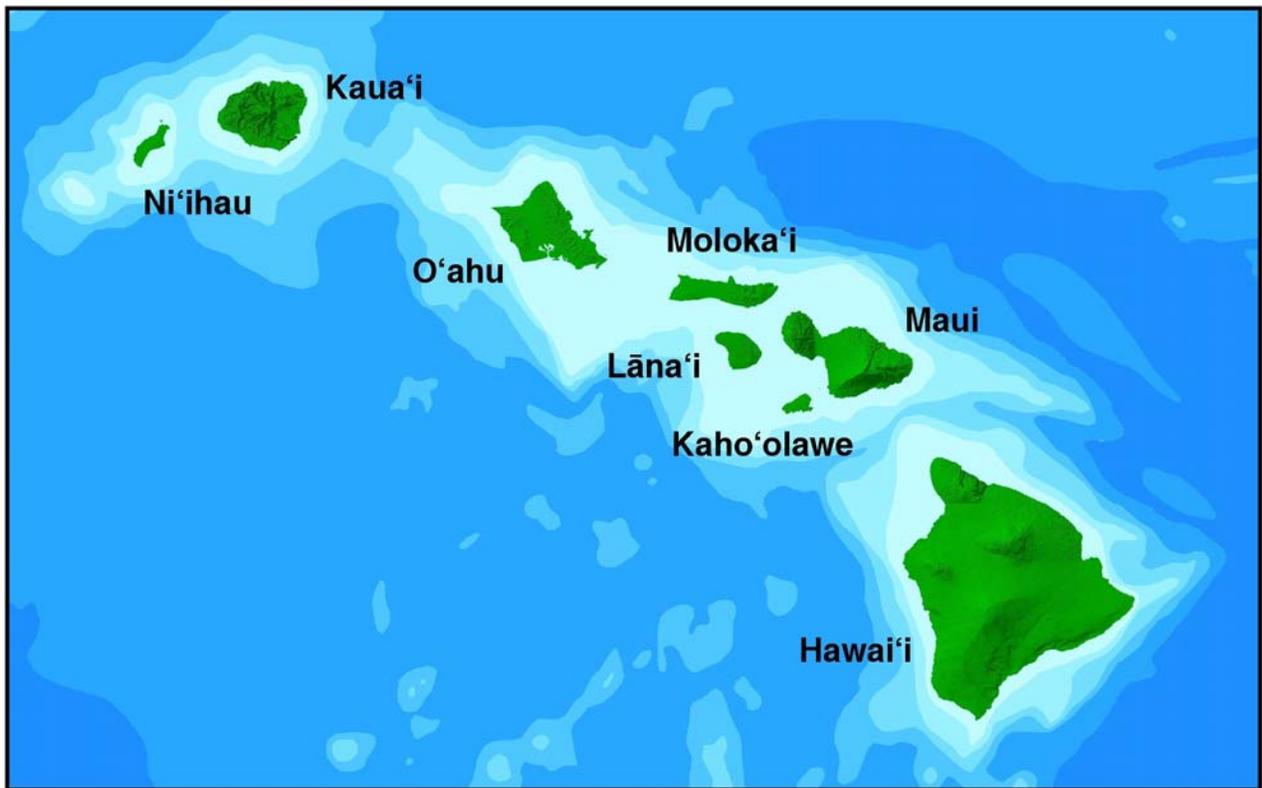


DRAFT VERSION

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



July 2, 2003

Preface

This is a DRAFT version of the Aquatic Invasive Species Management Plan for the State of Hawai‘i. It is submitted at this point for further review by agencies and organizations within and outside of Hawai‘i, the Federal Aquatic Nuisance Species Task Force, and to the public.

How to Provide Input on this Document: Please send written comments to Andi Shluker at the email, fax, or mail address below by July 23rd, 2003. Please be as specific as possible, and include page numbers if applicable. This document may also be accessed through the State of Hawai‘i Division of Aquatic Resources, Department of Land and Natural Resources' website, at <http://www.state.hi.us/dlnr/dar/index.html>

For further information regarding this draft of the Aquatic Invasive Management Plan for the State of Hawai‘i, please contact:

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This publication of the State of Hawai‘i Division of Aquatic Resources, Department of Land and Natural Resources, The Nature Conservancy, and relevant partners was made possible through a generous grant from the Hawai‘i Community Foundation.

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Acknowledgments

The plan is truly a collaborative effort, as over 100 individuals had direct input into this draft of the plan. This includes resource managers, policy makers, researchers, educators, industry representatives from the shipping, aquaculture, aquarium, and tourism industries, active ocean and freshwater users, as well as other stakeholders.

The Steering Committee and (active alternates) of this plan were a key component in the development process, and consists of the following representatives from Federal, State, Industry, and Non-governmental Organizations, listed in alphabetical order:

Scott Atkinson, **The Nature Conservancy**
Robbie Blane, **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, **Waikiki Aquarium**

Jo-Anne Kushima, **DLNR¹, Division of Aquatic Resources**
Kenneth Matsui, **Pets Pacifica/Petland**
Kim Moffie, **Hawai'i Audubon Society /
Pacific Fisheries Coalition**
Paul Murakawa, **DLNR, Division of Aquatic Resources**
Celia Smith, **University of Hawai'i**
Mike Yamamoto, **DLNR, Division of Aquatic Resources**
Leonard Young, **HDOA's¹ Aquaculture Development Program**
Ron Wiedenbach, **Hawai'i Aquaculture Association**

Additional ongoing participants at Steering Committee Meetings: Dorothy Alontaga, U.S. Department of Agriculture; Mandy Wilkinson, DLNR – Division of Forestry and Wildlife; Matt Zimmerman, Island Divers / Reef Check. Miki Lee, of Leeway Enterprises facilitated the Steering Committee and early public input meetings.

Focus Area Groups were also an instrumental component of the plan, and 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. The bulk of the information relating to identification of marine and freshwater AIS problems, as well as specific tasks suggested for management came from questionnaires, interviews, and meetings with representatives from these Focus Area Groups. These individuals are listed by specialty in Appendix D.

For many of the individuals involved in the Steering Committee and/or Focus Area Groups, numerous hours were donated to the development of this plan, including attending of meetings and extensive review of text. This involvement was generally in addition to their normal workload, and the time and effort put in by these individuals is truly appreciated.

Additional appreciation is extended to those who went "above and beyond", taking on the authoring of certain sections, and who include Dorothy Alontaga, Domingo Cravalho, Ron Englund, Scott Godwin, Paul Murakawa, Jo-Anne Kushima, Kim Moffie, Jennifer Smith, and Mike Yamamoto. Also to Ron Weidenbach for setting and keeping the pace during the lengthy Steering Committee meeting for the editing of the first draft of this plan

Additional contributors and industry representatives were also valuable in supplying details, answers, and suggestions relating to certain issues and questions that arose during the development of this plan.

Special thanks go out to Scott Smith (Washington Department of Fish and Game, and the State AIS Coordinator), Holly Crosson (California AIS Management Plan Coordinator), and Mark Systma (Oregon AIS Management Plan Coordinator) for being especially helpful in supplying direction and advice. Thanks to these States as well as Alaska, Massachusetts, and Maine, in allowing free use of their plan and other documents for assistance in the creation of this plan.

¹ *DLNR = Department of Land and Natural Resources*
HDOA = Hawai'i Department of Agriculture

Executive Summary

The purpose of this Aquatic Invasive Species (AIS) Management Plan for the State of Hawai'i is to enhance the coordination of current management efforts, address remaining problems areas and gaps, and identify additional actions needed to effectively address AIS issues in Hawai'i. 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 such state and regional management plans. With approval of a State AIS Management Plan by the Federal Aquatic Nuisance Species Task Force, federal matching funds for activities detailed in this plan may be available to implement tasks referred to in the plan. 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.

Aquatic Invasive Species (AIS) include species in marine, freshwater, brackish water, and estuarine environments, 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 Hawaii's native plants and animals, as well as their associated ecosystems. AIS can also have significant economic impacts. These economic impacts were recently experienced by the State and its partners with the control and clean-up efforts associated with *Salvinia molesta* (Giant Salvinia) in Lake Wilson/ Wahiawā Reservoir on O'ahu, which cost approximately 1 million dollars.

The threats posed by aquatic invasive species are clear, as is the need to address them in a proactive, coordinated fashion. While there are currently some efforts by state, federal, non-profit, and private entities to address various AIS issues, these are not enough to effectively manage the impacts of AIS in a comprehensive manner. Further, the majority of these efforts are funded by "soft-money", such as grants, and allow for only short-term implementation.

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. The goal of the plan is as follows:

To minimize the harmful ecological and economic 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:

- 1) Increase coordination and collaboration among those working to address AIS issues**
- 2) Minimize introductions into and throughout Hawai'i**
- 3) Ensure effective monitoring and early detection**
- 4) Establish effective systems for rapid response, eradication, control, and restoration**
- 5) Increase education and outreach**
- 6) Research to better understand the species-specific impacts and control options**
- 7) Ensure state laws and regulation effectively promote the prevention and control of AIS**

For each objective, a variety of tasks are presented. These tasks have been identified as being key "action items" in managing the issues of aquatic invasive species more effectively, before these species cause further environmental or economic damage.

This plan is structured for phased or incremental implementation, with high priority on the establishment of a statewide Aquatic Invasive Species Coordinator position, the establishment of an Aquatic Invasive Species Advisory Council, and a system for streamlined reporting of, and rapid response to newly detected invaders. It is expected that the AIS plan is to be a work in progress, with updates made to the plan at least yearly.

Introduction

What are Aquatic Invasive Species?

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 health².

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 not³. Nonnative species are also called alien, exotic, nuisance, and/or non-indigenous species. Though not all nonnative species will become invasive, those that do can have significant negative impacts in the areas they become established, as further detailed in Chapter 2.

Aquatic Invasive Species (AIS) include those invasive plants, animals, and/or microorganisms that inhabit or complete part of their lifecycle in marine, freshwater, brackish water, and/or other inland waterways.

While the specific biology of invasive species varies enormously, 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;
- rapid growth rate of individuals, thereby able to displace other plants or animals;
- easily dispersible to new localities; and
- have reproductive characteristics that allow for rapid population growth .

A nonnative species may also appear to be non-invasive until a change in environmental conditions, the introduction of another alien species, or other factors cause it to begin spreading in an invasive fashion. This "time lag" may be quite long, even years or decades, and the shift to invasive may be quite sudden.

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/Wahiawā 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.

Goal of the Hawai'i AIS Management Plan:

To minimize the harmful ecological and economic impacts of AIS, through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawai'i.

Scope of the Aquatic Invasive Species Management Plan

This Aquatic Invasive Species (AIS) Management plan has been drafted to address the issues surrounding aquatic invasive species in Hawai'i. Various efforts are already underway 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 that provides a framework in which to identify additional activities and tasks needed for the effective management of AIS in Hawai'i, and to provide opportunity for further coordination of the various efforts that are already underway.

² Definition taken 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 taken from Staples and Cowie 2001.

Should this comprehensive AIS Management Plan be approved by both the State itself (through DLNR and the Governor), as well as Federal ANS Task Force, Hawai'i will be eligible to receive federal grant funding from USFWS monies already allocated to address Aquatic Invasive Species. Additionally, by having a coordinated plan in place that identifies specific actions, it will be easier to obtain additional funding from other sources to target the implementation of specific tasks.

Though Hawai'i currently has various funded projects targeting AIS, in almost all cases, the funding for these projects is considered to be "soft-money" (e.g., grants). Long term dedicated funding sources will be needed to truly address AIS issues in Hawai'i in an effective manner.

In addition to being used to gather additional funding, the following benefits and goals of a AIS plan should not be overlooked⁵:

- Identification of invasive AIS problems and methods for addressing these problems
- Increased coordination and effectiveness of involved agencies and organizations
- Encouraging of agencies and organizations to share information, develop coordinated efforts, decrease duplication of efforts, and collaboratively support implementation

Section 1204 of 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, which included the establishment of a Federal ANS task force, as well as called for the development of state and regional management plans to assist in the control of AIS. In developing this plan, the coordinator has closely followed the guidelines from the Federal ANS Task Force, as presented in the "Guidance for State and Interstate Aquatic Nuisance Species Management Plans" (2000).

Process and Participation

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

Many individuals, organizations, and agencies are involved with the development of this plan. The overall organization of individuals and entities involved in the development of the AIS Management Plan is probably easiest described below with a diagrammatic depiction:

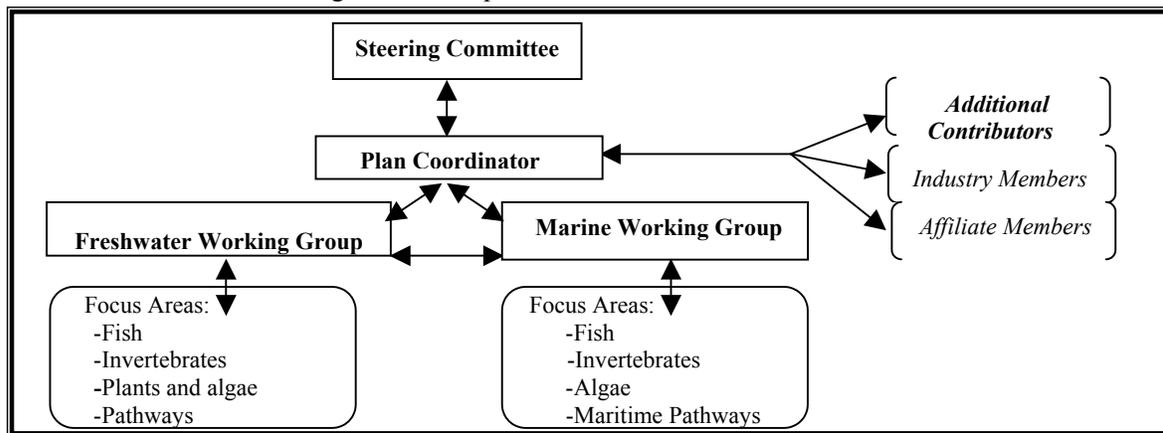


Figure 1. Diagrammatic description of entities involved in the development of the AIS Management Plan.

⁵ Taken from the Federal ANS Task Force "Guidance for State and Interstate Aquatic Nuisance Species Management Plans", http://www.anstaskforce.gov/state_guidance.htm

Many different entities are involved in the development of this plan. The Steering Committee is made up of representatives from state, federal, private agencies, as well as representatives from the following industries: tourism, aquaculture, aquarium/pet supply, and maritime shipping. Feeding into this Steering Committee are various Focus Area Groups. These focus groups are primarily made up of individuals with biological, natural resource management, and/or educational expertise. A full listing of the representatives of the Steering Committee and Focus Area Groups are listed in Appendix D. In addition to these two key groups, there were additional contributors who either assisted in supplying specific Focus Area information, or had general input regarding the plan. Affiliate members included those agencies and individuals who were interested in the development of the plan, but usually either due to lack of time availability, lack of resources, or lack of specialized knowledge, did not participate directly in the Focus Area Groups. An additional category of industry members consisted of those individuals and organizations who had concerns about impacts from the plan itself, and as such, wanted to be kept aware of the development process.

Information Collection Process:

This AIS Management Plan includes the direct input of numerous individuals with biological, natural resource management, and educational expertise, as well as industry and other public stakeholders. All members of the Steering Committee, Focus Area Groups, and Affiliates received initial assessment questionnaires that focussed on the key objectives of the plan: coordination; prevention; monitoring, early detection, and rapid response; control and eradication; education and outreach; research; and policy / legislation. Input to these questionnaires was gathered via written responses, phone conversations, and personal interviews. Additional information on these objectives 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.

The Use of the Term "Nuisance", or "Aquatic Nuisance Species (ANS)", in This Plan

The term "nuisance species" is sometimes 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 relevant federal legislation that have the word "nuisance" in the original terminology, including the Federal Aquatic Nuisance Species (ANS) Task Force.

It is expected that the AIS plan is to be a work in progress, with updates made to the plan at least yearly.

CHAPTER 2:

EXISTING AUTHORITIES AND PROGRAMS

Page Topic

2-1. Federal Authorities and Programs

2-9. State Authorities and Programs

2-14. Additional Organizations and Groups Involved with AIS in Hawai'i

2-18. Department of Agriculture's (HDOA) Permitting Process

2-21. Addressing the Gaps in Authorities and Programs

2-22. Hawaii's Ballast Water and Hull Fouling Program

Chapter 2. 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 on those that have been active in Hawai'i or are considered necessary to facilitate the implementation of this plan.

FEDERAL AIS AUTHORITIES AND PROGRAMS⁶

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 National Aquatic Nuisance Species Task Force. In February 1999, President Clinton signed Executive Order 13112, which requires all federal agencies to collaborate in developing a national invasive species management plan that will include terrestrial and aquatic species. A brief description of the Executive Order, the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA), the National Invasive Species Act (NISA), and other relevant laws is provided in the following section. Descriptions of federal agencies involved in AIS issues are also included.

Federal Acts (listed in chronological order)

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 U.S. Fish and Wildlife Service is the lead agency for enforcing the Lacey Act's prohibition of fish and wildlife imports.

Plant Quarantine Act (1912)

This Act gives APHIS authority to regulate importation and interstate movement of nursery stock and other plants that may carry harmful pests and diseases, and preempts state quarantines in interstate commerce.

Animal Damage Control Act (1931)

This Act gives 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.

Organic Act (1944; P.L. 78-425)

This act gives APHIS the authority to conduct pest eradication programs.

Federal Plant Pest Act (1957; 7 U.S.C. §§ 150aa-150jj)

This Act regulates the importation and interstate movement of plant pests and authorizes the Secretary of Agriculture to take emergency measures to destroy infected plants or materials. It prohibits persons from importing or entering plant pests into the U.S., or moving plant pests interstate, or accepting delivery of plant pests moving

⁶ Prepared by Kimberly Moffie, Pacific Fisheries Coalition

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into the U.S. or interstate, except in accordance with regulations enacted by the Secretary to prevent the dissemination of plant pests.

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

NEPA applies to the intentional introduction of non-indigenous species related to major federal actions. It requires federal government agencies to consider the environmental effects of their actions through the preparation of environmental impact statements (EIS). The effects of nonnative species, if harmful to the environment, must be included in the EIS.

APHIS may, however, approve and issue permits for importing non-indigenous species following preparation of an environmental assessment rather than an environmental impact statement. For example, permits for importing non-indigenous species into containment facilities or interstate movement between containment facilities are excluded from NEPA requirements.

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)

This Act was superseded by the Plant Protection Act, except for a section that states that no person shall import or enter any noxious weed identified in regulation into or through the United States. It defines noxious weeds as "any living stage (including, but not limited to, seeds and reproductive parts) of any parasitic or other plant of a kind, or subdivision of a kind, which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including... the fish and wildlife resources of the United States or the public health."

It authorizes the Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) to restrict the introduction and spread of nonnative noxious weeds through port-of-entry and follow-up activities, and authorizes permanent restrictions and emergency regulations.

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. Section 1204 of 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.⁷

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;
- 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.

⁷ Text from section NANPCA, Section 1204 is provided in Appendix I.

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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), requires the Secretary of Agriculture to operate a program to protect the State of Hawai'i from the introduction of prohibited plants, plant pests and injurious animals that may be contained in the mail.

The Department of Agriculture is to work with the Department of Interior, the Postal Service, and the State of Hawai'i to carry out activities under the program.

The Postal Services' "nonmailable matter" provisions (U.S.C. Title 39) are amended to include fish, wildlife and plants that are prohibited from transportation pursuant to the Lacey Act.

In order to assist the Department of Agriculture with its responsibilities, the Department of the Interior is required to:

- Enter into an agreement with the Secretary of Agriculture to protect Hawai'i from plants, plant pests and injurious animals under jurisdiction of the Department of the Interior.
- Work with the Secretary of Agriculture and the Postal Service to jointly establish a program to inform the public about the prohibitions against the shipment and transportation of plant pests and injurious animals.
- Cooperate with the Department of Agriculture, the Postal Service and the State of Hawai'i in a study to determine the proportion of plant pests and injurious animals that are being introduced in the State of Hawai'i. (USDA is responsible for conducting the study and reporting to Congress, not later than one year after the program commences.)
- Offer to enter into a 2-year agreement with the State of Hawai'i to enforce the Lacey Act amendments of 1981 in the State, not later than January 4, 1992.

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 Maska 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

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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; P.L. 106-224)

This Act replaces the Federal Noxious Weed Act and many other APHIS plant protection authorities. It consolidates and modernizes all major statutes pertaining to plant protection and quarantine (Federal Noxious Weed Act, Plant Quarantine Act). It permits APHIS to address all types of weed issues, increases maximum civil penalty for violations, and authorizes APHIS to take both emergency and extraordinary emergency actions to address incursions of noxious weeds.

This Act defines a noxious weed as: "any 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."

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

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

Federal Agencies that Address AIS Issues

Editor's Note: The following descriptions have been supplied from representatives from the respective agencies or supplied to representatives for editing and comments. Additional information or clarification on the activities of these or other non-listed federal agencies is welcomed and encouraged at any time throughout the drafting of this plan.

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 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)

The National Oceanic and Atmospheric Administration (NOAA) conducts research and gathers data about the global oceans, atmosphere, space, and sun, and applies this knowledge to science and service. A Commerce Department agency, NOAA provides these services through five major organizations: the National Weather Service, the National Ocean Service, the National Marine Fisheries Service, the National Environmental Satellite, Data and Information Service, and NOAA Research; and numerous special program units.

NOAA Fisheries

The mission of the NOAA Fisheries is to rebuild and maintain sustainable fisheries, promote the recovery of protected species, and protect and maintain the health of coastal marine habitats. The Office of Protected Resources (OPR) is charged with the implementation of the Endangered Species Act of 1973 (ESA) for marine and anadromous species. In addition, many species under the jurisdiction of NMFS are listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). NOAA Fisheries has a regional office and science center in Honolulu.

NOAA – National Sea Grant Program

The National Sea Grant Program is a partnership between the nation's universities and NOAA that began in 1966. Sea Grant encourages the wise stewardship of marine resources through research, education, outreach and technology transfer.

The Sea Grant Nonindigenous Species Site (SGNIS) 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.

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.

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 water resource development needs, which includes the mission areas of flood control, navigation, ecosystem restoration, and watershed planning. For ecosystem restoration this includes research on invasive species, and specific programs

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addressing invasive species issues include the Aquatic Nuisance Species Research Program, the Aquatic Plant Control Research Program, and the Water Operations Technical Support Program.

U.S Army Corps of Engineers – Aquatic Nuisance Species Research Program (ANSRP):

ANSRP provides Corps of Engineers managers and operational personnel up-to-date information on aquatic invasive species including basic life history and ecological information, risk assessment tools, preventative strategies, and cost-effective and environmentally sound management options. The main objective of this program is to conduct interdisciplinary research on the prevention, control, and management of aquatic invasive species that impact Corps of Engineers projects and public facilities. Aquatic invasive species are of concern in Corps of Engineers missions relating to maintenance of harbors, waterways, locks and dams, flood control, and ecosystem restoration. Utilizing the Worldwide Web, electronic media, paper publications, conferences, and regional, national, and international coordination, the results of the ANSRP will be widely disseminated.

U.S Army Corps of Engineers Aquatic Plant Control Research Program (APCRP)

APCRP is the Nation's only Federally authorized research program directed to develop technology for the management of non-indigenous aquatic plant species. The program provides effective, economical, and environmentally compatible methods for assessing and managing problem aquatic plants. APCRP research is producing information on the growth and ecological requirements of problem aquatic plants and is producing new biological, chemical, and ecological technologies for their management. Specific information on the biology and ecology of problem aquatic plants, obtained through research in the APCRP, has greatly improved the efficacy and diversity of management options, while minimizing adverse effects on the environment. Research efforts are currently focused on the development of ecologically based, integrated plant management strategies for submersed aquatic plants (i.e., Eurasian watermilfoil and hydrilla). In addition, innovative technologies are being developed to prevent the initial introduction and spread of non-indigenous aquatic plant species, and to replace problem aquatic plants with native species, providing much-improved aquatic habitat for fish and wildlife. These new technologies will be a significant asset in implementing clean water initiatives by restoring aquatic systems harmed by non-indigenous aquatic plant species.

U.S Army Corps of Engineers Water Operations Technical Support (WOTS) Program

The WOTS Program was initiated in FY 1985 to support technology transfer efforts for environmental and water quality operational studies. The program provides technology to solve water quality and related environmental problems resulting from the presence of non-indigenous aquatic species and tailwater fisheries at pump-back hydropower projects. The program also examines water quality impacts of shoreline erosion control and reservoir sedimentation, and other project operations related to environmental and water quality issues. The program annually publishes and distributes user manuals, information bulletins, technical notes, and technical reports. In addition, the program annually conducts specialty workshops, training personnel on the latest environmental and water quality management techniques.

United States Coast Guard (USCG)

The Coast Guard 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.

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- 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 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 Department of Agriculture (USDA)

The mission statement of the U.S. Department of Agriculture (USDA) is to enhance the quality of life for the American people by supporting production of agriculture by:

- Ensuring a safe, affordable, nutritious, and accessible food supply;
- Caring for agricultural, forest, and range lands;
- Supporting sound development of rural communities;
- Providing economic opportunities for farm and rural residents;
- Expanding global markets for agricultural and forest products and services; and
- Working to reduce hunger in America and throughout the world.

USDA – Animal Plant Health Inspection Service (APHIS)

The Animal and Plant Health Inspection Service (APHIS) is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. The Plant Protection Quarantine (PPQ) is part of the Animal Plant Health Inspection Service agency of USDA. APHIS-PPQ 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.

In 2003, PPQ's Agricultural Quarantine Inspection program involving quarantine inspection and enforcement activities for foreign importation was taken over by the Department of Homeland Security's Customs and Border Protection (CBP). Regulation of articles going from Hawai'i to other parts of the United States (Hawai'i Predeparture), policy, treatment, domestic control and survey programs, permitting, risk assessment, training, identification, et. al., currently remain as APHIS PPQ functions.

APHIS noxious weed activities include exclusion, permitting, eradication of incipient infestations, survey, data management, public education, and (in cooperation with other agencies and state agencies) integrated management of introduced weeds, including biological control. Aquatic weeds are included in the federal noxious weed list

APHIS investigates reports of alleged offenders and discovers new pathways into the United States. Aquatic weeds are included in the federal noxious weed list.

APHIS involves aquaculture as an agricultural industry, which includes fish as livestock, largely through the agency's Wildlife Services and Veterinary Services. APHIS aquaculture programs currently serve important aspects of both plant and animal aquaculture, especially involving disease, pest prevention, and wildlife damage management. APHIS also has become involved in facilitating importation and exportation in aquacultural products because of increased global trade.

United States Department of Homeland Security (DHS)

The Department of Homeland Security (DHS) was created on March 1 of 2003. Customs and Border Protection (CBP), one component of DHS, combines parts of USDA-APHIS-PPQ, 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. 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 preclearance 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 400 Ports of Entry in the US.

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

The U.S. Fish and Wildlife Service (USFWS) is the federal agency that provides federal funding for implementation of state and regional AIS management plans which have been approved by the ANS Task Force.

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 the 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 agent 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 Hawaiian Ecosystems at Risk (HEAR)

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 (formerly the National Biological Service). HEAR also works with the Botany Department of the University of Hawai'i.

Currently, HEAR is sponsored through PIERC by funding from the Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII).

The mission of the HEAR project 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.

HAWAI'I AIS AUTHORITIES AND PROGRAMS⁸

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, no centralized authority or management structure exists to coordinate AIS activities in Hawai'i.

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 2-11), to deal with the invasive species problem as authorized by an executive order created by 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 authorities that various state agencies have for managing AIS.

Hawai'i Department of Agriculture (HDOA)⁹

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

To accomplish program goals, the PQB 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*

Animal Lists: Hawai'i Administrative Rules Chapter 4-71

The importation of non-domestic animals, which includes aquatic species, are 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.

⁸ Prepared by Kimberly Moffie, Pacific Fisheries Coalition

⁹ Author: Domingo Cravalho, Hawai'i Department of Agriculture

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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.

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.

Import Requests

Permits are required for all live organisms in any stage of development that are imported into the State of Hawai'i. Application requests are reviewed by the appropriate 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 at the end of this Chapter.

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 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.

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 (Section 187A-2(1), HRS) 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 and Regulations

Aquatic Life

Section 187A-6.5 HRS, Release and confiscation of harmful aquatic life: No person shall release any live nonnative fish or other live nonnative 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) HRS. The department 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. (Sec. 187A-13 HRS). The Board of Land and Natural Resources (BLNR) 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).

Within the DLNR there is an animal species advisory commission that may serve in an advisory capacity to the Board of Land and Natural Resources (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 without the State into the State, or from one area in the State into another area in the State. (H.R.S. §197-2).

There is an aquatic life and wildlife advisory committee in each county of the State of Hawai‘i 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 into the State of Hawai‘i, whether it be from without 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 probable dispersal pattern 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).

Ballast Water

The DLNR is designated as the lead state agency for preventing the introduction and carrying out the destruction of alien aquatic organisms 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, 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 2-18.

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, oversee and regulate the importation of non-local species. This means that if a person wants to aquaculture a species not found in Hawai'i and would need to be imported, they would submit their request to import the species to the HDOA.

Hawai'i Invasive Species Council

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 legislations, 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. Although created in 2002, the Council under the Executive Order has never met.

The 2003 Hawai'i State Legislature passed SB1505 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.

Under H.R.S. § 187A-31, the DLNR was granted an unfunded mandate to develop a program for the prevention and destruction of alien aquatic organisms through the regulation of ballast water discharges and hull fouling organisms. The Coastal Zone Management Program was requested by its partner, DLNR, to provide the funds necessary to make the ballast water and hull fouling alien aquatic organism prevention program a reality.

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.

Hawai'i Department of Health

Vector Control Branch, Environmental Health Services Division

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 prevent the of entry of alien species. Increased attention has been focused towards 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 a proactive partner with other agencies in responding to public health and vector control concerns involving a wide variety of subjects. This partnership works 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.

Coordinating Group on Alien Pest Species (CGAPS)

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 alien pests. This group is further described under "Additional Organizations", beginning on page 2-24.

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 WORKING ON AIS ISSUES¹⁰

In addition to federal and state authorities, a number of additional organizations play a key role in addressing AIS issues Hawai'i. These groups include academic institutes, NGOs (non-governmental organizations), and multi-partnership groups. The following section describes some of these groups 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.

INVOLVED IN OVERALL ALIEN SPECIES ISSUES: (listed alphabetically):

The Bernice Pauahi Bishop Museum (Bishop Museum)

Soon after its founding in 1889, Bishop Museum established programs to study and document the plants and animals of Hawai'i and 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 for 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 databases. 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 phylogenetic order grouped by major taxonomic level, or it can be 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.
- **"Good Guys and Bad Guys" Trading Cards and Website:** Each year, the Hawai'i Biological Survey produces a series of trading cards that depict the "good guys" and "bad guys" of Hawaii's ecosystem. These cards are given out to school children 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 back side. The associated website helps supplement the information on these cards, and in some cases, provides additional information about each plant and animal. This site can be accessed at <http://hbs.bishopmuseum.org/good-bad/about.html>

¹⁰ This section compiled by Kimberly Moffie, Pacific Fisheries Coalition and Andi 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) (this group is also referenced under State Programs)

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 28 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, U.S. Postal Inspection Service, and the U.S. Postal Service. It has served as an umbrella organization to help garner support for island Invasive Species Councils. Currently, activities and members of CGAPS are largely terrestrial focussed. 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.

Hawai'i Coral Reef Initiative (HCRI)

The Hawai'i Coral Reef Initiative is a program established in 1998 to support and fund scientific research of the coral reef ecosystem that provides resource managers with better information to address these problem areas. With the results of sponsored research, resource managers can develop strategies to protect healthy reefs, and where possible, implement strategies to reverse degradation. The program is jointly managed by the state Division of Aquatic Resources and the University of Hawai'i.

The Nature Conservancy

The Nature Conservancy is devoted to protecting the World's outstanding natural ecosystems with an emphasis on conserving areas of high biological diversity. The Nature Conservancy of Hawai'i has focused for the past several decades on the conservation of native forest and the prevention of introduction and spread of nonnative 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 efforts to address the spread of aquatic nonnative species, including coordinating the development of this AIS Management Plan. In addition, TNC has been actively involved in the Marine Algae Group (MAG), as defined below, in organizing volunteer events and securing funding through outside grant sources for a variety of marine algae AIS related efforts.

University of Hawai'i (UH):

Researchers and graduate students from the University of Hawai'i have been an integral part of research efforts in many facets of AIS in both marine and freshwater systems. Key programs relating to AIS under the University of Hawai'i fall under the following programs:

- Botany Department
- Zoology Department
- Department of Education
- Hawaiian Institute of Marine Biology (HIMB)
- Center for Conservation Research and Training (CCRT)

Some of these are further detailed under specific efforts relating to marine algae and freshwater aspects, in the following section.

INVOLVED SPECIFICALLY WITH THE MANAGEMENT OF MARINE ALGAE
(listed alphabetically):

Alien Algae Working Group (AAWG), Alien Algae Research Team (AART)Alien Limu Group (ALG):

Various names for the now Marine Algae Group (as detailed below). These names have been used previously in various announcements and proposals, and they are presented here only to clarify that while they are no longer active names, the group they all referred to is still active in leading efforts for management of invasive algae species.

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, 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 for 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 the various entities involved with algae issues across the state together.

Paepae o He'eia:

A community based group focusing on fish pond restoration at He'eia Stream in O'ahu, in conjunction with a strong emphasis on community outreach and development. As part of their restoration efforts, this group will be involved in the removal of nonnative species like *G. salicornia*, *A. spicifera*, and *Kappaphycus* sp. and the seeding and cultivation of native species, such as *G. coronopifolia* back into the pond.

Reef Check:

Reef Check is an international network of volunteers. Teams of divers are matched with marine scientists to assess the coral reef health using a standardized protocol. The very first Reef Check was conducted on Kaua'i in 1997 and the program is now found in over 50 countries worldwide. The program is very active on O'ahu, with 16 Reef Checks planned for 2003 with quarterly training taking place at the Waikiki Aquarium. Reef Check volunteers are also active in other marine conservation causes, such as the "A'ohu Limu'e – No Alien Algae," nonnative algae removal efforts in Waikiki and 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 Hawai'i 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. The Island of Hawai'i is less impacted by invasive species than other islands, therefore the ReefWatcher Program will aggressively pursue the sharing of this guide book and other identification tools being developed by DAR.

Waikiki Aquarium (WAq):

The Waikiki Aquarium's mission supports excellence in education, research, and conservation. On-going volunteer nonnative algae clean-ups were initiated by the Aquarium in collaboration with TNC, DLNR, and UH researchers in August, 2002. The Aquarium will install an interactive outdoor exhibit highlighting the issues of invasive algae on Hawaii's reefs in early 2004. Representatives from the Waikiki Aquarium play a key role in MAG and in leading efforts to address algae issues in Hawai'i.

University of Hawai'i (UH):

Researchers and graduate students at the university 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.

Waipuilaani Beach Association:

Oversees the supervision and guidance of beach maintenance for the algae accumulations in north Kihei.

INVOLVED SPECIFICALLY WITH FRESHWATER AIS

UH – Center for Conservation Research and Training – Hawai'i Stream Research Center (HSRC):¹¹

Located on the island of Kaua'i, the Hawai'i Stream Research Center is a field research laboratory focusing on studies in Hawaiian freshwater ecology. HSRC was established in July 1996 as a cooperative project between the University of Hawai'i (Center for Conservation Research and Training), the State Department of Land and Natural Resources (Aquatic Resources Division), 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.

Community Groups and/or Site-Specific Efforts:

Various additional efforts are being undertaken by community and volunteer groups as well as site-specific restoration efforts, which includes the removal of AIS such as mangroves and pickleweed among others. These groups include Friends of He'eia, Friends of Ho'omaluhia Botanical Garden, Kailua Bay Advisory Council, Sierra Club, Youth for Environmental Service, Kawai Nui Heritage Foundation, Marine Corps Base Hawai'i, and numerous school groups. Many additional groups exist, and it is hoped they will all become identified in subsequent versions of this plan.

¹¹ HSRC description and activities taken directly from the HSRC website, from personal communication with M. Kido (HSRC), and from an article by T. Lewis, "UH's Stream Research Center helps a torn community decide a river's future", accessible at <http://www2.hawaii.edu/magazine/Hanalei.1.html>

HDOA's Permit Process for Importation into Hawai‘i¹²

Import Requests

As referred to earlier in this Chapter, permits are required for all live organisms in any stage of development that are imported into the State of Hawai‘i. 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 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 does not include all organisms, there is a submission process that can be employed to request for 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 and 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?

¹² This section authored by D. Cravalho, Hawai‘i Department of Agriculture, with additional editing by K. Moffie.

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- 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 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)?
 - Are there any other pertinent literature and a bibliography of any other citations that support the request and provide copies?

After the required information and application is provided, the materials will be 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, would be 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

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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 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.

GAPS IN GOVERNMENT PROGRAMS AND AUTHORITIES AFFECTING HAWAI'I

There is a need to assess current governmental programs for their effectiveness in addressing AIS issues in Hawai'i. Currently two such assessments are being undertaken:

- 1) 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. This analysis addresses:
 - the 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;
 - the effectiveness of penalties for the violations of laws and regulations;
 - the permitting process and post-permitting process;
 - state and federal agency authorities and gaps in authorities; and
 - recommendations to improve the permitting process.

A full report of this legal analysis is anticipated to be available in the Fall of 2003.

- 2) 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:
 - Identifying and collecting all existing work on invasive species policy from Pacific Island nations and other NGO organizations, such as SPREP, GISP, IUCN.
 - Identifying gaps in existing policies, best practices and lessons learned, particularly focusing on Australia and New Zealand as model programs
 - Determining the impact of world trade on invasive species
 - Investigating early warning systems in the Pacific Rim and determine how they compliment each other

HAWAII'S BALLAST WATER, BALLAST SEDIMENT, AND HULL FOULING MANAGEMENT PROGRAM¹³

SUMMARY

The primary purpose of this management program is to minimize the introductions of nonnative 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 (CZM's) Management Program, to begin efforts to develop a Ballast Water and Hull Fouling Management 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 Ballast Water and Hull Fouling Management 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.

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 management 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).

THE NEED TO ADDRESS MARITIME PATHWAYS

Hawai'i's isolation, and its lack of a large manufacturing base and lack of 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 maritime activity in Hawaiian waters.

These large commercial vessels (containerships, petroleum tankers, bulk carriers, roll-on roll-offs, and oversea barges) come to Hawai'i from all over the Pacific and Atlantic, and as far away as the Indian Ocean. 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 vector of marine nonnative species. 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

¹³ 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).

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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 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, and 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 and result 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 nonnative 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 toxic dinoflagellates that can cause poisoning in shellfish, *Vibrio cholerae*, which causes cholera in humans, and *Clostridium botulism C*, which causes botulism in animals and possibly humans, and is found in ballast sediment 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 organisms may be the most underestimated pathway for nonnative introductions. Fouling organisms are divided into two categories, micro- and macro-sessile. Micro-sessile are diatoms, algae, and bacteria. Macro-sessile organisms are mollusks, sea squirts, sponges, sea anemones, bryozoans, tubeworms, polychaetes, and barnacles. Both these categories of organisms can live on the hulls, and distribute cysts 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

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 at the end of this chapter.

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 Statutes (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 nonnative 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 nonnative 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.

In 2001, the Hawai'i Coastal Zone Management Program (CZM) awarded DLNR-DAR a grant for their proposal, "Ballast Water and Hull Fouling Alien Aquatic Organism Prevention Program". Under this grant, 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 D.

Phase I: BALLAST WATER AND BALLAST SEDIMENT MANAGEMENT PROGRAM¹⁴

The State of Hawai'i, 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.

BALLAST WATER EXCHANGE PLAN

General Requirements: all vessels carrying ballast water are required, unless exempt, to carry out a mid ocean ballast water exchange or other treatment marine waters. Hawai'i Administrative Rules, Section 13-76-17, (Ballast water exchange requirements).

Mid-ocean means open waters beyond Hawaii's Exclusive Economic Zone within an area no closer than 200 miles from any shore in a depth exceeding 2000 meters.

The purpose of this exchange requirement is to limit the possibility of transferring nonnative 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.

¹⁴ Text in this section provided by P. Murakawa and J. Kushima, both of DLNR-DAR.

MID-OCEAN BALLAST WATER EXCHANGE METHODS

Currently, doing a ballast water exchange in mid-ocean is the single, most practical method of ballast water management. A mid-ocean ballast water exchange can be accomplished by two methods, sequential empty and refill method or by a flow through method. Though studies show that mid ocean ballast water exchange is only 70-90 percent effective at changing ballast water and only 75 percent effective at eliminating ballast sediment, it is the only acceptable method until a more effective and cost saving method is found.

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, when the vessel goes over or through a wave(s). The forefoot emerges and impacts heavily on the ocean surface. Excessive slamming can lead to structural damage.

2. Flow through method

The flow through method involves pumping open ocean water into full ballast tanks until approximately three times the tanks 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) The vessel may be exempt if: a) it has a United States Coast Guard (USCG) approved ballast water treatment system, b) any 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) vessels of innocent passage or force majeure, and e) any vessel, to the extent 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 program 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. Non compliance of any of the requirements of the State of Hawai'i's Ballast Water Management Program 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 into state marine waters and possibly introducing nonnative aquatic organisms and pathogens that may be present in the sediment.

The approved method of disposal of ballast sediment are mid ocean disposal or under 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 back into state marine waters, they will be subject to fines and/or imprisonment.

Phase II: HULL FOULING MANAGEMENT PROGRAM¹⁵

The second component (hull fouling) of the State's comprehensive ballast water and hull fouling management plan 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 implementation of a systematic approach for the management of marine species introductions through hull fouling poses challenges, which are complex. 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. 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.

¹⁵ Text for this section provided by S. Godwin (Bishop Museum), J. Kushima (DLNR-DAR) and P. Murakawa (DLNR-DAR)

Update on the Key Findings and Recommendations From the Original AAOTF (1998):

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 each¹⁶.

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, Ballast Sediment, and Hull Fouling Management 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 has 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 must 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, Ballast Sediment, and Hull Fouling Management Program, if a vessel complies with A.868 (20), then it fulfills the State of Hawai‘i requirements for ballast water 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 nonnative aquatic organisms. Here are a few examples:

¹⁶ Many thanks to P. Murakawa of DLNR-DAR for researching the current status of these recommendations and writing the accompanying text.

Chapter 2 . Existing Authorities and Programs

DRAFT Component - AIS Management Plan for the State of Hawai'i – July 2, 2003

- Nonindigenous freshwater and estuarine species introductions and their potential to affect sportsfishing in the lower stream and estuarine regions of the south and west shores of O'ahu, Hawai'i. Hawai'i Biological Survey, Bishop Museum. February 2000.
- South O'ahu marine invasions shipping study. Hawai'i Biological Survey, Bishop Museum. February 2001.
- Nonindigenous marine species in Kāne'ohe Bay, O'ahu, Hawai'i. Hawai'i Biological Survey, Bishop Museum. June 2002.
- Nonindigenous marine species at Waikiki and Hawai'i Kai, O'ahu, Hawai'i. Hawai'i Biological Survey, Bishop Museum. October 2002.

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 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 nonnative 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.

CHAPTER 3:

DEFINING THE PROBLEMS

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3-1.	Marine Systems
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3-7.	Potential Pathways
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3-15.	Identification of AIS or Potential AIS in Hawai'i
3-20.	Case Study: Examining the Idea of "Pest to Profit"

Defining the Problem

Overview:¹⁷

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; more often they are subtle and may escape notice for some time. Throughout the world, the negative impacts of invasive species occur in three broad categories:

Human health and quality of life

examples:

- public health problems associated with parasites and disease;
- impacts to humans causing annoyance, discomfort, illness;
- decreased recreational opportunities.

Economic

examples:

- increased cost of doing business by interfering with current systems, processes, or equipment (such as from hull fouling);
- decreased property values;
- crop pests or increased production costs (such as greater 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

Environmental

examples:

- loss of native biodiversity, due to preying upon native species and decreased habitat availability for native species;
- ecology changes of freshwater, estuarine and nearshore marine ecosystems;
- alterations in nutrient cycling pathways;
- decreased water quality.

Specific examples of the above impacts in Hawai‘i are further detailed throughout the following pages:

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. There is little guidance to help with addressing control issues within a coral reef environment.

MARINE ALGAE¹⁸

At least 19 species of macroalgae have been intentionally or passively introduced into the state since the mid 1950s (Doty 1961, Brostoff 1989, Rodgers and Cox 1999, Russell 1987, 1992, Smith et al. 2002, Woo 2000, Smith et al. in review). 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

¹⁷ Overview text and categories of impacts are taken from Staples and Cowie, 2001, and from Remec, A., personal communication.

¹⁸ Adapted and excerpts taken directly from the grant proposal, “The Development of a Control Program for Harmful Algal Blooms on Coral Reefs in Hawai‘i”, submitted under a ECOHAB/ 2003 STAR Grant. Principal Investigators: Atkinson, S.A Smith, C.M., Hunter, C.L, AND from the grant proposal, “Nuisance Macroalgal Blooms in coastal Maui: assessment and integration of physical factors and biological processes.” Submitted to EPA. Principal Investigators: Smith, C.M., Harrigan, J.F., Nishimoto, R.T., Sansone, F.J, Tribble, G.

species (Smith et al. 2002). Each of these 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* sp. in particular have been observed in recent surveys to be invading coral habitat and overgrowing reef building corals in Kāneʻohe Bay, the south shore of Oʻahu including the world famous Waikiki area, and the south shore of Molokaʻi, which harbors some of Hawaii's most intact and expansive coral reef ecosystems (Russell 1983, Russell 1992, Hodgson 1994, Cox and Rogers 1999, Nishimura 2000, Woo 2000, Smith et al. 2001, Eldredge and Smith 2001). These species thus pose and an immediate threat to the health of Hawaii's coral reef ecosystems (Smith et al. 2002).

Ecological Effects of Algal Blooms (both of introduced 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, and 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 organismal diversity on reefs (McClanahan et al. 1999). Indeed, in the past several years, algae blooms on Hawaii's coral reefs have caused dramatic decreases in biodiversity and coral cover (Rodgers and Cox 1999, Nishimura 2000, Woo 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).

Economic Costs:

In addition to the ecological damage caused by blooms, extensive economic costs are also incurred. Recurring and persistent blooms of the red nonnative alga, *Hypnea musciformis*, (Hodgson 1994, Smith et al. 2002) on the island of Maui have been estimated, in a recent study conducted by Caesar et al. (in press), to cost Maui County alone over \$20 million per year. This loss 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 rotting, and foul smelling algae on the beaches. The resulting tax loss to the state from this one community alone is estimated to be in excess of \$1.8 million annually.

Native Algae Species Are Also of Concern for Hawai'i¹⁹

Though they do not fall under the definition of AIS because of their native status, several native macroalgae also form large blooms stretching across vast miles of shoreline which are also causing significant problems. Aside from the well-documented case of *Dictyosphaeria cavernosa* in Kāneʻohe Bay, Oʻahu, most of the significant native algal blooms in Hawai'i have persistently occurred in coastal Maui waters, and involve the 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, Waipuʻilani 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 area due to the strong offensive odor that is produced, combined with the issue that many feel that the nearshore waters are too polluted with the algae to swim in. Given that the stretch of beach is lined with large condominium complexes and is a popular tourist destination, the impact on the area is considered quite severe, and harmful to the economy as detailed above. These native species, *D. cavernosa*, *C. sericea*, and *U. fasciata*, are identified in this plan because they pose the same threats as their nonnative counterparts. To propose to address the threats associated with nonnative algae blooms, without considering these native blooms, would present an incomplete picture and subsequently lead to incomplete management solutions.

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

Currently, blooms of nonnative algae are occurring in relatively discrete areas. For example:

¹⁹ Adapted and excerpts taken directly from the First Quarterly Status Report to the U.S. Environmental Protection Agency, Grant #X-97922901-0, Special Appropriation-Nuisance Seaweed Control, Kihei, Maui, Hawai'i. Authored by Coloma-Agaran, G.

- The island of Hawai'i has relatively few species of nonnative algae, and populations seem to be isolated in the Kona and Hilo areas.
- 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 of invasive algae offer some hope for controlling the expansion of the harmful blooms, before they spread to other areas. However, in the past several years there is 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. in press). This suggests that, without human intervention, these blooms will continue and the nonnative species are likely to spread, increasing the problems at other sites throughout the state of Hawai'i in years to come.

MARINE FISH²⁰

Thirty-four species of marine fishes have been introduced into Hawaiian waters, and at least twenty of these introduced species have become established (Staples and Cowie 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 (Staples and Cowie 2001). Potentially, many more cases exist but have gone undocumented in Hawai'i.

A Brief History of Introduced Marine Fish to Hawai'i²¹:

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. Of these eleven species, three are known to be established in the nearshore reef fisheries of Hawai'i. Two of these, the ta'ape and roi are discussed below; the third is *Lutjanus fulvus* (to'au).

Several tilapias have been introduced from Africa to Hawai'i and other tropical Pacific Islands. *Oreochromis mossambicus* was purposely introduced to Hawai'i and elsewhere for aquatic weed control, food, and as a tuna baitfish (Nelson and Eldredge 1991). *Sarotherodon melanotheron* accidentally escaped from confinement in Hawai'i, where it was being evaluated as a tuna baitfish (Randall 1987). These eurytopic mouth-brooders may be outcompeting pond-cultured milkfish *Chanos chanos* (Nelson and Eldredge 1991) and wild mullet (Randall 1987).

One species of baitfish, the Marquesan sardine, *Sardinella marquesensis*, was purposely introduced into Hawai'i for aku fishing, but with little apparent success (Williams and Clarke 1983). However, two other fishes, (the mullet *Valamugil engeli* and the goatfish *Upeneus vittatus*) 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).

Taape and Roi:

Two primary species stand out regarding potential marine fish aquatic invasive species: ta'ape (*Lutjanus kasmira*/blueline snapper) and roi (*Cephalopholis argus*/peacock grouper). Both of these species were introduced by the State for 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, key researchers in this field feel that roi

²⁰ Except where cited in the first paragraph, this introductory section is compiled from personal communication with Birkeland, Dierking, Friedlander, Parrish, and Walsh 2003.

²¹ Text from this section excerpted directly from DeMartini et al. 1999, with some additions from Oda and Parish, 1982.

and ta'ape may have less impact than is perceived by the fishers and aquarium collectors, and research to date suggests that ta'ape and roi are not necessarily biological concerns in regards to native fisheries. As such, a primary focus of this AIS Management Plan in regards to marine fish should be to better understand the true impacts of ta'ape and roi upon the native species.

MARINE INVERTEBRATES

How Many Alien Marine Invertebrate Species are Here?²²

Through the Hawai'i Biological Survey at Bishop Museum, a count of the total number of marine and brackish water nonnative invertebrate species that have been introduced to Hawai'i has been compiled to be 287. Of these, 201 species (70%) are considered to be introduced, and 86 (30%) cryptogenic (not demonstratively native or introduced). 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 species, two hundred forty eight (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.

Arthropods have been the most successful marine invaders by number, with 71 suspected nonnative crustacean species, while 53 nonnative molluscs have made it to Hawai'i. Hydroids, bryozoans, and ascidians are the most successful if based as a percentage of their totals in their taxonomic groups²³. The greatest number of marine invertebrates have probably arrived in Hawai'i through hull fouling, but many may have also arrived with solid ballast and in ballast water.

Commercial Importation:

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 to Hawai'i; and littleneck clams (*Tapes japonicum*) from Japan (Yap 1977).²⁴ 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 sea water systems, including mangroves and fishponds, and is a generalist feeder.²⁵

Distribution of Nonnative Marine Invertebrates²⁶

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 from the harbors in 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

²² Text from this section taken directly from Preskitt et al. 2001, "The Guidebook of Introduced Marine Species of Hawai'i"; and Eldredge and Carlton 2002, "Hawaiian Marine Invasions: A Preliminary Assessment".

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

²⁴ Text directly from DeMartini et al. 1999, "Status of Nearshore Sports and Commercial Fishing and Impacts on Biodiversity in the Tropical Insular Pacific".

²⁵ Coles, S. (Bishop Museum), personal communication. 2003.

²⁶ This section compiled by Godwin, S. (Bishop Museum) and Coles, S. (Bishop Museum)

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 but also has been 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.

FRESHWATER SYSTEMS

A History of Introductions²⁷

Today, more than 50 species of nonnative fishes, invertebrates, reptiles, amphibians and plants are established in our streams and reservoirs. Some of these plants and animals were intentionally released (both through authorized and non-authorized introductions) with the hope that they would become established, and in some way improve the quality of life here in Hawai'i. Others were simply dumped in our streams, likely with no 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 authorized introductions, going back at least to 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, ricepaddy eel, snakehead, common carp, the Japanese weather fish (dojo), and the soft-shelled turtle. A few additional species, such as goldfish, 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 our streams and reservoirs for mosquito control. Various species of tilapia were brought in to help the sugar plantations control weeds in their irrigation systems and to provide baitfish for the aku (skipjack tuna) fishery. Several species of sportfish, including trout, large and small mouth bass, tucunare, oscar, and channel catfish were brought in by the State for recreation purposes.

By the 1970s, over 70 different species had been intentionally introduced into the freshwater ecosystems, and approximately half had established themselves. At this time, there was also an increase of knowledge regarding native and introduced species, which led to a decline in new introductions. Previously unappreciated, the native flora and fauna of Hawai'i were now recognized as being unique and precious in their own right. The focus shifted from 'improving' these resources to preserving what was left. There was an end to State sponsored introductions of nonnative species, and a system was established to review requests for new imports by others.

Despite this new awareness of the impact that nonnative species were having on our freshwater ecosystems, during the 1980's and 1990's more nonnative species appeared in our streams and reservoirs, through both authorized and accidental introductions. Species such as the convict cichlid, midas cichlid, johanni cichlid, jewel cichlid, suckermouth catfish, armored catfish, stickfish, apple snail, and grass shrimp can all trace their origins to the aquatic species distributors and hobby enthusiasts. The Asiatic clam, which is 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.

²⁷ Text from this section taken directly from the DLNR-DAR website, http://www.state.hi.us/dlnr/dar/stream_alien.htm, key author: Mike Yamamoto, AND from Yamamoto and Tagawa 2000. "Hawaii's Native and Exotic Freshwater Animals".

The results of these introductions are varied. Some of the impacts 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, which are voracious predators that feed on native 'o'opu (gobies) and 'opae (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 banks 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 'o'opu.

Freshwater Plants:

Freshwater habitats in Hawai'i are especially vulnerable to invasions by nonnative species, as there are almost no native freshwater plant species other than algae in streams and ponds. Coincidentally, freshwater plant invasions are among some of the most costly and difficult in the world to deal with²⁸. Hawai'i directly experienced these high costs and difficulties associated with control efforts during the recently outbreak of giant salvinia (*Salvinia molesta*) in Lake Wilson, O'ahu (which is further detailed on page 5-2). 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 bottom²⁹.

Freshwater 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, and many others. Because of their potential as disease vectors, aquatic insects 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 affect 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 for aquatic insects include being transported and imported in: recycled material such as tires, aquatic plants, aquaculture material, ship ballast, 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

²⁸ These first two sentences taken from Staples, in Staples and Cowie 2001.

²⁹ Taken directly from Staples, in Staples and Cowie 2001

Potential Pathways and Mechanisms Aiding in the Introduction and Dispersal of Aquatic Alien Species³⁰

This section highlights some of the priority pathways by which aquatic invasive species may have been imported or are likely to arrive by. 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 to allow for risk analysis and risk management strategies, which are needed to ultimately allow 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 introductions. Examples of additional mechanisms for introduction and transport include fisheries activities, aquaculture, the aquarium industry, and live seafood shipments.

For freshwater nonnative introductions, authorized introductions played the largest role in the past. Authorized introductions still occur, and 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 symbionts and pathogens
- D) Fisheries gear and debris
 - Fouling organisms on nets and floats

II. Recreational Boating

- A) Hull fouling
 - see above with commercial shipping
- B) Bilge pump discharge
 - see above with commercial shipping

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

³⁰ 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 slightly altered and added to from its original version.

-Pathogens

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

III. Public Sector and Research

A) Authorized release

-Bio-control

-Stocking programs

B) Non-authorized or unintentional release

-Accidental release of experimental target organisms

-Release of associated pathogens and symbionts

IV. Private Sector

A) Live seafood shipments

B) Aquarium release

C) Release for cultural practices

D) Illegal imports

-Foreign Cargo, Domestic Cargo

-Foreign Passengers, Domestic Passengers

-Mail

-Private Aircraft and Vessels

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. 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

III. Public Sector and Research

A) Authorized release of target species

-Stocking programs

-Bio-control

B) Inadvertent release from interisland transport

IV. Private Sector

A) Live seafood shipments

B) Interisland transport of aquarium pets

C) Sportfishing boats, sailboats, personal recreation boats

-hull fouling, bilge water associated organisms

Defining the Problem:
Areas of Concern in the Prevention System

Editor's Note: An original version of this section entitled, "Problem 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. Additional thanks to D. Cravalho and N. Rymer of the Hawai'i Department of Agriculture, and to D. Alontaga of the U.S. Department of Agriculture, for their time spent researching, editing, and updating the 1992 document to accurately reflect the current situation.

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.

Despite the efforts of many agencies and efforts described in this AIS Management Plan, unwanted alien species (both aquatic and terrestrial) are still entering Hawai'i. 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 referred to above, which focussed largely on terrestrial species. They 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.

A. 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

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, as 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, technology and best practice are used to target more detailed inspection of passengers and goods which pose higher risk, without using limited resources inspecting 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 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 HDOT-A have 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 were the normal discoveries, however only just recently a live ball python was 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, but due to budget shortfalls and staff shortages, this process has been reduced, thus further reducing the amount of adequate passenger clearance conducted by HDOA. Although there is no supporting data, HDOA believes passengers and accompanying baggage pose a significant risk of intentional pest introductions (i.e., illegal animals).

Mail

Due to the limited authority to inspect first-class mail, only a small fraction of mail entering Hawai'i is inspected. 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 inspection; 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 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

Foreign aircraft and vessels must report their arrivals, passengers, and cargo for review by Customs Border Protection (DHS-CBP) and U.S. Fish and Wildlife Service. 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, it raises the 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 in trying to inspect 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 effectiveness and best use for each pathway. Information about the evaluations and techniques could be better shared between the state and federal 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, if not difficult, 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. Problems arise when possible violations to quarantine laws and regulations are discovered, and 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 and the shipper declares it will be sent to the mainland poses a risk. 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.

Inspector Training to Cover Hawai'i Concerns

Military cooperators are trained to inspect transfers of military goods and personnel from overseas into Hawai'i. Periodic meetings and trainings among federal personnel including the military pest control branch, refresh inspectional techniques and applicable federal regulations. The State of Hawai'i may want to expand the possibilities of requesting military assistance for state regulations, if possible.

B. 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 has been no clear reporting mechanism for the public or agency staff that detects 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, DOH controls human disease vectors and DLNR controls forest pests. Consequently, gaps do 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 is 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

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 Hawaiian biological control programs have been pioneering and productive, they have two major needs. One, is that while modern programs 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, include 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. 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 alien 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 freshwater fish, apple snails, certain types of marine algae, some freshwater plants, as well as other alien 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.

Miller, S. and A. Holt. 1992. The alien pest species invasion in Hawai'i: Background Study and Recommendations for Interagency Planning. (This publication will soon be posted on the web, and details will be noted in future drafts of this plan).

Defining the Problem: **Species that are Known to be Invasive or Considered Likely to Be Invasive**

Background and Process

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 invasive, or have the potential to be invasive in Hawai'i. This list is meant for assistance 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 considered to have the potential to be invasive, it also helps to educate resource managers, policy makers, researchers, educators, industry, and the general public of the wide range of aquatic invasive species and associated issues that exist in Hawai'i.

This section is a required component of State Management Plans, as specified by the Federal ANS Task Force. Other states have described the purpose of this section as following, and these are appropriate for this 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." (WA)
- "(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..." (ME)

What Will Happen to Those Species Listed in this Section?

This is not a regulatory list of any kind, though it does refer to species that are already regulated, per the process of importation through Department of Agriculture (further detailed in Chapter 2 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 stream 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.

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

Most of the species listed in the next few pages are already established in Hawaiian waters. Others, though not yet established, have the ability to become potential threats if they escape or are released into the aquatic environment. In the preparation of this section, concerns were raised by some industry members that listing species not yet here would be overstating the issues. However, prevention of potential problems is a major component of national and state efforts dealing with invasive species, and it is important to note those species that have the potential of finding their way into the waters of Hawai'i. As such, this section will also include some one-time, even "no-time" occurrences that may be possible threats, should they get established. This is not meant to overstate the problem, but rather to help raise awareness levels that there is potential for additional problems 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 industry; 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 they 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 focussed 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 aquarium species into our streams must also be continued. The importance of 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.

Marine Versus Freshwater Listings

The original intent of this section was to identify "all known and suspected AIS concerns...even if no consensus existed about which species warrant attention", per the guidelines from the Federal ANS Task Force. For the marine species, the listings presented here do encompass for the most part all known and suspected AIS concerns, though there still remain many introduced species that we do not know the threat of.

However when creating this section for freshwater species, it became clear that there is disagreement between managers/researchers and industry members, as well as between resource managers and researchers themselves over which species should be considered invasive. As such, the freshwater species listed here are presented as a representation of the vast scope of AIS and their associated threats, and should not be considered the sole threats to the freshwater ecosystems of Hawai'i. A good amount of further effort will be needed to more formally and objectively assess "priority species" for future versions of this plan using risk assessments and other tools.

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 to focus attention and resources towards. 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 Classes³¹

The following Management Classes list nonnative species already in Hawai'i that are known to be invasive or thought to present a risk of becoming invasive. Priority management actions to be taken for these species are discussed within each Management Class. 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. There may be overlap in some of the categories, and some species may fit more than one category. It is acknowledged that this is not a perfected system, but it is intended to be a starting point.

The selections of the species given as examples were made with a wide range of input from members of the Focus Area Groups, as well as from the AIS Management Plan Steering Committee. 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. The examples are not meant to be a complete list of all of Hawaii's aquatic invasive species. As there are over 343 documented introduced marine and brackish water species³², over 50 established introduced freshwater species (many more of which were introduced, but not established)³³, and an additional approximate 300+ introduced aquatic insects³⁴, it is not feasible to list all species here. Rather, these examples are intended to provide a basis for discussion, and to illustrate species for each Management Category. In many cases, further work is needed to identify the presence, distribution,

³¹ 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, 1991.

³² Eldredge and Carlton 2002.

³³ Yamamoto and Tagawa 2000.

³⁴ R. Englund, personal communication 2003.

status, and threat of the various introduced species in Hawai'i before they can be divided into the following management classes.

These management classes are suggested solely for the purpose of prioritizing management efforts and are not intended to be used for regulatory or permitting purposes. Hawai'i has an extensive permitting and review process, which is detailed on page 2-14 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 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

Algae

Dictyota flabellata (**Phaeophyta, brown algae**)

Freshwater Species

Plants

Typha latifolia (**Common cattail**)

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 includes species that are approved for import and managed under other regulations for commercial or recreational purposes, but that still have known or potential impacts on native species, ecosystems, or the human use of these ecosystems.

Primary management actions include:

- Prevention of 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

Algae

Kappaphycus spp.,

Gracilaria salicornia (**Rhodophyta, red alga**)*

Invertebrates

Scylla serrata (**Samoan crab**)*

Brackish Water Plants

Rhizophora mangle (**Mangroves**)

Batis maritima (**Pickleweed**)

Freshwater Species

Plants:

Salvinia molesta (**Kariba weed**)

Eichhornia crassipes (**Water hyacinth**)*

Pistia stratioides (**Water lettuce**)*

Egeria densa (**Elodea or Anacharis**)

Invertebrates

Pomacea sp. (**Apple snails**)*

Fish

Micropterus dolomieu (**Smallmouth bass**)*

Hemichromis elongatus (**Jewel cichlid**)*

Tilapia spp. (**Tilapia**)*

Clarias fuscus (**Chinese catfish, puntat, paltat**)*

Hypostomus c.f. watwata (**Armored catfish**) *

Poecilids (**Topminnows**)*

Trachemys scripta elegans, *Pelodiscus sinensis* and *Palea steindachneri* (**Freshwater turtles**)*

* indicates that species is valued for recreational purposes or commercially cultured in Hawai'i

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 dispersal to new waters
- Mitigation of impacts
- Further evaluation and research of potential control methods

Marine Species

Algae:

Acanthopora spicifera (**Rhodophyta, red algae**)
Hypnea musciformis (**Rhodophyta, red alga**)

Invertebrates

Carijoa riisei (**Snowflake coral**)
Chtamalus proteus (**Caribbean barnacle**)
Gonodactylus falcatus (**Philippine mantis shrimp**)

Fish:

Valamugil engeli (**Australian mullet**)

Freshwater Species

Invertebrates:

Macrobrachium lar (**Tahitian prawn**)
Neocaridina denticulata sinensis (**Grass Shrimp**)
Corbicula fluminea (**Asiatic Clam**)
Myzobdella lugubris (**Leech**)
Trichoptera (**Caddisflies**)
Culicidae (**Mosquitoes**)

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 dispersal to new waters
- Further research to evaluate their invasive potential
- Continued monitoring of existing populations to determine rate of spread

Marine Species

Algae

Avrainvillea amadelpha (**Chlorophyta-green alga**)

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**)

Fish:

Lutjanus kasmira (**Ta‘ape, blueline snapper**)
Cephalopholis argus (**Roi**)
Lutjanus fulvus (**To‘au**)
Herklotsichthys quadrimaculatus (**Goldspot herring**)
Mobranchius rotundiceps obliquus, *O. ferox*, and
Parablennius thysanius (**Blennies**)

Freshwater Species

Fish

Misgurnus anguillicaudatus (**Dojo, Weather loach, Japanese weatherfish**)

EXAMPLES OF 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. The Hawai'i Department of Agriculture (HDOA) maintains lists for restricted and prohibited species, as detailed in Chapter 2; not all of these restricted or prohibited species are listed in this section. 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 serve to 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 to prevent the introduction into State waters. Other examples are of concern due to the potential for inadvertent introductions through various anthropogenic means. This should not be considered a complete listing.

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**)^a

- *Scyphozoa* (**Jellyfish**)
- *Anthozoa*
 - Octocorallia*
 - Hexacorallia*
- *Hydrozoa*

Other

Boiga irregularis (**Brown tree snake**)^b

Freshwater Species

Fish

Piranha

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**)

Freshwater snakes

^a. Cnidarians as a whole, contain species that have demonstrated the ability to act invasively in habitats that are both characteristic and unique for their home ranges, once they have become established in Hawai'i. 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.

^b. Brown tree snakes are a terrestrial species. It is noted 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.

Taking a Closer Look:
Examining the Idea of "Pest to Profit": The Case of the Apple Snails³⁵

Apple snails (*Pomacea canaliculata*; "channeled apple snail") pose complex management issues. The species is known to be invasive in freshwater natural and agricultural systems of Hawai'i, but many in the aquaculture industry also feel strongly that it has significant commercial potential.

Channeled apple snails are native to South America, and in the early 1990's, were introduced into taro farms to be used as a secondary cultured species to be sold to restaurants (Ako in Kubota 2003).

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 USA, 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 USDA 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 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 to 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 important culturally in Hawai'i.

According to Sea Grant³⁶, "apple snails were intentionally introduced in some taro patches in the hopes that they could be harvested as native 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 efforts include 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 the drying out of 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"³⁷, 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.

~continued~

³⁵ 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.

³⁶ Via the Sea Grant webpage, <http://www.sg.ohio-state.edu/publications/ANSreport/applesnail.pdf>

³⁷ Hawaiian Escargot is a trademark of BoKe' Farms of Hawai'i.

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 they are self-sufficient and able to breed their own. (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: 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. There is also speculated to be unregulated culture and/or collection of these snails, and they are readily available alive in open markets, such as in Chinatown on O'ahu, and other locations.

A Range of Management Issues to Be Addressed

As far as management issues are concerned, 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 the 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 and increased demand by additional culturing of the species, as opposed to additional collecting of snails from the wild. They feel that this would likely encourage additional farming, both regulated and non-regulated, of the species, and that this could potentially counteract any associated control benefits that the collecting idea originally stemmed from. Particularly, there are concerns about snails escaping from aquaculture and taro farms into areas where they are not currently present, thereby exacerbating the pest problem. (There are also researchers who are working with apple snails, and who are not 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 point 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.

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CHAPTER 4:

PROPOSED ACTIONS

<u>Page</u>	<u>Topic</u>
4-1.	Introduction
4-2.	<u>Objective 1:</u> Increase Coordination and Collaboration Among Those Involved with AIS Issues.
4-9.	<u>Objective 2:</u> Minimizing Introductions Into and Throughout Hawai'i
4-19.	<u>Objective 3:</u> Ensure Effective Monitoring and Early Detection
4-24.	<u>Objective 4:</u> Establish Effective Systems for Rapid Response, Eradication, Control, and Restoration
4-34.	<u>Objective 5:</u> Increase Education and Outreach
4-41.	<u>Objective 6:</u> Research to Better Understand the Species-Specific Impacts and Control Options
4-45.	<u>Objective 7:</u> Ensure State Laws and Regulations Effectively Promote the Prevention and Control of AIS.

Specific Management Actions Proposed

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 and are presented in this draft plan. The majority of the following tasks have been agreed upon by one or more associated Focus Area Groups. Suggestions and input for additional tasks and strategies are still welcome and encouraged.

Scope of This Section

While the following information does incorporate 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 to address specific AIS, while still coordinating with statewide efforts.

Freshwater and Aquatic Systems

Throughout this plan, the term "freshwater" and "aquatic" are used. "Aquatic" is meant to include all marine and inland bodies of water. "Freshwater" is meant to include all inland and non-marine water bodies, and includes streams, wetlands, anchialine ponds, as well as brackish and estuarine waters. Artificial systems of reservoirs and lakes are also generally included in this term, unless noted differently. These terms do *not* include freshwater systems involved with closed-system aquaculture, landscaping (water gardens), or similar.

Prioritization of Tasks and Implementation:

The tasks below are not yet prioritized, except with the general notation of the realistic year that they should be implemented. The order they are listed does not represent the order of priority for implementation.

Many of the suggested tasks below will require additional funding sources in order to be implemented. These tasks presented here are what "should" happen in order to have an effective statewide AIS management program. 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. The entities listed in parentheses after each task are meant to represent the key entity that has the responsibility (and in some cases, the 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 key entities listed. As these tasks get implemented, it is likely that some of these key entities will change. They are presented here as a guideline.

Because Hawai'i has no true AIS program as of yet, many details are included in with the following tasks. These "comments" and "updates" are intended to give the reader a better sense of the systems we already have in place, and what is needed. It is hoped that after reading the other information presented in the plan, in association with comments and updates presented with these tasks, the reader should have a solid understanding of the issues facing Hawai'i in terms of AIS. It is anticipated that future years' version of this plan would have less of this background text, as those involved in AIS issues become more aware of the associated details.

The objectives, strategies, and tasks will come under regular review, and this plan is intended to adapt to changing circumstances. It is anticipated that an annual report will be produced by the HI AIS Coordinator and the HI AIS Advisory Council, which will include recommendations for updating and modifying the following management activities.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Association
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
HDOH	Hawai'i Department of Health	TNC	The Nature Conservancy
		WAq	Waikiki Aquarium

Goal of the Hawai'i AIS Management Plan:

To minimize the harmful ecological and economic impacts of AIS through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawai'i.

Objective 1:
Increased Coordination and Collaboration

STRATEGY 1A. Continue and improve communication and collaboration among county, state, and federal AIS programs and activities throughout all of the Hawaiian islands.

Comment: A schematic showing the relationship of entities referred to tasks 1A1- 1A5 is shown in Figure 2, at the end of task 1A5.

Supporting Existing Invasive Species Management Entities:

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

Comment: The Hawai'i Invasive Species Council is described on page 2-12, and associated legislation is presented in Appendix I. 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.

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, DLNR-DAR) 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 28 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.

Creation of new entities/positions:

1A3. Create a statewide AIS Advisory Council 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, DLNR-DAR) YEAR 1

Update: This AIS Advisory Council should report to the head of DLNR-DAR, (or new entity as referred to in 1A8), to CGAPS, as well as to the Governor via the soon to be formed Hawai'i Invasive Species Council referred to in 1A1. 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

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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.

1A4. Ensure coordination with, and input from, the diverse industry and professional groups affected (or potentially affected) by AIS management efforts. (DLNR-DAR, HI AIS Advisory Council, AIS Coordinator) 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 1A6.

1A5. Create subgroups/committees/working groups to allow for further collaboration and communication among specific issues. (HI AIS Advisory Council, AIS Coordinator) YEAR 1

Comment: 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 on page 1-2, 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. The suggested groups include:

- **Continued collaboration among the Marine Algae Group (MAG).**
Comment: The Marine Algae Group (MAG) has already been instrumental in developing and implementing the Alien Algae Control Plan as well as management aspects for the native algae blooms. MAG is further defined in Chapter 2, page 2-16.
- **Development of a Freshwater Working Group.**
Comment: A dedicated subcommittee within the AIS Advisory Council is needed to address the breadth of freshwater AIS issues. This group is considered to be a key in the implementation of many of the freshwater tasks, and as such, is designated in the remainder of this document as the Freshwater AIS Subcommittee.
- **Development of Alien Marine Invertebrate Group.**
Comment: This would be composed of a team of scientists and resource managers currently working on marine invertebrate AIS issues in Hawai'i.
- **Continued communication among the Marine Fish Researchers**
Comment: Currently, there is a high level of communication and collaboration among researchers and resource managers working on marine fish AIS issues.
- **Development of island-specific working groups.**
Comment: Interest has already been expressed by those on the Big Island to form their own island AIS working group to address issues specific to their island. Additionally, those involved in marine algae issues on the Big Island, have also expressed a need and desire to form a Big Island component of the Marine Algae Group.

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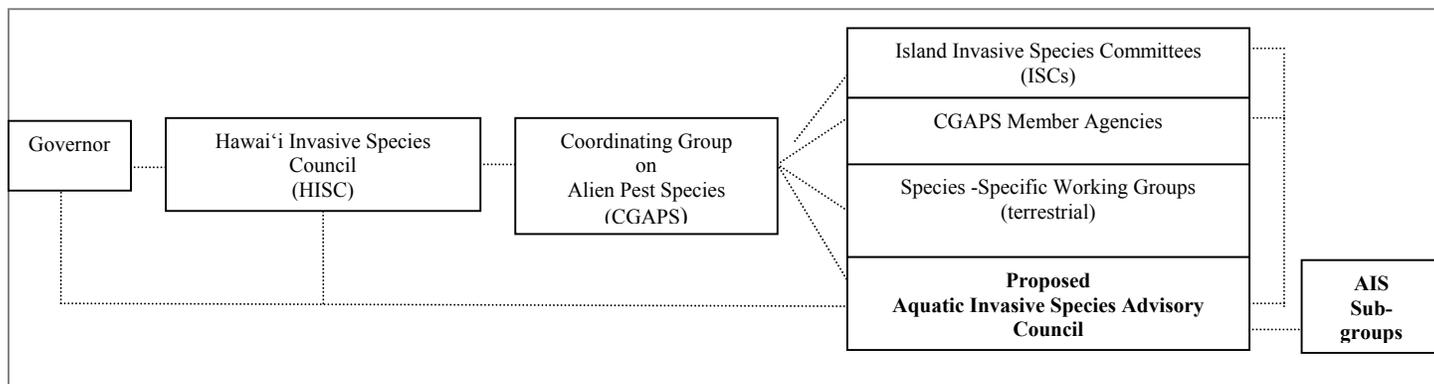


Figure 2. The above diagram is intended to represent communication and advisory lines only. It is presented to give a clearer picture of where the proposed Aquatic Invasive Species Advisory Council and sub-groups would fit in with current entities dedicated to invasive species. Dotted lines represent direct communication channels. Relationships among the above ISCs, CGAPS Member Agencies, and Species-Specific Working Groups and AIS Sub-groups are not presented in the interest of maintaining readability in this diagram.

1A6. Create and fund a position for a FTE Statewide Coordinator for AIS issues. (DLNR-DAR) YEAR 1

Comment: The AIS Coordinator would facilitate the Hawai‘i AIS Advisory Council referred to in 1A1, 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.

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 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.

1A7. Create and fund additional positions, and employ personnel that are focussed 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-DAR)

- 1) 1 FTE Marine Alien Species Biologist (YEAR 1-2)
- 2) 1 FTE Freshwater Alien Species Biologist (YEAR 1-2)
- 3) 2-4 field technicians per island (YEARS 2-5)

Comment: Given the large scope and diversity of freshwater and marine components of AIS, the two invasive species biologist positions, -one marine and one freshwater -,are warranted. The AIS Coordinator and Marine and Freshwater Alien Species Biologists would work together to help coordinate and carry out marine and freshwater 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. These biologist positions are also considered integral to the implementation of multiple tasks included in this plan, but will not be listed as a lead entity until it is more clear as to when these positions would be funded.

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1A8. 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 on page B-1, 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 Marine AIS Biologist and AIS Coordinator referred to in Tasks 1A6 and 1A7 in identifying and developing solutions to address algae AIS issues.

1A9. Explore the feasibility of creating a new permanent, independent entity/division/commission either within the Department of Land and Natural Resources (DLNR), or outside of DLNR entirely, with the mission of specifically dealing with both aquatic and terrestrial invasive species. (DLNR-DAR) YEAR 1-2.

Comment: Efforts still need to be made to assess the best organizational structure to 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. Once formed, this entity would include those positions listed in 1A6 and 1A7, as well as be directly involved with the AIS Advisory Council referred to in 1A3. Ideally, this would ultimately include personnel and resources that currently lie within the DLNR divisions of DOFAW, and DOCAR, (and possibly HDOA), who are already working with invasive species issues.

Working with Existing Entities and Organizations in the State Which Address Invasive Species:

1A10. Explore the feasibility of involvement within the Invasive Species Committees (ISC's) on each island. (AIS Coordinator, CGAPS, HI AIS Advisory Council, DLNR-DAR) 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‘, 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.

1A11. 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 1

Update: Currently, there are various site-based restoration efforts, such as by the community group, Paepae o He‘eia, 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.

1A12. Increase the integration of AIS issues into existing conferences (AIS Coordinator, HI AIS Advisory Council, DLNR-DAR, Bishop Museum, UH) YEAR 1

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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.

Activities and Projects:

1A13. Hold an annual conference on the topic of AIS in Hawai'i. (AIS Coordinator, DLNR-DAR) YEAR 3

Comment: AIS issues, though currently included in conferences referred to in 1A12, 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

1A14. Create a centralized communications forum (such as a list-server) to focus on Hawaii's AIS issues.

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 1A10, as well as national servers such as ALIENS. However, there is a need for a focussed discussion group on AIS issues in Hawai'i.

1A15. Create a centralized website for AIS aspects in Hawai'i. (AIS Coordinator) Year 2

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, as well as be a site to post new information and updates. Ultimately, a system would be set up for users to record observations of invasive species, as well as links to each of the researchers who are working on a specific area or species, to allow users to contact them for further information.

1A15. Evaluate current databases available; and integrate those efforts to allow for a centralized database for Hawai'i AIS, with GIS capabilities. (AIS Coordinator, University of Hawai'i, Bishop Museum, DLNR-DAR) 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 sites such as USGS, 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.

1A17. Develop a centralized system for the recording of stocking activities across the State. (DLNR-DAR) YEAR 2

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

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1B1. Participate in appropriate national and international conferences dealing with the management and control of AIS issues. (UH, Bishop Museum, WAq, DAR) ONGOING

Update: These conferences function to increase knowledge of efforts and successes elsewhere, as well as to ensure awareness of Hawai'i'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, WAq, 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 involved in the Western Regional Panel. (HI AIS Advisory Council, DLNR-DAR, 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 AIS Task Force Meeting in November 2002, presenters from Hawai'i suggested to the Task Force that the development of a Pacific Island Regional Panel would be the most effective way for Hawai'i to get involved in panel efforts. The Task Force agreed, and encouraged representatives from Hawai'i to move forward with putting together a proposal for this idea.

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, IMO, GISP, ISAC, and SPREP. (DLNR/DAR, Bishop Museum, UH) ONGOING

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

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

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. (HI AIS Advisory Council, Freshwater AIS Sub-committee, AIS Coordinator, DLNR-DAR, CGAPS, HDOA). YEAR 1
Update: A preliminary listing of examples of AIS species 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 in identifying priority species for management. (HI AIS Advisory Council, AIS Coordinator, DLNR-DAR, CGAPS, UH, HDOA). YEAR 1.
Update: A "Weed Risk Assessment Model" has been developed by a researchers in Hawai'i to assess the invasiveness of potential species. Though primarily terrestrial –based, this model could likely be expanded as well as incorporated with other models being developed elsewhere, to be an effective tool in identifying priority species for management. There are also various additional risk assessment procedures that have been developed by other states, as well as national and international groups.

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1C3. Develop and implement a method to identify priority sites of concern regarding Aquatic Invasive Species. (HI AIS Advisory Council, Subgroups referred to in 1A5, DLNR-DAR, AIS Coordinator) 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, 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 Committee) 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 sources available both in Hawai'i and nationally. (AIS Coordinator, UH, Bishop, DLNR-DAR) YEAR 1-5

1E2. Create stable, long-term funding sources to assist in the implementation of some of the AIS management activities identified in this plan. (HI Invasive Species Council, HI AIS Advisory Council, CGAPS)

4- 8

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Objective 2:

Minimize the Introductions of AIS Into and Throughout Hawai'i.

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-DAR, HDOA, EPA, DOH) 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.

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) YEAR 1-2

Update: In Hawai'i, most ships arrive full of cargo and leave empty, taking on water for ballast while discharging cargo; this tends to make the Hawaiian Islands exporters of ballast water, rather than recipients.³⁸ As a result, although the principal mechanism for distribution of marine nonindigenous species worldwide is usually considered to be in ship's ballast water (Carlton 1985; Carlton and Geller 1993), the most likely vector for local movement of organisms between the Hawaiian Islands is fouling on slow moving cargo barges. Researchers at the Bishop Museum are undertaking the task of assessing the impact of hull fouling introductions, through a grant by the Hawai'i Coral Reef Initiative. This is further detailed under "Current Research Efforts." However, ballast water is still a pathway that needs to be assessed for its potential impacts. Initial work has been done by researchers at the Bishop Museum to assess the impact of ballast water, but this is preliminary, and additional efforts are warranted to assist in the ballast water management program.

2A3. 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. (DLNR-DAR, Bishop Museum, HI AIS Advisory Council) YEAR 1-2

Update: Researchers from Bishop Museum have submitted a proposal to HCRI to determine the present and potential mechanisms for the introduction and dispersal of nonnative aquatic species.

2A4. Once a more comprehensive listing of vectors and pathways is identified that is referred to in the above task, perform a risk analysis to identify and assess the potential of current

³⁸ Eldredge, L.G. "Fouling of Marine Ecosystems by Invasive Alien Species: A Call to Action" Prepared for the preceding on "The Impacts of Invasive Alien Species on Island Ecosystems" Conference, Hosted by the Global Invasive Species Programme (GISP) Honolulu 2002.

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practices to introduce and transport AIS into and throughout Hawaii's waters. (DLNR-DAR, HI AIS Advisory Council, AIS Coordinator) YEAR 2-4

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 regarding prohibited and restricted species. This includes monitoring of 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 incoming shipments of restricted or prohibited AIS. –Also identified in Education and Outreach (USDA, HDOA, AIS Coordinator) 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 clear guidelines exist for inspectors /enforcement officers at pre-border, border, and post-border levels for maritime activities. (DLNR-DAR, USCG) YEAR 1

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 between HDOA and USDA to ensure consistency and compatibility with regulations and inspection efforts. (HDOA, USDA) YEAR 1.

2B5. Continue to enforce procedures and restrictions on imports of nonnative species that are already established in Hawaii's waters. (HDOA, DLNR-DAR) ONGOING

Comment: It is often assumed that once a nonnative species has been introduced and becomes established, that the damage is done and restrictions on further imports and introductions of that same species can be relaxed. Numerous researchers have emphasized that this is not the case, because when a nonnative species (a host) is introduced, it brings with it only a) 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.

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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. (AIS Coordinator, HI AIS Advisory Council, USDA) Year 2

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 above, to prevent further introductions and spread of AIS. (EPA, DOH, HDOA) YEAR 1

Update³⁹: 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.

2B8. Identify "ecologically sensitive" marine and freshwater area 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. (HI AIS Advisory Council, DLNR-DAR, USFWS, Kaho'olawe Island Reserve Commission) YEAR 2

Comment: USFWS already has 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. 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. 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 1

³⁹ Taken from the EPA website on the National Pollutant Discharge Elimination System, <http://cfpub.epa.gov/npdes/>

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

2D1. Work with aquarium, water garden, other appropriate industries, as well as cultural groups to educate all aquarists, store owners, and consumers of the importance of not releasing unwanted ornamentals back into aquatic systems. –This is also referred to in Education, Objective 5 (AIS Coordinator, DLNR-DAR) 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. Designate a place(s) on each island where people can dispose of unwanted fish, ensure that this is an easily accessible site, and that people are aware of where it is. (DLNR-DAR) YEAR 1-2

2D3. Work 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. (AIS Coordinator, DLNR-DAR) YEAR 1

Update: 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.

2D4. Work with the aquaculture industry, aquaculture development programs, and wetland agriculture representatives to ensure farmers understand the importance of containment systems as well as the threat that escapees may pose on native species and habitats. (DLNR-DAR, SeaGrant, UH-Aquaculture Development Program, HDOA, AIS Coordinator, Freshwater AIS Subcommittee) 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.

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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. (HDOA, DLNR-DAR, Aquaculture Industries) 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.

2D6. 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. (Freshwater AIS Sub-committee, AIS Coordinator, DLNR-DAR) YEAR 2

Comment: Best Management Practices have been implemented across the nation for various issues. To a large degree they have been shown to be effective in industry compliance. This concept should be explored to its fullest potential in addressing AIS issues.

2D7. Increase the trade, cultivation, purchase and interest in native species within the hobby trades and industries by promoting the value of native species over nonnative species, supporting and encouraging the cultivation of native species, and identifying trends within hobby trades in order to suggest native counterparts that serve the same niche. –Also listed in Education and Outreach, (DLNR-DAR, HI AIS Advisory Council) YEAR 2

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

2E1. Establish protocols to prevent the transfer of AIS from research, monitoring and control activities, and incorporate this aspect into funding requests. (University of Hawai'i, Bishop Museum, HCRI) 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 this component of protocols to prevent spread should be incorporated into grant applications that address AIS.

2E2. Prohibit in-water (non-lab) based research experiments that introduce or involve the culture of nonnative species into areas where they do not naturally exist, as there is a high probability for escape. (DLNR-DAR, 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.

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

2F1. Add known AIS plant and algae species to existing regulation lists under HDOA. (HDOA, DLNR-DAR, Freshwater AIS Sub-committee) YEAR 1

2F2. Assess if current systems for disease sampling of shipments and stocks of live fish are considered "adequate" to keep contaminated stocks from being distributed via aquaculture, the aquarium trade, and/or government stocking programs. (HDOA, DLNR-DAR, Freshwater AIS Advisory Sub-committee) 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, 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".

Marine Specific Prevention Strategies and Tasks:

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

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 2-17. 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-DAR, 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 management plan 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 2B1. (DLNR-DAR, USCG) YEAR 1

Update: Currently, no funding has been identified to implement the first phase of the ballast water and hull fouling plan. 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 the United States Coast Guard (USCG) to be the enforcement for the management programs. These implementation and enforcement aspects should to be addressed by the State DLNR within Year 1.

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2G3. Continue the efforts of the ballast water and hull fouling management program, and associated task force, and initiate measures to have a permanent program coordinator and program with dedicated funding incorporated into DAR's programs. (DLNR-DAR, AAOTF, 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 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.

2G4. Identify and address gaps in the Ballast Water Management Program that have not been addressed in the administrative rules. (DLNR-DAR, 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:

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

Comment: 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 time⁴⁰. Identification and promotion of alternatives 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 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 a higher priority 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-DAR) 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.

- **Method for verification of ballast water exchange**

- **Exploration of alternative treatment methods for ballast water exchange.**

⁴⁰ D. Hazlehurst (Matson Shipping), personal communication.

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- **Dissemination of information to the public relating to ballast water issues.**

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-DAR, USCG, AAOTF) YEAR 2-3

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. Assess the impacts of hull fouling as a pathway for AIS introductions in Hawai'i. (Bishop Museum, AAOTF) ONGOING

Update: As referred to in 2G3, researchers from the Bishop Museum are conducting a study, "The Assessment of Hull Fouling as a Mechanisms for the Introduction and Dispersal of Marine Alien Species in the Main Hawaiian Islands". The field component of this study includes:

- SCUBA surveys of overseas and commercial barges operating within Hawai'i, motor yachts and sailboats arriving from overseas destinations, and fishing boats.
- Development of an initial visual survey method and scoring system to determine if SCUBA surveys would be necessary.
- Dry dock surveys of vessels being serviced, including commercial barges, foreign fishing boats, other commercial vessels, research vessels, and USCG 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, motor yachts, and sailboats.

2G7. Raise awareness of hull fouling issues with governments, relevant industries (including tourism), recreational sector, and local communities (especially those closely associated with coral reefs as well as schools). (Bishop Museum, DLNR-DAR, AAOTF). YEAR 1

Comment: This task partially taken from recommendations from the Global Invasive Species Programme (GISP). Through the AAOTF, efforts are currently being focussed 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.

2G8. Continue to work with and develop voluntary methods, best management practices, and management protocols for the cleaning of hulls for 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. (Bishop Museum, DLNR-DAR, AAOTF) YEAR 1-3.

Comment: Taken from recommendations made by the from the Global Invasive Species Programme (GISP).
Update: 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 USCS, 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

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address these and other aspects relating to best management practices and management protocols, as well as what will be feasible to ask/require from Hawai'i's boating community.

2G9. Evaluate the feasibility of establishing a quarantine area and an onshore ballast water disposal/treatment facility. (DLNR-DAR, AAOTF) 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 2-27. 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,⁴¹ indicate that it may not be a feasible option.

2G10. Evaluate the feasibility of establishing surveillance programs to detect and implement penalties for "polluters" who introduce AIS via fouling. (AAOTF, DLNR-DAR) 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. It 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.

Freshwater-Specific Prevention Strategies

STRATEGY 2H: Assess and minimize activity relating to planned, authorized introductions of nonnative species into freshwater systems.

Issue Addressed: Planned introductions into freshwater systems still are occurring through the State by DLNR-DAR and Department of Health. These include the production of channel catfish and rainbow trout for the stocking of public fishing areas at Nu'uauu (O'ahu) and Koke'e (Kaua'i)⁴² 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 (Freshwater AIS Sub-committee, DOH, DLNR-DAR, 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.⁴³ Though mosquito control certainly needs to be addressed in Hawai'i, Poecilids are known to be harmful to native insect and fish species.⁴⁴ 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

⁴¹ S. Smith, personal communication, 2003.

⁴² Taken directly from the DLNR-DAR's Anuenue Fisheries Research Center (AFRC) website, www.state.hi.us/dlnr/dar/afrc/index

⁴³ Timbol et al. 1989 and R. Englund (Bishop Museum), pers. comm. 2003.

⁴⁴ Text directly from Timbol et al. 1989

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certain situations⁴⁵; 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.

(FANS, HI AIS Advisory Council, HSRC, Bishop Museum, DLNR-DAR) 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 cataloging of the history of introductions, regarding freshwater invasive species in Hawai'i in order to avoid repeating similar problems on other islands.

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-DAR) YEAR 1

Comments: Based on casual conversations with freshwater fishing enthusiasts, it appears that the spread of smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) in Kauai's streams and reservoirs is due to unauthorized stocking.⁴⁶

⁴⁵ M. Yamamoto (DLNR- DAR), pers.comm. 2003.

⁴⁶ Taken directly from Timbol et al. 1989.

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Objective 3:

Effective Monitoring and Early Detection

The Importance of Early Detection⁴⁷: 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. Early detection of the presence of a new nonnative species before established populations spread beyond the point of introduction is vital.

There are many programs and efforts currently in place for surveying and monitoring, as defined below and in Appendix B. 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.

A summary of Freshwater Monitoring Programs:

DLNR-DAR has a state-wide 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."⁴⁸ Additionally, many public and private entities are involved in the surveying and monitoring of freshwater systems throughout Hawai'i. This includes Bishop Museum, University of Hawai'i, and others, as further detailed under "current efforts". These studies have greatly increased our baseline knowledge of occurrence, distribution, and abundance of nonnative freshwater 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 state-wide, the 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 freshwater systems has also been done by EPA, DOH, various watershed organizations, and others, focusing on aspects associated water quality and / or native species. Though these studies greatly add to our knowledge of the systems, but in many cases (especially on the islands other than O'ahu), introduced species were often overlooked or just briefly addressed.

A Summary of Marine Monitoring Programs:

Current marine monitoring programs such as the Hawai'i Coral Reef Assessment and Monitoring Program (CRAMP), focus primarily on the spatial and temporal patterns of corals and fish. 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 monitoring programs. 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 fish species would likely get noticed rather quickly. However with 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 monitor 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

⁴⁷ Adapted directly from an overview of "NOAA's Draft Plan for a National Coastal Marine Alien Species Program". Lead author: D. Turgeon.

⁴⁸ M. Yamamoto (DLNR-DAR), personal communication.

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developed into an extensive monitoring program as yet. Similarly, many inventory studies have been done 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.

STRATEGY 3A: Continue current monitoring efforts to better understand the spatial and temporal distribution of AIS populations, and to detect new incipient populations.

Related to Current Marine AIS Monitoring:

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. (DLNR-DAR, Bishop Museum) 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 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. (HCRI, UH, WAq) 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 Moloka'i's nearshore waters, as well as the waters of Kāne'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 Monitoring System to detect new populations of invasive species. (NOAA, Bishop Museum) ONGOING

Update: NOAA is currently developing a Marine Invasive Species Early Warning System, and has designated Hawai'i to be a pilot state in the project. Hawai'i has been designated by NOAA as a pilot site for a pilot site for NOAA's proposed Marine Invasive Species Early Warning System for Coastal Alien Species⁴⁹. 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.

Related to Current Freshwater AIS Monitoring:

3A4. Continue with current AIS freshwater inventory and monitoring efforts. (DLNR-DAR, Bishop Museum, UH-CCRT) ONGOING

⁴⁹ 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 current efforts as well as 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 (GIS) system to be accessible by all agencies, groups and organizations engaged in AIS detection and monitoring. -This is also referred to in Objective 1. (UH-HSRC, DLNR-DAR) YEAR 2

Update: Mapping is an important step in determining the spatial distribution of freshwater 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 freshwater AIS. However as quoted from the HSRC 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"⁵⁰

3B2. Obtain funding for Bishop Museum to incorporate its historical collections and report findings into a database compatible with the current standard HDAR stream database. (AIS Coordinator, Bishop Museum, 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 HDAR stream database.

MARINE RELATED:

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.

3B3. Assess existing marine monitoring programs and identify areas where expansion of efforts could assist in more effective detection of AIS. (HI AIS Advisory Committee, DLNR-DAR, MAG, Marine Invertebrate Working Group) YEAR 2-3

3B4. Based on the results from the assessment in 3A3, implement a standardized, long term marine monitoring program and early warning system, that is accepted by the state, to detect new AIS populations and the spread of existing ones. (DLNR-DAR, UH, WAq, HCRI) YEAR 2

Comment⁵¹: 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

⁵⁰ Quote is from the Hawai'i Stream Research Center's webpage, www2.hawaii.edu/hsrc/home/aquaorg.htm

⁵¹ 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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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.

Freshwater Related:

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. (Freshwater AIS Sub-committee, DLNR-DAR, Bishop Museum, HSRC, USGS) YEAR 1-2

Comment: As referred to above, various freshwater 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 freshwater 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.

3B6. Implement appropriate changes identified in the assessment referred to in 3B5 (Freshwater AIS Sub-committee, DLNR-DAR, HSRC, Bishop Museum, UH) YEAR 2-3

3B7. Maintain long-term yearly monitoring stations (for all freshwater biota) on at least one pristine stream for each main Hawaiian Island. (DLNR-DAR) YEAR 2

3B8. Identify funding to survey, map, and monitor the distributions of introduced freshwater mollusk species (Bishop Museum, DLNR-DAR) Year 1

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 ad-hoc basis, as there is funding specifically for this. Funding mechanisms need to be identified to continue this work in a more formalized manner.

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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 invasive species that they may come across. (AIS Coordinator, DLNR-DAR, 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 freshwater 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 freshwater systems. –This is also referred to in Education and Outreach. (AIS Coordinator, MAG, Freshwater AIS Sub-committee, DLNR-DAR) 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 which 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 \$50,000 grant has been awarded by HCF to assist in the development of an Alien Algal Watch program within ReefWatchers.
- **Expansion of current marine monitoring and freshwater 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.
Update: 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).

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Objective 4:

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 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, Freshwater AIS Sub-committee, 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 of newly detected populations, to prevent their establishment in the first place. Though 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/ Wahiawā 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 and Control efforts.

Many of the following tasks in this strategy refer to examples seen with the recent control efforts with *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.

Numerous examples of Rapid Response Plans exist and/or are currently in development on regional, national and international levels. Locally, Rapid Response Plans exist addressing some terrestrial species, through the Invasive Species Committees (ISCs) on each island. For this reason, it is emphasized that the tasks below should be considered only as a preliminary listing/outline of tasks that would need to be considered for development of a full scale rapid response plan. 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. 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.

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, AIS Coordinator, DLNR-DAR) YEAR 1

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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."⁵²

4A2. Develop a system to allow for centralized and formalized AIS reporting. (HI AIS Advisory Council, AIS Coordinator) 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 . The importance of responding to a known 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 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) 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), and methods to address the pathway of introductions. (AIS Coordinator, HI AIS Advisory Council) YEAR 2

Comment: Without previously developed plans, new AIS populations can become established while agencies are developing and agreeing upon appropriate eradication measures.⁵³ Again, this was seen with Salvinia, where multiple meetings were necessary to try to figure out numerous elements from lead agencies, 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 mechanisms for the establishment and administration of permanent funding to implement emergency response plans. (AIS Coordinator, HI AIS Advisory Council DLNR-DAR) 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 using New Zealand's approach in which some of the terrestrial monitoring and rapid response work is contracted out to approved private businesses. (HI AIS Advisory Council, DLNR-DAR) YEAR 2

⁵² 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.

⁵³ Thanks to the Alaska State Plan for this comment.

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STRATEGY 4B: Prioritize organisms on which to focus control efforts and develop specific control plans to address these.

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 among other factors, the threat posed by the species, as well as the expected level of effectiveness of control and/or eradication efforts -This is also referred to in Strategy 1C and task 4A1 (AIS Coordinator, DLNR-DAR, Freshwater AIS Sub-committee, MAG) 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.

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, control 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.

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.

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. Develop species-specific, or location-specific action plans, as appropriate. (HI AIS Advisory Council, Freshwater AIS Sub-committee, DLNR-DAR, AIS Coordinator) YEAR 1

Comment: There is a clear need to develop specific control plans for certain species or certain areas. The specifics of such action plans are generally not included in the scope of a State AIS Plan such as this one, however the State and other associated entities have a responsibility to develop such plans, and to work with others who are trying to address AIS issues in Hawai‘i. This may include the formation of statewide, species-specific working groups as referred to in task 1A5, to allow for the sharing of knowledge when developing such

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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. However, at this point, this type of collaboration among freshwater interests not as defined.

Marine Specific Control Strategies: Algae⁵⁴

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 (Rogers and Cox 1999, Smith et al. 2002, Zemke-White in press). 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: 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 algae 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 and 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 MLCD. -Also listed in Education and Outreach. (MAGNET, TNC) 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 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, UH, and WAQ is developing protocols for the expansion of such events, and will encourage outer island participation.

⁵⁴ Introductory text from the grant proposal, “The Development of a Control Program for Harmful Algal Blooms on Coral Reefs in Hawai‘i”, submitted under a ECOHAB/ 2003 STAR Grant. Principal Investigators: Atkinson, S.A Smith, C.M., Hunter, C.L

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4D2. Establish protocols to prevent the transfer of nonnative algae from clean-up and monitoring events. –Also listed in Prevention, task 2E1. (MAG, TNC, DLNR-DAR) YEAR 1

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, WAq) 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. [insert most current details]

4D4. Implement a large-scale volunteer effort, similar to the efforts at Waikiki MLCD, for the removal of *Kappaphycus* spp. and *G. salicornia* at Kāneʻohe Bay. (MAG, HCRI, DLNR-DAR, UH, WAq, NOAA, HIMB, Kāneʻohe Marine Base) YEAR 2

Update: Two proposals have been submitted for support in continuing invasive algae control efforts of *Kappaphycus* spp. at Kāneʻohe Bay, using both volunteer efforts and a mechanical removal device. Two preliminary events were held in October of 2002 to remove drifting algal biomass from the reef at Coconut Island in Kāneʻohe 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, WAq) YEAR 2

Native Grazers and 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. (UHM-Z, DLNR-DAR) YEAR 2

Update: It appears that native urchins being used for the task above may have been harvested from test plots in Kāneʻohe 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 AND 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, WAq, MAG, Paepae o Heʻeiʻa) YEAR 1

Update: Preliminary protocol is being developed by researchers from UH and WAq, and is further detailed in the Research Objective section. Traditional Hawaiian planting methods are also being explored by the non-profit group, Paepae o Heʻeiʻa, 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. (WAq, UHM-B, MAG, DLNR-DAR) YEAR 2.

Other Complimentary Control Methods and Marine Algae Control:

4D10. Examine the potential for additional treatment methods, such as changes in salinity and temperature, etc., to be effective in the control of nonnative algae without causing further ecological damage. (UH) YEAR 2

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 3. 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 Waipu‘ilani Beach, Maui. (MC-DPW, WBA) YEAR 1

Update: The Waipu‘ilani 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 Sea Grant, MC-DPW) 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 Waipu‘ilani 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. (MCSG, MC-DPW) 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.

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Marine-Specific Control Strategies: Invertebrates

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 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-DAR). YEAR 3-5

Marine-Specific Control Strategies: Fish

As addressed in Chapter 3, the need for control and/or eradication measures on marine fish AIS in Hawai‘i is still being assessed by researchers and resource managers, and 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

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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: Promote The Harvesting Of Potentially Invasive Marine Fish Species Such As Ta‘ape And Roi.

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. Develop a market for ta‘ape by encouraging its use within local communities, restaurants, tourism establishments and local and mainland. (DLNR-DAR) YEAR 2

Comment: Ta‘ape is highly thought of in its native South Pacific range, but is not a preferred food fish in Hawai‘i. Increased market pressure would facilitate fishing the population down. Previous efforts suggest that there is a potential market in communities in the mainland; these efforts should be re-evaluated and further explored on a local level.

4G2. Develop and possibly subsidize the distribution of affordable ciguatera test kits that would allow a viable fishery for roi. (DLNR-DAR) YEAR 2

Update: There is currently a test kit available for approximately \$5.00 per sample, which is an improvement over previous years. However, the state has never invested in promoting or distributing this kit. Other areas, such as South Florida, invested heavily in kits ten to fifteen years ago because of the associated economic incentives. 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.

Specific Control Strategies: Freshwater

For effective management of freshwater 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 development of the key priority species 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 freshwater systems in Hawai‘i are no longer in their natural state; these include reservoirs and fishing parks such as Wahiawā 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.

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STRATEGY 4H: Explore and utilize the various methods available to control priority freshwater AIS.

Mechanical Removal:

4H1. Continue and expand volunteer events for the removal of freshwater plant AIS at specific sites (Freshwater AIS Sub-committee, AIS Coordinator, 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, DLNR-DAR) YEAR 2

Chemical Methods:

4H3. Continue ongoing chemical treatment methods at existing sites and use these methods to treat new infestations. (DLNR-DAR, USFWS, Numerous site-specific entities). ONGOING

4H4. Continue to prudently explore the utilization of ichthyocides for a few selected study sites. –This is also referred to under Objective 6: Research. (DLNR-DAR, DOH, HDOA, USFWS) YEAR 1

Updates: Various entities are involved in the exploration of ichthyocides for control of freshwater 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 freshwater 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, DOH, and HDOA.

BioControl Methods:

4H5. Continue to prudently explore the utilization of biocontrol options for *Salvinia molesta* and other key priority freshwater plant AIS species, and ensure extensive testing and evaluation measures. (USDA, HDOA, DLNR-DAR) ONGOING

Update: Various research efforts are currently underway for the use of biocontrol agents in the treatment of Salvinia, Salvinia- further detailed in Appendix B.

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

Comment: As detailed in task 1A11, 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 species from selected, isolated golf course water traps, and then translocating native damselfly larvae to these habitats. (Bishop Museum, DLNR-DAR) YEAR 3

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Control Strategies for Both Marine and Freshwater 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 "Perspectives: Examining the idea of 'Pest to Profit'", on page 3-20.

4J1. Form a working group to evaluate the benefits and risks associated with the marketing and promoting 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, Sea Grant, DOH, Freshwater AIS Sub-committee, MAG) 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.

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 3. 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.

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. This is an important step in linking the proliferation of certain AIS to larger water quality issues.

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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Objective 5: **EDUCATION AND OUTREACH**

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. Target audiences include:

- **pet shops, aquarium dealers, nurseries, and landscapers as well as wholesalers and shippers dealing in aquarium fish to inform buyers of the dangers of releasing nonnative organisms into the wild.** (Freshwater AIS Sub-committee, AIS Coordinator, Pet Industry) 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.
- **recreational boaters, fishers, and marine tourism boats.** (DLNR-DAR) ONGOING
Update: As part of the EPA grant proposal⁵⁵, 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.** (Freshwater AIS Sub-committee, 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 and expand public service announcements on a variety of AIS-related topics to be aired at regular intervals in order to reinforce the message among the general public and to reach new audiences (DLNR-DAR) YEAR 1

Comment: 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 update and re-institute 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, Freshwater AIS Sub-committee, DLNR-DAR, AIS Coordinator) YEAR 2

⁵⁵ Recently, an EPA grant was awarded to a team from DLNR-DAR, the University of Hawai'i, and the Waikiki Aquarium 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 as "the EPA grant".

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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.

(Bishop Museum, DLNR-DAR). YEAR 1

Comment: This is fundamental in gaining political and popular support on this issue.

5A5. Develop airport displays and an in-flight video to educate travelers on the threats of AIS, management efforts, and how they can help to minimize the spread of such species. (DLNR-DAR) 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. 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.

5A6. Develop and produce an in-flight video highlighting the threats of AIS. (DLNR-DAR, HDOA, AIS Coordinator) YEAR 2

Update: Various airlines show an in-flight video provided by HDOA, which highlights the threats of terrestrial invasive species in Hawai'i. Efforts should be made to incorporate an AIS component into this video.

5A7. Develop and produce video highlighting the threats and solutions regarding AIS from ballast water and hull fouling for private companies within the maritime industries. (DLNR-DAR, AIS Coordinator) YEAR 3

5A8. Incorporate ballast water and hull fouling issues into maritime education system curriculum in the US and abroad. (AIS Coordinator, DLNR-DAR) YEAR 5

Comment: This may prove to be difficult, but preparing a video about AIS in different languages & sending them to the major training collages, shipping companies, as well as venues for non-commercial vessels would likely be beneficial in the long-run.

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) 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-DAR, CGAPS, HAS) 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-DAR) 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

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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. (Bishop Museum, UH, DLNR-DAR, AIS Coordinator)
YEAR 1

5C2. Conduct specific training and develop field guides for researchers and resource managers who are in the field for monitoring and other efforts. (Bishop Museum, UH, DLNR-DAR, AIS Coordinator) YEAR 1

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.

5C3. Educate resource management and regulatory agencies and their staff regarding dangers of the introduction of parasites. (DLNR-DAR) YEAR 2

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.

5C4. 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 (USDA, HDOA, AIS Coordinator, DLNR-DAR) YEAR 2-5

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:

5D1. Work with and train existing marine volunteer programs and active ocean users across the islands in the identification of marine AIS in beach, intertidal and shallow reef areas. –Also listed under Monitoring (Bishop Museum, ReefCheck, UH-Zoology) 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 which 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

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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.

5D2. Develop a educational tools for the identification of AIS for volunteer groups that can also be used by dive and snorkel boats. (DLNR-DAR, UH, WAq, 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 grant to the Bishop Museum and UH-Zoology, and a second HCRI 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.

5D3. Hold workshops geared toward community groups. (DLNR-DAR, UH, WAq) YEAR 1

Update: As described in EPA grant proposal, a series of training workshops will be geared towards community groups tied to Kāne‘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.

5D4. 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-DAR) YEAR 2

Suggested ideas include:

- Creation of a "limu badge" to use with scouts
- Implementing the "Adopt a Reef" concept: have groups keep a section of the reef clear of invasive species.

5D5. Implement a pilot project for the eradication of nonnative algae by volunteer groups. (DLNR-DAR, UH-B, WAq) 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.

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. (DLNR-DAR, 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

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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-DAR, UH-B, UH-Education, 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 College of Education and Botany Department, as well as with DLNR-DAR, on the development of nonnative limu (algae) curricula. This is primarily funded by the Waikiki Aquarium, with support from 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 the proper disposal method for organisms that have been used within the classroom, to ensure that this does not contribute to the release or transfer of AIS.

(MAG, DLNR-DAR) YEAR 1

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.

(UH-B, UH-Hilo, 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. Expand the involvement of the general public with clean-ups events at Waikiki Marine Life Conservation District, and have reasonably consistent volunteer events similar to, but smaller scale than, Waikiki MLCD events. –Also referred to in the Control section. (MAG) YEAR 1

5F2: Continue with and update printed efforts such as posters and brochures focusing on AIS. (MAG, DLNR-DAR) YEAR 1

Update: A \$4,000 USFWS grant was awarded in 2002 to a partnership with UH, WAq, and TNC for the development and printing of an informational brochure on nonnative/invasive marine algae on Hawai'i'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.

5F3. 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, Freshwater AIS Sub-committee, MAG, Bishop Museum) YEAR 1

Update: Currently, a few individuals from UH, Bishop Museum, DLNR-DAR and MAG have given guest presentations to various groups on specific topics relating to AIS issues. However, there is a need for a

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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.

5F4. Increase local television, radio and newspaper media coverage of Hawaii's AIS issues and programs addressing these issues. (AIS Coordinator, DLNR-DAR, 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-DAR, 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.

5F5. Incorporate AIS issues into education and outreach addressing terrestrial invasive problems. (CGAPS, HI AIS Advisory Council, AIS Coordinator, DLNR-DAR) 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 focussed largely on terrestrial issues, preliminary integration of AIS issues into CGAPS has begun, and further integration is anticipated.

5F6. Create displays at state parks, on school bulletin boards, in libraries, aquariums, and recreational facilities to improve public awareness of AIS. (DLNR-DAR, UH, WAq, AIS Coordinator, CGAPS) YEAR 1

Update: As part of the EPA grant, in early 2004 a team from DLNR-DAR, UH, and WAq 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.

5F7. Coordinate efforts between UH and Bishop with DLNR-DAR and Sea Grant Educators on neighbor islands and provide materials to incorporate AIS issues into their presentations. (DLNR-DAR, UH-B) 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.

5F8. 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-DAR, MAG) YEAR 2

5F9. Create portable presentation boards to show at public events such as, boat shows, conferences, volunteer events, etc., highlighting the threats of AIS. (DLNR-DAR, AIS Coordinators) YEAR 2

STRATEGY 5G: Integrate AIS educational efforts into local, cultural, and ethnic community efforts.

5G1. Work with native Hawaiian groups and other community groups, emphasizing the threats that AIS pose to native species and traditional practices. –Also referred to under Coordination (HI AIS Advisory Council) YEAR 1

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5G2. Work with cultural leaders to ensure that education efforts will be culturally sensitive and translated into the main locally spoken languages. (All participating agencies and organizations)
YEARS 1-5

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, Piko'i 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.

5G4. Create articles for newspapers or newsletters regularly read by individuals in various cultural and ethnic audiences.

STRATEGY 5H: Promote clarification of issues regarding key species 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-DAR) 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-DAR, 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

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 with existing studies regarding AIS in Hawai'i. (UH, Bishop Museum, DLNR-DAR) 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 research topics that will be directly applicable to the management of AIS in Hawai'i. (UH, Bishop Museum, MAG, Freshwater AIS Sub-committee, DLNR-DAR, HI AIS Advisory Council) 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 are presented below. The following 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 Freshwater Topics

Relating to Biology and Ecology Aspects of Freshwater Invasive 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 freshwater systems.**
Comment: This aspect is also referred to in Objective 2.
- **Examine possible competition between native and invasive fish species by examining diets of native and introduced fish species.** Specifically, investigate the diet of native fish species in streams with and without introduced fish species. Also evaluate native invertebrate taxa in the diet of introduced fish.
- **Quantitatively examine the impacts of invasive fish species on native invertebrates.**
Comment: Some species are known to be invasive, but there is not published work to support this in Hawai'i. 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.

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- **Develop a risk analysis protocol for nonnative mollusks.**
Update: R. Cowie 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 Freshwater Organisms

- **Establish if introduced penaeid shrimp diseases (IHHN, Whitespot, Taura Syndrome, Bacalourhas, Yellowhead virus, etc.) are in feral penaeid shrimp or in our native penaeid shrimp, *Penacus marginatus*.**
Comment: The native and feral penaeid shrimp can be associated with brackish water and estuarine systems as well as marine systems.

Relating to Freshwater 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 Big Island, by using rotenone to remove invasive fish species**

Relating To More Effective Freshwater AIS Control Measures

- **Design and perform test methods for more effective control of AIS in Hawaiian ecosystems**

Suggested Marine Algae Research Topics

- **Assess the contribution of nonnative algal species to the diet of the threatened green sea turtle.**
(NOAA, UHM-B, WAq). YEAR 2
Update: Turtle diet studies are ongoing at the NOAA Fisheries Honolulu Laboratory. A new grant has just been submitted to 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.**
(USDA, HDOA, NOAA) YEAR 3
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 impact would be limited.

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- **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.
- **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.**

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 MF4 and MF5 above. There still will remain 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.**

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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.

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.

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 assessment studies on the impacts of AIS to Hawai‘i (HCRI, DLNR-DAR, UH) YEARS 2-5

Update: A large scale comprehensive study on the “Economic Valuation of Hawaii’s Coral Reefs”, funded by HCRI, 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**
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.**

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Association
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
HDOH	Hawai‘i Department of Health	TNC	The Nature Conservancy
		WAq	Waikiki Aquarium

Objective 7:⁵⁶

Take appropriate steps to ensure that state laws and regulations efficiently promote the prevention and control of AIS

Issue Addressed: 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 Hawai'i waters from the introduction and spread of AIS.

Proposed Actions:

7A1. Establish a Regulatory Review subcommittee. (DLNR, HDOA, HI AIS Advisory Council)
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, will emphasize working in a coordinated fashion with existing state, federal, and international programs. The committee will invite input from all groups affected by the 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 2-21. 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.

Comment: The boundaries of the State of Hawai'i include the waters up to 3 miles offshore;⁵⁷ beyond that is not considered part of the State. As discussed in Chapter 2, the statutes that address HDOA import authority require import permits to bring any organisms into the State from outside of Hawai'i⁵⁸. This poses

⁵⁶ Thanks to K. Moffie (Pacific Fisheries Coalition) for taking the leadership on authoring this section and to Scott Smith (Washington Department of Fish and Game) for his valuable input.

⁵⁷ 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.

⁵⁸ The statutes that refer to PQ authority is 150A (HRS).

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	MAG	Marine Algae Group
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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, Lō'ihi, and transported to Oahu would be treated as out-of-state organisms, and subject to the importation review and permitting process as described earlier in this document. Lō'ihi, which is located off the south coast of the big island, is outside of the 3-mile boundary defining state waters. Representatives from HDOA have acknowledged 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 establishes or increases the state's authority to control the intentional and unintentional introduction of new species.

Proposed Actions:

7B1. Identify 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) 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, 2003.⁵⁹

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.⁶⁰

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.⁶¹

7B2. Provide authority to establish the AIS Advisory Council, as described in Objective 1A3. YEAR 1

7B3. Provide the DLNR with the authority to establish an Aquatic Invasive Species Rapid Response Program, as detailed in Strategy 4A. YEAR 1

⁵⁹ Act 85, see Appendix I.

⁶⁰ See Appendix I.

⁶¹ See Appendix I.

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Association
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HDOH	Hawai'i Department of Health	TNC	The Nature Conservancy
		WAq	Waikiki Aquarium

7B4. Enact and enforce rules governing the discharge of treated and/or exchanged ballast water. (DLNR, USCG) YEAR 1

Comment: This task is also referred to in Strategy 2G, with additional details regarding the ballast water program all these tasks are presented in Chapter 2, beginning on page 2-22.

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. (DLNR, HDOA, DOT) YEAR 1

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 is needed for Federal grants.

7C1. Provide state funding for the AIS Coordinator position as detailed in task 1A6. YEAR 1

7C2. Provide funding for the AIS Advisory Committee, as described in task 1A3. YEAR 1

7C3. Provide 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. YEAR 1

7C4. Provide funding to the DLNR for the creation of an Aquatic Invasive Species Rapid Response Program as described in Strategy 4A. YEAR 1

7C5. Provide a mechanism (i.e. 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. YEAR 2-5

Acronyms:

AAOTF	Alien Aquatic Organism Task Force	MAG	Marine Algae Group
DLNR-DAR	Department of Land and Natural Resources, Division of Aquatic Resources	NOAA	National Oceanic and Atmospheric Association
EPA	Environmental Protection Agency	UH	University of Hawai'i
HAS	Hawai'i Audubon Society	USDA	U.S. Department of Agriculture
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		WAq	Waikiki Aquarium

CHAPTER 5:

CASE STUDIES

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- 5-1. The Need For Rapid Response:** Rapid Response Leads to Eradication of a Potentially Devastating Marine AIS in Australia
- 5-2. Control of a Site-Specific Problem:** DLNR-DAR addresses *Salvinia Molesta* in Lake Wilson, O'ahu
- 5-4. The Importance of Community Involvement in Addressing AIS:** The Kailua Neighborhood Board and *Salvinia Molesta* in Kawainui Marsh, O'ahu
- 5-5. Industry's Role:** Proactive Efforts by the Aquaculture Industry at NELHA (Natural Energy Laboratory of Hawai'i Authority) to Minimize Introductions and Transfer of AIS

CASE STUDY: THE NEED FOR RAPID RESPONSE

***Rapid Response Leads to Eradication
of a Potentially Devastating Marine AIS in Australia***

The Invasion⁶²:

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 Concern⁶³:

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 exclude most other species, leading to a substantial reduction in biodiversity in infected areas as well as extensive economics impacts.

The Response⁶⁴:

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.

⁶² This section is directly excerpted from Coles, S.L. and Eldredge, L.G. 2002. Nonindigenous species introductions on coral reefs: a need for information. Pac. Sci. 56:191-209.

⁶³ This section is directly excerpted from CRIMP (Centre for Research on Introduced Marine Pests) Infosheet 10, posted on the web at http://crimp.marine.csiro.au/Reports/infosht10_Mytil020153.pdf. Updated February 2001.

⁶⁴ This section is directly excerpted from Coles, S.L. and Eldredge, L.G. 2002. Nonindigenous species introductions on coral reefs: a need for information. Pac. Sci. 56:191-209.

CASE STUDY: MULTI-AGENCY CONTROL OF A SITE-SPECIFIC PROBLEM - GIANT SALVINIA

***DLNR-DAR addresses
Salvinia Molesta in Lake Wilson, O'ahu⁶⁵***

The Invasion:

Lake Wilson (also known as Wahiawā Reservoir) is located in central O'ahu. The lake is managed as a public fishing area and has high value in the Wahiawā 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 was 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. One of the primary nutrient sources in the lake is the City and County's Wastewater Treatment facility.

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 Wahiawā 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.

~continued~

⁶⁵ 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, the importance of a rapid response in addressing ANS issues, and the need for site and/or species specific management plans.

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 Lesson:

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.

THE IMPORTANCE OF COMMUNITY INVOLVEMENT IN ADDRESSING AIS

***An Editorial on The Kailua Neighborhood Board
and Salvinia Molesta in Kawainui Marsh, O'ahu⁶⁶***

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 Kapaa 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.

⁶⁶ 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.

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 AIS⁶⁷**

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.

⁶⁷ 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.

CHAPTER 6:

PROGRAM IMPLEMENTATION AND EVALUATION

- 6-1. Priorities for Action
- 6-2. Program Monitoring and Evaluation
- 6-3. Implementation Table (*still in development*)

Priorities for Action

Though all tasks identified in this plan are considered important for effective management of AIS in Hawaii, the identification of priority actions is a key step to begin implementation. This section should truly be considered a "work in process", and will be updated in future drafts and versions of this plan.

Overall AIS Management Priorities:

- Hire a permanent Aquatic Invasive Species Coordinator,
- Establish a long-term Aquatic Invasive Species Advisory Council,
- Develop rapid response systems for incipient aquatic threats,
- Develop a system for that allows for risk assessment and a way to prioritize established AIS,
- Increase documentation about the economic and ecological impacts of AIS,
- Increase knowledge on the biology and ecology of AIS, as well as methods for their control,
- Identify and secure additional funding, not only from grant sources, but also long-term sources.

Marine AIS Management Priorities:

- Implement and fund the Ballast Water and Hull Fouling Management Program.

Marine Algae

- Research to better understand the cause of blooms,
- Develop a range of control options that are appropriate for a coral reef environment.

Marine Fish

- Research to better understand and quantify the impacts of ta'ape and roi.

Marine Invertebrates

- Assess the distribution and threat of the many nonnative marine invertebrate species that are in our waters,
- Examine the ability for control of key species like *Carijoa riisea*.

Freshwater AIS Management Priorities:

- Increase coordination among freshwater researchers, resource managers, and representatives from relevant industries,
- Continue and increase education efforts, especially those focussing on unauthorized release of organisms into aquatic systems.

Program Monitoring and Evaluation

A systematic monitoring and evaluation of the implementation and results of tasks put forth in this plan is considered an integral component the AIS Management Plan.

The Steering Committee of this AIS Management Plan recommends that a formal evaluation be conducted, regarding the efficiency and effectiveness of the AIS management program and the plan itself.

They suggest that this evaluation process be conducted at least yearly for the first two years, beginning after an AIS Coordinator is hired. This evaluation process should include a method for 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; involved agencies and entities, including the Hawai'i Invasive Species Council (HISC), the Coordinating Group on Alien Pest Species (CGAPS), and the Federal Aquatic Nuisance Species (ANS) Task Force; policy makers and legislative staff, industry representatives, and be made available to the general public.

DRAFT Component - AIS Management Plan for the State of Hawai'i – July 2, 2003
Implementation Table

Tasks			Current Funding Sources		Recent Efforts (\$/FTEs)		Planned Efforts (\$000/FTEs)								Future Needs (beyond FY '05)	Budget Justification
							FY '04				FY '05					
Task #	Title/Summary	Implementing Entity	Dedicated	Grant Funding	\$ (000)	FTE	dedicated		seeking		dedicated		seeking		\$ (000)/yr	
							\$ (000)	FTE	\$ (000)	FTE	\$ (000)	FTE	\$ (000)	FTE		
<i>1. Increased Coordination and Collaboration</i>																
1A1	Support HISC	HIAISAC, AISC														
1A2	Increase AIS issues w/GGAPS	HIAISAC, AISC														
1A3	AIS Council	AIS MPC, DLNR-DAR														
1A4	Coordinate w/industry	DLNR-DAR, HIAISAC, AISC														
1A5	FTE AIS coordinator	DLNR-DAR														
1A6	FTE Marine Alien sp biologist, 1 Freshwater, & 2-4 field techs per island	DLNR-DAR														
1A7	FTE Marine Algae Control	TNC, RC														
1A8	Explore new DLNR division	DLNR-DAR														
1A9	Aquatics in ISCs	AISC,CGAPS,HIAISAC, DLNR-DAR														
1A10	Identify community groups	AISC														
1A11	AIS in current conferences	AISC,HIAISAC, DLNR-DAR, B														
1A12	Annual AIS conference	AISC, DLNR-DAR														
1A13	Central communication forum															
1A14	Central website for HI AIS	AISC														
1A15	Central database for HI AIS	AISC, UH, BM, DLNR-DAR														
1A16	Record stocking centrally	DLNR-DAR														
1B1	Participate in AIS conferences	UH, BM, WAq, DLNR-DAR														
1B2	Pac. Island Regional Panel	HIAISAC, DLNR-DAR, BM														
1B3	Expand part. - regional efforts	DLNR-DAR, BM, UH														
1B4	Form international partnerships	HIAISAC, AISC, BM														
1C1	Priority spp. subcommittee.	HIAISAC, FWAISS, AISC, DLNR-DAR, CGAPS, HDOA														
1C2	Dev. risk assessment strategy	HIAISAC, AISC, DLNR-DAR, CGAPS, UH, HDOA														
1C3	Method to ID priority sites	HIAISAC, AISC, MAG, FWG, MIG, Island-spec groups														
1D1	Ensure inclusion of AIS in efforts	AISC, HIAISAC														

Funding and proposed budget numbers are currently being compiled, and are not included in this draft.

This page is included as an example of what the implementation table will look like, and only the first page of tasks are shown.

Lead entities and proposed year of implementation for all tasks are included within the text for each task, in Chapter 4

Appendices

Appendix:

- A Descriptions to Accompany Problem and Potential Problem Species Identified in Chapter 3**
- B Details of Selected Current AIS Activities**
- C A Summary of Current and Past Key AIS Research**
- D AIS Management Plan Participants and Contributors**
- E Public Input Meetings**
- F Aquaculture Entities in Hawai'i**
- G Glossary**
- H Literature Cited *(not included in this draft)***
- I Recent State Legislation**

APPENDIX A:

Descriptions for Problem and Potential Problem Species Listed in Chapter 3

This section provides additional details and descriptions to those species listed under Problem Definition, to further clarify and justify why the species listed were chosen⁶⁸.

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 (4/8/200, 3/18/2001, 5/5/2002) and on all occasions there have been live samples of *D. flabellata*. 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.

FRESHWATER AQUATIC PLANTS:

***Typha latifolia* (Common cattail)** – Cattail is an invasive wetland rush 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 River 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 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. Currently, the USFWS has appropriated funds to the Sea Grant to survey and eradicate the common cattail on Kaua'i. The Kaua'i Invasive Species Committee is working with Sea Grant to control known populations using foliar sprayed Rodeo mixed with a 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 that still have known or potential impacts on native species, ecosystems, or the human use of these ecosystems.

MARINE ALGAE:

***Kappaphycus* spp. (Rhodophyta, red algae)**–*Kappaphycus alvarezii*, *K. striatum* and *Eucheuma denticulatum* were all introduced to O'ahu (Kane'ohē 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'ohē 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'ohē but without sexually mature samples, identification is not possible. Nevertheless, *Kappaphycus* generally forms large, three-dimensional mats similar to *G. 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'ohē 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'ohē. 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.

⁶⁸ 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 (Waikiki Aquarium); for marine invertebrates - S. Godwin and L. Eldredge (both of the Bishop Museum); for freshwater species - M. Yamamoto (DLNR-DAR), for freshwater insects - R. Englund (Bishop Museum); for brackish and fresh water plants – M. Wilkinson (DLNR) .

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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 and while the population isn’t entirely continuous, it can be found from Kane‘ohe to Ala Moana Beach Park on O‘ahu (sites of particular abundance are: Kualoa Beach park, throughout Kane‘ohe Bay, Alan Davis/Queen’s Beach, Hawai‘i Kai and Waikiki) and reports suggest that it is now common on much of Moloka‘i’s south shore (from Kamalo to Kaunakakai).

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). In many cases this alga has become an ecological dominant and can frequently be seen overgrowing or growing over live reef building corals. Evidence suggests that *G. salicornia* 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.

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.

FRESHWATER 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 the 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.

BRACKISH WATER PLANTS⁶⁹:

***Rhizophora mangle* (Mangroves)** – 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, Lāna‘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

⁶⁹Text 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.

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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 is 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 26-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.

FRESHWATER 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*. *Pomacea bridgesi* and *Pila conica* display a preference for dead and decaying plant and animal matter, and *P. canaliculata* consumes live plants. Most researchers and resource managers consider *P. canaliculata* to be the most destructive of the three species, but some aquaculturists disagree 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 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" on page 3-20.)

FRESHWATER FISH:

***Micropterus dolomieu* (Smallmouth bass)** – The smallmouth bass was introduced by the Hawai‘i Division of Fish and Game 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 populations that are already established. 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 most 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.

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Poeciliids (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.

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 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 aside 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 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)**⁷⁰ –*Carijoa riisei* is an octocoral originally described as *Telesto rusei*, and later revised to *Telesto riisei*, 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-

⁷⁰ Much of the following text for *C. riisei* taken from the proposal, "Assessment of Nonindigenous Species on Coral Reefs in the Main Hawaiian Islands, with Emphasis on Introduced Invertebrates", submitted to Hawai‘i Coral Reef Initiative. Principal Investigators: Coles, S.L. and Eldredge, L.G. 2001 AND Grigg, R.W., Invasion of a deep black coral bed by an alien species, *Carijoa riisei*, off Maui, Hawai‘i. In press. 2003.

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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. 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)**⁷¹ – This small barnacle that 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 (*Gonodactylus 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.

FRESHWATER 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 Molokai. 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 with 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.

***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

⁷¹ Much of this text for the description of *C. proteus* was gathered from C. Zabin, personal communication, 2003.

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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*.

FRESHWATER 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 “non-indigenous” 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. Because of the dynamic distribution of this species it is difficult at this time to make any conclusions about its status as an alien 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 epiphytized 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

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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 Kāne‘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 species 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 warm, temperate-subtropical, shallow water. 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 and 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. Ascidiates are suspension feeders that use a mucous net to filter plankton from the water. This species name has been applied to large number of ascidiates 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)**⁷² –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 has 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 taape 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 taape pose a threat to the native species.

⁷² Species description taken directly from Oda and Parrish 1982; Staples and Cowie 2001; Parrish and Holland 2000; and Friedlander et al. 2002.

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***Cephalopholis argus* (Roi)**⁷³– 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 foodfish. 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 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. 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)**⁷⁴ – 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)**⁷⁵: 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 Kāne‘ohe Bay, and 3) The fang blenny, *Omobranchus ferox*, documented in 2000 (Englund and Baumgartner, 2000), has begun to spread from Hālawā 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.

FRESHWATER 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.

⁷³ Species description from Birkeland et al. 2002., and from Friedlander, pers. comm.

⁷⁴ Species description is directly from DeMartini et al. 1995

⁷⁵ Species description supplied from E. Baumgartner, pers. comm.

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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. These concerns are based on the invasive characteristics displayed by these species in areas with similar environmental conditions and 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 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

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 to 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 (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.

Invertebrate:

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.

- **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, alien 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 be 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 an alien species from this group would be the same as for the Octacorallia.

- **Hydrozoa**

Includes the hydroids, milleporines (fire corals) and stlyasterine (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 stlyasterine corals described in Hawai‘i. This group could be a competitor for space with native Hydrozoa.

***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.

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***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 from 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 be 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.

POTENTIAL FRESHWATER AIS

Fish:

Piranha – In terms of freshwater alien fishes, the group of fishes collectively referred to as piranhas represent the worst case scenario. Although members of this group are prohibited entry into Hawai‘i, fishes do get smuggled in. One, possibly two, live specimens were recovered from the Wahiawā 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.

Invertebrate:

***Placobdelloides bdellae* (Leech)** – attach to humans and is a vector for human disease. It has been collected from aquatic plant containers on both Kaua‘i and O‘ahu, but fortunately, has not yet been found in the wild. Every effort must be made to prevent this leech from becoming established because of its potential to transmit human disease.

***Ceratopogonidae and Simuliidae* (Nono Flies)** – Nono flies are native to the Marquesas and French Polynesia, which are the nearest Pacific Island group to Hawai‘i with flowing streams. It is also in the Cook Islands, of where Hawai‘i currently has twice weekly direct flights with. 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.

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***Dreissena polymorpha* (Zebra mussel)** – The impacts of this species are known throughout North America and in many parts of the world. Currently, there is debate as to whether this species could survive the climate here. 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 doing 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

***Boiga irregularis* (Brown tree snake)** – The brown tree snake (BTS) is a terrestrial species. However, because 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.⁷⁶ 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 combination 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 of Concern:

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 alien 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 incrustata*. 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-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, is considered to show invasive-like properties on the island of Maui specifically in the Kahului and Kihei areas where it often co-occurs and blooms with the alien 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

⁷⁶ Taken directly from the 1999 publication by The Department of the Interior for Insular Affairs entitled, "Integrated Pest Management Approaches to Preventing the Dispersal of the Brown Tree Snake and Controlling Snakes in Other Situations".

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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.

Appendix B: Details of Current AIS Activities

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 these 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 2.

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 involved with these efforts, with additional participation from EPA, Maui County, and Maui residents.

"A‘ohe Limu‘ē - No Alien Algae" volunteer-based nonnative algae removal efforts:

The main objectives of these removal events are both 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 focus to develop and fully implement a mechanism by which to control harmful algal blooms 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 to 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 for 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 by the use of this 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. The reduction of nonnative algal biomass as a result of these methods has an immediate positive impact on reefs in that it removes algae that shades and overgrows corals, allowing corals to recover. However, further controlled study is needed to determine if the use of urchins is practical and ecologically sound.

Appendix B: Details of Current AIS Activities

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 near natural densities of urchins on healthy reef will be used, 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.^{77, 78}

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 community groups, such as Paepae o He‘ei‘a and others.

In addition to the above key efforts as part of the Alien Algae Control Program, there are large efforts underway to address the large blooms of native species, as referred to in the Overview of Key Issues.

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 for 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:^{79,80} DPWEM spends \$60,000 per year for the removal of seaweed in of 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 U.H. 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:^{81,82}

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*.

⁷⁷ Adapted and excerpts taken directly from a 2003 proposal to NOAA [Get more information from E.Co].

⁷⁸ Excerpts taken directly from a 2003 permit application to “Plant Native Limu at the He‘ei‘a Reef, authored by Kukea-Shultz, K.

⁷⁹ Excerpts taken directly from the grant proposal and workplan for the “Control of Nuisance Seaweed on the Beaches of Kihei, Maui County” submitted by Maui County Sea Grant on behalf of Maui County Department of Public Works to the U.S. EPA. Principal Contact: Norcross, Z.

⁸⁰ Norcross, Z. and Parsons, R., personal communication 2003

⁸¹ Information gathered during phone conversations with Wendy Wiltse, EPA and Celia Smith, UH-Botany. April, 2003.

⁸² Adapted and excerpts taken directly from the grant proposal, “Nuisance Macroalgal Blooms in coastal Maui: assessment and integration of physical factors and biological processes.” Submitted to EPA. Principal Investigators: Smith, C.M., Harrigan, J.F., Nishimoto, R.T., Sansone, F.J., Tribble, G.

Appendix B: Details of Current AIS Activities

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 also 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 efforts, 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.

DETAILS ON CURRENT ACTIVITIES: INVERTEBRATES AND FISH

The bulk of efforts regarding marine invertebrate and fish AIS species are researched based, and are further detailed under in Objective 6 and Appendix C.

DETAILS ON CURRENT ACTIVITIES: FRESHWATER

SURVEYING AND MONITORING

Many various stream surveying programs exist throughout the State, and 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 freshwater AIS monitoring will submit descriptions of their projects if they are not already identified).

Ongoing Stream surveys by DLNR-DAR:

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 nonnatives species are having on native stream animals.

Surveys and Studies by Bishop Museum / Hawai‘i Biological Survey and Partners

- **State-Wide Invertebrate Surveys:** In coordination with HDAR, the Hawai‘i Biological Survey of the Bishop Museum is conducting surveys for 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. (DAR, Bishop Museum)

Appendix B: Details of Current AIS Activities

- **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, DAR)
- **Biodiversity Investigations of Hawaiian Stream Algae:** Survey efforts of Hawaiian stream algae have been ongoing since early 2001 DAR, Bishop, and UH, under a variety of different projects, and aim to catalogue the diversity of freshwater algae in Hawai‘i. Establishment of a species-list for Hawai‘ian 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. (DAR, UH, Bishop Museum)
- **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 introduction and spread of nonnative snails on an ad hoc basis. (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, 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 the UH's 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 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, 2) developing a model community-based stream monitoring program

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.**⁸³ 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. As part of the NAWQA Program, the USGS is evaluating water-quality conditions on the island of O‘ahu. Beginning in October 1998, and continuing for a period of 3

⁸³ 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.

Appendix B: Details of Current AIS Activities

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 WWWeb 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 Databases

HDAR 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:⁸⁴

This database is primarily an educational database, heavily focussed on freshwater aspects (both nonnative and native). Users can look at photos, review existing records, and submit records of their sightings. This project is been 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 & professional researchers who live in Hawaii's watershed areas develop & test hypotheses to understand the impacts of human behavior & natural events on its ecology. It can be accessed at <http://www.hawaii.edu/environment/>

HSRC Aquatic GAP project to develop GIS coverages for freshwater AIS in Hawai‘i.

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.

Heritage Program Gap Analysis Project.

⁸⁴ Text taken from <http://www.hawaii.edu/environment/>

Appendix C: Current and Past AIS Research

Current Freshwater Research

1. Engage in the identification of native versus nonnative freshwater algae species. (UH, DAR) ONGOING
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. (DAR, UH) ONGOING

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, DAR) ONGOING

Update: 1) A current three-year study in Waipi‘o Valley Hi‘ilawe/Lālākea 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, USFWS) ONGOING

Update: R. Englund and other researchers at Bishop Museum are currently conducting a "Tripler Damsselfy Project": With U.S. Fish & Wildlife Service funding, long-term monitoring and the potential translocation of the rarest population of native damsselfies 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* damsselfy is now found in only 100 meters of stream habitat. Efforts to save this damsselfy 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 damsselfy 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, protists, etc. that may cause diseases in native fish. (DLNR-DAR, SE Louisiana University) ONGOING

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 Hawai‘i’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) ONGOING

Update: Funded by USDA, R. Cowie from UH - CCRT is investigating the systematics of the *Pomacea*

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HDOA	Hawai‘i Department of Agriculture	UH-CCRT	Center for Conservation Research and Training (under UH)
HDOH	Hawai‘i Department of Health	UHM-Z	University of Hawai‘i at Manoa, Zoology Department
EPA	Environmental Protection Agency	USDA	U.S. Department of Agriculture
HCRI	Hawai‘i Coral Reef Initiative	USFWS	U.S. Fish and Wildlife Service
TNC	The Nature Conservancy	TNC	The Nature Conservancy
		WAq	Waikiki Aquarium

Appendix C: Current and Past AIS Research

canaliculata group of species, and addressing the specific identity of the pest species both in Hawai‘i and the South-East Asia, using molecular techniques.

7. Research host specificity testing for biocontrol of Giant Salvinia. (DLNR-DAR, DOH, USDA)

Update: 1) In cooperation with the State Department of Agriculture (DOH), the DAR is in the process of evaluating the Salvinia weevil, *Cyrtobagous salviniae* 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 other than the target species. 2) USDA-APHIS-PPQ is also assisting with testing of biological control w. *C. salviniae* for use in Hawai‘i.

Current Marine Research: Algae

1. Better identify boundary areas of invasive algae blooms. (UHM-B, Waikiki Aquarium) YEAR 1

Update: An HCRI sponsored grant, “Alien algae on Hawaiian reefs: distributional changes and ecological responses”, led by researchers at UHM-B, UHM-Z, and WAq will re-survey the 89 sites previously surveyed in 2000-2001. This study will generate detailed distribution maps to assist in the 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. (UHM-Z, UHM-B, WAq). YEAR 1

Update: Research has recently begun under the UH-Manoa Zoology, funded by HCRI, 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 UHM-Botany and the Waikiki Aquarium, which will build upon preliminary results from this HCRI study, are currently being developed.

3. Identify short and long term -term impacts of a mechanical suction system on the native benthic community. (TNC, UHM-B, WAq). YEAR 1

Update: A proposal has been recently submitted by individuals from UHM, WAq, and TNC, focusing 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-B, WAq, DOH, DAR, UH-Oceanography, USGS) YEAR 2-6

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 interdisciplinary team led by UH-Botany 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 just recently awarded in 2003 to the UH-Botany 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.⁸⁵ (Maui County, EPA, UH) YEAR 1

⁸⁵ Excerpts taken directly from the grant proposal and workplan for the “Control of Nuisance Seaweed on the Beaches of Kihei, Maui County” submitted by Maui County Sea Grant on behalf of Maui County Department of Public Works to the U.S. EPA. Principal Contact: Norcross, Z.

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Appendix C: Current and Past AIS Research

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-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. (UHM-B, WAq, TNC) YEAR 2

Update: Preliminary protocol is being developed, and a proposal has been submitted to NOAA, 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. (WAq, UHM-B, UHM-Z, HCRI) ONGOING

Update: Research is currently being funded under HCRI to look at these alternative approaches, and researches 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 them 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. (University of Hawai‘i, DLNR-DAR) ONGOING

Update: A new 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, 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. Experimental removal of species within the genus *Cephalopholis* on the Great

C-3

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Barrier Reef has shown that predation by these groupers can have a drastic effect on the local reef fish community, species composition, and abundance. *Cephalopholis argus* is common on the Kona Coast of the Big Island and fishermen blame predation by the roi for a decline in the number of reef fish. However, the commercial aquarium fishermen are removing 400,000 to 450,000 fish per year, 170,000 of which are yellow tang. This may indicate that recruitment of reef fishes is plentiful and *Cephalopholis argus* may not have as much effects on the local fish community outside its natural range. Are the groupers having a large enough impact on reef fish populations to be “competing with fishermen?” 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.

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 the fish's 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.⁸⁶ The 1997-2000 study of ta‘ape (Parrish et al. 2000) referred to in the Overview did not address 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 of 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. (Hawai‘i Cooperative Fishery Unit, Sea Grant) 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 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. (University of Hawai‘i, Hawai‘i Cooperative Fisheries Research Unit, 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 and 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.

⁸⁶ Taken directly from Parrish and Holland 2001.

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EPA	Environmental Protection Agency	USDA	U.S. Department of Agriculture
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Appendix C: Current and Past AIS Research

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 Geographic 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.

Current Marine Research: Invertebrates

1. “Nonindigenous Marine Species Introductions in the Harbors of Nāwiliwili and Port Allen, Kaua‘i, Kaunakakai, Moloka‘i; Kahalui, Maui; Hilo and Kawaihae, Hawai‘i”.⁸⁷ (Bishop) ONGOING

This study, funded by the Hawai‘i Community Foundation, will focus on harbors on neighbor islands to determine whether nonindigenous species occur in similar frequency, and whether they represent a significant source of competition for native species. This information is critical for determining whether marine invasive species are a significant economic or environmental problem throughout the 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 Nāwiliwili and Port Allen, Kaua‘i; Kaunakakai, Kahalui, and Maalaea, 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 nonindigenous marine species
- Evaluate the findings in terms of the extent of invasions and impact of nonindigenous marine species, and make recommendations regarding the need for management and control.

2. “The Assessment of Hull Fouling as a Mechanisms for the Introduction and Dispersal of Marine Alien Species in the Main Hawaiian Islands”⁸⁸ (Bishop) ONGOING

This study is funded by the Hawai‘i Coral Reef Initiative 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 concerned with formulating management decisions and proposed solutions. This collaborative component was also discussed previously, under the “Hull Fouling Working Group”, under Entities and Activities. 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

⁸⁷ Excerpted directly from the proposal of the same name, submitted to the Hawai‘i Community Foundation. Principal investigators: Coles, S.L. and Eldredge, L.G. 2001.

⁸⁸ Adapted and excerpts taken directly from the proposal of the same name, submitted to the Hawai‘i Coral Reef Initiative. Principal investigators: Godwin, S. and Eldredge, L.G. 2002.

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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”⁸⁹ (Bishop) ONGOING

This study is being funded by the Hawai‘i Coral Reef Initiative 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 nonindigenous species on native reef organisms.
- Compare results with findings from studies in the principal harbors of these islands, and evaluate the potential impact that non indigenous species from the harbors have had on the surveyed reef .
- Present summaries of findings on a web site and at public workshop 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 nonindigenous species found on the coral reef systems they have invaded, and assess the economic and environmental 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 (to M. Hadfield), 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?

⁸⁹ Adapted and excerpts taken directly from the proposal of the same name, submitted to the Hawai‘i Coral Reef Initiative. Principal investigators: Coles, S.L. and Eldredge, L.G. 2002

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- *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

Summary of Previous AIS Research and Published Papers⁹⁰

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 marine AIS issues are encouraged to submit a description of their work to be included in future drafts.

Previous Publications Relating Marine AIS Issues in Hawai‘i

1) Presence and distribution of introduced marine organisms (Coles et al. 1997, 1998, 1999a, 1999b, 2002a, 2002b; 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 Kāne‘ohe Bay, Waikiki, and waters off Hawai‘i Kai (Kuapā 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 of marine nonindigenous 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)

⁹⁰ 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.

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Previous Publications Relating to Marine Pathways for AIS in Hawai‘i

1) South O‘ahu Marine Invasion Shipping Study (Godwin and Eldredge 2001).

This study prepared for DLNR-DAR focussed on the analysis of the anthropogenic transport mechanisms associated with maritime shipping (ballast water, ballast sediments and hull fouling)

Previous Publications Relating To Marine Algae AIS in Hawai‘i

1) “Macroalgal Ecology and Taxonomic Assessment for HCRI-RP sites” (_____)

Funded by HCRI and led by a team of scientists from the University of Hawai‘i – 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.

2) “Ecological Success of Alien / Invasive Algae in Hawai‘i” (_____)

This study, also funded by HCRI and led by researchers from the Waikiki Aquarium and UHM-Botany and Zoology, 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.

Previous Publications Relating to Marine Fish AIS in Hawai‘i

TA‘APE:

1) "Ecology of Commercial Snappers and Groupers Introduced to Hawaiian Reefs" (Oda and Parrish 1982).

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 focussed on feeding and habitat utilization of the ta‘ape, and sought to explain its effects on the local inshore fishery.

2) "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 Hawai‘i Cooperative Fishery Research Unit (HCFRU), 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.

3) "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

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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 species⁹¹.

Roi

4) Preliminary Gut Sampling of Roi⁹²

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.

5) DLNR-DAR Monitoring Studies⁹³

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; where there were lots of roi, there were also lots of other piscivores.

PREVIOUS PUBLICATIONS RELATING TO FRESHWATER AIS ISSUES IN HAWAI‘I

1) “The loss of native biodiversity and continuing nonindigenous 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.

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, Arakaki, Preston, Coles and Eldredge, 2000). 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.

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) “Biodiversity of freshwater and estuarine communities in lower Pearl Harbor, O‘ahu, Hawai‘i with observations on introduced species” (Englund, Preston, Wolff, Coles, Eldredge and Arakaki, 2000). 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.

⁹¹ Findings taken from Powerpoint presentation by Walsh, W.J. 2003.

⁹² This description taken from Birkeland et al. 2002.

⁹³ Findings taken from Powerpoint presentation by Walsh, W.J. 2003.

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Previous Publications Relating to Freshwater Invertebrate AIS in Hawai‘i

Crustaceans

1) **Crustaceans. In: Hawai‘i’s Invasive species. A guide to invasive plants and animals in the Hawaiian Islands** (Eldredge and Englund 2001).

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.

2) **“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.

Aquatic Insects

1) **“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.

2) **“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 (Zygotera: 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.

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 by researchers at the Bishop Museum have been undertaken to examine the introduction, distribution, ecology, and impacts of nonnative freshwater mollusks in Hawai‘i. Some of these are listed here:

Publications covering introduction, distribution, and/or ecology of the apple snail:

1) **“Food preference and reproductive plasticity in an invasive freshwater snail”** (Lach, Britton, Rundell, & Cowie 2001). This study covers the ecology of apple snails in Hawai‘i.

2) **“The Spread of the Introduced Freshwater Apple Snail *Pomacia canaliculata* (Lamarck) (Gastropoda: Ampullariidae) on O‘ahu, Hawai‘i”** (Lach & Cowie 1999).

This is an update of the 1995 survey by Cowie, listed below, covering all Hawaiian islands.

3) **“Identity, Distribution and Impacts of Introduced Ampullariidae and Viviparidae in the Hawaiian**

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Islands” (Cowie, 1995). This survey covers all Hawaiian islands.

4) “New Records of Introduced Land and Freshwater Snails in the Hawaiian Islands” (Cowie, 1996).

Publications covering the introduction and spread of other nonnative freshwater snails:

5) “New records of alien nonmarine mollusks in the Hawaiian Islands” (Cowie 1999). This publication describes the introduction and spread of nonnative snails.

6) “Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands” (Cowie, 1998).

7) “Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands” (Cowie, 1997).

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 2001).

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.

Previous Publications Relating to Freshwater Fish AIS In Hawai‘i

1) 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.

2) “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.

3) “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.

4) “Alien rainbow trout (*Oncorhynchus mykiss*) (Salmoniformes: Salmonidae) diet in Hawaiian Streams” (Kido, Heacock, and Asquith 1999).

The diet of the rainbow trout introduced 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, particularly dragonfly (*Anax strennus*) and damselfly (*Megalagrion heterogamias*) naiads, 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.

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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.

5) “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.

6) “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.

PREVIOUS PUBLICATIONS RELATING TO GENERAL STREAM MONITORING IN HAWAI‘I

A variety of stream monitoring efforts have also been undertaken across the State. Though these were not specifically focussed on AIS aspects, many of the studies did include observation and subsequent discussion on AIS. A few examples are given here:

- **“Baseline and monitoring studies of Alakahi, and Onomea streams, Hamakua Coast, Hawai‘i” (Kido 1998).**
- **“A descriptive study of selected physicochemical and biological characteristics of the Wainiha River, Kaua‘i”(Timbol,, Kido, and Heacock. 1990).**
- **“A descriptive study of selected biological and physicochemical characteristics of Limahuli Stream, Haena, Kaua‘i” (Timbol, Kido, and Heacock 1989)**
- **“Stream Channel Modifications in Hawai‘i, Part. A: Statewide Inventory of Streams; Habitat Factors and Associated Biota” (Timbol and Maciolek 1978)**

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HDOA Hawai‘i Department of Agriculture
HDOH Hawai‘i Department of Health
EPA Environmental Protection Agency
NOAA National Oceanic and Atmospheric Association

UH University of Hawai‘i
UHM-Z University of Hawai‘i at Manoa, Zoology Department
USDA U.S. Department of Agriculture
USFWS U.S. Fish and Wildlife Service
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Appendix D: AIS Management Plan Participants and Contributors

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Appendix D: AIS Management Plan Participants and Contributors

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 Allen Griffin, Mulkern Landscaping
 Joakium Hjelm, Island Divers Hawai‘i Francis Hun, Boke Farms
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*though not directly involved in the drafting of the plan, these individuals were kept updated on the development process.

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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 2.

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Appendix E: Public Input Meetings

Comments from the Maui Scoping Meeting - April 14th, 2003⁹⁴

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.⁹⁵

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 algae (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.
- 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.

⁹⁴ 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.

⁹⁵ 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.

Appendix E: Public Input Meetings

- 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 algae.
- 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.

Appendix E: Public Input Meetings

Comments from the Freshwater Invasive Species Scoping Meeting Hilo, Hawai‘i (Big Island), April 23, 2003

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 these 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 have 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 ANS⁹⁶ 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.

⁹⁶ 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.

Appendix E: Public Input Meetings

- Establish an amnesty turn in location for ANS for all of Hawai‘i’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 Hawai‘i’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.
 - 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.

Appendix E: Public Input Meetings

Comments from the Industry and Stakeholder Meeting – April 25, 2003⁹⁷

This meeting was held on April 25, 2003 in Honolulu, Hawai‘i. The primary purposes of the meeting were to solicit questions, concerns, and suggestions from stakeholders on the development of Hawai‘i’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 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 Hawai‘i’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 Hawai‘i’s 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 – Suggestions

- 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).
- Re: snail farming --
 - 200 yds. from any open waterways (streams, ponds, etc.).
 - farming of snails should be done in closed, recirculating systems.

⁹⁷ 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.

Appendix E: Public Input Meetings

•state should allow and pay for snail growers to police themselves and monitored by an individual with some powers by the state.

Prevention – Suggestions

- 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) – take 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.

Appendix E: Public Input Meetings

- 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

Appendix F: Major Aquaculture Entities in Hawaii

(in alphabetical order)⁹⁸

The following organizations play key roles in the aquaculture industry of Hawai‘i. 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.

Aquaculture Development Program (ADP) - Under the State 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 production and service businesses started, and once started - to help ensure their success through active assistance.

In terms of addressing ANS 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 the U.S. Department of Agriculture. 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 and staff are located at The Oceanic Institutes on windward O‘ahu.

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. Unlike the other centers, which work within a defined geographical region, the CTSA "region" encompasses tropical and subtropical species wherever they are cultured. Research projects span the American Insular Pacific.

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.

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:

⁹⁸ All descriptions come either directly from the organization's web pages, or from representatives of the respective organization.

Appendix F: Major Aquaculture Entities in Hawaii

- 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

The National Sea Grant Program is detailed on page 2-5. The major role of 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 aquafarmers. 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>

Appendix G: 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, Inadvertant, 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.² *Synonyms:* Exotic, Nonnative

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).⁴ *Synonym:* Aquatic Nuisance Species (ANS)

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

Appendix G: Glossary

- 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

Appendix G: Glossary

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.⁹ *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

Appendix G: Glossary

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 *Hawai‘i’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.”

DRAFT Document – AIS Management Plan for Hawai‘i – July 2, 2003
Appendix H: Literature Cited

(Literature Cited is Not Included in this Draft Version)

Appendix I – Recent State Legislation

Report Title⁹⁹:

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 calvenscens*, 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

⁹⁹ This text is taken direct, and no edits have been made except for spacing.

Appendix I – Recent State Legislation

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).

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;

Appendix I – Recent State Legislation

(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:

Appendix I – Recent State Legislation

(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.

Appendix I – Recent State Legislation

(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.

Appendix I – Recent State Legislation

Report Title¹⁰⁰: 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.

¹⁰⁰ This text has been taken direct, and no edits have been made except for spacing.

Appendix I – Recent State Legislation

Report Title¹⁰¹: Alien Aquatic Organisms; DLNR; DOA

THE SENATE

S.R. NO. 115

TWENTY-SECOND LEGISLATURE, 2003

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.

¹⁰¹ This text has been taken direct, and no edits have been made except for spacing.