce a "package" of information that can be used in the public schools to educate children about invasive species and what to do or not to do to help keep them from spreading.
- Increase funding for education and outreach programs.
- Contact PADI for Project Aware (1800-729-7234), ask for either Project Aware or Kristen. They have grant money available – not enough for a major impact, but enough to be used in conjunction with other funds.

Regulations and Rules—Suggestions

- Make legislature aware of the problem of ANS and fund this type of program.
- Need to impress upon the state legislature and administration the importance of the need to dedicate funds to address this problem at all levels.
- Consider changing the ease at which animals are approved for import into the state, specifically new organisms.
- Place stress on importation permits for ecological impacts and risks. Examine cost of control and cleanup.
- Obtain authority to ban the sale of harmful alien species.

- Write regulations that provide a framework for monitoring, enforcement, and rapid response.
- Create clear guidelines that are allowed to be flexible to deal with a variety of events.
- Simplify regulations so individuals and companies are not swamped in paperwork and dealing with several different departments.
- Establish precise authorities and dedicated funding to effectuate enforcement activities.

Questions Asked

- How do you define "alien species?" Outside 3 miles? i.e. bacteria, etc. from Loihi?
- What is the baseline and how often is it monitored and updated?
- Do we need to differentiate between native and alien?
- Should we identify "pest species" in general and determine how to deal with the pest most cost effectively?
- Do we have a game plan – how to deal with a detected alien introduction if one does get in?

Concerns Raised

- Most eradication programs have been terrestrial systems. Marine environment – very difficult to eradicate species, therefore prevention is critical.
- Define "alien species" from a legislative viewpoint.
- Biological – need to work with legislature.
- Biocontrol is scary – use as a last resort – using a new species not already here.
- Protocols for outside bio-control candidates have improved – learn from mistakes.
- Develop controls using local species, i.e. papaya..
- Banning species already okay to come in… or already here.

Stakeholders' Highest Hopes – Elements of a Great Plan

- Government buy-in; Government support; Government participation
- Makes policymakers aware of rapid response to deal with new invasive species
  - ◊ Early authorization; pre-approval
  - ◊ Identifies biggest threats (taxonomically)
  - ◊ Give authority to a specific entity
  - ◊ Multi-jurisdictional work
  - ◊ Use of MOUs
- Measurable goals; Measurable results – define evaluative measures
- Very clear definitions
- Flexible – easy to change if/as needed
- Concise – very clear and simple rules/regulations
- Enforceable rules/regulations
- High profile – more people involved and in the water
- Engages and keeps community involvement
  - ◊ Open/active communication with communities
  - ◊ Active volunteers
- Involves/educates the general public – regular, broad
- Cost effective
- Should not unduly burden business
- Not financed by a tax increase – do not burden taxpayers
- Conveys the message of the importance of the ANS management plan for Hawai'i in economic and environmental terms
- Rank ANS threats
  - ◊ Likelihood of arrival of specific species and the resulting potential threats; Examine pathways of arrival; Helps DOA
- Coordinators have an obligation to respond to stakeholders and continue involvement and dialogue

THE NEED TO LIMIT THE SCOPE OF THE AQUATIC INVASIVE SPECIES MANAGEMENT PLAN

During the public scoping meetings and public comment period for the State of Hawai'i Aquatic Invasive Species Management Plan, questions and comments were raised regarding aspects that were not included in the plan. These aspects included

- the introduction of pathogens or bacteria from bilge/gray/black water from vessels;
- toxic waste and garbage;
- genetically modified organisms (GMO's)

These issues are already largely regulated through existing authorities because they deal with human health concerns. There is State, Federal, or international law covering many of the associated aspects. In addition, most of the issues in terms of introductions of pathogens are not necessarily seen as just as "invasive" issues, because they involve all pathogens, not just nonnative ones. Therefore, because these issues are already being addressed by other mechanisms, in combination with the idea that they are not explicitly dealing with primarily invasive organisms, the Federal Aquatic Nuisance Species Task Force had determined the issues to be largely out of the scope of state management plans. This does not mean that these issues cannot be addressed in future versions of the plan, should the State deem it appropriate.

However, though these aspects will not be covered as part of the plan, laws and other aspects relating to them are addressed briefly below[5]. This is done solely to help clarify the aspects, and to note that these aspects were not simply overlooked in developing this plan.

Bilge water

The bilge of a ship is the area at the very bottom of the hull; this area collects water and other substances (including oil) from various operational sources such as water lubricated shaft seals, cooling systems, evaporators and other machinery. It is illegal to dump bilge water at sea under international (MARPOL Annex I) and Federal (EPA-40CFR110 and USCG-33CFR151) regulations, unless it is treated to have an oil content of less than 15 parts per million and it does not leave a visible sheen on the surface of the water. Treated bilge water can only be discharged at sea if the vessel is "underway", and is not in a "special area". The "special area" category was setup by the International Maritime Organization (IMO) to protect certain areas that have heavy maritime traffic or low water exchange caused by being land locked.

Gray water and black water

Gray water is covered under Federal (USCG-33CFR151) regulations. Gray water is drainage from dishwasher, shower, laundry, bath, and washbasin drains. It can only be discharged from vessels that are underway at a speed of not less than 6 knots and more than 3 nautical miles from shore. Gray water cannot be dumped in port. Black water (sewage) is wastewater from toilets, urinals, medical sinks and other similar facilities. Black water is covered under regulations of the Environmental Protection Agency section 312 (33 U.S.C. 1322). The discharge requirements for black water are the same as for gray water, except black water must be processed before it can be discharged. Marine Sanitation Devices (MSD) are required by the US Coast Guard (33CFR159) and are used to prevent the discharge of untreated or inadequately treated black water. MSD use physical, chemical and/or biological processes to treat black water so it can be discharged. Vessels that have an approved MSD can dump treated black water within 3 miles from shore.

Toxic waste and garbage

The dumping of toxic waste is never permitted. There are international regulations (Annex V of MARPOL) concerning the disposal of garbage outside "special areas". As far as the 3-mile limit on garbage being dumped, there are U.S. Coast Guard regulations (33CFR151) covering this matter. It is illegal to dump all plastics at sea. Trash (non-plastic) and garbage (food waste) are not to be discharged within 3 nautical miles and must be ground to less than one inch pieces in order to be discharged 3-12 nautical miles offshore. Beyond 12 nautical miles, these items can be discharged with no size limitations. These items cannot be discharged in "special areas" described previously.

In 1996, the IMO created and adopted a protocol that is intended to replace the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. The 1996 Protocol is more restrictive than the 1972 Convention, but it is not yet in force. Although the United States has signed the Protocol, it has not yet ratified it. The 1996 Protocol specifies that only seven items can be dumped at sea: 1) Dredged material, 2) Sewage sludge, 3) Fish waste or material resulting from industrial fish processing operations, 4) Vessels and platforms or other man-made structures at sea, 5) Inert, inorganic geological material, 6) Organic material of natural origin, and 7) Bulky items primarily comprising iron, steel, concrete and similar unharmful materials.

Cruise ships

The State of Hawai'i and the members of the North West Cruise Ship Association signed a memorandum of understanding on October 2002 covering all of the items mentioned above. Cruise ships are also covered for the ballast water issue under the State's ballast water and hull fouling Alien Aquatic Organism Prevention Program. Cruise ships are also governed by the same laws as other vessels.

Genetically Modified Organisms (GMOs)

The Federal Aquatic Nuisance Species Task Force has not included GMO's as an issue to deal with as part of the invasives realm at this point.[6] However, the Task Force has indicated that they will likely take a closer review at this issue. As such, at least for the first year's version of this plan, GMO's will not be covered, beyond how they are already covered by regulations in place, such as the Hawai'i Department of Agriculture's permit process for importations, further detailed in Appendix H.

Summary

The Steering Committee acknowledges that the above items are of concern to human health and the environment, and may even be possible pathways for new introductions into Hawai'i. Though they will not be further discussed in this plan, these aspects will be incorporated into further discussions to see if and how they should be integrated into the solutions for addressing aquatic invasive species.

[5]Text on bilge/gray/black water as well as toxic wastes and garbage prepared by P. Murakawa (DLNR), with the assistance of L. Paul (Hawai'i Audubon Society), Dale Hazlerhurst (Matson Shipping), and Liz Fairey (NOAA).

[6]Sharon Gross (Federal ANS Task Force), Personal Communication 2003.

Appendix G: **Aquaculture Development Entities in Hawai‘i**

The following organizations and groups (listed in alphabetical order) play key roles in the aquaculture industry of Hawai‘i, in terms of development, funding, research, and/or promotion of the industry. Through the writing of this plan, it became clear that these organizations can also play pivotal roles in helping to address AIS issues throughout the State, and resource managers should engage these and other organizations when seeking long-term solutions.[1]

Aquaculture Development Program (ADP)—Under the Hawai‘i Department of Agriculture

ADP provides a wide range of support for Hawaii's aquaculture industry. ADP is a planning, development and problem-solving organization, whose goals are to get (aquaculture) production and service businesses started, and once started to help ensure their success through active assistance.

In terms of addressing AIS issues, the Aquaculture Development Program houses the Disease Diagnosis and Prevention Program managed by the State Aquaculture Veterinarian, who provides diagnostic services to the aquaculture industry. Services include inspection of imported farmed species; assistance with maintaining health status of farms and research facilities, such as the University of Hawai‘i, Oceanic Institute, and Anuenue Fisheries Research Center; inspection of the health status of newly introduced aquaculture nonnative species; and provision of a voluntary disease survey and certification program for pathogen-free shrimp to broodstock exporters. In the future, plans are to extend the surveillance program to the cultured aquarium species.

Additional major areas of assistance that ADP provides to the industry include: planning and coordination, information dissemination, business and site counseling, marketing, research, and development funding. More information can be found at http://www.hawaiiaquaculture.org/introduction.htm

Center for Tropical and Subtropical Aquaculture (CTSA)

CTSA is one of five regional aquaculture centers in the United States established by Congress and funded by an annual grant from the U.S. Department of Agriculture's Cooperative State Research Education and Extension Service. The regional aquaculture centers integrate individual and institutional expertise and resources in support of commercial aquaculture development.

CTSA was established in 1986 and is jointly administered by The Oceanic Institute and the University of Hawai‘i. The CTSA administrative office is located at The Oceanic Institute on windward O‘ahu, and the publications and information office is located at the University of Hawai‘i at Manoa.

The Center for Tropical and Subtropical Aquaculture's mission is to support aquaculture research, development, demonstration and extension education to enhance viable and profitable U.S. aquaculture. CTSA is industry driven and currently funds research projects throughout the American Insular Pacific which address aquaculture industry challenges. Unlike the other centers, which work within a defined geographical region, the CTSA "region" encompasses tropical and subtropical species wherever they are cultured. More information can be found at www.ctsa.org.

Hawai‘i Aquaculture Association (HAA)

The Hawai‘i Aquaculture Association (HAA) was formed in 1993 for the purpose of unifying the various aquatic plant and animal producers and researchers in the State to address concerns and to promote the industry as a whole. The mission of the HAA is to foster the development of commercial aquaculture production in Hawai‘i. The HAA brings together the various commercial and support entities of the Hawai‘i aquaculture industry to facilitate information exchange and to create a united industry perspective. It provides a political presence by acting as a unified voice for the industry on issues affecting the stability and growth of the industry. More information can be found at www.hiaqua.org.

The Oceanic Institute

The Oceanic Institute, founded in 1960, is a not-for-profit, research and development organization dedicated to marine aquaculture, biotechnology, and coastal resource management. It is located at Makapu‘u Point on O‘ahu and has additional research facilities on the island of Hawai‘i. The Institute develops leading marine science technologies designed to increase aquatic food production and to restore marine fisheries. Research on the culture of marine shrimp and finfish species includes complete life-cycle technologies, nutrition, aquatic feeds, and environmentally responsible production system design. The Oceanic Institute offers educational and professional training workshops, conducts collaborative research, provides technical services, and enters into partnerships to protect the ocean's resources and to advance the aquaculture industry. The Institute is affiliated with Hawai‘i Pacific University. More information can be found at http://www.oceanicinstitute.org/

[1]All descriptions come either directly from the organization's web pages or from representatives of the respective organization.

Pacific Aquaculture and Coastal Resources Center (PACRC)

The Pacific Aquaculture and Coastal Resources Center (PACRC) is now being developed at two sites on the Big Island of Hawai‘i: a coastal site (Keaukaha) adjacent to the Hilo port, and an inland site (Panaewa) six miles away. Its long-term goals are to:

- provide infrastructure needed for world-class aquaculture and marine science programs at the University of Hawai‘i at Hilo;
- support commercial aquaculture, fisheries and eco-tourism in east Hawai‘i; and
- transfer technologies developed and tested at the Center to similar coastal areas throughout the world.

At Keaukaha, an old wastewater treatment plant is being converted into the physical core of the Center. The initial focus at Keaukaha will be ornamental fish culture and the cultivation of pearl oysters while the primary purpose of the Panaewa site will be quarantine, health management and integrated agriculture-aquaculture farming systems. More information can be found at http://www.uhh.hawaii.edu/~pacrc/

Sea Grant Extension Service’s (SGES) Aquaculture Extension Program—Under the University of Hawai‘i

The major role of the University of Hawaii’s Sea Grant Extension Service’s (SGES) Aquaculture Extension Program is to serve as a bridge between researchers involved in developing technologies to improve production capabilities, hatchery operations, husbandry practices, identification of new species and transferring the developed technologies to Hawaii’s aqua-farmers. Community outreach and public education are also important components of the aquaculture extension program. All of the activities are focused on developing the aquaculture industry in Hawai‘i to become a significant contributor to the State’s economy.

There are three major long term goals of the aquaculture extension project that remain the same from previous years. However, specific activities under each objective continually change to incorporate current farmers’, researchers’ and administrators’ concerns and needs, as well as reflect supplementary funding secured to carry out specific projects. The major goals are:

1. Incorporate advanced culture techniques that result in efficient and cost effective production of aquafarming activities within the State.
2. Contribute to the continued diversification of aquaculture activities by increasing the number of species being cultured for both food and ornamental markets. Increase the amount of research and development initiatives which will ultimately result in Hawai‘i becoming a major center for technology development.
3. Collect and disseminate aquaculture information to aquafarmers, businesses, researchers, and to the general public. Participate in the educational programs in schools by providing technical support to the aquaculture activities.

More information on SGES can be found at http://www.soest.hawaii.edu/SEAGRANT/extension.html

Import Requests for Non-Domestic Animals

As referred to earlier in Chapter 3, the importation of non-domestic animals is regulated by a permit system pursuant to H.A.R. § 4-71. Application requests are reviewed by the appropriate Hawai'i Department of Agriculture (HDOA), Plant Quarantine Branch (PQB) specialist to determine the entry status of the organism, as well as any permit requirements and conditions that must be met before a permit is issued. Permit requirements may include one or all of the following:

- Site inspection approval to determine if proper safeguards can be maintained at the facility to prevent the unintentional release or unauthorized removal of the organisms imported under permit.
- Require pre-entry disease- and parasite-free certification by a licensed veterinarian from the place of origin.
- Proper effluent disinfection by approved methods and disposal of discharge water.
- Subject to post-entry inspections during normal business hours by PQB personnel.

Permit conditions that are established by the Board of Agriculture may also include the following:

- Proper labeling and declaration of shipments upon arrival for inspection and clearance by PQB personnel at designated ports-of-entry.
- Imported animals may be held under strict quarantine conditions until examined and released by the State Aquaculture Disease Specialist.
- Transport water must be disinfected to prevent the entry of parasites that may be associated with the holding water.
- Submission of semi-annual inventory reports to account for any births or deaths, animals shipped or sold, and the current status or disposition of the organisms currently under permit.

Review Process for Unlisted Species

Due to the complexity and broad scope of responsibilities concerning the import of non-domestic animals and microorganisms, the PQB employs the use of five specialists within the program to handle permit requests. Their specialties include invertebrate and aquatic biota, insects, land vertebrates, microorganisms, and plants. Because the lists incorporated in H.A.R. § 4-71 do not include all organisms, there is a submission process that can be employed to request review of unlisted organisms. This request must be submitted to the Board of Agriculture for their review and determination. Prior to the Board's action the request will go through a multi-tiered review process.

The applicant or requestor will need to provide information including:

- Reasons for the introduction including the purpose of the introduction and if for research, what is the long-term purpose of the introduction;
- Person (or persons) responsible to conduct the work or research and held accountable for the safeguarding and use of the organism;
- Description and location of the facility with the exact address of the site, including the following plans:
  - ◊ How will the organism be contained to prevent escape, accidental release or theft?
  - ◊ What additional precautions will be taken to prevent escape, accidental release or theft of the organism?
  - ◊ If applicable, what will be done to assure compliance of the facility and its operational procedures with animal welfare provisions?
- Method of disposition (if necessary) after completion of study or use.
  - ◊ How will the organism be disposed of after completion of study or use?
  - ◊ What methods or treatments are available and could be used to capture or eradicate this organism should it escape or be released unintentionally?
  - ◊ What methods or treatments are available and could be used to control this organism should it become established in the wild?.
- An abstract of the organism including the following information:
  - ◊ Whether the organism has any close relatives (genera or species) occurring in Hawai'i;
  - ◊ The biology of the organism including its reproductive habits (sexual or asexual), growth rate, biotic potential, size at maturity, longevity, etc.
  - ◊ What does the organism feed on, including any related foods or hosts in Hawai'i, and addressing primary and secondary foods or hosts?
  - ◊ What is the native range of the organism, including other areas where it is established, cultured, or farmed?
  - ◊ What are the temperature requirements of the organism addressing both optimal temperature range and

[1]This section authored by D. Cravalho, Hawai'i Department of Agriculture, with additional editing by K. Moffie.

maximum or minimum temperatures at which this organism can survive or reproduce?

- ◊ What are the habitat (i.e., ocean reef, flowing streams) and niche (i.e., algae feeder, predator) requirements of the organism?
- ◊ What precautions (i.e., health certification, quarantine, treatments) will be taken to prevent the introduction of pathogens, parasites or attached organisms with, in, or on the introduced organism?
- ◊ What other pre- and post-entry requirements will be taken to prevent the introduction of contaminants?

- Any other documented information that supports and justifies the request including:
  - ◊ Is this organism considered a pest in its native range or in any other area where the organism was introduced and became established? Describe the circumstances.
  - ◊ What are the potential environmental, economic and societal impacts of pathogens, parasites or other contaminants that may accompany the introduction?
  - ◊ What is the potential for this organism to become established in Hawai'i should it escape confinement, and how might it become established?
  - ◊ What other permits have been received or applied for relative to the request (i.e., USDA, USFWS, State Health or Land and Natural Resources Departments)?
  - ◊ Any other pertinent literature and a bibliography of any other citations that support the request.

After the required information and application is provided, the materials are reviewed by the appropriate PQB Specialist for accuracy and completeness. Once the information is accepted, the PQB Specialist prepares and submits a formal request for review and comment by the appropriate subcommittee, which in the case of aquatic organisms, is the Advisory Subcommittee on Invertebrate and Aquatic Biota. This Advisory Subcommittee is made up of the following technical consultants:

- Department of Land and Natural Resources—Division of Aquatic Resources Administrator
- Department of Agriculture—Aquaculture Development Program Manager
- State Aquaculture Disease Specialist
- Waikiki Aquarium Director
- University of Hawai'i—Zoology Department Representative
- National Marine Fisheries Service Director
- Bernice Pauahi Bishop Museum Ichthyologist
- Bernice Pauahi Bishop Museum Invertebrate Zoologist
- Pet Industry Representative

After receiving feedback upon the initial review of the request, the recommendation and comments from the Advisory Subcommittee are compiled by the PQB and forwarded to the Advisory Committee on Plants and Animals for its review at a public meeting. The Advisory Committee focuses on the environmental issues associated with the organism and also accepts and considers any testimony given from the general public in support of, or against the request. The Advisory Committee members include:

- Department of Agriculture—Plant Industry Division Administrator
- Department of Land and Natural Resources—Division of Forestry and Wildlife Representative
- Department of Health—Office of Environmental Quality Control Administrator
- Department of Health—Sanitation Branch Manager
- University of Hawai'i—Plant and Environmental Protection Sciences Representative
- University of Hawai'i—Hawai'i Undersea Research Laboratory Biologist
- University of Hawai'i—College of Tropical Agriculture and Human Resources Plant Pathologist
- Honolulu Zoo Director
- Private Industry Representative

The recommendation and comments from the Advisory Committee are then compiled, and after considering the recommendation and comments from the Advisory Subcommittee, the PQB makes a recommendation and forwards the request to the Board of Agriculture for a final determination. The Board will review the earlier discussions by the two advisory committees, weigh the environmental issues and economic benefits in relation to the introduction, and make a decision on the request. Members of the Board include:

- Department of Agriculture Chairperson
- Department of Land and Natural Resources Chairperson
- Department of Business Economic Development and Tourism Chairperson
- University of Hawai'i—College of Tropical Agriculture and Human Resources Dean
- Hawai'i County Member
- Kaua'i County Member
- Maui County Member
- Member-at-Large (3 Representatives)

If the Board approves the request and the organism is proposed for listing, then the appropriate list found under H.A.R. § 4-71 will need to be amended to include the requested organism by following the rulemaking process as required by H.R.S. Chapter 91. Once the list amendments are completed, the permit requirements and conditions must then be addressed by the Board prior to entry of the organism under permit.

Appendix I: **Glossary**

Accidental introduction: introduction of a nonindigenous species that occurs as a result of activities other than purposeful importation, transportation or introduction, such as by the discharge into open waters of ballast water or water used to transport live fish, mollusks or crustaceans for aquaculture or other purpose (often unknowing release of nonindigenous organisms without any specific purpose). Improper disposal (e.g., "aquarium dumping"), or similar releases is considered an intentional introduction, not an accidental introduction. *Synonyms:* Incidental, Inadvertent, Unintentional.[1]

Alien Species: with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem. *Synonyms:* Exotic, Nonnative[2]

Aquatic: the phrase "aquatic ecosystems in the United States" means freshwater, marine and estuarine environments (including inland waters and wetlands), located wholly or in part, in the United States.[3]

Aquatic Invasive Species (AIS): a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters.

AIS include nonindigenous species that may occur in inland, estuarine and marine waters and that presently or potentially threaten ecological processes and natural resources.

In addition to adversely affecting activities dependant on waters of the United States, AIS may adversely affect individuals, including health effects.[1]

In simpler terms, animal or plant species that have been introduced into new ecosystems throughout the United States and the world and are having harmful impacts on the natural resources in these ecosystems and the human use of these resources (as defined by the federal Aquatic Nuisance Species Task Force). *Synonym:* Aquatic Nuisance Species (ANS)[4]

Aquatic Species: all animals and plants as well as pathogens or parasites of aquatic animals and plants totally dependent on aquatic ecosystems for at least a portion of their life cycles. In the definition from the Federal ANS Task Force, bacteria, viruses, parasites and other pathogens of humans are excluded.[1]

Ballast Water: any water and associated sediments used to manipulate the trim and stability of a vessel.[1]

Benthic: relating to the substrate (bottom) of a lake, pond, ocean, or other water bodies, which often provide habitat for a variety of organisms.[5]

Biodiversity (or biological diversity): the variability among living organisms and the environments to which they belong; including diversity at the genetic, species, population, and ecosystem levels.[6]

Biological control (biocontrol): the use of living organisms, such as predators, parasites, and pathogens, to control pest insects, weeds, or diseases.[7]

Control: activities to eliminate or reduce the effects of AIS, without being able to eradicate completely, develop means to adapt human activities and facilities to accommodate infestations, and prevent the spread of AIS from infested areas. Control may involve activities to protect native species likely to be adversely affected by AIS and restoration of native species or habitat.[1,3,8]

Cryptogenic species: an organism of unknown origin; may be introduced or native.[4]

Ecological integrity: the extent to which an ecosystem has been altered by human behavior; an ecosystem with minimal impact from human activity has a high level of integrity; an ecosystem that has been substantially altered by human activity has a low level of integrity.[8]

Ecosystems: in the broadest sense, these are natural or "wild" environments as well as human environments, including infrastructure elements. An ecosystem may be an animal or plant in the case where the species involved is a pathogen or parasite.[1]

Endemic species: naturally restricted to a particular place and found nowhere else. Many Hawaiian endemics are restricted to a single island, mountain range, or even gulch.[8]

Environmentally sound: methods, efforts, actions or programs to prevent introductions or control infestations of AIS that minimize adverse impacts to the structure and function of an ecosystem and adverse effects on non-target organisms and ecosystems and emphasize integrated pest management techniques and nonchemical measures.[1]

Epiphyte: an organism that grows on another plant or animal upon which it depends for mechanical support but not for nutrients.[5]

Eradicate: the act or process of eliminating an aquatic invasive species.[7]

Established: when used in reference to a species, this term means occurring as a reproducing, self-sustaining population in an open ecosystem, i.e. in waters where the organisms are able to migrate or be transported to other waters. *Synonym:* Naturalized.[1]

Exotic: an organism introduced from a foreign country (i.e. one whose entire native range is outside the country where found); a subcategory of introduced. [2] *Synonyms:* Alien, Nonnative

Fouling: entanglement, clogging, or obstruction by an undesired organism that may threaten the diversity or abundance of native species or the ecological stability and/or uses of infested waters.[5]

Incipient invasives: known or potentially invasive alien species that have been introduced to a place but that are not yet established there.[8]

Indigenous: existing within a historical ecological range, usually within a balanced system of coevolved organisms, i.e. the range an organism would or could occupy without direct or indirect introduction and/or care by humans.[4]

Infestation: an invasive population that is living in and overrunning an ecosystem to an unwanted degree or harmful manner.[4]

Intentional introductions: the import or introduction of nonindigenous species into, or transport through, an area or ecosystem where it is not established in open waters for a specific purpose, such as fishery management. Includes introductions when the purpose of such import or transport is not direct introduction into an open ecosystem, such as improper disposal ("aquarium dumping"), or similar releases. Synonyms: Purposeful, Deliberate.[1]

Integrated pest management: the control of pests utilizing a practical, economical, and scientifically based combination of chemical, biological mechanical or physical, and cultural control methods. Coordinated application of non-chemical control methods is emphasized in order to reduce or eliminate the need for pesticides. Integrated pest management is a balanced approach which considers hazard to the environment, efficacy, costs, and vulnerability of the pest. It requires: (1) identification of acceptable thresholds of damage; (2) environmental monitoring; and (3) a carefully designed control program to limit damage from the pest to a predetermined acceptable level.[1]

Introduction: the transfer of an organism to an ecosystem outside the historic range of the species of which the organism is a member.[3]

Invasion: an infestation of an aquatic invasive species.[3]

Invasive species (invader): a nonindigenous or cryptogenic species that may threaten the diversity or abundance of native species or the ecological stability and/or uses of infested waters and, the introduction of which into an ecosystem may cause harm to the economy, environment, human health, recreation, or public welfare.[3,4]

An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. *Synonym:* Nuisance

Localized: a confined, reproducing population of an introduced organism that can be eliminated using standard methods.[2]

Locally established: an introduced organism with one or more naturally reproducing populations but with a very restricted distribution and no evidence of natural range expansion (in general, limited to a relatively confined area, such as a small lake).[2]

Naturalization: the final phase of acclimatization, when the introduced species finds a "vacant niche" in a community.[2]

Native species: a species within its natural range or natural zone of dispersal, i.e. within the range it could or would occupy without direct or indirect introduction and/or care by humans.[10]

Nonindigenous Species: any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organism transferred from one country into another. Nonindigenous species include both nonnatives and transplants. *Synonyms:* Introduced, Exotic, Alien, Foreign, Nonnative, Immigrant, Transplants.[1]

Nonnative: any species introduced by man into an ecosystem outside its native range (includes exotic plus transplanted).[2] *Synonyms:* Alien, Exotic

Nuisance: See "Invasive". Editor's note: The term "nuisance" is used in early legislation and text regarding aquatic invasive species. Currently both "nuisance" and "invasive"" are both considered acceptable terminology.

Parasite: an organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host.[5]

Pathogen: any agent that causes disease in plants or animals; typically referring to microbes such as bacteria, viruses, or protozoan parasites.[4]

Pathway: the means by which aquatic species are transported between ecosystems.[1]

Pioneer infestation: a small AIS colony that has spread to a new area from an established colony.[2]

Population: all individuals of a single species within a defined habitat or geographic area.[4]

Prevention: measures to minimize the risk of unintentional introductions of nonindigenous aquatic species that are, or could become, AIS into waters of the United States.[1]

Priority species: an AIS that is considered to be a significant threat to Hawaii's waters and is recommended for immediate or continued management action to minimize or eliminate their impact.[7]

Risk assessment: a science based process to evaluate the economic and/or environmental risk(s) of non-indigenous species.[10]

Species: a group of organisms all of which have high degree of physical and genetic similarity, can generally interbreed only among themselves, and show persistent differences from members of allied species. Species may include subspecies, populations, stocks, or other taxonomic classifications less than full species.[1]

Stakeholders: any and all interested parties.[10]

Time-lag: the period (often years or decades) between the time when an alien species is introduced to a place and when it begins to demonstrate invasiveness there.[8]

Treatment: mechanical, physical, chemical, biological, or other process or method of killing, removing, or rendering infertile, harmful organisms.[3]

Undesirable impact: economic, aesthetic, or environmental degradation that is not necessary for, and is not clearly outweighed by, public health, environmental, or welfare benefits.[3]

Vector: a biological pathway for a disease or parasite, i.e., an organism that transmits pathogens to various hosts. Not a synonym for Pathways.[1]

Waters of the United States: the navigable waters and the territorial sea of the United States. Since AIS can move or be transported by currents into navigable waters, all internal waters of the United States, including its territories and possessions, are included. The Territorial Sea of the United States is that established by Presidential Proclamation Number 5928 of December 27, 1988.[1]

[1]ANS Program Report, http://www.anstaskforce.gov/ansrpt-intro.htm.

[2]Taken from "Washington State ANS Management Plan," September 2001.

[3]National Aquatic Invasive Species Act (NAISA) of 2002.

[4]Taken from "State of Maine Action Plan for Managing Invasive Aquatic Species," October 2002.

[5]Taken from "Massachusetts Aquatic Invasive Species Management Plan," July 2002.

[6]*Halting the Invasion*, Environmental Law Institute, Washington DC, August 2002.

[7]Taken from "Montana Aquatic Nuisance Species (ANS) Management Plan," October 15, 2002.

[8]Hawaii's Invasive Species, Staples, G.W. and Cowie, R.H. , Mutual Publishing, 2002.

[9]President Clinton Executive Order 13112, February 1999.

[10]Taken from "Alaska Department of Fish and Game Aquatic Nuisance Species Management Plan."

Report Title:
Invasive Species

Description:
Statutorily establishes the temporary Hawaii Invasive Species Council to address the invasive species problem in Hawaii; prohibits importation or sale of Salvinia molesta and Salvinia minima and Pistia stratiotes. (CD1)

THE SENATE **S.B. NO.1505**
TWENTY-SECOND LEGISLATURE, 2003 S.D. 1
STATE OF HAWAII H.D. 2
C.D. 1

A BILL FOR AN ACT

RELATING TO INVASIVE SPECIES.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the silent invasion of Hawaii by insects, disease-bearing organisms, snakes, weeds, and other pests is the single greatest threat to Hawaii's economy and natural environment and to the health and lifestyle of Hawaii's people. Invasive species already cause millions of dollars in crop losses, the extinction of native species, the destruction of native forests, and the spread of disease. Every day the media reports another serious case of an invasive species attacking Hawaii, whether it is the Coqui frog, Salvinia molesta, Miconia calvescens, or dengue fever. Yet there are many more harmful species that threaten to invade Hawaii and wreak further damage. Even one new pest, such as the brown tree snake or the red imported fire ant, could forever change the character of the islands. Stopping the influx of new invasive species and containing their spread is essential to Hawaii's future well-being.

Unwanted invasive species are entering Hawaii at an alarming rate--about two million times more rapidly than the natural rate. In 1993, the federal Office of Technology Assessment declared Hawaii's alien pest species problem as the worst in the nation. Hawaii's evolutionary isolation from the continents and its modern role as the commercial hub of the Pacific make these islands particularly vulnerable to destruction by invasive species. Gaps in invasive species prevention systems and a lack of public awareness further add to this serious problem.

The present problem is severe. The future, though, may be even more dire. Slow, piecemeal action will not be sufficient. Drastic improvements must be made now to stem the tide of invasive species.

Last year, then-Governor Benjamin Cayetano issued Executive Order No. 2002-03, establishing the Hawaii invasive species council in recognition of the urgent need to protect Hawaii's natural resources and economy as well as the health and quality of life of Hawaii's residents and visitors from invasive species. The Hawaii invasive species council's special purpose is to foster coordinated approaches that support local initiatives for the prevention and control of invasive species, such as the coordinating group on alien pest species and the island invasive species committees. The Hawaii invasive species council has since initiated development of coordinated invasive species policy.

The legislature finds that the silent invasion of Hawaii by alien invasive species is the single greatest threat to Hawaii's economy, natural environment, and the health and lifestyle of Hawaii's people and visitors. Invasive species cause millions of dollars in crop damage, the extinction of native species, the destruction of native ecosystems, and the spread of many diseases.

The purpose of this Act is to:

(1) Provide statutory authority to the Hawaii invasive species council to continue its special purpose to foster and organize coordinated approaches among various executive departments, federal agencies, and international and local initiatives for the prevention and control of invasive species; and

(2) Affirm the objective of the State to rid Hawaii of invasive species.

This Act does not create any new function of government or require additional funding.

SECTION 2. As used in this Act, unless the context requires otherwise:

"Council" means the Hawaii invasive species council.

"Department" means any entity that is a member of the Hawaii invasive species council established under section 3(a).

[1]This text is taken direct, and no edits have been made except for spacing.

SECTION 3.

(a) There is established a temporary invasive species council for the special purpose of providing policy level direction, coordination, and planning among state departments, federal agencies, and international and local initiatives for the control and eradication of harmful invasive species infestations throughout the State and for preventing the introduction of other invasive species that may be potentially harmful. The council shall:

(1) Maintain a broad overview of the invasive species problem in the State;

(2) Advise, consult, and coordinate invasive species-related efforts with and between the departments of agriculture, land and natural resources, health, and transportation, as well as state, federal, international, and privately organized programs and policies;

(3) Identify and prioritize each lead agency's organizational and resource shortfalls with respect to invasive species;

(4) After consulting with appropriate state agencies, create and implement a plan that includes the prevention, early detection, rapid response, control, enforcement, and education of the public with respect to invasive species, as well as fashion a mission statement articulating the State's position against invasive species;

(5) Coordinate and promote the State's position with respect to federal issues, including:

(A) Quarantine preemption;

(B) International trade agreements that ignore the problem of invasive species in Hawaii;

(C) First class mail inspection prohibition;

(D) Whether quarantine of domestic pests arriving from the mainland should be provided by the federal government;

(E) Coordinating efforts with federal agencies to maximize resources and reduce or eliminate system gaps and leaks, including deputizing the United States Department of Agriculture's plant protection and quarantine inspectors to enforce Hawaii's laws;

(F) Promoting the amendment of federal laws as necessary, including the Lacey Act Amendments of 1981, Title 16 United States Code sections 3371-3378; Public Law 97-79, and laws related to inspection of domestic airline passengers, baggage, and cargo; and

(G) Coordinating efforts and issues with the federal Invasive Species Council and its National Invasive Species Management Plan;

(6) Identify and record all invasive species present in the State;

(7) Designate the department of agriculture, health, or land and natural resources as the lead agency for each function of invasive species control, including prevention, rapid response, eradication, enforcement, and education;

(8) Identify all state, federal, and other moneys expended for the purposes of the invasive species problem in the State;

(9) Identify all federal and private funds available to the State to fight invasive species and advise and assist state departments to acquire these funds;

(10) Advise the governor and legislature on budgetary and other issues regarding invasive species;

(11) Provide annual reports on budgetary and other related issues to the legislature twenty days prior to each regular session;

(12) Include and coordinate with the counties in the fight against invasive species to increase resources and funding and to address county-sponsored activities that involve invasive species;

(13) Review state agency mandates and commercial interests that sometimes call for the maintenance of potentially destructive alien species as resources for sport hunting, aesthetic resources, or other values;

(14) Review the structure of fines and penalties to ensure maximum deterrence for invasive species-related crimes;

(15) Suggest appropriate legislation to improve the State's administration of invasive species programs and policies;

(16) Incorporate and expand upon the department of agriculture's weed risk assessment protocol to the extent appropriate for the council's invasive species control and eradication efforts; and

(17) Perform any other function necessary to effectuate the purposes of this Act.

(b) The council members shall be appointed by the governor not later than January 1, 2004. The council shall be administratively attached to the office of the governor and shall be composed of:

(1) The president of the University of Hawaii, or the president's designated representative;

(2) The director, or the director's designated representative, of each of the following departments:

(A) Business, economic development, and tourism;

(B) Health; and

(C) Transportation; and

(3) The chairperson, or the chairperson's designated representative, of each of the following departments:

(A) Agriculture; and

(B) Land and natural resources.

(c) Representatives of federal agencies and members of the private sector shall be asked to participate or consulted for advice and assistance.

(d) The council shall meet no less than twice annually to discuss and assess progress and recommend changes to the invasive species programs based on results of current risk assessments, performance standards, and other relevant data.

(e) The council shall submit a report of its activities to the governor and legislature annually.

SECTION 4. A state department that is designated as a lead agency under section 3(a)(7), with respect to a particular function of invasive species control, shall have sole administrative responsibility and accountability for that designated function of invasive species control. The lead agency shall:

(1) Coordinate all efforts between other departments and federal and private agencies to control or eradicate the designated invasive species;

(2) Prepare a biennial multidepartmental budget proposal for the legislature forty days before the convening of the regular session of the legislature in each odd-numbered year, showing the budget requirements of each of the lead agency's assigned invasive species function that includes the budget requirements of all departments that it leads for that species, as well as other federal and private funding for that invasive species;

(3) Prepare and distribute an annual progress report forty days prior to the convening of each regular session of the legislature to the governor and the legislature that includes the status of each assigned function; and

(4) Any other function of a lead agency necessary to effectuate the purposes of this Act.

SECTION 5. Notwithstanding any other law to the contrary, and in addition to any other authority provided by law that is not inconsistent with the purposes of this Act, a department is authorized to examine, control, and eradicate all instances of invasive species identified by the council for control or eradication and found on any public or private premises or in any aircraft or vessel landed or docked in waters of the State.

SECTION 6.

(a) Whenever any invasive species identified by the council for control or eradication is found on private property, a department may enter such premises to control or eradicate the invasive species after reasonable notice is given to the owner of the property and, if entry is refused, pursuant to the court order in subsection (d).

(b) If applicable, a duplicate of the notice so given shall be left with one or more of the tenants or occupants of the premises. If the premises are unoccupied, notice shall be mailed to the last known place of residence of the owner, if residing in the State. If the owner resides out of the State or cannot be expeditiously provided with notice, notice left at the house or posted on the premises shall be sufficient.

(c) The department may instead cause notice to be given, and order the owner to control or eradicate the invasive species, if such species was intentionally and knowingly established by the owner on the owner's property and not naturally dispersed from neighboring properties, at the owner's expense within such reasonable time as the department may deem proper, pursuant to the notice requirements of this section.

(d) If the owner thus notified fails to comply with the order of the department, or its agent, within the time specified by the department, or if entry is refused after notice is given pursuant to subsection (a) and, if applicable subsection (b), the department or its agent may apply to the

district court of the circuit in which the property is situated for a warrant, directed to any police officer of the circuit, commanding the police officer to take sufficient aid and to assist the department member or its agent in gaining entry onto the premises, and executing measures to control or eradicate the invasive species.

(e) The department may recover by appropriate proceedings the expenses incurred by its order from any owner who, after proper notice, has failed to comply with the department's order.

(f) In no case shall the department or any officer or agent thereof be liable for costs in any action or proceeding that may be commenced pursuant to this Act.

SECTION 7.

(a) Whenever any invasive species is found on state or county property or on a public highway, street, lane, alley, or other public place controlled by the State or county, notice shall be given by the department or its agent, as the case may be, to the person officially in charge thereof, and the person shall be reasonably notified and ordered by the department to control or eradicate the invasive species.

(b) In case of a failure to comply with the order, the mode of procedure shall be the same as provided in case of private persons in section 6.

SECTION 8. The invasive species council may adopt rules pursuant to chapter 91, Hawaii Revised Statutes, to effectuate this Act.

SECTION 9. Section 150A-6.1, Hawaii Revised Statutes, is amended to read as follows:

"§150A-6.1 Plant import.

(a) The board shall maintain a list of restricted plants that require a permit for entry into the State. Restricted plants shall not be imported into the State without a permit issued pursuant to rules.

(b) The department shall designate, by rule, as restricted plants, specific plants that spread or may be likely to spread an infestation or infection of an insect, pest, or disease that is detrimental or potentially harmful to agriculture, horticulture, the environment, or animal or public health. In addition, plant species designated by rule as noxious weeds are designated as restricted plants.

(c) No person shall import, offer for sale, or sell any Salvinia molesta or Salvinia minima and pistia stratiotes plants or portion thereof within the State."

SECTION 10. Section 150A-9.5, Hawaii Revised Statutes, is amended by amending subsection (c) to read as follows:

"(c) Interim rules adopted by the department pursuant to this section shall be effective as stated by such rules; provided that:

(1) Any interim rule shall be published at least once statewide within twelve days of issuance; and

(2) No interim rule shall be effective for more than one ~~[hundred eighty days.]~~ year."

SECTION 11. Statutory material to be repealed is bracketed and stricken. New statutory material is underscored.

SECTION 12. This Act shall take effect upon its approval and shall be repealed on July 1, 2008.

Report Title[2] : Alien Aquatic Organisms; DLNR; DOA

HOUSE OF REPRESENTATIVES **H.R. NO. 123**

TWENTY-SECOND LEGISLATURE, 2003 H.D. 1

STATE OF HAWAII

HOUSE RESOLUTION

requesting the department of agriculture and department of land and natural resources to update and report to the legislature on their efforts to monitor and restrict the importation of invasive alien aquatic organisms and their efforts to eradicate these organisms.

WHEREAS, many intentional introductions of alien aquatic plants and animals are potentially harmful to both the environment and the economy of the State when they become established in bodies of marine, brackish, and fresh water; and

WHEREAS, these alien aquatic organisms enter the State through various means, including aquarium, aquaculture, nursery, and research imports, the United States Postal Service and commercial delivery services, and commercial airlines; and

WHEREAS, more than 350 invasive marine, brackish, and fresh water species have already become established in Hawaii, clogging lakes and wetlands, altering aquatic ecosystems and habitats, displacing native plant and animal species, and causing economic damage; and

WHEREAS, once invasive organisms become established in the aquatic environment, control is often difficult and expensive and eradication is frequently impossible without destroying native plant and animal species along with alien species; and

WHEREAS, the Department of Agriculture (DOA) is the lead agency for purposes of preventing the intentional introduction of alien aquatic organisms into the State, but lacks:

(1) Expertise in limnology and marine biology;

(2) The authority to prevent the sale and transport of alien aquatic organisms within the State; and

(3) The responsibility for eradicating invasive organisms once they become established in the aquatic environment; and

WHEREAS, the Department of Land and Natural Resources (DLNR) is the lead agency for purposes of eradicating alien aquatic organisms once they become established and has the expertise in limnology and marine biology, but no authority to prevent the intentional introduction of these organisms into the State; now, therefore,

BE IT RESOLVED by the House of Representatives of the Twenty-second Legislature of the State of Hawaii, Regular Session of 2003, that DOA and DLNR are requested to update and report to the Legislature on their efforts to:

(1) Monitor and restrict the importation of invasive alien aquatic organisms; and

(2) Eradicate these types of organisms; and

BE IT FURTHER RESOLVED that DOA and DLNR are requested to submit their report, which may include any necessary proposed legislation, to the Legislature no later than 20 days prior to the convening of the Regular Session of 2004; and

BE IT FURTHER RESOLVED that certified copies of this Resolution be transmitted to the Chairperson of the Board of Land and Natural Resources and the Chairperson of the Board of Agriculture.

[2]This text has been taken direct, and no edits have been made except for spacing.

Report Title[3] : Alien Aquatic Organisms; DLNR; DOA

THE SENATE **S.R. NO. 115**

TWENTY-SECOND LEGISLATURE, 2003 H.D.

STATE OF HAWAII

SENATE RESOLUTION

URGING A JOINT EFFORT BETWEEN THE DEPARTMENT OF AGRICULTURE AND THE DEPARTMENT OF LAND AND NATURAL RESOURCES TO STOP THE IMPORTATION OF ALIEN AQUATIC ORGANISMS THAT COULD BECOME INVASIVE.

WHEREAS, many intentional introductions of alien aquatic plants and animals are potentially harmful to both the environment and the economy of the State when they become established in bodies of marine, brackish, and fresh water; and

WHEREAS, these alien aquatic organisms enter the State through various means, including aquarium, aquaculture, nursery, and research imports, the United States Postal Service and commercial delivery services, and commercial airlines; and

WHEREAS, more than three hundred fifty invasive marine, brackish, and fresh water species have already become established in Hawaii, clogging lakes and wetlands, altering aquatic ecosystems and habitats, displacing native plant and animal species, and causing economic damage; and

WHEREAS, once invasive organisms become established in the aquatic environment, control is often difficult and expensive and eradication is frequently impossible without destroying native plant and animal species along with alien species; and

WHEREAS, the Department of Agriculture is the lead agency for purposes of preventing the intentional introduction of alien aquatic organisms into the State, but lacks:

(1) An expertise in limnology and marine biology;

(2) The authority to prevent the sale and transport of alien aquatic organisms within the State; and

(3) The responsibility for eradicating invasive organisms once they become established in the aquatic environment; and

WHEREAS, the Department of Land and Natural Resources is the lead agency for purposes of eradicating alien aquatic organisms once they become established and has the expertise in limnology and marine biology, but no authority to prevent the intentional introduction of these organisms into the State; now, therefore,

BE IT RESOLVED by the Senate of the Twenty-second Legislature of the State of Hawaii, Regular Session of 2003, that the Department of Agriculture and the Department of Land and Natural Resources are urged to develop a joint procedure whereby no potentially invasive alien aquatic organisms can be imported into the State without the approval of both the Department of Agriculture and the Department of Land and Natural Resources; and

BE IT FURTHER RESOLVED the Department of Agriculture and the Department of Land and Natural Resources are requested to report their recommendations, including any necessary proposed legislation, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2004; and

BE IT FURTHER RESOLVED that certified copies of this Resolution be transmitted to the Chairperson of the Board of Land and Natural Resources and the Chairperson of the Board of Agriculture.

[3]This text has been taken direct, and no edits have been made except for spacing.

Appendix K: **Listing of Known Nonnative Species in Hawai‘i**

The following tables list the known nonnative, and in some cases, cryptogenic aquatic species within Hawai‘i. Tables should be viewed as preliminary listings, and may not encompass every nonnative species within the State. It is also emphasized that these are listings of nonnative species, and in no way are these tables presented to imply that all of these species are thought to pose a threat, or to have invasive qualities.

Table K-1

Table K-1. LISTING OF NONNATIVE and CRYPTOGENIC MARINE INVERTEBRATE AND MARINE FISH SPECIES IN HAWAI'I

Source: Carlton, J. T., and L. G. Eldredge. Draft manuscript. Marine bioinvasions of Hawai'i: the introduced and cryptogenic marine and brackish water animals and plants of the Hawaiian Archipelago. This list includes all marine invertebrate and fish species considered introduced or cryptogenic. Not all are known to be established. The list is in alphabetic order by genus within the phylum. In the final revision of the Carlton and Eldredge manuscript, there will likely be additional species noted. It should also be noted that not all of these species are necessarily considered to be a threat, or to have invasive characteristics.

Phylum	Family	Scientific Name	Biogeographic status
Ciliophora	Folliculinidae	*Ascobius simplex*	Cryptogenic
Ciliophora	Cephaloidophoridae	*Cephaloidophora communis*	Introduced
Ciliophora	Folliculinidae	*Eufolliculina lignicola*	Introduced
Ciliophora	Folliculinidae	*Halofolliculina annulata*	Cryptogenic
Ciliophora	Folliculinidae	*Lagotia viridis*	Cryptogenic
Ciliophora	Folliculinidae	*Metafolliculina andrewsi*	Cryptogenic
Ciliophora	Folliculinidae	*Metafolliculina nordgardi*	Cryptogenic
Ciliophora	Folliculinidae	*Mirofolliculina limnoriae*	Introduced
Ciliophora	Folliculinidae	*Parafolliculina violaceae*	Cryptogenic
Ciliophora	Vorticellidae	*Zoothamnium sp.*	Cryptogenic
Porifera	Desmacellidae	*Biemna fistulosa*	Cryptogenic
Porifera	Callyspongiidae	*Callyspongia diffusa*	Cryptogenic
Porifera	Microcionidae	*Clathria procera*	Cryptogenic
Porifera	Clionidae	*Cliona vastifica*	Cryptogenic
Porifera	Dysideidae	*Dysidea arenaria*	Cryptogenic
Porifera	Dysideidae	*Dysidea avara*	Cryptogenic
Porifera	Dysideidae	*Dysidea sp.*	Introduced
Porifera	Raspailiidae	*Echinodictyum asperum*	Cryptogenic
Porifera	Niphatidae	*Gelliodes fibrosa*	Introduced
Porifera	Halichondriidae	*Halichondria coerulea*	Cryptogenic
Porifera	Halichondriidae	*Halichondria melanadocia*	Introduced
Porifera	Heteropiidae	*Heteropia glomerosa*	Cryptogenic
Porifera	Spongiidae	*Hyatella intestinalis*	Cryptogenic
Porifera	Crambidae	*Monachora ungiculata*	Introduced
Porifera	Mycalidae	*Mycale armata*	Introduced
Porifera	Mycalidae	*Mycale cecilia*	Introduced
Porifera	Phloeodictyidae	*Pellina eusiphona*	Cryptogenic
Porifera	Chalinidae	*Sigmadocia caerulea*	Introduced
Porifera	Suberitidae	*Suberites zeteki*	Introduced
Porifera	Tedaniidae	*Tedania reticulata*	Cryptogenic
Porifera	Halichondriidae	*Topsentia dura*	Cryptogenic
Porifera	Halichondriidae	*Topsentia sp.*	Cryptogenic
Porifera	Mycalidae	*Zygomycale parishii*	Introduced

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nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Cnidaria	Actinodiscidae	*Actinodiscus nummiformis*	Introduced
Cnidaria	Magistiidae	*Anomalorhiza shawi*	Introduced
Cnidaria	Ulmaridae	*Aurelia sp.*	Introduced
Cnidaria	Bougainvilliidae	*Bougainvillia muscus*	Introduced
Cnidaria	Telestidae	*Carijoa riisei*	Introduced
Cnidaria	Carybdeidae	*Carybdea sivickisi*	Introduced
Cnidaria	Cassiopeidae	*Cassiopea andromeda*	Introduced
Cnidaria	Campanulariidae	*Clytia hemisphaerica*	Introduced
Cnidaria	Clavidae	*Cordylophora caspia*	Introduced
Cnidaria	Nephtheidae	*Dendronephthya sp.*	Cryptogenic
Cnidaria	Diadumenidae	*Diadumene franciscana*	Introduced
Cnidaria	Diadumenidae	*Diadumene leucolena*	Introduced
Cnidaria	Diadumenidae	*Diadumene lineata*	Introduced
Cnidaria	Sertulariidae	*Dynamena cornicina*	Cryptogenic
Cnidaria	Sertulariidae	*Dynamena crisioides*	Cryptogenic
Cnidaria	Eudendriidae	*Eudendrium sp.*	Cryptogenic
Cnidaria	Bougainvilliidae	*Garveia sp.*	Cryptogenic
Cnidaria	Plumulariidae	*Halopteris diaphena*	Cryptogenic
Cnidaria	Moerisiidae	*Moerisia horii*	Cryptogenic
Cnidaria	Plumulariidae	*Monotheca margaretta*	Cryptogenic
Cnidaria	Acroporidae	*Montipora turgescens*	Cryptogenic
Cnidaria	Campanulariidae	*Obelia bidentata*	Introduced
Cnidaria	Campanulariidae	*Obelia dichotoma*	Introduced
Cnidaria	Halocordylidae	*Pennaria disticha*	Introduced
Cnidaria	Magistiidae	*Phyllorhiza punctata*	Introduced
Cnidaria	Plumulariidae	*Plumularia setacea*	Cryptogenic
Cnidaria	Corynidae	*Sarsia tubulosa*	Introduced
Cnidaria	Sertulariidae	*Sertularella diaphana*	Cryptogenic
Cnidaria	Sertulariidae	*Sertularia subtilis*	Cryptogenic
Cnidaria	Syntheciidae	*Synthecium megathecum*	Introduced
Cnidaria	Sertulariidae	*Tridentata turbinata*	Cryptogenic
Cnidaria	Clavidae	*Turritopsis nutricula*	Introduced

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TABLE K-1, continued

nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Nematoda	Camallanidae	*Spirocamallanus istiblenni*	Cryptogenic
Nematoda	Camallanidae	*Camallanus cotti*	Introduced
Ctenophora	Platyctenidae	*Vallicula multiformis*	Introduced
Platyhelminthes	Convolutidae	*Convolutriloba sp.*	Cryptogenic
Platyhelminthes	Dactylogyridae	*Neobenedenia melleni*	Cryptogenic
Platyhelminthes	Heterophyidae	*Ascocotyle tenuicollis*	Introduced
Platyhelminthes	Bothriocephalidae	*Bothriocephalus acheilognathi*	Introduced
Platyhelminthes	Dactylogyridae	*Salsuginus seculus*	Introduced
Platyhelminthes	Euplanidae	*Taenioplana teredini*	Introduced
Annelida	Capitellidae	*Capitella sp.*	Cryptogenic
Annelida	Chaetopteridae	*Chaetopterus sp.*	Cryptogenic
Annelida	Opheliidae	*Armandia intermedia*	Cryptogenic
Annelida	Tubificidae	*Bathydrilus adriaticus*	Cryptogenic
Annelida	Sabellidae	*Branchiomma nigromaculata*	Cryptogenic
Annelida	Spirorbidae	*Eulaeospira orientalis*	Cryptogenic
Annelida	Phyllodocidae	*Eulalia sanguinea*	Introduced
Annelida	Serpulidae	*Ficopomatus enigmaticus*	Introduced
Annelida	Serpulidae	*Hydroides brachyacantha*	Introduced
Annelida	Serpulidae	*Hydroides crucigera*	Introduced
Annelida	Serpulidae	*Hydroides dirampha*	Introduced
Annelida	Serpulidae	*Hydroides elegans*	Introduced
Annelida	Spirorbidae	*Janua pagenstecheri*	Introduced
Annelida	Spirorbidae	*Leodora knightjonesi*	Cryptogenic
Annelida	Tubificidae	*Limnodriloides claviger*	Cryptogenic
Annelida	Tubificidae	*Limnodriloides rubicundus*	Cryptogenic
Annelida	Lumbrineridae	*Lumbrineris sphaerocephala*	Cryptogenic
Annelida	Spionidae	*Malacoceros sp.*	Cryptogenic
Annelida	Nerillidae	*Mesonerilla fagei*	Cryptogenic
Annelida	Spionidae	*Minuspio sp.*	Cryptogenic
Annelida	Piscicolidae	*Myzobdella lugubris*	Cryptogenic
Annelida	Nereididae	*Namalycastis abiuma*	Cryptogenic
Annelida	Nereididae	*Namalycastis brevicornis*	Cryptogenic
Annelida	Nereididae	*Namalycastis hawaiiensis*	Cryptogenic
Annelida	Nereididae	*Namalycastis senegalensis*	Cryptogenic
Annelida	Nereididae	*Namanereis amboinensis*	Cryptogenic
Annelida	Nereididae	*Namanereis littoralis*	Cryptogenic
Annelida	Nereididae	*Neanthes arenaceodonta*	Introduced
Annelida	Nereididae	*Neanthes succinea*	Introduced
Annelida	Spirorbidae	*Neodexiospira foraminosa*	Cryptogenic

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nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Annelida	Spirorbidae	*Neodexiospira nipponica*	Cryptogenic
Annelida	Spirorbidae	*pseudocorrugata*	Cryptogenic
Annelida	Tubificidae	*Phallodrilus molestus*	Cryptogenic
Annelida	Tubificidae	*Phallodrilus rectisetosus*	Cryptogenic
Annelida	Nereididae	*Platynereis abnormis*	Cryptogenic
Annelida	Spionidae	*Polydora nuchalis*	Introduced
Annelida	Spionidae	*Polydora websteri*	Introduced
Annelida	Serpulidae	*Pomatoleios kraussii*	Introduced
Annelida	Sabellidae	*Sabellastarte spectabilis*	Introduced
Annelida	Serpulidae	*Salmacina dysteri*	Cryptogenic
Annelida	Serpulidae	*Serpula sp.*	Cryptogenic
Annelida	Spirorbidae	*Simplicaria pseudomilitaris*	Cryptogenic
Annelida	Spintheridae	*Spinther japonicus*	Cryptogenic
Annelida	Spirorbidae	*Spirorbis marioni*	Cryptogenic
Annelida	Spionidae	*Streblospio benedicti*	Introduced
Annelida	Tubificidae	*Tectidrilus bori*	Cryptogenic
Annelida	Tubificidae	*Thalassodrilides gurwitschi*	Cryptogenic
Annelida	Spirorbidae	*Vinearia koehleri*	Cryptogenic
Arthropoda	Scyphacidae	*Alloniscus oahuensis*	Introduced
Arthropoda	Phoxichilidiidae	*Anoplodactylus arescus*	Introduced
Arthropoda	Phoxichilidiidae	*Anoplodactylus portus*	Cryptogenic
Arthropoda	Apseudidae	*Apseudes n. sp.*	Introduced
Arthropoda	Scyphacidae	*Armadilloniscus ellipticus*	Introduced
Arthropoda	Xanthidae	*Atergatopsis immigrans*	Introduced
Arthropoda	Balanidae	*Balanus amphitrite*	Introduced
Arthropoda	Balanidae	*Balanus eburneus*	Introduced
Arthropoda	Balanidae	*Balanus reticulatus*	Introduced
Arthropoda	Aoridae	*Bemlos concavus*	Cryptogenic
Arthropoda	Uncertain	*Buchnerillo sp.*	Introduced
Arthropoda	Janiridae	*Caecijaera horvathi*	Introduced
Arthropoda	Portunidae	*Callinectes sapidus*	Introduced
Arthropoda	Caprellidae	*Caprella equilibra*	Cryptogenic
Arthropoda	Caprellidae	*Caprella penantis*	Introduced
Arthropoda	Caprellidae	*Caprella scaura*	Introduced
Arthropoda	Portunidae	*Carcinus maenas*	Introduced
Arthropoda	Portunidae	*Charybdis (Charybdis) hellerii*	Introduced
Arthropoda	Chthamalidae	*Chthamalus proteus*	Introduced
Arthropoda	Corophiidae	*Corophium acherusicum*	Introduced
Arthropoda	Corophiidae	*Corophium baconi*	Introduced

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TABLE K-1, continued

nonnative marine list
~continued from previous page~

Phylum	Family	Scientific Name	Biogeographic status
Arthropoda	Corophiidae	*Corophium insidiosum*	Introduced
Arthropoda	Gammaridae	*Elasmopus rapax*	Introduced
Arthropoda	Corophiidae	*Ericthonius brasiliensis*	Introduced
Arthropoda	Sphaeromatidae	*Exosphaeroma sp.*	Introduced
Arthropoda	Pilumnidae	*Glabropilumnus seminudus*	Introduced
Arthropoda	Sphaeromatidae	*Gnorimosphaeroma rayi*	Introduced
Arthropoda	Gonodactylidae	*Gonodactylaceus mutatus*	Introduced
Arthropoda	Aoridae	*Grandidierella bispinosa*	Introduced
Arthropoda	Aoridae	*Grandidierella japonica*	Introduced
Arthropoda	Halophilosciidae	*Halophiloscia couchii*	Introduced
Arthropoda	Mysidae	*Holmesimysis costata*	Introduced
Arthropoda	Pseudozuxidae	*Leptochelia dubia*	Cryptogenic
Arthropoda	Ischyroceridae	*Leucothoe micronesiae*	Introduced
Arthropoda	Ligiidae	*Ligia exotica*	Introduced
Arthropoda	Limnoriidae	*Limnoria tripunctata*	Introduced
Arthropoda	Philosciidae	*Littorophiloscia culebrae*	Introduced
Arthropoda	(Palaemoninae)	*Macrobrachium lar*	Introduced
Arthropoda	Palaemonidae (Palaemoninae)	*Macrobrachium rosenbergii*	Introduced
Arthropoda	Anthuridae	*Mesanthura sp.*	Introduced
Arthropoda	Nannastacidae	*Nannastacus sp.*	Introduced
Arthropoda	Grapsidae	*Nanosesarma minutum*	Introduced
Arthropoda	Panopeidae	*Neopanope sp.*	Introduced
Arthropoda	Olibrinidae	*Olibrinus truncatus*	Introduced
Arthropoda	Talitroidae	*Orchestia platensis*	Introduced
Arthropoda	Grapsidae	*Pachygrapsus fakaravensis*	Introduced
Arthropoda	Panopeidae	*Panopeus lacustris*	Introduced
Arthropoda	Panopeidae	*Panopeus pacificus*	Introduced
Arthropoda	Caprellidae	*Paracaprella pusilla*	Introduced
Arthropoda	Sphaeromatidae	*Paracerceis sculpta*	Introduced
Arthropoda	Leucothoidae	*Paraleucothoe flindersi*	Introduced
Arthropoda	Limnoriidae	*Paralimnoria andrewsi*	Introduced
Arthropoda	Pleustidae	*Parapleustes derzhavini*	Introduced
Arthropoda	Apseudidae	*Parapseudes pedispinis*	Introduced
Arthropoda	Isaeidae	*Photis hawaiensis*	Cryptogenic
Arthropoda	Callipallenidae	*Pigrogromitus timsanus*	Introduced
Arthropoda	Pilumnidae	*Pilumnus oahuensis*	Introduced
Arthropoda	Podoceridae	*Podocerus brasiliensis*	Introduced
Arthropoda	Porcellionidae	*Porcellio lamellatus lamellatus*	Introduced

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nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Arthropoda	Harpacticoida	*Psammopsyllus stri*	Introduced
Arthropoda	Calanoida	*Pseudodiaptomus marinus*	Introduced
Arthropoda	Nannastacidae	*Schereocumella sp.*	Introduced
Arthropoda	Majidae	*Schizophrys aspera*	Introduced
Arthropoda	Portunidae	*Scylla serrata*	Introduced
Arthropoda	Sphaeromatidae	*Sphaeroma quoyanum*	Introduced
Arthropoda	Sphaeromatidae	*Sphaeroma walkeri*	Introduced
Arthropoda	Stenothoidae	*Stenothoe gallensis*	Introduced
Arthropoda	Stenothoidae	*Stenothoe valida*	Cryptogenic
Arthropoda	Cyclopoida	*Teredicola typica*	Introduced
Arthropoda	Cheluridae	*Tropichelura insulae*	Introduced
Arthropoda	Upogebiidae	*Upogebia sp.*	Introduced
Mollusca	Semelidae	*Abra sp.*	Introduced
Mollusca	Barleeidae	*Amphithalamus inclusus*	Introduced
Mollusca	Anomiidae	*Anomia nobilis*	Introduced
Mollusca	Teredinidae	*Bankia bipalmulata*	Introduced
Mollusca	Pyramidellidae	*Boonea cincta*	Introduced
Mollusca	Bullidae	*Bulla adamsi*	Introduced
Mollusca	Facelinidae	*Caloria indica*	Cryptogenic
Mollusca	Chamidae	*Chama elatensis*	Introduced
Mollusca	Chamidae	*Chama fibula*	Cryptogenic
Mollusca	Chamidae	*Chama lazarus*	Introduced
Mollusca	Chamidae	*Chama pacifica*	Introduced
Mollusca	Pyramidellidae	*Chrysallida trachis*	Introduced
Mollusca	Veneridae	*Clinocardium nuttallii*	Introduced
Mollusca	Ostreidae	*Crassostrea amasa*	Introduced
Mollusca	Ostreidae	*Crassostrea gigas*	Introduced
Mollusca	Ostreidae	*Crassostrea virginica*	Introduced
Mollusca	Calyptraeidae	*Crepidula aculeata*	Introduced
Mollusca	Calyptraeidae	*Crucibulum spinosum*	Introduced
Mollusca	Cuthonidae	*Cuthona perca*	Introduced
Mollusca	Cypraeidae	*Cypraea kuroharai*	Cryptogenic
Mollusca	Fissurellidae (Diodorinae)	*Diodora ruppelli*	Introduced
Mollusca	Vermetidae	*Eualetes tulipa*	Introduced
Mollusca	Pyramidellidae	*Evalea sp.*	Introduced
Mollusca	Haliotidae	*Haliotis spp.*	Introduced
Mollusca	Hiatellidae	*Hiatella arctica*	Introduced
Mollusca	Pyramidellidae	*Hinemoa indica*	Cryptogenic

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TABLE K-1, continued

nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Mollusca	Hipponicidae	*Hipponix australis*	Cryptogenic
Mollusca	Pyramidellidae	*Iolaea eucosmia*	Introduced
Mollusca	Pyramidellidae	*Ivadella navisa*	Introduced
Mollusca	Teredinidae	*Lyrodus affinis*	Introduced
Mollusca	Teredinidae	*Lyrodus pedicellatus*	Introduced
Mollusca	Pholadidae	*Martesia striata*	Introduced
Mollusca	Thiaridae	*Melanoides tuberculata*	Introduced
Mollusca	Veneridae	*Meretrix meretrix*	Introduced
Mollusca	Myidae	*Mya arenaria*	Introduced
Mollusca	Mytilidae	*Mytilus galloprovincialis*	Introduced
Mollusca	Goniodorididae	*Okenia pellucida*	Introduced
Mollusca	Ostreidae	*Ostrea conchaphila*	Introduced
Mollusca	Pyramidellidae	*Peristichia pedroana*	Introduced
Mollusca	Pteriidae	*Pinctada fucata martensi*	Introduced
Mollusca	Pyramidellidae	*Pyrgulina oodes*	Cryptogenic
Mollusca	Ostreidae	*Saccostrea cucullata*	Introduced
Mollusca	Myidae	*Sphenia coreanica*	Introduced
Mollusca	Thiaridae	*Tarebia granifera*	Introduced
Mollusca	Teredinidae	*Teredo bartschi*	Introduced
Mollusca	Teredinidae	*Teredo clappi*	Introduced
Mollusca	Teredinidae	*Teredo furcifera*	Introduced
Mollusca	Cardiidae	*Tivela stultorum*	Introduced
Mollusca	Tridacnidae	*Tridacna crocea*	Introduced
Mollusca	Tridacnidae	*Tridacna derasa*	Introduced
Mollusca	Tridacnidae	*Tridacna squamosa*	Introduced
Mollusca	(Trochinae)	*Trochus niloticus*	Introduced
Mollusca	Veneridae	*Venerupis philippinarum*	Introduced
Ectoprocta	Aeteidae	*Aetea truncata*	Introduced
Ectoprocta	Vesiculariidae	*Amathia distans*	Introduced
Ectoprocta	Vesiculariidae	*Bowerbankia cf. gracilis*	Introduced
Ectoprocta	Vesiculariidae	*Bowerbankia cf. imbricata*	Introduced
Ectoprocta	Bugulidae	*Bugula dentata*	Introduced
Ectoprocta	Bugulidae	*Bugula neritina*	Introduced
Ectoprocta	Bugulidae	*Bugula robusta*	Introduced
Ectoprocta	Bugulidae	*Bugula stolonifera*	Introduced
Ectoprocta	Scrupocellariidae	*Caberia cf. boryi*	Cryptogenic
Ectoprocta	Bugulidae	*Caulibugula caliculata*	Introduced
Ectoprocta	Bugulidae	*Caulibugula dendrograpta*	Introduced
Ectoprocta	Cryptosulidae	*Cryptosula pallasiana*	Introduced
Ectoprocta	Smittinidae	*Parasmittina delicatula*	Cryptogenic
Ectoprocta	Savignyellidae	*Savignyella lafontii*	Introduced
Ectoprocta	Schizoporellidae	*Schizoporella errata*	Introduced
Ectoprocta	Schizoporellidae	*Schizoporella unicornis*	Introduced
Ectoprocta	Hippothoidae	*Trypostega venusta*	Cryptogenic
Ectoprocta	Watersiporidae	*Watersipora edmondsoni*	Introduced

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nonnative marine list
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Phylum	Family	Scientific Name	Biogeographic status
Ectoprocta	Watersiporidae	*Watersipora subovoidea*	Introduced
Ectoprocta	Vesiculariidae	*Zoobotryon verticillatum*	Introduced
Entoprocta	Pedicellinidae	*Barentsia sp.*	Introduced
Chordata	Ascidiidae	*Ascidia sp.*	Introduced
Chordata	Ascidiidae	*Ascidia sp.A*	Introduced
Chordata	Ascidiidae	*Ascidia sp.B*	Introduced
Chordata	Ascidiidae	*Ascidia sydneiensis*	Introduced
Chordata	Cionidae	*Ciona intestinalis*	Introduced
Chordata	Styelidae	*Cnemidocarpa irene*	Introduced
Chordata	Styelidae	*Cnemidocarpa sp.*	Cryptogenic
Chordata	Corellidae	*Corella minuta*	Introduced
Chordata	Didemnidae	*Didemnum candidum*	Introduced
Chordata	Didemnidae	*Didemnum perlucidum*	Introduced
Chordata	Didemnidae	*Diplosoma listerianum*	Introduced
Chordata	Styelidae	*Eusynstyela aliena*	Introduced
Chordata	Pyuridae	*Herdmania momus*	Introduced
Chordata	Pyuridae	*Herdmania sp.*	Introduced
Chordata	Pyuridae	*Microcosmus exasperatus*	Introduced
Chordata	Ascidiidae	*Phallusia nigra*	Introduced
Chordata	Styelidae	*Polyandrocarpa sagamiensis*	Introduced
Chordata	Styelidae	*Polyandrocarpa zooritensis*	Introduced
Chordata	Polyclinidae	*Polyclinum constellatum*	Introduced
Chordata	Styelidae	*Styela canopus*	Introduced
Chordata	Styelidae	*Symplegma brakenhielmi*	Introduced
Chordata	Styelidae	*Symplegma reptans*	Introduced
Chordata	Clupeidae	*Dorosoma petenense*	Introduced
Chordata	Clupeidae	*quardrimaculatus*	Introduced
Chordata	Clupeidae	*Sardinella marquesensis*	Introduced
Chordata	Poecilidae	*Poecilia latipinna*	Introduced
Chordata	Poecilidae	*Poecilia mexicana*	Introduced
Chordata	Poecilidae	*Limia vittata*	Introduced
Chordata	Poecilidae	*Gambusia affinis*	Introduced
Chordata	Serranidae	*Cephalopholis argus*	Introduced
Chordata	Lutjanidae	*Lutjanus fulvus*	Introduced
Chordata	Lutjanidae	*Lutjanus gibbus*	Introduced
Chordata	Lutjanidae	*Lutjanus kasmira*	Introduced
Chordata	Mullidae	*Upeneus vittataus*	Introduced
Chordata	Cichlidae	*Oreochromus mossambicus*	Introduced
Chordata	Cichlidae	*Sarotherodon melanotheron*	Introduced
Chordata	Mugilidae	*Moolgarda engeli*	Introduced
Chordata	Blennidae	*Parablennius thysanius*	Introduced
Chordata	Blennidae	*Omobranchus ferox*	Introduced
Chordata	Blennidae	*Omobranchus rotundiceps*	Introduced
Chordata	Gobiidae	*Mugiligpbius cavifrons*	Introduced
Chordata	Pomacanthidae	*Centropyge favissima*	Introduced

~End~

TABLE K-2

Table K-2. Listing of Nonnative and Cryptogenic Marine Algae Species in Hawai‘i

Submitted by Smith J., and Hunter, C. after Russell 1992. This list includes all marine algae species considered introduced or cryptogenic. Not all are known to be established, and not all of these species are known to have invasive characteristics.

Genus	Species	Date	Success	Biogeographic status
Acanthophora	*spicifera*	after 1950	highly successful	Introduced
Avrainvillea	*amadelpha*	after 1981	successful	Cryptogenic
Dictyota	*flabellata*	unknown	unknown	Introduced
Eucheuma	*denticulatum*	from 10/70 to late 1976	not successful	Introduced
Eucheuma	*isiforme*	Jan-74	no	Introduced
Gracilaria	*epihippisora*	4/71 9/78	marginal	Cryptogenic / Introduced
Gracilaria	*eucheumoides*	mid 1970's	unknown	Introduced
Gracilaria	*salicornia*	4/71, 9/78	highly successful	Cryptogenic / Introduced
Gracilaria	*tikvahiae*	mid 1970's	successful	Introduced
Gracilaria	*sp.*	1971	unknown	Introduced
Hypnea	*musciformis*	Jan-74	highly successful	Introduced
Kappaphycus	*alvarezii*	9/74 to late1976	successful	Introduced
Kappaphycus	*striatum*	8/70 to late1976	successful	Introduced
Lola	*lubrica*	1976	no	Introduced
Macrocystis	*pyrifera*	1972, 1980's	no	Introduced
Nemacystus	*decipiens*	1950's	successful	Cryptogenic
Pilinella	*californica*	1976	no	Introduced
Porphyra	*sp.*	unknown	unknown	Introduced
Wrangelia	*bicuspidata*	1974	successful	Cryptogenic

TABLE K-3

Table K-3. LISTING OF ESTABLISHED NONNATIVE INLAND WATER FISH AND MACRO-INVERTEBRATE SPECIES IN HAWAI'I

Submitted by M. Yamamoto. This list represents all of the known established nonnative inland water fishes and macro-invertebrates. Not all of these species are necessarily considered to be a threat, or to have invasive characteristics. This listing does not include other inland aquatic animals, such as waterbird species.

Phylum	Scientific Name	Common Name
Chordata	*Gambusia affinis*	mosquitofish
Chordata	*Poecilia reticulata*	guppy, rainbowfish
Chordata	*Poecilia latipinna*	sailfin molly
Chordata	*Poecilia salvatoris*	liberty molly
Chordata	*Limia vittata*	Cuban molly
Chordata	*Xiphophorus helleri*	green swordtail
Chordata	*Xiphophorus maculatus*	moonfish, platy
Chordata	*Oreochromis mossambicus*	Mossambique tilapia
Chordata	*Oreochromis macrochir*	
Chordata	*Tilapia melanopleura*	
Chordata	*Tilapia zillii*	
Chordata	*Sarotherodon melanotheron*	black-chin tilapia
Chordata	*Amphilophus citrinellum*	Midas cichlid
Chordata	*Amphilophus labiatum*	Red devil
Chordata	*Archocentrus nigrofasciatus*	convict cichlid
Chordata	*Hypsophrys nicaraguensis*	Nicaragua cichlid
Chordata	*Parachromis managuensis*	Jaguar cichlid
Chordata	*Thorichthys meeki*	firemouth
Chordata	*Melanochromis johannii*	Johanni cichlid
Chordata	*Hemichromis elongatus*	Five spot
Chordata	*Astronotus ocellatus*	Oscar
Chordata	*Cichla ocellaris*	tucunare
Chordata	*Micropterus dolomieui*	smallmouth bass
Chordata	*Micropterus salmoides*	largemouth bass
Chordata	*Lepomis macrochirus*	bluegill
Chordata	*Oncorhynchus mykiss*	rainbow trout
Chordata	*Misgurnus anguillicaudatus*	dojo
Chordata	*Clarias fuscus*	Chinese catfish
Chordata	*Ictalurus punctatus*	channel catfish

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Phylum	Scientific Name	Common Name
Chordata	*Cyprinus carpio*	carp, koi
Chordata	*Carassius auratus*	goldfish, funa
Chordata	*Channa striata*	pongee
Chordata	*Monopterus albus*	rice paddy eel
Chordata	*Hypostomus c.f. watwata*	armored catfish
Chordata	*Ancistrus c.f. temmincki*	bushy-nose
Chordata	*Liposarcus multiradiatus*	long-fin armored catfish
Chordata	*Corydoras aeneus*	bronze catfish
Chordata	*Xenentodon cancila*	stickfish
Chordata	*Dorosoma petenense*	threadfin shad
Chordata	*Mugilogobius cavifrons*	mangrove goby
Chordata	*Omobranchus ferox*	fang-toothed blenny
Anthropod	*Procambarus clarkii*	crayfish
Anthropod	*Macrobrachium lar*	Tahitian prawn
Anthropod	*Neocaradina denticulata sinensis*	grass shrimp
Mollusca	*Cipangopaludina chinensis*	Chinese mystery snail
Mollusca	*Pomacea canaliculata*	apple snail
Mollusca	*Pomacea bridgesi*	apple snail
Mollusca	*Pila conica*	apple snail
Mollusca	*Family Planorbidae*	ramshorn snail
Mollusca	*Family Thiaridae*	thiarid snails
Mollusca	*Family Physidae*	pouch snails
Mollusca	*Corbicula fluminea*	Asiatic freshwater clam
Chordata	*Bufo marinus*	cane toad
Chordata	*Rana catesbiana*	bullfrog
Chordata	*Rana rugosa*	wrinkled frog
Chordata	*Chrysemys scripta elegans*	red-eared slider
Chordata	*Palea steindachneri*	wattle-necked turtle
Chordata	*Pelodiscus sinensis*	Chinese softshell turtle

~End~

TABLE K-4

Table K-4. LISTING OF ESTABLISHED NONNATIVE PLANTS ASSOCIATED WITH INLAND WATER HABITATS IN HAWAI'I

Species submitted by M. Yamamoto and M. Wilkinson. This list represents a partial compilation of the known established nonnative inland water plants, including those found in freshwater, wetland, marsh, and estuarine systems. Not all of these species are necessarily considered to be a threat, or to have invasive characteristics. This listing only includes plants considered to be aquatic, and does not include coastal, beach strand, or wet-forest plants. This list should be considered preliminary, and be used in conjunction with the species presented in Table K-5.

Genus	Species	Common name	Note
Atriplex	*semibaccata*	Australian saltbrush	
Azolla	*filiculoides*	azolla, duckweed	floating freshwater
Batis	*maritima*	Pickleweed, 'akulikuli kai	
Brachiaria	*mutica*	California grass	open marshy areas
Bruguiera	*gymnorrhiza*	oriental mangrove	
Ceratopteris	*thalictroides*	water sprite	freshwater
Chara	*Chara sp.*	Chara	freshwater
Echinochloa	*colona*	Jungle rice	
Egeria	*densa*	elodea	freshwater
Eichornia	*crassipes*	water hyacinth	freshwater
Ipomoea	*spp.*	ong choi	freshwater
Lemna	*spp.*	duckweed	freshwater
Leptochloa	*uninervia*	leptochloa	
Limnophila	*spp.*	Limnophila	freshwater
Ludwigia	*spp.*	Ludwigia	freshwater
Melaleuca	*quinquenervia*	paperbark	
Myriophyllum	*aquaticum*	parrot feather	freshwater
Nymphaea	*spp.*	waterlily	submerged freshwater
Paspalum	*conjugatum*	Hilo grass	
Paspalum	*vaginatum*	Seashore paspalum	brackish water
Pistia	*stratiotes*	water lettuce	freshwater
Pluchea	*carolinensis*	sourbrush	wetlands, fishponds
Rhizophora	*mangle*	red mangrove	
Sagittaria	*sagittaefolia*	arrowhead	freshwater
Salvinia	*molesta*	Kariba weed	freshwater
Spergularia	*marina*	saltmarsh sand spurry	
Typha	*latifolia*	common cattail	emergent freshwater
Vallisneria	*spp.*	eel grass	freshwater

TABLE K-5

Table K-5. USDA National Plants Database listing of nonnative wetland plants in Hawai'i.

Compiled by K. and F. Starr. Listing of nonnative plants in Hawai'i that have some wetland status. Listing is in alphabetical order, by species. List was created by querying the USDA National Plants Database for any nonnative species found in the Hawai'i region with an OBL (Obligate Wetland) or FAC (Facultative) status, as detailed at the end of the table. This list does not include all freshwater nonnative plants, and should be used in conjunction with Table K-4. This table may have some overlap with Table K-4. Not all of these species are considered to have invasive properties. The full list of these species (along with common names and links to further information) can be found at the following link: http://plants.usda.gov/cgi_bin/topics.cgi?earl=wetland.html

Family	Species	Status	Family	Species	Status
Lythraceae	*Ammannia auriculata Willd.*	OBL	Convolvulaceae	*Ipomoea violacea L.*	FACW-
Lythraceae	*Ammannia coccinea Rottb.*	OBL	Juncaceae	*Juncus acuminatus Michx.*	OBL
Melastomataceae	*Arthrostemma ciliatum Pavón ex D. Don*	FACW	Juncaceae	*Juncus bufonius L.*	FACW+
Azollaceae	*Azolla filiculoides Lam.*	OBL	Juncaceae	*Juncus effusus L.*	OBL
Bataceae	*Batis maritima L.*	OBL	Juncaceae	*Juncus ensifolius Wikstr.*	FACW
Poaceae	*Brachiaria mutica (Forsk.) Stapf*	FACW	Juncaceae	*Juncus planifolius R. Br.*	FACW
Rhizophoraceae	*Bruguiera gymnorrhiza (L.) Lam.*	OBL	Juncaceae	*Juncus polyanthemos Buch.*	OBL
Ceratophyllaceae	*Ceratophyllum demersum L.*	OBL	Lemnaceae	*Lemna minor L.*	OBL
Pteridaceae	*Ceratopteris thalictroides (L.) Brongn.*	OBL	Poaceae	*Leptochloa uninervia (J. Presl) A.S. Hitchc. & Chase*	FACW
Verbenaceae	*Clerodendrum inerme (L.) Gaertn.*	FACW	Scrophulariaceae	*Lindernia antipoda (L.) Alston*	FACW
Poaceae	*Coix lacryma-jobi L.*	FACW+	Scrophulariaceae	*Lindernia crustacea (L.) F. Muell.*	FACW
Araceae	*Colocasia esculenta (L.) Schott*	OBL	Onagraceae	*Ludwigia octovalvis (Jacq.) Raven*	OBL
Commelinaceae	*Commelina diffusa Burm. f.*	FACW	Onagraceae	*Ludwigia palustris (L.) Ell.*	OBL
Combretaceae	*Conocarpus erectus L.*	FACW	Pontederiaceae	*Monochoria vaginalis (Burm. f.) K. Presl ex Kunth*	OBL
Cyperaceae	*Cyperus difformis L.*	OBL	Haloragaceae	*Myriophyllum aquaticum (Vell.) Verdc.*	OBL
Cyperaceae	*Cyperus haspan L.*	FACW+	Nymphaeaceae	*Nymphaea lotus L.*	OBL*
Cyperaceae	*Cyperus involucratus Rottb.*	FACW	Poaceae	*Paspalum distichum L.*	FACW+
Cyperaceae	*Cyperus papyrus L.*	OBL	Poaceae	*Paspalum vaginatum Sw.*	FACW+
Cyperaceae	*Cyperus pilosus Vahl*	FACW	Araceae	*Pistia stratiotes L.*	OBL
Cyperaceae	*Cyperus trinervis R. Br.*	FACW	Polygonaceae	*Polygonum punctatum Ell.*	OBL
Cyperaceae	*Cyperus virens Michx.*	FACW+	Poaceae	*Polypogon interruptus Kunth*	FACW+
Scrophulariaceae	*Dopatrium junceum (Roxb.) Buch.-Ham. ex Benth.*	OBL	Poaceae	*Polypogon monspeliensis (L.) Desf.*	FACW
Poaceae	*Echinochloa colona (L.) Link*	FACW	Potamogetonaceae	*Potamogeton pectinatus L.*	OBL
Poaceae	*Echinochloa crus-galli (L.) Beauv.*	FACW	Rhizophoraceae	*Rhizophora mangle L.*	OBL
Asteraceae	*Eclipta prostrata (L.) L.*	FACW	Cyperaceae	*Rhynchospora caduca Ell.*	FACW*
Hydrocharitaceae	*Egeria densa Planch.*	OBL	Brassicaceae	*Rorippa sarmentosa (G. Forst. ex DC.) MacBr.*	FACW+
Pontederiaceae	*Eichhornia crassipes (Mart.) Solms*	OBL	Alismataceae	*Sagittaria latifolia Willd.*	OBL
Cyperaceae	*Eleocharis geniculata (L.) Roemer & J.A. Schultes*	OBL	Chenopodiaceae	*Salicornia virginica L.*	OBL
Cyperaceae	*Eleocharis radicans (A. Dietr.) Kunth*	OBL	Poaceae	*Schizostachyum glaucifolium (Rupr.) Munro*	FACW*
Poaceae	*Eriochloa punctata (L.) Desv. ex Hamilton*	FACW	Lemnaceae	*Spirodela polyrrhiza (L.) Schleid.*	OBL
Cyperaceae	*Fimbristylis aestivalis (Retz.) Vahl*	FACW+	Typhaceae	*Typha domingensis Pers.*	OBL
Cyperaceae	*Fimbristylis schoenoides (Retz.) Vahl*	FACW	Typhaceae	*Typha latifolia L.*	OBL
Apiaceae	*Hydrocotyle verticillata Thunb.*	OBL	Lentibulariaceae	*Utricularia gibba L.*	OBL
Clusiaceae	*Hypericum mutilum L.*	FACW	Xyridaceae	*Xyris complanata R. Br.*	FACW
Convolvulaceae	*Ipomoea aquatica Forsk.*	OBL	Xyridaceae	*Xyris platylepis Chapman*	OBL*
	~continued in next columns~		Poaceae	*Zizania latifolia (Griseb.) Turcz. ex Stapf*	OBL

Code	Wetland Type	Comments
OBL	Obligate Wetland - Occurs almost always (estimated probability 99%) under natural conditions in wetlands.	
FACW	Facultative Wetland - Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.	
FAC	Facultative - Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).	
FACU	Facultative Upland - Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).	

"A positive (+) or negative (-) sign was used with the Status Indicator categories to more specifically define the regional frequency of occurrence in wetlands. The positive sign indicates a frequency toward the higher end of the category (more frequently found in wetlands), and a negative sign indicates a frequency toward the lower end of the category (less frequently found in wetlands). An asterisk (*) following a regional Indicator identifies tentative assignments based on limited information from which to determine the indicator status."

TABLE K-6

Table K-6. LISTING OF INTRODUCED AQUATIC INSECT SPECIES IN HAWAI'I

Compiled by R. Englund. This preliminary list of introduced aquatic insects was gathered from references published by the Bishop Museum, and from Bishop Museum collection data. The list was mainly derived from Nishida (2002) and other references. Many more introduced species of aquatic insects are found in the Hawaiian Islands than appear on this preliminary list. *Source:* Nishida, G. M. 2002. Hawaiian terrestrial arthropod checklist, 4th Edition (Searchable database on the internet at http://www.bishopmuseum.org/bishop/ento/entodbhome.html). Hawai'i Biological Survey. Bishop Mus. Tech. Rep. 12. 313 pp.

Order	Family	Genus	Species	Describer/Year	Habitat Fresh (0-5 ppt) Estuarine (6-26 ppt) Marine (>26 ppt)
Coleoptera (aquatic beetles)					
	Dysticidae	*Copelatus*	*parvulus*	(Boisduval, 1835)	Fresh
		Hydrovatus	*acuminatus*	(Motschulsky, 1859)	Fresh
		Hydrovatus	*confertus*	(Sharp, 1882)	Fresh
		Hygrotus	*medialis*	(Le Conte, 1851)	Fresh
		Rhantus	*gutticollis*	(Say, 1834)	Fresh
	Hydrophilidae	*Enochrus*	*sayi*	(Gundersen, 1977)	Fresh, Estuarine
		Tropisternus	*lateralis humeralis*	(Motschulsky, 1859)	Fresh
			salsamentus	(Fall, 1901)	Fresh
	Scirtidae	*Scirtes*	*sp.*	(Beardsley & Mau, 1976)	Marine
Diptera (aquatic flies)					
	Canacidae	*Canaceiodes*	*angulatus*	Wirth, 1969	Marine
	Ceratopogonidae	*Atrichopogon*	*jacobsoni*	(Meijer, 1907)	Estuarine
		Forcipomyia	*hygrophila*	Kieffer, 1925	Fresh?
		Forcipomyia	*picea*	(Winnertz, 1852)	Fresh?
	Chironomidae	*Cricotopus*	*bicinctus*	(Meigen, 1818)	Fresh
		Goeldichironomus	*holoprasinus*	(Goeldi, 1905)	Fresh
		Larsa	*planensis*	(Johannsen, 1946)	Fresh?
		Polypedilum	*nubiferum*	(Skuse, 1889)	Fresh
		Pseudosmittia	*maculiventris*	(Edwards. 1933)	Fresh
	Culicidae	*Aedes*	*aegypti*	(Linnaeus, 1762)	Fresh
		Aedes	*albopictus*	(Skuse, 1864)	Fresh
		Aedes	*nocturnus*	(Theobald, 1903)	Fresh
		Culex	*quinquefasciatus*	(Say, 1823)	Fresh
		Toxorhynchites	*amboinensis*	(Doleschall, 1857)*	Fresh
		Toxorhynchites	*brevipalpis*	Theobald, 1901	Fresh
		Toxorhynchites	*inornatus*	(Walker, 1865)	Fresh
		Wyeomyia	*mitchellii*	(Theobald, 1905)	Fresh
	Chloropidae	*Apallates*	*hermsi*	(Sabrosky, 1941)	Fresh?
		Cadrema	*pallida*	(Lowe, 1865)	Fresh
	Dixidae	*Dixa*	*longistyla*	(Takahashi, 1958)	

~continued on next page~

TABLE K-6, continued

Introduced Aquatic Insect Species

~continued from previous page~

Order	Family	Genus	Species	Describer/Year	Habitat
					Fresh (0-5 ppt) Estuarine (6-26 ppt) Marine (>26 ppt)
Diptera (aquatic flies), continued.					
	Dolichopodidae	*Amblypsilopus*	*pallidicornis*	(Grimshaw, 1901)	Fresh?
		Chrysoma	*globiferum*	(Wiedemann, 1830)	Fresh
		Chrysotus	*globiferum*	(Aldrich, 1896)	Fresh
		Condylostylus	*longicornis*	(Fabricius, 1775)	Fresh
		Dolichopus	*exsul*	(Aldrich, 1922)	Fresh
		Pelastoneurus	*lugubris*	(Loew, 1861)	Fresh
		Syntormon	*flexible*	(Becker, 1922)	Fresh
		Tachytrechus	*angustipennis*	(Loew, 1862)	Fresh
		Thinophilus	*hardyi*	(Grootarert & Evenhuis)	Marine
	Empidae	*Hemerodromia*	*stellaris*	(Melander, 1947)	Fresh
	Ephydridae	*Brachydetera*	*ibari*	(Ninomiya, 1930)	Fresh
Heteroptera (true bugs)					
	Corixidae	*Trichocorixa*	*reticulata*	(Guerin-Menevill, 1857)	Fresh, Esturarine
	Mesoveliidae	*Mesovelia*	*amoena*	Uhler, 1894	Fresh
		Mesovelia	*mulsanti*	White, 1879	Fresh
	Notonectidae	*Anisops*	*kuroiwae*	(Matsumura, 1915)	Fresh
		Buenoa	*pallipes*	(Fabricius, 1775)	Fresh
		Notonecta	*indica*	(Linnaeus, 1771)	Fresh
	Saldidae	*Micracanthia*	*humilis*	(Say, 1832)	Fresh
Lepidoptera (aquatic moth)					
	Pyralidae	*Genus*	*Species*		Fresh
Odonata (Dragonflies and Damselflies)					
	Coenagrionidae	*Enallgma*	*civile*	(Hagen, 1862)	Fresh
		Ischnura	*posita*	(Hagen, 1862)	Fresh
		Ischnura	*ramburii*	(Selys-Longchamps, 1850)	Fresh
	Libellulidae	*Crocothemis*	*servilia*	(Drury, 1770)	Fresh
		Orthemis	*ferruginea*	(Fabricius, 1775)	Fresh
		Tramea	*abdominalis*	(Rambur, 1842)	Fresh
		Tramea	*lacerata*	(Hagen, 1862)	Fresh
Trichoptera (Caddisflies)					
	Hydropsychidae	*Cheumatopsyche*	*analis*	(Banks, 1903)	Fresh
	Hydroptilidae	*Hydroptila*	*arctia*	(Ross, 1938)	Fresh
		Hydroptila	*icona*	(Mosely, 1937)	Fresh
		Hydroptila	*potosina*	(Bueno-Soria, 1984)	Fresh
		Oxyethira	*maya*	(Denning, 1947)	Fresh

Appendix L: **References**

Alaska Department of Fish and Game 2002. "Alaska Aquatic Nuisance Species Management Plan".

ANS (Aquatic Nuisance Species) Task Force. 2000. "Guidance for State and Interstate Aquatic Nuisance Species Management Plans". www.anstaskforce.gov/state_guidance.htm.

Atkinson, S.A., Smith, C.M., and C.L. Hunter. 2003a. "The Development of a Control Program for Harmful Algal Blooms on Coral Reefs in Hawai'i." *Unpublished proposal submitted to the EPA.*

Atkinson, S.A., Smith, C.M., Hunter, C.L., Conklin, E., Smith, J. and E. Co. 2003b. "Community-Based Coral Reef Habitat Restoration through the Removal of Invasive Marine Algae." *Unpublished proposal submitted to NOAA*

Australian Department of Fisheries. 2000. "Introduced Marine Aquatic Invaders". http://www.fish.wa.gov.au/hab/broc/marineinvader/marine08.html.

Baldwin, W. J. 1984. "A note on the occurrence of the gold spot herring, *Herklotsichthys quadrimaculatus* (Rppell) in Hawai'i". *Pac. Sci.*, 38(2): 123-126.

Baltz, D.M. 1991. "Introduced fishes in marine systems and inland seas". *Biological Conservation*. 56: 151-177.

Birkeland, D., Walsh, W.J., and J. Dierking. 2002. "Feeding biology of the introduced fish *roi (Cephalopholis argus*) and its impact on Hawaiian coral reef-fishes and fisheries". *Unpublished proposal submitted to the Hawai'i Coral Reef Initiative Research Program.*

Brostoff, W. 1989. *Avrainvillea amadeplha* (Codiales, Chlorophyta) from Oahu, Hawaii. *Pac. Sci* 43:166-169.

Centre for Research on Introduced Marine Pests (CRIMP). 2001. "*(Mytilopsis sallei)* Black-Striped Mussel". Marine Pest Information Sheet, Infosheet 10. http://crimp.marine.csiro.au/Reports/Infosht10_Mytil0201S3.pdf

Cesar, H., Vanbeukerling, P. and S. Prince. In press. An economic valuation of Hawaii's coral reefs. *Hawai'i Coral Reef Initiative Research Program Final Report.*

Chapman, W. M. and L.P. Schultz. 1952. "Review of the fishes of the blennioid genus *Ecsenius*, with descriptions of five new species". *Proc. U. S. Nat. Mus*., 102(331): 507-528.

Cohen, A. N. and J.T. Carlton. 1995. "Nonindigenous Aquatic Species in a United States Estuary: a case study of the biological invasions of the San Francisco Bay and delta." http://www.anstaskforce.gov/sfinvade.htm.

Coles, S.L., DeFelice, R.C. Eldredge, L.G., Carlton, J.T., Pyle, R.L., and A. Suzumoto, A. 1997. "*Biodiversity of marine communities in Pearl Harbor, O'ahu, Hawai'i, with observations on introduced exotic species*". Bernice P. Bishop Museum Dep. Nat. Sciences, Honolulu, prepared for Dep. Defense Legacy Proj. 106, Draft Report, 66pp + appendices.

Coles, S.L., De Felice, R.C., Smith, J.E., Muir, D. and L.G. Eldredge. 1998. "Determination of baseline conditions for introduced marine species in nearshore waters of the island of Kaho'olawe, Hawai'i". *Bishop Mus. Tech. Rep. No. 14*. 26pp.

Coles, S. L., DeFelice, R. C. and L.G. Eldredge, with the assistance of Godwin, L. S., Pyle, R. L. and A. Suzumoto. 1999a. "Nonindigenous marine species introductions in the harbors of the south and west shores of Oahu, Hawai'i". Bernice P. Bishop Mus. Hawaii Biol. Surv., *Bishop Museum Tech. Rept. No. 15*, 210 p.

Coles, S.L., DeFelice, R.C., Eldredge, L.G. and J.T. Carlton. 1999b. "Historical and recent introduction of nonindigenous marine species into Pearl Harbor". *Marine Biology* 134:147-158.

Coles, S. L., DeFelice, R.C., and L.G. Eldredge. 2002a. "Nonindigenous species in Kane'ohe Bay, O'ahu, Hawai'i ". *Bishop Mus. Tech. Rep.* No. 24, 353 pp.

Coles, S. L., DeFelice, R.C., and L.G. Eldredge. 2002b. "Nonindigenous species at Waikiki and Hawai'i Kai, Oahu, Hawai'i". *Bishop Mus. Tech. Rep.* No. 25, 245 pp.

Coles, S.L. and L.G. Eldredge. 2001a. "Assessment of Nonindigenous Species on Coral Reefs in the Main Hawaiian Islands, with Emphasis on Introduced Invertebrates". *Unpublished proposal submitted to the Hawai'i Coral Reef Initiative Research Program*

Coles, S.L. and L.G. Eldredge. 2001b. "Nonindigenous Marine Species Introductions in the Harbors of Nawiliwili and Port Allen, Kaua'i, Kaunakakai, Moloka'i; Kahalui, Maui; Hilo and Kawaihae, Hawai'i". *Unpublished proposal submitted to the Hawai'i Community Foundation.*

Coles, S.L. and L.G. Eldredge. 2002. "Nonindigenous Species Introductions on Coral Reefs: a need for information". *Pac. Sci.* 56:191-209.

Coloma-Agaran, G. 2003. First Quarterly Status Report for "Nuisance Seaweed Control, Kihei, Maui, Hawai'i." *Unpublished report submitted to EPA.*

Coordinating Group on Alien Pest Species (CGAPS). 1997. "*The Silent Invasion*". Prepared by The Nature Conservancy of Hawai'i and member agencies of CGAPS.

Coordinating Group on Alien Pest Species (CGAPS). 2003. *"Status Report: Island-based Partnerships and Statewide Coordination to Protect Hawaii*". Prepared by CGAPS in collaboration with Big Island Invasive Species Committee (BIISC), Maui Invasive Species Committee (MISC), Kaua'i Invasive Species Committee (KISC), O'ahu Invasive Species Committee (OISC), Moloka'i/Maui Invasive Species Committee (MoMISC).

Cowie, R.H. 1995. "Identity, Distribution and Impacts of Introduced Ampullariidae and Viviparidae in the Hawaiian Islands". *Journal of Medical and Applied Malacology* 5: 61-67.

Cowie, R.H. 1996. "New Records of Introduced Land and Freshwater Snails in the Hawaiian Islands". *Bishop Museum Occasional Papers* 46: 25-57.

Cowie, R.H. 1997. "Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands". *Bishop Museum Occasional Papers* 50: 1-66.

Cowie, R.H. 1998. "Patterns of introduction of non-inidgenous non-marine snails and slugs in the Hawaiian Islands". *Boidiversity and Conservation* 7 (3): 349-368.

Cowie, R.H. 1999. "New records of alien nonmarine mollusks in the Hawaiian Islands". *Bishop Museum Occasional Papers* 59: 48-50.

Cowie, R.H. 2001. Mollusks. *In*: *Hawai'i's Invasive species. A guide to invasive plants and animals in the Hawaiian Islands* (eds. Staples, G.W. & Cowie, R.H.), p. 66-72. Mutual Publishing & Bishop Museum Press, Honolulu.

Cowie, R.H. 2002. Apple snails (Ampullariidae) as agricultural pests: their biology, impacts and management. In: *Molluscs as Crop Pests* (ed. G.M. Barker), p. 145-192. CABI Publishing, Wallingford.

Cox, G.W. 1999. *Alien Species in North America and Hawaii: Impacts on Natural Ecosystems*. Island Press. Washington, D.C. 387 pages.

Dahl, T. E. 1990. Wetlands Losses in the United States 1780s to 1980s. Washington D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service. 21 pp.

Davidson, K., Hamnett, M., and Minato, C. (eds). 2003. "The First Four Years: Hawai'i Coral Reef Initiative Research Program (1998 - 2002). Social Science Research Institute, University of Hawai'i at Manoa. 72 pp.

DeFelice, R.C., Coles, S.L., Muir, D. and L.G. Eldredge 1998. "Investigations of the marine communities of Midway Harbor and adjacent lagoon, Midway Atoll, Northwestern Hawaiian Islands". *Report to US Fish and Wildlife Service*, Honolulu, 12pp + append.

DeFelice, R., Minton, D., and S. Godwin. 2002. "Records of shallow -water marine invertebrates from French Frigate Shoals, Northwestern Hawaiian Islands with a note on nonindigenous species". *Hawaii Biological Survey Tech. Rep.* 23 Bishop Museum, Honolulu.

DeMartini, E.E., Mundy, B.C., and J.J. Polovina. 1999. "Status of nearshore sports and commercial fishing and impacts on biodiversity in the tropical insular pacific", in *Marine and Coastal Biodiversity in the Tropical Island Pacific Region* (Eldredge, L.G., Maragos, J.E., Holthus, P.F. and Takeuchi, H.F. eds.) Volume 2: 345-346

Department of Land and Natural Resources, Division of Forestry and Wildlife. ____."Hawaii's most invasive Horticultural Plants: an introduction". http://www.state.hi.us/dlnr/dofaw/hortweeds/index.html.

Department of Land and Natural Resources, Division of Aquatic Resources. _____.Anuenue Fisheries Research Center. http://www.state.hi.us/dlnr/dar/afrc/index.

Done, T.J. 1992. Phase shifts in coral reef communities and their ecological significance. *Hydrobiologia* 247:121-132

Doty, M.S. 1961. *Acanthophora,* a possible invader of the marine flora of Hawai'i. *Pac. Sci., 15*:547-52

Drigot, D., 1999. "Mangrove Removal and Related Studies at Marine Corps Base Hawai'i", DoD Legacy Resource Management Program, Tech Note M-3N. In *Technical Notes: Case Studies from the Department of Defense Conservation Program*. Ed. Undersecretary of Defense: Environmental Security Office, Arlington, VA.

Drigot, D. 2001. "An ecosystem-based management approach to enhancing endangered waterbird habitat on a military base", In *Evolution, Ecology, Conservation, and Management of Hawaiian Birds: A Vanishing Avifauna*, Studies in Avian Biology No. 22, Cooper Ornithological Society (c/o Western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, CA 93012).

Drigot, D.C., B. A. Wilcox, and K. N. Duin. 2001. "Marine Corps Base Hawaii Integrated Natural Resources Management Plan and Environmental Assessment (MCBH INRMP/EA) (2001-2006)". Prepared by MCBH Environmental Department and Sustainable Resources Group International Inc. (SRGII), for MCBH, November.

Eldredge, L.G. 1987. "Coral reef alien species". In *Human impacts on coral reefs: Facts and recommendations,* ed. B. Salvat, 215-28. Antenne Museum-EPHE, French Polynesia.

Eldredge, L.G. 1994. Perspectives in aquatic exotic species management in the Pacific Islands". In *Introductions of commercially significant aquatic organisms to the Pacific Islands, Volume 1.* South Pacific Commission, Noumea.

Eldredge, L.G. and J.T. Carlton. 2002. "Hawaiian Marine Invasions: a preliminary assessment". *Pacific Science*, 56 (2): 211-212.

Eldredge, L.G. and R.A. Englund. 2001a. "Crustaceans". In: *Hawaii's Invasive species. A guide to invasive plants and animals in the Hawaiian Islands* (Staples, G.W. & Cowie, R.H., eds.), p. 63-65. Mutual Publishing & Bishop Museum Press, Honolulu.

Eldredge, L.G. and R.A. Englund. 2001b. "Other invertebrates". In: *Hawaii's invasive species. A guide to invasive plants and animals in the Hawaiian Islands* (eds. Staples, G.W. & Cowie, R.H.), p. 73-75. Mutual Publishing & Bishop Museum Press, Honolulu.

Eldredge, L,G. and C.M. Smith. 2001. A guidebook to introduced marine species in Hawai'i. *Bishop Museum Technical Report.*

Englund, R.A. 1999. "The impacts of introduced poeciliid fish and Odonata on endemic *Megalagrion* (Odonata) damselflies of O'ahu Island, Hawai'i." *Journal of Insect Conservation* 3:225-243.

Englund, R.A. 2001. "Long-term monitoring of one the most restricted insect populations in the United States, *Megalagrion xanthomelas* (Selys-Longchamps), at Tripler Army Medical Center, O'ahu, Hawai'i (Zygoptera: Coenagrionidae)". *Odonatologica* 30(3): 255-263.

Englund, R.A. 2002. "The loss of native biodiversity and continuing nonindigenous species introductions in freshwater, estuarine, and wetland communities of Pearl Harbor, O'ahu, Hawaiian Islands". *Estuaries* 25(3): 418-430.

Englund, R.A. and K.T. Arakaki. 2003. "Report on long-term aquatic insect monitoring in 2002 by Hawai'i Biological Survey, Bishop Museum in Pelekunu Valley, Moloka'i Hawai'i". Report for the Nature Conservancy of Hawai'i, Moloka'i Office Contribution No. 2003-001 to the *Hawai'i Biological Survey*. 10 pp.

Englund, R.A., Arakaki, K., Preston, D.J., Coles, S.L., and L.G. Eldredge. 2000a. "Nonindigenous freshwater and estuarine species introductions and their potential to affect sportfishing in the lower stream and estuarine regions of the south and west shores of O'ahu, Hawai'i." *Bishop Museum Technical Report* No. 17. Bishop Museum, Honolulu, Hawai'i. 121 pp.

Englund, R.A., Preston, D.J., Wolff, R., Coles, S.L., Eldredge, L.G., and K. Arakaki. 2000b. "Biodiversity of freshwater and estuarine communities in lower Pearl Harbor, O'ahu, Hawai'i with observations on introduced species". *Bishop Museum Technical Report* No. 16. Bishop Museum, Honolulu, Hawai'i. 166 pp.

Englund, R.A. and E. Baumgartner. 2000. "The Fang-Toothed Blenny *Omobranchus ferox* (Herre, 1927) from Pearl Harbor, O'ahu, a probable unintentional introduction to the Hawaiian Islands". *Bishop Museum Occasional Papers* 64: 61-63.

Englund, R.A and Y. Cai. 1999. "The occurrence and description of *Neocaridina denticulata sinensis* (Kemp, 1918) (Crustacea: Decapoda: Atyidae), a new introduction to the Hawaiian Islands". *Bishop Museum Occasional Papers* 58:58-65.

Englund, R.A. and L.G. Eldredge. 2001. Fishes. *In*: *Hawaii's Invasive species. A guide to invasive plants and animals in the Hawaiian Islands* (eds. Staples, G.W. & Cowie, R.H.), p. 32-40. Mutual Publishing & Bishop Museum Press, Honolulu.

Englund, R.A. and D.A. Polhemus. 2001. "Evaluating the effects of introduced rainbow trout (*Oncorhynchus mykiss*) on native stream insects on Kaua'i Island, Hawai'i". *Journal of Insect Conservation* 5: 265-281.

Environmental Law Institute. August 2002. "*Halting the Invasion: State Tools for Invasive Species Management*". Washington D.C., 112 pages.

Environmental Protection Agency. ____"National Pollutant Discharge Elimination System". http://cfpub.epa.gov/npdes/.

Executive Order 13112. February 3, 1999. http://www.invasivespecies.gov/laws/execorder.shtml.

Flint, O.S., Jr., Englund, R.A.. and B. Kumashiro. 2003. "A reassessment and new State records of Trichoptera occurring in Hawai'i with discussion on origins and potential ecological impacts". *Bishop Museum Occasional Papers* 73:

Font, W.F. and D. C. Tate. 1994. Helminth parasites of native Hawaiian freshwater fishes: an example of extreme ecological isolation. *J. Parasitology,* vol. 80, no. 5, pp. 682-688.

Friedlander, A.M., Parrish J.D., and R.C. DeFelice. 2002. "Ecology of the introduced snapper *Lutjanus kasmira* (Forsskal) in the reef fish assemblage of a Hawaiian bay". *Journal of Fish Biology* 60:28-48.

Garrison, J.S.E., Rauzon, M.J., Duin, K.N., and B.A. Wilcox. 2002. "Marine Corps Base Hawai'i Invasive Species Management Study". *Final Report, prepared for MCBH Environmental Department* under contract through Naval Facilities Engineering Service Center, Port Hueneme, CA 93043, December.

Godwin S. and L. G. Eldredge. 2001. "South O'ahu Marine Invasion Shipping Study". Final report prepared for the Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources*. Bishop Museum Technical Report No. 20*.

Grigg, R.W. 2003. "Invasion of a Deep Black Coral Bed by an Alien Species, *Carijoa riisei*, off Maui, Hawai'i." *In press.*

HASS, 2000., 2003. Hawai'i Agricultural Statistics Service. P.O. Box 22159, Honolulu, HI 96823-2159. http://www.nass.usda.gov/hi/rlsetoc.htm

Hawai'i Coral Reef Initiative Research Program. 2003. "*Scope of Work for 2003 Alien Species Projects*".

Appendix L: **References**

HDOA (Hawai'i Department of Agriculture) 2002. "*Kahului Airport Pest Risk Assessment*". Plant Quarantine Branch. Internal publication. 41pp. + attachments.

Hawai'i Sea Grant. 2000. "Highlights in Aquatic Nuisance Species Research and Outreach", *in Aquatic Nuisance Species Report: an update on Sea Grant Research and Outreach Projects.* www.sg.ohio-state.edu/publications/ANSreport/applesnail.pdf.

Hawai'i Stream Research Center. _____. http://www2.hawaii.edu/hsrc/home/aquaorg.htm.

Henderson, Scott. 1992. "A Natural Resources Survey of the Nearshore Waters of Mokapu Peninsula, Kaneohe Marine Corps Air Station", prepared under contract for MCAS Kaneohe Bay, by Naval Command Control and Ocean Surveillance Center, Environmental Sciences Division, Hawaii Lab.

Hodgson, L.M. 1994. Maui Algae Project. *A technical report submitted to Hawai'i Department of Health, Environmental Planning Office.*

Hurley, T 2001. "Airport inspectors find plenty of trouble", *Honolulu Advertiser*, Wednesday, February 7, 2001. http://myadvertiser.com/2001/Feb/07/27localnews30.html.

Ikuma, E.K., Sugano, D., and J.K. Mardfin. 2002. "Filling the Gaps in the Fight Against Invasive Species". Legislative Reference Bureau, Report No. 1, 2002. Accessible online at www.state.hi.us/lrb/

Kido, M.H., Heacock, D.E., and A. Asquith. 1999. "Alien rainbow trout *(Oncorhynchus mykis)* (Salmoniformes: Salmonidae) diet in Hawaiian Streams". *Pacific Science* 53 (3): 242-251.

Kraus, F. and D. Cravalho. 2001. "The Risk to Hawai'i from Snakes". *Pacific Science* 55 (4): 409-417.

Kubota, G.T. 2003. "Poi takes a Pounding - damaged crops have growers reducing supplies". *The Honolulu Advertiser*. 16 May 2003 p. A1, A8.

Kushima, J. 1989. "Taape Market Development Project". Final Report. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawai'i.

Lach, L., Britton, D.K., Rundell, R.J. and R.H. Cowie. 2001. "Food preference and reproductive plasticity in an invasive freshwater snail". *Biological Invasions* 2(4) [2000]: 279-288.

Lach, L. and R.H. Cowie. 1999. "The Spread of the Introduced Freshwater Apple Snail *Pomacea canaliculata* (Lamark) (Gastropoda: Ampullariidae) on O'ahu, Hawai'i". *Bishop Museum Occasional Papers* 58: 66-71.

Lewis, T. ____."UH's Stream Research Center Helps a Torn Community Decide a River's Future". Hawai'i Stream Research Center http://www2.hawaii.edu/hsrc/home/aquaorg.htm.

Loope, L. L., and D. Mueller-Dombois. 1989. "Characteristics of invaded islands". Pages 257-280 in: H.A. Mooney et al editors. *Ecology of biological invasions: a global synthesis*. John Wiley & Sons, Chichester, England.

Loope, L.L. 1999. "Hawai'i and the Pacific Islands"*, in Status and Trends of the Nation's Biological Resources, United States Geological Survey Publication*. http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm.

Macdonald, G. A., Abbott, A.T., and F. L. Petersen. 1983. *Volcanoes in the sea: the geology of Hawaii.* University of Hawaii Press, Honolulu. 519 pp.

Maine Department of Fish and Wildlife. October 2002. "State of Maine Action Plan for Managing Invasive Aquatic Species".

McClanahan, T.R., V. Hendrick, M.J. Rodriguez, N.V.C. Polunin. 1999. Varying responses of herbivores and invertebrate-feeding fishes to macroalgal reduction on a coral reef. *Coral Reefs* 18:195-203.

Miller, S. and A. Holt. 1992. "*The Alien Pest Species Invasion in Hawai'i: Background Study and Recommendations for Interagency Planning*". The Nature Conservancy of Hawai'i and the Natural Resources Defense Council. Accessible online via links from: www.hear.org/articles/pdfs/tnchnrpp1992.pdf

Massachusetts (State of). July 2002. "Massachusetts Aquatic Invasive Species Management Plan".

Montana (State of). October 2002. "Montana Aquatic Nuisance Species (ANS) Management Plan".

Murakawa, P., Kushima, J., and S. Godwin. 2002. "State of Hawaii's Ballast Water, Ballast Sediment and Hull Fouling Management Program Guidelines". *Unpublished.*

Murakawa, P, Kushima, J., and S. Godwin. 2002. "Alien Aquatic Organism Task Force". *Unpublished.*

National Invasive Species Council. 2001. "*Meeting the Invasive Species Challenge*". Management Plan. 74 pages.

Nelson S.G. and L.G. Eldredge. 1991. "Distribution and status of introduced cichlid fishes of the genera *Oreachromis* and *Tilapia* in the islands of the South Pacific and Micronesia". *Asian Fish Science* 4:11-22.

Nishida, G. M. 2002. Hawaiian terrestrial arthropod checklist, 4th Edition (Searchable database on the internet at http://www.bishopmuseum.org/bishop/ento/entodbhome.html). Hawaii Biological Survey. *Bishop Mus. Tech. Rep. 12*. 313 pp

Nishimura, N.J. 2000. Assessment of genetic variability in the invasive red alga *Gracilaria salicornia* using multi-locus DNA fingerprinting. *Master's Thesis, University of Hawai'i, Honolulu, HI.*

Norcross, Zoe. 2002. "Control of Nuisance Seaweed on the Beaches of Kihei, Maui County". *Grant proposal and work plan Submitted to the EPA by Maui County Sea Grant on behalf of the Maui County Department of Public Works.*

Oda, D.K., and J.D. Parrish. 1981. "Ecology of commercial snapper and groupers introduced to Hawaiian reefs". *Proceedings of the Fourth International Coral Reef Symposium, Manila*, 1981, Vol. 1:59-67.

Oregon State ANS Management Plan. 2001.

Parrish, J.D., Aeby, G.S., E.J. Conklin, E.J., and G.L. Ivey. 2000. "Interactions of nonindigenous blueline snapper (Ta'ape) with native fishery species". *Final Report to the State of Hawai'i, Department of Land and Natural Resources, Division of Aquatic Resources.*

Parrish, J.D. and K.N. Holland. 2001. "Analysis of habitat use and movement patterns of native and alien demersal fishery species". *Unpublished proposal to University of Hawai'i Sea Grant College Program*.

Polhemus, D.A., Maciolek, J., and J. Ford. 1992. "An Ecosystem Classification of Inland Waters for Tropical Pacific Islands". *Micronesica* 25(2): 155-173.

Preskitt, L.B., Smith, C.M., Abbott, I.A., DeFelice, R.C., Eldredge, L.G., and J.T. Carlton. 2001. "A *Guidebook of Introduced Marine Species of Hawai'i".* Bishop Museum and University of Hawai'i.

Price, S. 1983. Climate. Pages 53-62 in: R.W. Armstrong, editor. "*Atlas of Hawai'i"*. University Press of Hawai'i, Honolulu.

Pyle, R. L. 2002. Checklist of the birds of Hawaii – 2002. *Elepaio* 62(6):137-148.

Randall, J. E. 1980. "New records of fishes from the Hawaiian Islands". *Pac. Sci*., 34(3): 211-232.

Randall, J.E. 1987a. "Introductions of marine fishes to the Hawaiian Islands". *Bull. Mar. Sci*. 41:490-502.

Randall, J. E. 1987b. "Collecting reef fishes for aquaria. 29-39. *in B. Salvat (ed.) Human impacts on coral reefs: facts and recommendations*". Antenne Museum E.P.H.E., French Polynesia. 253 p.

Randall, J. E. 1997. "The hawkfish *Cirrhitichthys serratu*s Randall, a junior synonym of C. falco Randall." *Micronesia*, 30(1): 199-203.

Randall, J. E., J. L. Earle, T. Hayes, C. Pittman, M. Severns, & R. J. F. Smith (1993). "Eleven new records and validations of shore fishes from the Hawaiian Islands." *Pacific Science*, vol. 47 (3): 222-239.

Randall, J. E. & Heemstra, P. C. 1991. "Revision of Indo-Pacific groupers (Perciformes: Serranidae: Epinephelinae), with descriptions of five new species*"*. *Indo-Pacific Fishes No. 20*, 332 p.

Rauzon, M. J. and L. Tanino. 1998. "Bird Monitoring During Mangrove Removal at Nu'upia Ponds Wildlife Management Area, Kaneohe Bay, Marine Corps Base Hawaii", Prepared by Marine Endeavors. Prepared for Marine Corps Base Hawaii under subcontract to SCS/CRMS, Inc., through US Army Corps of Engineers, Pacific Ocean Division, January.

Rauzon. M. J. and Drigot, D. C. 2002. "Red Mangrove Eradication and Pickleweed Control in a Hawaiian Wetland, Waterbird Responses, and Lessons Learned." In *Turning the Tide: The Eradication of Invasive Species, Proceedings of the International Conference on Eradication of Island Invasives* Ed. C. R. Veitch and M. N. Clout, Occasional Paper of the IUCN Species Survival Commission No. 27, International Union for Conservation of Nature and Natural Resources (IUCN)-The World Conservation Union (Gland, Switzerland and Cambridge, UK).

Rodgers, S.K. and E.F. Cox. 1999. "Rate of spread of introduced rhodophytes *Kappaphycus alvarezii, Kappaphycus striatum,* and *Gracilaria salicornia* an their current distributions in Kane'ohe Bay, O'ahu, Hawai'i". *Pac. Sci*. 54:232-241

Russell, D.J. 1983. "Ecology of the imported red seaweed *Euchuma striatum* Schmitz on Coconut Island, O'ahu, Hawai'i". *Pac. Sci.* 37:87-107.

Russell, D.J. 1987. "Introductions and establishment of alien marine algae". *Bull. Mar. Sci.*42:641-642.

Russell, D.J. 1992. "The ecological invasion of Hawaiian reefs by two marine red algae, *Acanthophora spicifera* (Vahl) Boerg. and *Hypnea musciformis* (Wulfen) J. Ag., and their association with two native species, *Laurencia nidifica* J.Ag. and *Hypnea cervicornis* J.Ag.". *J. Ag. Int. Counc. Explor. Sea Mar. Sci.Symp.* 194:110-125.

Russell, D.J. and G.H. Balazs. 1993. "Colonization by the alien marine alga *Hypnea musciformis* (Wulfen) J.Ag. (Rhodophyta: Gigartinales) in the Hawaiian Islands and its utilization by the green sea turtle, *Chelonia mydas L.*" *Aquatic Botany* 46:53-60.

Sabaj, M.H. and R.A. Englund. 1999. "Preliminary identification and current distributions of two suckermouth armored catfishes (*Loricariidae*) introduced to O'ahu streams". *Bishop Museum Occasional Papers* 59:50-55.

Scott, S. 2003. "Ocean watch. Very blue fish at Hanauma Bay is not native". *Honolulu Star-Bulletin*, January 3, 2003. http://starbulletin.com/columnist/column.php?id=2125&col_id=35]

Sea Grant. 2000. "Highlights in Aquatic Nuisance Species Research and Outreach", in *Aquatic Nuisance Species Report: An update on Sea Grant Research and Outreach Projects*.

Sea Grant Website: http://www.sg.ohio-state.edu/publications/ANSreport/applesnail.pdf

Shultz-Kukea, K. 2003. "Planting Native Limu at the He'eia Reef". *Unpublished permit application.* Smith, C.M., J.F. Harrigan, R.T. Nishimoto, FJ. Sansone, and G. Tribble. 2002. "Nuisance Macroalgal Blooms in coastal Maui: assessment and integration of physical factors and biological processes". *Unpublished proposal submitted to the EPA*.

Smith, J.E., Hunter, C.L., and C.M. Smith. 2002. "Distribution and Reproductive Characteristics of Nonindigenous and Invasive Marine Algae in the Hawaiian Islands". *Pacific Science 56 (3) 299-215.*

Smith, J.E., Hunter, C.L., Conklin, E.J., Most, R., Sauvage, T., Squair, C. and C.M. Smith. (In press). "The Ecology of the Invasive Red Alga *Gracilaria salicornia* (C. Agardh) E.Y. Dawson on O'ahu, Hawai'i".

Speitel, Tom. 2002. "Hawaii Watersheds". www.hawaii.edu/environment.

Springer, V. G. 1971. "Revision of the fish genus *Ecsenius (*Blenniidae, Blenniinae, Salariini*)*". *Smithsonian Contrib*. Zool. No. 72, 74 p.

Springer, V. G. 1991. "Documentation of the blenniid fish *Parablennius thysanius* from the Hawaiian Islands". *Pac. Sci.*, 45(1): 72-75.

Staples, G.W. and R.H. Cowie (eds) 2001. *Hawaii's Invasive Species: a guide to invasive pants and animals in the Hawaiian Islands*. Mutual Publishing, Honolulu. 115 pages.

Strasburg, D.W. 1956. "Notes on the blennioid fishes of Hawaii with description of two new species*". Pacific Science*. 10(3):241-267.

Stimson, J., Larned, S.T., and E. Conklin. 2001. "Effects of herbivory, nutrient levels, and introduced algae on the distribution and abundance of the invasive macroalga *Dictyosphaeria cavernosa* in Kane'ohe Bay, Hawai'i". *Coral Reefs* 19:343-357.

Sustainable Resources Group International Incorporated (SRGII). 2002a. (Prepared byGarrison, J.S.E., Rauzon, M.J., Duin, K.N., and B.A. Wilcox.) "Marine Corps Base Hawai'i Invasive Species Management Study". *Final Report, prepared for MCBH Environmental Department* under contract through Naval Facilities Engineering Service Center, Port Hueneme, CA 93043, December.

Sustainable Resources Group International Incorporated (SRGII). 2002b. "Marine Corps Base Hawaii Coral Reef Ecosystem Management Study, Final Report", prepared for MCBH Environmental Department under contract through Naval Facilities Engineering Service Center, Port Hueneme, CA 93043, December.

Tamaru, C.S. 1999. Control of the apple snail (*Pomacea canaliculata*), Planning Project. *Contract #40785. Final Report. Submitted to the Department of Hawaiian Homelands, State of Hawai'i,* 20 pp.

TenBruggencate, J. 1997. "Some Hawai'i Pests Arrived by Invitation". *The Honolulu Advertiser*. 17 February, 1997.

Timbol, A. S., M.H. Kido, and D.E. Heacock. 1989. "A descriptive study of selected biological and physicochemical characteristics of Limahuli Stream, Haena, Kaua'i". *National Tropical Botanical Garden, Masterplan for Limahuli Garden and Preserve.*

Turgeon, D. 2002. "Draft Plan for a National Coastal Marine Alien Species Program". *National Oceanic and Atmospheric Association, National Ocean Service (NOAA,NOS) draft document.*

US Department of the Interior. 1999. "*Integrated Pest Management Approaches to Preventing the Dispersal of the Brown Tree Snake and Controlling Snakes in Other Situations*".

US Geological Survey. ____."National Water-Quality Assessment Program – Water Resources of Hawai'i and the Pacific". http://hi.water.usgs.gov/nawqa/index.html

US Geological Survey. ____."Water-Related Activities of USGS in Hawaii – Assessment of Benthic Invertebrates as Indicators of Stream Quality in Hawaii". http://hi.water.usgs.gov/projects/project_invert.htm.

Vroom, P. and C.M. Smith. 2001. The Challenge of Siphonous Green Algae. American Scientist 89(6): 524-351.

Washington State ANS Management Plan. September 2001.

Wil Chee-Planning, Inc. 2002. "Final Environmental Assessment and Finding of No Significant Impact for Mangrove Removal and Endangered Species Habitat Improvements, Marine Corps Base Hawai'i", for MCBH through contract to US Army Corps of Engineer District, Honolulu, Fort Shafter, Hawaii, August.

Williams, V.R. and T.A. Clarke. 1983. "Reproduction, growth, and other aspects of the biology of the gold spot herring, *Herklotsichthys quadrimaculatus* (Clupeidae), a recent introduction to Hawai'i". *Fish. Bull.* 81 (3):587-597.

Woo. M. 1999. "Ecological impacts and interactions of the introduced red alga *Kappaphycus striatum* in Kaneohe Bay, O'ahu". *M.S. thesis, University of Hawai'i at Manoa,* Honolulu.

Yamamoto, M.N. ____. Department of Land and Natural Resources, Division of Aquatic Resources website: www.state.hi.us/dlnr/dar/stream_aliens.htm.

Yamamoto, M.N. and A.N. Tagawa. 2000. "*Hawaii's Native and Exotic Freshwater Animals"*. Mutual Publishing, Honolulu. 200 pages.