CRB

Managing Coastal Aquatic Invasive Species in California: Existing Policies and Policy Gaps

By Adrianna A. Muir, Ph.D.
Environmental Fellow

Requested by
Senate Natural Resources and Water Committee

California State Library
FOUNDED 1850
PRESERVING OUR HERITAGE, SHAPING OUR FUTURE

www.library.ca.gov/crb

January 2011

CRB 11-001

CALIFORNIA RESEARCH BUREAU

The Calfornia Research Bureau is a division of The California State Library. This report, and others, are available for download from the California Research Bureau website at www.library.ca.gov/crb. To request publications call (916) 653-7843.

CRB
CALIFORNIA RESEARCH BUREAU
A BUREAU OF THE CALIFORNIA STATE LIBRARY

January 26, 2011

The Honorable Fran Pavley
Chair, Senate Natural Resources and Water Committee
California State Senate

The Honorable Darrell Steinberg
Senate President pro Tempore
California State Senate

Dear Senator Pavley and Senate President pro Tempore Steinberg,

The California Research Bureau is pleased to release this report titled *Managing Coastal Aquatic Invasive Species in California: Existing Policies and Policy Gaps*. This report has been drafted in response to a request from the Senate Natural Resources and Water Committee, based on concerns that California lacks a robust framework that can guide policy, regulatory and fiscal decisions in response to aquatic invasive species.

CRB's Senior Environmental Policy Fellow, Adrianna Muir, Ph.D., undertook the complex task of crafting a framework for understanding the challenges that coastal aquatic invasive species create for California. Her review found that scientific, economic and legal research have not yet established a clear and compelling approach to how policymakers and the public should respond to the threats that these species present.

While considerable literature exists on coastal aquatic invasive species, their environments and how they invade places like California, science has not yet identified an approach to understanding the confluence of these themes that can guide the state's response. That knowledge gap remains, in part, because responding to coastal aquatic invasive species will impact multiple policy areas and levels of government, from the work of municipal agencies and special districts, state departments and programs, to the regulatory roles of international bodies and national foreign policy.

As Dr. Muir points out in this work, policy and programmatic responses to coastal aquatic invasive species may need to consider coastal and land use regulations, water quality initiatives, environmental regulation, international trade, transportation systems, fish and wildlife policies, market restrictions and other policy arenas. Further, many of the challenges associated with aquatic invasive species are compounded by the diverse ways in which these species enter California and how they are released into the environment. The task facing Dr. Muir in researching and writing this report was made more difficult by the diverse nature of the aquatic invasive species themselves, which include plants, fish, crustaceans, algae and other species that can live and thrive throughout our coastal aquatic ecosystems.

Dr. Muir has brought together materials that cut across many scientific and policy fields. She has organized that information in ways that allow the reader to recognize numerous opportunities to respond to the threats that these species create.

900 N Street, Suite 300
P.O. Box 942837
Sacramento, CA 94237-0001

(916) 653-7843 phone
(916) 654-5829 fax
www.library.ca.gov/crb

In drafting this report, the CRB was called upon to provide the background information that is needed for the state to begin to design a policy framework to reduce the impact of aquatic invasive species. Dr. Muir's efforts went well beyond this challenge. She has highlighted, in each domain, opportunities for crafting that framework. Yet the hard work of drafting and implementing such a policy framework remains to be done.

CRB wants to recognize and thank the numerous experts who served as advisors and consultants on this process. Their input and guidance were essential to this work, although the responsibility for the contents of this report remain with Dr. Muir and CRB.

Respectfully,

Toby Ewing, Ph.D
Director

Managing Coastal Aquatic Invasive Species in California: Existing Policies and Policy Gaps

By Adrianna A. Muir, Ph.D.

Senior Environmental Policy Fellow

Requested by
Senate President pro Tempore Darrell Steinberg

ISBN 1-58703-260-0

California Research Bureau
900 N Street, Suite 300
P.O. Box 942837
Sacramento, CA 94237-0001
(916) 653-7843 phone
(916) 654-5829 fax

ACKNOWLEDGEMENTS

I would like to thank the California Research Bureau for the opportunity to perform this research. I also thank Senate President pro Tempore Darrell Steinberg, William Craven of the Senate Committee on Natural Resources and Water, and Abe Doherty of the Ocean Protection Council for realizing the need for this research.

This study was funded by the California Coastal and Marine Initiative Program of the Resources Legacy Fund Foundation. Supplementary travel funds were provided by the National Science Foundation Alliance for Graduate Education and the Professoriate and the Marine Bioinvasions Conference Scientific Steering Committee.

Helpful discussion and comments on this report were given by numerous science and policy experts. Valuable administrative and technical assistance were provided by the California Research Bureau: Pamela Rasada, Senior Policy Analyst; Brian Sala, Assistant Director and Toby Ewing, Director. I especially thank the advisory group for this project who were very generous in their time and assistance:

Abe Doherty, California Ocean Protection Council
Bill Craven, California Senate Natural Resources & Water Committee
Susan Ellis, California Department of Fish and Game
Julie Horenstein, California Department of Fish and Game
Edwin Grosholz, University of California, Davis
Maurya B. Falkner, California State Lands Commission
Nicole Dobroski, California State Lands Commission
John Berge, Pacific Merchant Shipping Association
Diane Cooper, Taylor Shellfish Farms

In addition, I thank Matthew Muir, Joel Gerwein, and Su Corbaley who reviewed this manuscript. I thank Edwin Grosholz, Holly Crosson, and the California Department of Fish and Game for providing me with previous drafts of the California Aquatic Invasive Species Management Plan and unpublished material. I also thank Susan Williams for providing me with unpublished material from Lodge et al. (2006).

Much of the information in this report was obtained from many others not acknowledged by name. Many were referred to me by professionals in the field, including some present at the International Conference on Aquatic Invasive Species (April 19-23 2009, Montreal, Canada) and at the Aquatic Invasive Species Mid-Atlantic Workshop (December 2, 2009, Baltimore, MD). Portions of this research were presented at the International Conference on Marine Bioinvasions, Portland, Oregon, August 24-27, 2009.

CONTENTS

EXECUTIVE SUMMARY

Coastal Aquatic Invasive Species (CAIS) increasingly threaten California's coastal estuarine and marine habitats. With no natural predators, these non-native species become abundant, creating changes in natural ecosystems and habitats. Their presence not only threatens native species and state fisheries, but can also impact infrastructure development, the economy, and human health. It has been reported that some 600 CAIS are already present in California.

California has made some progress managing invasive species, but current strategies are cumbersome and haphazard. They are cobbled together using disparate authorities from numerous laws and regulations that were not designed for this purpose, thereby allowing preventable introductions and crippling California's response to new invasions. In these challenging economic times California cannot afford to disregard the threat presented by CAIS. Inadequate response to new and ongoing invasions will further disrupt native ecosystems and continue to increase economic losses incurred by coastal industries, while also escalating the direct and indirect cost of response and mitigation.

California could position itself as an environmental CAIS leader. Due to the diversity of its coastline habitats, the state is in a unique position to provide broad-reaching guidance through the vetting and strengthening of the states policy and management strategies.

This report highlights the CAIS policy and management challenges facing California. It focuses on six areas of concern (Authority, Prevention, Research, Control, Implementation, and Coordination) and also addresses the vectors, or pathways, through which invasive species are introduced.

AUTHORITY:

California Coastal Aquatic Invasive Species Policy

California's response to invasive species has been hampered by inadequate authority to respond to invasions. In the absence of explicit policy guidance, public agencies have been required to draw upon laws and regulations that were not originally intended for this purpose. As a result, responses to CAIS are neither strategic nor comprehensive.

To put in place policy reforms that result in a more comprehensive and effective approach, California policymakers must address the complex ecological, economic, and social systems that will determine invasive species outcomes.

Policy Opportunities

California could establish an explicit CAIS management and policy framework, including a high-level goal statement with language that establishes agreed-upon definitions of key terms, and identifies measurable, easily monitored outcomes.

California can enact unifying legislation to improve coordination and collaboration among state, local, national, and international partners.

PREVENTION, RESEARCH, AND CONTROL:

California Coastal Aquatic Invasive Species Management

Management efforts to prevent, research, and control CAIS in California are cumbersome and created through a diverse set of government and non-government organizations throughout the state. California lacks a strong prevention strategy to insure that potential new invasions are minimized through early-detection and regional cooperation. There is no agreed-upon strategy and decision-making tool to control new and ongoing invasions. There is no leadership to direct and coordinate response, avoid redundant efforts, or oversee the use of funds. A structured management framework and centralized leadership, as laid out in the California Aquatic Invasive Species Management Plan (Department of Fish and Game 2008), should be put in place.

Management Opportunities

Prevention of new invasions can be accomplished through several importation and release policies that apply risk analysis. The state can invest in risk assessment development and implementation, as well as streamlining the list amendment process and clearly defining conditions for obtaining permits.

Establishment of a monitoring program for high priority species and coastal sites is strongly encouraged. Collaboration with the federal government may improve inspections of imported goods, border crossings, and Internet sales and purchases.

Current education campaigns can be better coordinated, expanded, and formalized into the public education system, and made mandatory for certain industries.

Restoration can be better integrated into CAIS control through collaboration of invasive species and restoration staff and through the use of grants and permits.

Increased research on basic economic impacts, open databases, database coordination, and centralization, agreed-upon research priorities, and statewide listings of active research can serve to better inform management.

Improve eradication and control by providing state agencies with procedural outlines, establishing state leads on projects, providing decision-makers quick access to experts, and redrafting guidelines for environmental permits.

Provide rapid response and emergency eradication through a well-coordinated program with access to emergency funding and local cooperation.

IMPLEMENTATION:

California Coastal Aquatic Invasive Species Enforcement Funding

Many existing policies lack effectiveness because of insufficient enforcement, awareness, and funding. Gaps in enforcement can be improved by increased accountability. Funding for CAIS management can be increased through strategic coordination of existing funds and fiscal strategies focused on alternative, private sources.

Enforcement and Funding Opportunities

Enforcement can be improved through the establishment of a CAIS oversight committee, and by coordinating personnel to increase overall capacity.

Prudent funding options include investment in prevention, emergency funding, the creation of long-term fiscal strategies, and the reorganization of existing funds to support coordinated efforts and target high-priority needs. Creative solutions for increasing funding also exist, including imposing market-based fees.

COORDINATION:

California Coastal Aquatic Invasive Species Leadership

California has a diverse though uncoordinated set of engaged stakeholders from non-governmental organizations (NGOs), industry, local citizen groups, and academia. Increased coordination of stakeholders within California can serve to improve CAIS management locally, state-wide, regionally, nationally, and internationally.

Coordination Opportunities

Effective coordination can be achieved by designating a coordinating institution to serve as a leader of CAIS management among local, state, regional, and federal legal entities. General coordination will be more effective alongside an invasive species council.

The Invasive Species Council of California (ISCC) was recently created to fill part of the coordination gap for CAIS issues. Ensure that the ISCC leads effectively on CAIS issues through statute or regulation, and increase representation of CAIS interests.

The California Aquatic Invasive Species Management Plan (CAISMP) was published in 2008 and lists objectives for aquatic invasive species management, including CAIS. Yet there are no performance-based criteria by which to monitor success. Adding and monitoring quantitative performance measures could increase CAISMP success.

VECTORS (PATHWAYS):

California's Coastal Aquatic Invasive Species

CAIS vectors include: Commercial shipping (ballast water, hull fouling), recreational boaters, and the trade in live organisms (aquaculture, live seafood, live bait, aquaria and aquatic ornamental plants). Though more research is needed to fully understand vectors and their management, implementation of existing knowledge can help prevent CAIS

introductions. Education of and collaboration with pertinent industries and interest groups is also essential to incentivize their cooperation and to formulate effective policies.

Vector Management Opportunities

Ballast Water: To facilitate compliance by the commercial shipping industry, California can continue to promote the testing of ballast water treatment systems, research an agreed-upon method for ballast water testing, and provide incentives to ship owners who install ballast water treatment systems. California can encourage coordination with other states, countries, and the federal government on these policies.

Hull Fouling: California can reduce the introduction of CAIS via hull fouling by encouraging EPA approval of affordable anti-fouling options, and by incentivizing regular hull cleaning and dry-docking.

Recreational Boating: Enact policies that require boaters to follow management practices and inspections, institute a permitting policy for coastal boaters, and increase access and use of boat cleaning stations.

Trade in Live Organisms: To more actively manage these vectors, California could support research to gauge their relative contributions to CAIS, and increase management of specific trades. Authority can be enacted to require distributors and retailers to provide a minimum amount of information about traded species. To enforce trade restrictions via the mail and Internet, California could coordinate with the federal government on international and interstate oversight and on improving Internet software. Lastly, education and outreach efforts can expand their audiences to the private sector and general public that trade, distribute, sell, and buy CAIS.

This policy analysis serves to fulfill a portion of Objective 8 in the California Aquatic Invasive Species Management Plan: review the international, federal, and California laws and regulations that govern CAIS in California; identify the gaps, redundancies, and inconsistencies therein; and identify options to strengthen policies and programs for CAIS management. Analysis was based on guidance from policy frameworks, legal and scientific literature, software analysis, and interviews with California experts.

This report identifies 24 major international and federal policies affecting California CAIS management and seven main California laws, associated with over 50 California Code of Regulation sections that directly or indirectly address CAIS management. Many researchers and regulators agree that current international, federal, and California state policies are inadequate because they do not provide for comprehensive management.

The success of California's management of CAIS will depend on a strategic plan and policy framework that is robust and flexible. Policymakers must recognize that environmental and vector contexts change frequently. Hence, the appropriateness of certain policies also will vary over time. California needs a flexible framework to respond to future pressures from CAIS. Regular assessments will help to inform invasive species policy and to mitigate the negative impacts of aquatic invasive species on California's coast.

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1: INTRODUCTION TO COASTAL AQUATIC INVASIVE SPECIES

California's current response to invasive species has been hampered by a convoluted patchwork of laws and regulations, many of which were not originally intended for this purpose. As a result, invasive species largely remain an unaddressed or ineffectively addressed challenge. Nowhere is this more apparent than the California coast. The estuarine and marine habitats of the California coast provide enormous environmental and economic benefits through natural resources and ecosystem services, while also sustaining the state's rich cultural heritage. These unique and valuable resources are increasingly threatened by coastal aquatic invasive species (CAIS). Indeed, California's coast has experienced more negative environmental and economic effects from coastal aquatic invasive species than any other coast in the world (Molnar et al. 2008).

According to the California Aquatic Invasive Species Management Plan (CASIMP) approximately 600 invasive aquatic species have entered the estuarine or marine habitats of California (DFG 2008a). As the California coast is being fundamentally changed, the number of invasions continues to increase (Carlton 1996, Cohen and Carlton 1998, Ruiz et al. 2000). The problem is urgent and many experts agree that the state's current policy and management strategy is not meeting California's needs.

California's limited capacity to manage coastal invasive species was recognized by the Senate Committee on Natural Resources and Water and the California Ocean Protection Council (OPC). The purpose of this report is to respond to the concerns of Senate President pro Tempore Darrell Steinberg and the OPC regarding the ecological state of California's coast. Senator Steinberg, representing the OPC, has indicated both the need to better understand how the coast is currently being protected against aquatic invasive species and the progress that can be made to improve CAIS management in California. This need is echoed by Objective 8 in the California Aquatic Invasive Species Management Plan: "Review the laws and regulations governing aquatic invasive species in California and overlaps, compare them to other state and federal aquatic invasive species laws, and recommend changes to improve our ability to protect California's waters from the introduction and spread of aquatic invasive species" (DFG 2008a). Specifically, there is a need for a review of gaps in California's laws and regulations that manage aquatic invasive species in estuarine and marine habitats.

Aim of this report

This report intends to present options to strengthen California's current invasive species policies. Its analysis considers many efforts to manage invasive species, including non-governmental programs and outreach efforts, as well as failed attempts to enact policy. This work goes further than California's policy history and explores beyond the state for lessons that could be important for identifying gaps in current approaches and strategies that improve policy response (Costello et al. 2007).

Specifically, this report outlines current, international, national, and state policies that pertain to the management of invasive species along the California coast (Chapter 2: Existing Policy). Highlighted areas show where existing invasive species laws and regulations are inadequate, inconsistent, and redundant. In addition, situations are identified where agencies could be doing more to fully exercise the authority available to them. Weaknesses are accompanied by options that show how those weaknesses can be addressed. The goal is to provide options to make California's policy approach to coastal invasive species management more comprehensive (Chapter 3: Policy Gaps and Options). In addition, this report calls attention to policies specific to coastal aquatic invasion vectors (commercial shipping: ballast water, hull fouling; recreational boating; the trade in live organisms: aquaculture, seafood, bait, aquarium, and aquatic ornamental plants). Despite the uniqueness of California's coast and the specificity of these vectors, the policy discussion presented in that chapter (see Sect. 3.3) may be relevant to general invasive species prevention and management.

The scope of this report only extends to AIS in the coastal ecosystem of California, defined as the estuarine and marine habitats within 200 nautical miles to the shore, including the San Francisco Bay. For ease of presentation and discussion, policy and management will be classified into the following categories: authority, prevention, research, control, implementation, and coordination (see Box 1.1).

Box 1.1: Categories of invasive species management

The following categories are based on the Environmental Law Institute analysis of Florida's invasive species policy (ELI 2004a). Categories correspond roughly to those used in the National Invasive Species Management Plan (NISC, 2001), "Halting the Invasion" (ELI, 2002), and the California Aquatic Invasive Species Management Plan (DFG 2008a).

Authority – Laws and regulations that broadly outline the jurisdiction for invasive species management and designate responsibility to government entities.

Prevention – Legal tools and measures taken to prevent the introduction or establishment of new invasive species. Includes import and release restrictions and permits, risk assessment development, early detection programs, and education and outreach.

Research – Research programs, both governmental and nongovernmental, that contribute to the general understanding of invasive species from the perspective of science as well as other disciplines. Includes basic scientific research as well as specific research on the control of invasive species.

Control – Government attempts to control established invasive species with the intention of eradicating or limiting the spread of invasive populations. Includes quarantine, rapid response programs, traditional control methods, and restoration of native species and habitat.

Implementation – Enforcement of government policies and programs and the availability of funding to carry out such measures.

Coordination – Collaborative efforts and effective communication between government agencies (across jurisdictions and departments) and with public partnerships. Includes the presence of organized invasive species councils and management plans.

The information presented in this report is not largely new. The CAISMP has also addressed many of the shortcomings for management in AIS and has offered suggestions how California can address those shortcomings (DFG 2008a). However, this report is the

first to concentrate solely on California's AIS management in its coastal ecosystem. This report is timely as there is an on-going invasive species policy debate and a recognized need for improved management. It is important to note that the law in this area is constantly changing and the materials presented in this report are current up to January 2010.

What are invasive species?

The concept of invasive species is founded on the idea of particular species being nonnative to a region. Classifying a species as nonnative is typically based on their introduction after a certain era in history (e.g., after the 18th century arrival of Spanish settlers in California) and to a certain geographic location (e.g., the coastal waters of California). An example of a nonnative aquatic species along the California coast would be the salt marsh aquatic cordgrass *Spartina alterniflora* that was introduced during the 1970s from the east coast of the United States and is now found widely in the San Francisco Bay-Delta Estuary. For the purpose of this report, we use the working definition of nonnative species (also known as: non-indigenous, exotic, or alien species) found in the California Aquatic Invasive Species Management Plan (CAISMP) as "species that enter an ecosystem beyond historic geographic range." According to this CAISMP definition, more than 250 nonnative species have been found in the San Francisco Bay-Delta Estuary (DFG 2008a).

Only a fraction of nonnative species are problematic. Indeed, nonnative species may benefit California. The small numbers of nonnative species that can cause harmful effects are classified as "invasive" (OTA 1993, Mack and Lonsdale 2002). As defined in the 2008 CAISMP, invasive species (also known as: nuisance or noxious species) are the subset of nonnative species that

> establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy (DFG 2008a).

The CAISMP definition implies that there must be some harm or unwanted impact from the presence of the species in question. Along the California coast, examples of CAIS include numerous seaweeds, crustaceans, and invertebrates (see Box 1.2). Some areas along the coast are more invaded than others. The San Francisco Bay-Delta Estuary is the most invaded estuary in the world (Cohen and Carlton 1998).

Box 1.2: Examples of aquatic invasive species along the coast of California.

- The European green crab (*Carcinus maenas*) is highly invasive along the entire coast of California and is thought to prey on numerous native species in the coastal environment (Grosholz and Ruiz 1995).
- A predatory whelk snail, the Atlantic oyster drill (*Urosalpinx cinerea*), was introduced through ballast water and now thrives by taking advantage of available nutrients in the ecosystem and preying on 80-90 percent of California's only native oyster (Fimrite 2009, Kimbro et al. 2009).
- The European shore crab (*Carcinus maenas*) is an abundant omnivore that was introduced to California in 1990 from seaweed used as packaging for bait worms (Grosholz et al. 2000).
- The Chinese mitten crab (*Eriocheir sinesis*) is believed to have been intentionally released in California in 1992 (Cohen and Carlton 1997).
- The Japanese marine alga wakame (*Undaria pinnatifida*) was introduced to California in 2000 and has since spread along the coast from hull fouling (Thronber et al. 2004).
- The Mediterranean alga *Caulerpa taxifolia* was introduced near San Diego by a release from an aquarium tank in 2001 (Anderson 2005, Zaleski and Murray 2006).
- Cordgrass (*Spartina alternaflora*) was intentionally introduced by the Army Corps of Engineers and is now widely spread in the San Francisco Bay-Delta Estuary and creates meadow where there had once been tidal mud flats (Ayers et al. 2004, Levin et al. 2006, Niera et al. 2006).
- A sabellid polychaete, or fan worm (*Terebrasabella heterouncinata)* introduced from South Africa, now parasitizes the shells of abalone and several other native gastropods leading to their decreased marketability (Kuris and Culver 1999, Naylor et al. 2001).
- The invasive wireweed alga *(Sargassum muticum*) was accidentally introduced with oysters from Japan in the 1940s and is now widespread along the California coast and excludes many tide pool and subtidal native species (UC IPM 2006a).

Why are CAIS a problem?

Invasive species have become a worldwide problem in all major ecosystems, including coastal estuarine and marine habitats. The National Research Council ranked invasive species as one of the most serious threats to native marine biodiversity (NRC 1995, Naylor et al. 2001). A wide variety of ecological and economic impacts are caused by invasive species as they interact with native species and habitat (Lovell et al. 2006).

New data indicate that introduced species are among the top factors associated with threatening or endangering sea birds, sea turtles, and marine fish (Kappel 2005, Venter et al. 2006, Naylor et al. 2001). Ultimately, CAIS can lead to irreversible impacts on fisheries, industrial development and infrastructure, human welfare, and ecosystem resources and services (Carlton 2001, Lovell et al. 2006). Impacts of CAIS have recently been identified by the Interagency Ocean Policy Task Force as one of the major objectives of strategic ocean management plans (Interagency Ocean Policy Task Force, 2009).

Ecological impacts

Recent reviews of well-studied coastal AIS suggest that the majority of these species have negative effects on native species, including threatened and endangered species (Grosholz 2002, Williams 2007, Williams and Smith 2007). Evidence of negative impacts includes the loss of native biodiversity, competition for limited resources, and interruption of the food web (WWF 2009). For example, as noted by Padilla and Williams, invasive aquarium species and aquatic ornamental plants displace native species, carry pathogens, clog waterways and prevent boating, prey on native species, and are a direct threat to human health (Padilla and Williams 2004). Other coastal aquatic invasive species are known to convert environmental habitats, thereby excluding native species (DFG 2008a).

Economic impacts

In addition to negatively impacting native species and habitats, invasive species can affect the economy through their direct and indirect effect on natural resources. Economic impacts of invasive species include the losses from invasive species damage and the costs of invasive species management (Keller and Lodge 2007). From 2004-2009, global losses from AIS were estimated to be at least $50 billion (WWF 2009). In 2003, AIS were responsible for a loss of $9 billion in the United States (Pimentel et al. 2003).

In California, it is estimated that AIS have resulted in millions of direct and indirect costs due to ecological impacts, industry losses, and control and monitoring efforts. For example, removing the invasive alga *Caulerpa taxifolia* from a Southern California lagoon cost $4.3 million in 2003-2004 (Padilla and Williams 2004). Economic damages are difficult to estimate, but accumulating evidence suggests that invasive species can cause massive economic losses (Carlton 2001, WWF 2009). As the largest ocean economy in the United States, California is at risk of potentially devastating economic impacts as a result of coastal AIS (LAO 2004).

How do AIS arrive?

Invasive species are introduced into their new range through many pathways, intentionally and unintentionally. Intentional introductions include invasions that result from bringing nonnative species into new habitats for economic benefits or development needs. For example, the California Department of Fish and Game permits the importation and release of aquatic nonnative species for recreational and biological pest control purposes (OTA 1993).

Invasive species may also arrive unintentionally. Indeed, many AIS can be linked to a variety of unintentional pathways, such as accidental release, contamination of shipments, or stowaways in vessels (Hulme et al. 2008). Unintentional introductions also can result when invasive species spread or expand their range from a neighboring region where the species is already established, such as by natural means or due to warming ocean temperatures (EPA 2008). For example, Japanese eelgrass (*Zostera japonica*) expanded into California from Washington and Oregon (DFG 2008a).

Box 1.3: Major vectors of coastal aquatic invasive species in California.

Commercial Shipping: Commercial shipping is an active global industry and uses 11 major seaports along the California coast. Many organisms, such as barnacles, mussels, and seaweeds, can be transported by both ballast water and hull fouling, and distinguishing between the two vectors can be difficult (Carlton 2001).

- **Ballast** – Ballast is the material (water or sediment) used on board a ship to regulate stability of the vessel (DFG 2008a). Ballast is regularly taken in from the ocean to steady a ship and later discharged based on the weight of cargo. Discharging ballast water into ecosystems can release as many as 4,000 different species, including larval organisms, viruses, bacteria, protists, fungi, and algae that hitchhike in the typical ship's ballast (Lindström Battle 2004, Carlton 1999, Ruiz and Carlton 2003, Padilla and Williams 2004). In 2005, approximately 9.1 million tons of ballast water were discharged into California waters (DFG 2008a).
- **Hull Fouling** – Fouling is the accumulation of plants and animals attached to submerged surfaces such as ship hulls and other equipment (Hewitt et al. 2007, DFG 2008a). Large shipping vessels can transport hull fouling organisms attached to the vessel thereby introducing and spreading coastal aquatic invasive species when fouling organisms detach or spawn from a ship's hull into the coastal ecosystem.

Recreational Boating: Aquatic invasive species can be attached to the hull of recreational boats (see Hull Fouling), but also can be found in the propellers, bilge water, and other equipment (e.g., fishing gear, lines, tackle, buoys, traps and nets) associated with recreational boating. Boating can introduce or spread coastal aquatic invasive species when they detach or spawn from the boat and its associated equipment (DFG 2008a).

Trade in Live Organisms: In general, all businesses that trade live organisms can be a vector for invasive species at some point in their operation, from importation, species maintenance, and sales. Of particular concern are the following industries: aquaculture, live seafood, live bait, aquaria species, and aquatic ornamental plants. Most exotic freshwater fish introduced into the United States originated from the aquarium and bait trades (Fuller et al. 1999).

- **Aquaculture** – Aquaculture, the farming of fish, shellfish, and aquatic plants, is among the fastest-growing segments of the world food economy (Naylor et al. 2001). United States aquaculture, of which 20 percent is marine species, is currently a $1 billion/year industry which is projected to triple by 2025 (NOAA 2009). California has the most diverse aquaculture industry in the United States, producing both marine fish and shellfish in approximately 40 registered coastal facilities (DFG 2008a, Silvas and Caldwell 2008). The main risks that this industry pose are the escape of AIS from aquaculture facilities located along the coast and the distribution of pathogens (DFG 2008a). Aquaculture is a major vector of nonnative seaweeds, fish, invertebrates, parasites, and pathogens (Naylor et al. 2001).

Routes or pathways by which invasive species arrive are called vectors of introduction. Vectors are the natural and human connections that allow movement of species from place to place (DFG 2008a).

Trade within and between countries is considered the main vector of invasive species. To date, most research has focused on vectors that bring invasive species from foreign countries (Ruiz and Carlton 2003, Gren 2008). Although less frequent, invasive species also spread within countries and along coastlines and can have equally severe local impacts (Carlton 2001, Mueller and Hellmann 2008).

Box 1.3 Major vectors of coastal aquatic invasive species in California (cont.)

Trade in Live Organisms (cont.):

- **Live Seafood –** The live seafood trade poses a risk to the coastal ecosystem because of the release of both the live seafood itself and the live plants used as packaging material. Coastal AIS can be introduced from the live seafood trade via the discharge of tank flushings and the disposal of shells and fish waste. In addition, live seafood can be intentionally released in the hope of establishing a self-sustaining population for harvest (DFG 2008.)
- **Live Bait –** Trade in live bait also can introduce invasive species via the bait's packing material as well as the release of the bait itself. Release can happen during fishing and harvesting activities or during disposal of unwanted bait. Baitworm boxes packaged with the seaweed wormweed (*Ascophyllum nodosum*) are well recognized to be an important vector for the transfer of benthic invertebrates between regions of the United States (Crawford 1999). Live bait and its associated packing material also can be contaminated with parasites and pathogens that lead to harmful invasions (DFG 2008a,Yarish 2009).
- **Aquarium and Aquatic Ornamental Plants –** The aquarium and aquatic ornamental plant (also known as watergardening and aquascaping) industries, fueled by hobbyist demand, produce $25 billion annually in the U.S. and continue to grow (Padilla and Williams 2004). Aquaria and aquatic ornamental plants can spread aquatic invasive species via the disposal of tank flushings, release of unwanted organisms, and ritualistic release for religious purposes (Severinghaus and Chi 1999, West 1997). Over 150 invasive species from aquariums and aquatic ornamental culture, including vertebrates, invertebrates, plants, and microbes, have invaded natural ecosystems (Padilla and Williams 2004). One third of the world's "100 Worst Invaders" are introduced via aquarium or water garden release (GISP 2008). Once escaped, aquarium species have a high probability of survival and reproduction because they are large and usually traded as adults. Similarly, aquarium organisms are typically selected to be hardy enough to survive collection and transport (Wabnitz et al. 2003). Keller and Lodge believe that the water garden trade may be the most likely source of new invaders from contamination because (1) it delivers significantly more contaminants than other trades across a range of plant morphologies, (2) a large proportion of these contaminants are gastropods, and (3) they are displayed outside for sale so they are more likely to be adapted to the environment into which they might escape (Keller and Lodge 2007). Approximately 90 percent of plants in the nursery trade arrive with live invertebrate animals attached. The United States imports nearly half of the marine organisms distributed worldwide (Padilla and Williams 2004).

California coastal AIS are introduced by the following vectors: commercial shipping and fishing, recreational boating and fishing, construction, water delivery and diversion systems, containers and packing material, dredge spoil, floating vegetation and debris, and intentional release (ISAC 2003a, DFG 2008a, Hulme et al. 2008). Additionally, trade in live organisms is a strong vector of AIS introductions because of the traded species themselves and any associated hitchhiking species or disease contamination (Keller and Lodge 2007, DFG 2008a). Therefore, all trades that import live nonnative animals and plants pose a risk of aquatic invasion, including: aquaculture, live seafood, live fishing

bait, aquarium pets, and aquatic ornamental plants (Naylor et al. 2001, Reichard and White 2001, Maki and Galatowitsch 2004, Weigle et al. 2005, Rixon et al. 2005).

Increases in global trade via mail order and Internet sales have exacerbated the risk of invasion while hindering their prevention (Maki and Galatowitsch 2004). For more exhaustive lists of AIS vectors, see Carlton (2001), ISAC (2003), Global Invasive Species Information Network (GISIN), and the California Department of Fish and Game California Aquatic Non-native Organism Database (CANOD).

A subset of vectors poses the most risk to the coastal ecosystem. The discharge of ballast water by the commercial shipping industry has received the most attention in California. In addition, recreational boating can transport invasive species from one body of water to another if coastal AIS are attached to the boat's hull, propeller blades, or equipment. Trades in aquaculture, live seafood, live bait, and aquarium species and aquatic ornamental plant species also pose a risk to the coastal ecosystem (Ruiz et al. 1997, Minton et al 2005, Hulme et al. 2008, Molnar et al. 2008). The following coastal AIS vectors that serve as the focus of this report are also listed in the CAISMP as requiring management for their role in the introduction of AIS to California: commercial shipping, recreational boating, aquaculture, live imported seafood, live bait, aquarium species and aquatic ornamental plants (Box 1.3).

1.2: Introduction to Management of Coastal Aquatic Invasive Species

How are invasive species managed?

Several options are available to mitigate the negative impacts of coastal AIS through management. Nonnative species can become nearly impossible to eliminate in coastal ecosystems after they become established, thus management is prioritized by experts as prevention, eradication, and then control (Thresher and Kuris 2004).

Each management option is constrained by the extent of the invasion, the immediate threat and perceived urgency of the invasion, and the resources available to respond (DFG 2008a). With limited economic resources, policy makers and natural resource managers must carefully consider where to focus management efforts. A guiding principle for choosing a management strategy has been to maximize total benefits while minimizing costs (Gren 2008). In addition, the precautionary principle (as defined by UNEP 1992) is recognized by the OPC as an effective policy approach. Under the precautionary principle, strong action to prevent establishment or spread of a nonnative species is justified in the absence of scientific certainty that the introduction will not cause environmental harm (Leprieur et al. 2009).

Prevention

Prevention is the best way to eliminate risks and impacts of invasive species as well as the associated management costs (NISC 2008). Prevention refers to stopping their

importation, intentional release, and unintentional escape of invasive species (ELI 2007). By preventing or changing activities that introduce invasive species, future costs will be reduced (Carlton and Ruiz 2005, Doelle et al. 2007, Williams and Grosholz 2008). The Office of Technology Assessment reported that effort invested in prevention paid off 17-fold in later reduction of expenses (OTA 1993, Jenkins 2002). In the San Francisco Bay-Delta Estuary, for example, the invasion of aquatic species is so widespread that the most useful allocation of resources is the prevention of further introductions (Cohen and Carlton 1995).

Prevention measures are recommended when the costs of monitoring and inspection are relatively low and the expected damage and spread of invasive species is high. Recently, a greater awareness of the economic and environmental impacts of invasive species has led many industries to consider how voluntary industry practices, regulatory risk assessments, and best management practices can be used to prevent introductions of invasive species (Margolis et al. 2005). When prevention is not possible, as when AIS are already widely spread along a coast, focus shifts to control measures (Gren 2008).

Eradication

Preventing invasive species from entering an ecosystem is never foolproof, so secondary measures of monitoring are required (Davis 2009). If small initial populations of invasive species are detected early enough, they can be eradicated (Rejmanek and Pitcairn 2002). Early detection consists of finding invasive species populations when they are still in localized concentrations and still relatively isolated. The goal of eradication is to completely remove or kill all of a species from a local site (Anderson 2007).

Investment in an intensive, rapid-eradication response and follow-up is justified when there is evidence of high risk of spread and damage of the species. Otherwise, investment in further data collection can be a more cost-effective strategy than the implementation of costly measures that mitigate damage (Gren 2008). Examples of useful data collection efforts typically include collecting more information on the abundance of the species and its rate and direction of spread.

Eradication measures are recommended when (1) the invasive species population is small, (2) the growth rate of the population is high, and (3) the benefits from avoided damages exceed the cost of management (Olson and Roy 2002). Eradication efforts have the best chance of succeeding when they are followed by repeated searches for residual organisms (Mack and Lonsdale 2002). Along the California coast, there have been several examples of eradication (Box 1.4). An ongoing success is the eradication and continued prevention of the highly invasive alga, *Caulerpa taxifolia*, in Southern California lagoons. This alga, imported via the aquarium trade, was successfully eradicated in 2000 and is continuously prevented by follow-up surveys and control (Anderson 2005).

Box 1.4: Examples of California coastal aquatic invasive species eradication programs

Common name (Scientific name)	Project Initiation Date	Project Status as of 2008
Black mangrove (Avicennia marina)	1980	Completed 2000; reappeared 2006
Cordgrasses (Spartina alterniflora S. patens, and hybrids)	2005	Ongoing
Sabellid parasite (Terebrasabella heterouncinata)	1996	Successful
Wakame seaweed (Undaria pinnatifida)	2002	Unsuccessful
Killer algae (Caulerpa taxifolia)	2000	Successful
Atlantic rockweed (Ascophyllum nodosum)	2002	Successful
Japanese eelgrass (Zostera japonica)	2003	Ongoing
Periwinkle snail (Littorina littorea)	2005	Near completion
Horn snail (Batillaria attramentaria)	2006	Ongoing
European green crab (Carcinus maenas)	2006	Ongoing

* Source: Williams and Grosholz 2008.

Control

Control efforts attempt to manage invasive species in a contained area or to limit its abundance to prevent further spread and effects on native species (Anderson 2007, DFG 2008a). Control includes any effort to suppress or reduce invasive species using mechanical (e.g., hand or machine removal), chemical (e.g., toxic chemical release), or other methods (e.g., altering the species' physiology, genetics, or ecology) (Carlton 2001, DFG 2008a).

Control of an invasive species is recommended when (1) prevention has failed, (2) the invasion has spread over a large range or to a large population size, and (3) eradication is no longer feasible. Common control methods for AIS include herbicides, electro-fishing, and hand- or mechanical collection. As an example of mechanical control, screens were used in 2000 to mechanically remove the Chinese mitten crab (*Eriocheir sinensis*) in the San Francisco Bay-Delta Estuary (Carlton 2001). Such efforts will continue to be necessary as the total number of invasive crabs increases (Lovell et al. 2006).

Another aspect of control is the restoration of native species and habitat to reduce the disturbance caused by the control measures themselves and to prevent reinvasion (Myers et al. 2000). Successful restoration projects should include long-term monitoring to ensure that reinvasion does not occur.

Policy

Public policy shapes each of the management options for prevention, eradication, and control (Keller and Lodge 2007, van den Bergh et al 2002). For example, policies can regulate which species can and cannot be imported from other countries, which prevention measures must be taken by industry to reduce risk, and which control methods are available for species management (Davis 2009). Policies that apply to invasive species generally originate from restrictions of importation and release of species, entities that manage invasive species and provide funding, and laws and regulations providing for the protection of native species and habitats (J. Horenstein, personal communication).

Box 1.5: Four invasive species management approaches[*]:

Command and control: These policies include bans on the importation of certain species, quarantine procedures, and permit requirements. Command and control policies are commonly used but they are effective only when all managed groups are in compliance with the policies.

Economic instruments: These instruments, often based on the "polluter-pays principle," include finance charges on imports and subsidies on control. Companies have the option to adjust activities that introduce a risk for invasions. This flexibility allows finance charges to change according to threat levels and creates incentive for companies to comply with existing regulations but to still develop innovative technologies to mitigate the effects of invasive species. Efficacy of economic instruments is low because of the challenge of identifying the point of introduction and the party responsible for the introduction.

Markets for trading: Markets are based on a trade of quotas between companies, where quotas have been set according to maximum spread probability of specific species in specific regions. Affected companies can trade costs to control activities with high spread probabilities by offsetting those costs with permits purchased from companies that engage in less risky industry activities.

Information: These policies promote education and outreach efforts to educate or disseminate knowledge on the threats of invasive species. These policies intend to appeal to concern for the environment, health, and the economy. Compared to other types of policy, costs of information campaigns are generally low, but the efficacy may be insufficient to mitigate impacts.

[*]Source: Gren 2008

Because invasive species originate globally, but manifest locally, policies have been proposed for many levels of government jurisdiction, from international protocols to local ordinances. Box 1.5 describes four broad invasive species management approaches.

Education and outreach

Another crucial management tool is coordinated outreach efforts to educate various stakeholders, including the public, industry, managers, and decision makers, about the threat of invasive species. Many people may unknowingly release an invasive species

because they believe that they are helping their pet to "return to the wild" only to harm the native habitat. Well-intended, yet uninformed actions can be prevented by coordinated education and outreach efforts aimed at particular habitats, species, industries, and interest groups.

The default approach to invasive species management is to (1) do nothing and adapt to the nonnative species; or (2) retain the management status quo (van den Bergh et al. 2002, Lodge et al. 2006). To accept all of the changes caused by invasive species requires a management objective that accepts coexisting with invasive species and their associated costs – the "Learn to Love `Em" approach.

Management decisions such as these require a pragmatic perspective that occasionally includes adapting to the presence of invasive species and bearing their costs. Inaction may be the best option when an invasive species does not respond to other management efforts (Davis 2009). Indeed, from an economic perspective, this strategy is justified when other policy options are ineffective or the cost of inaction is low (van den Bergh et al. 2002). But, given the severe damage caused by many invasive species along the coast of California, stakeholders rarely see inaction as justified.

What are the issues making this complex?

Despite the wide range of options available for invasive species management, eliminating or reducing their risks can be a major challenge. For example, preventative management is thwarted by both the inherent variability of invasions as well as the limitations of current technology to detect invasion sources. Therefore the task of identifying which vectors are introducing particular invasive species is difficult.

Invasive species management is linked to ecological systems, global and local economies, and the political and social context in which management efforts occur. Each of these factors, such as social context, has its own set of driving forces (e.g., consumer preference for nonnative species) and interactions (e.g., decreased commercial activity during economic recessions). In brief, invasive species management on the California coast is complex because of both the nature of management in marine habitats and the many different economic and social factors that interact in the affected environment. It should be noted that emphasizing the complexity of the challenge is not without criticism. Some experts assert that focus on the complexity detracts from the harmful reality of invasive species and hinders progress by policy makers, scientists, and other stakeholders (Brown 2006). The challenge for policy makers is to make decisions that are robust despite many possible events or probabilities (Gren 2008).

Management in coastal ecosystems

Management of AIS in estuarine and marine habitats can be difficult (Box 1.6). Less is known about AIS management in coastal environments relative to other ecosystems (e.g., terrestrial invasive plant species in agricultural ecosystems). Other impediments to aquatic management include the challenging logistics of limited visibility and access, personnel training and special equipment, and the water matrix itself. For example,

detection and monitoring efforts for AIS can be challenging and costly because AIS spread in a three-dimensional fluid system and can occur at extremely low densities in large volumes of water. Moreover, many eradication and control options that are effective on land or in freshwater ecosystems are not applicable to the coastal ecosystem because the coastal ecosystem is more connected by ocean currents (Meliane and Hewitt 2005). The absence of clearly defined political or ecological boundaries in the coastal ecosystem also limits management options.

Box 1.6: Fundamental differences between marine and terrestrial ecosystems that affect options for management:[*]

- Information on the biology of most marine species and communities is more limited than in terrestrial systems, which increases scientific and public uncertainty about the outcomes of control actions.
- The ocean is perceived by the public and managers as an "open" system despite increasing evidence to the contrary for some species. The perception that management undertaken at one location will ultimately affect large areas of coastline leads to three consequences:
  - Marine stakeholders may oppose contentious management activities, even for those located some distance away (e.g., release of a biological control agent or concentrated chemical).
  - Local eradication efforts (e.g., physical removal) can be perceived as futile if ocean currents are believed to rapidly distribute invasive species.
  - The responsibilities of invasive species management are diffuse so that the costs, benefits, and decision-making authority become limited.
- Coastal managers can adopt a defeatist attitude towards the control or eradication of marine invasive species, largely because of the system's perceived open nature.
- The public perceives the ocean and coast to be essentially pristine. This perception can persist despite conspicuous evidence to the contrary.

[*]Source: Thresher and Kuris 2004

There are few examples of efforts to control estuarine and marine plant and animal invasive species. The challenges inherent to coastal ecosystem management have led to only a few of the available management options being used or considered. Options that are viewed as most acceptable are those that have minimal impact, and rely on the natural resilience of an ecosystem or physical removal of the invasive species. Such an approach may lead managers of estuarine and marine habitats to use less effective control methods (Thresher and Kuris 2004). Chemical biocides and physical control have been attempted on localized invasions where the effects of the control measure are easily reversible, but biological control (the use of a species to control a pest species) has yet to be done in estuarine and marine habitats.

Lack of ecological information

The scientific and management community have struggled to generate practical knowledge and tools for preventing invasive species introductions in coastal ecosystems, or for controlling and eradicating ongoing invasions. The most sought after set of

ecological data is information that informs dependable risk assessment tools. Risk assessment quantitatively estimates the probabilities that a specific invasive species will be introduced into certain habitats via specific vectors. But risk assessment is currently available for very few nonnative species. The predictive value of risk assessment is frequently constrained by the stochastic, or random, nature of invasions (Batabyal 2007). The process of how a nonnative species becomes invasive or not still is poorly understood, though these processes are crucially important for predicting coastal invasions. Moreover, a time lag often occurs between when a nonnative species is introduced and when it becomes a problematic invasion. Other information, including geographic origin, vector of introduction, and time of introduction, is frequently lacking but necessary to generate practical management tools.

Economic issues

Global economy and transport increase the introduction and spread of invasive species (NISC 2001). Certain invasive species vectors are driven by economic incentives and financial gains that can conflict with invasive species management. The incentives for industries to manage invasive species introductions (intentional or unintentional) can be influenced by the complicated dynamic of international supply and demand. Industries responsible for introducing invasive species often do not feel the cost of invasive species impacts. For example, the cost of the invasive algae introduced by the aquarium industry does no harm to that industry and is, therefore, external to their business. In other cases, like aquaculture, the industry itself has an economic stake in preventing introductions of nonnative species because of harm to their products or to the environment (Naylor et al. 2001).

Policy can be used to balance the competing goals of sustaining economic activity and protecting the environment from invasive species (Lodge and Shrader-Frechette 2003). Robust decisions that are based on economic data, considering environmental losses, are more likely to receive regulatory agreement by a responsible private sector as well as other stakeholders (ELI 2004a).

Sociopolitical context

Finally, invasions occur within an important societal and political context. Many management tools depend on public support and political will. For example, a persistent challenge for policy makers and resource managers is to define whether a nonnative species is causing "significant harm" and thus should be managed as an invasive species. Not only is the decision maker's choice contentious and subject to interpretation, but it is not clear who is authorized to make that decision. How that issue is resolved could determine whether the management of nonnative species is justified on economic and practical grounds, or not justified based on ecological and economic risks.

Public awareness of risk, protectionist vs. isolationist policies, and environmental beliefs all play a role in the politics of invasive species management (Margolis et al. 2005). The social landscape is diverse. One public interest group may demand the management of invasive species that threaten wildlife, while another may oppose control methods

because invasive species are themselves wildlife (Stoett 2007). Further, the societal pressures that inform policies are likely to change over time (Margolis et al. 2005, Thresher and Kuris 2004). Therefore it is important that public policy incorporates societal expectation, and adapts to the context in which those policies operate (Meliane and Hewitt 2005, Stoett 2007). Management of invasive species will continue to be of limited success until policy accounts for these underlying factors (van den Bergh et al. 2002).

Although challenging, effective invasive species management will require a consideration of the interactions between ecology and economics, politics and society (Davis 2009). Now recognized as an interdisciplinary challenge, a comprehensive approach to invasive species policy is essential if it is to result in cost-effective protection of California's coastal ecosystem and resources (Lodge et al. 2006).

Each invasion depends on a unique set of ecological, economic, and societal conditions (Ricciardi, 2009). Therefore, an *a priori* policy approach is considered by some to be an inadequate tool for the job. From this perspective, responses must be tailored for each invasion and those approaches must be supported by policy (Lovell et al. 2006). However a broad policy approach is needed when information and time are lacking to form specific policies and the invasion requires immediate management.

Invasive species along the California coast

California is unique in size, citizen concern for the environment, and international economic trade. California also has a unique geography, economy, and political and social context compared to other invaded coasts in the United States and elsewhere. California's coast has 3,500 miles of tidal shoreline spanning two Northeast Pacific Ecoregions: the temperate Northern California Ecoregion and the warm temperature Southern California Bight Ecoregion (WWF 2009). California encompasses a much larger area than other states, and shares an international border with Mexico. As a major center of international, interstate, and intrastate trade, the state's management strategy requires a substantial investment of resources and a good understanding of international issues of policy and coordination. These properties should be reflected in California's invasive species policy.

California also has a diverse set of engaged stakeholders from non-governmental organizations (NGOs), industry, local citizen groups, and academia. While the interest and activities of these groups can be a valuable asset, the diversity of their viewpoints and values contributes to disagreement, conflicting public messages, and difficult coordination. Furthermore, California's position as a Pacific coast trade hub and immigration and vacation destination, also make it vulnerable to invasions (DFG 2008a).

Because of the state's unique social, political, economic and ecological characteristics, policies that function in other parts of the country may not be successful along the California coast. In comparison to other states, California has a more developed approach to invasive species management and a reputation as a leader in progressive environmental issues. Opportunities exist to improve California's approach to coastal AIS.

CHAPTER 2: EXISTING POLICY

To understand policies regarding aquatic invasive species (AIS), a search was conducted using multiple library and Internet sources in consultation with many invasive species experts. Search refinements focused on policies directly and indirectly addressing coastal invasive species prevention or management, and those addressing invasive species as an environmental concern for conservation or restoration. For complete and thorough reference of international and United States' policies on invasive species, refer to the Global Invasive Species Programme, the National Invasive Species Information Center, Indiana-Illinois Sea Grant, and to the Environmental Law Institute. What follows is a brief summary of international, federal, and State laws that apply to coastal AIS (see Box 2.1). For more legal reference, please refer to Appendix 1.

2.1: INTERNATIONAL POLICY: LAWS, CONVENTIONS, PROTOCOLS, AND GUIDELINES

Invasive species and the problems they pose are of global concern. They naturally tend to raise inter-jurisdictional issues and often are introduced or spread by global transport and trade. Invasive species introduced into the United States create risk for Canada and Mexico, as well as any other country that trades with the United States. Because AIS are a global threat, prevention and management is an international issue requiring international policy (Lodge et al. 2006, Watson-Wright 2009). International policies can facilitate effective global coordination (J. Berge, personal communication). That cooperation is needed for protection of estuarine and marine habitats where boundaries are fluid and the cause and effect of invasive species are on an international scale.

Unilateral action by one country is often insufficient to manage the range of pathways, activities, and processes that cause introductions and enhance dispersal of nonnative species. For example, it is not effective for one country to impose strict ballast water regulations while neighboring countries ignore the issue (van den Bergh et al. 2002). Aside from global policies, regional policies pertaining to multiple nations within a shared ecological region, allow agreements tailored to ecological boundaries rather than political boundaries and do not require global consensus (Doelle et al. 2007). Numerous organizations and bodies coordinate invasive species prevention and management on an international scale (see Box 2.2).

International policies and guidelines are often formulated and adopted by countries that then pass enabling statutes and promulgate regulations to implement those agreements. To date, more than 50 international and regional, multi-national, and legal instruments have been adopted to address introductions of nonnative species (Shine et al. 2000, Hewitt and Campbell 2007).

The vast majority of international policies addressing the estuarine or marine habitat do not create binding agreements (Meliane and Hewitt 2005, Lodge et al. 2006). For

Box 2.1: Major international, United States, and California state policies related to coastal aquatic invasive species listed chronologically.

Year	International	Federal	California
1900		Lacey Act	
1931		Animal Damage Control Act	
1947		Federal Insecticide, Fungicide, and Rodenticide Act	
1952	International Plant Protection Convention		
1969			Porter-Cologne Water Quality Control Act
1970		National Environmental Policy Act	California Environmental Quality Act
1971	Convention on Wetlands of International Importance		
1972		Clean Water Act	
1973		Endangered Species Act	
1975	Convention on International Trade in Endangered Species		
1979	Technical Barriers to Trade Agreement (WTO)		
1982	United Nations Convention on the Law of the Sea		
1990		Nonindigenous Aquatic Nuisance Prevention and Control Act	
1992	Convention on Biological Diversity		Alien Species Prevention Enforcement Act
1994	North American Agreement on Environmental Cooperation		
1995	Code of Conduct for Responsible Fisheries		
1995	Agreement on the Application of Sanitary and Phytosanitary Measures (WTO)		
1996		National Invasive Species Act	
1997			California Endangered Species Act
1999		Executive Order 13112	Ballast Water Management for Control of Nonindigenous Species Act
2000		Plant Protection Act	
2001	Control of Harmful Anti-Fouling Systems on Ships		
2002	Jakarta Mandate on Marine and Coastal Biological Diversity		
2003			Marine Invasive Species Act
2004	International Convention for the Control and Management of Ships' Ballast Water and Sediments		
2005	Code of Practice on the Introduction and Transfers of Marine Organisms		California Clean Coast Act
2006			Coastal Ecosystems Protection Act
2009			Invasive Species Council of California

example, there currently are no binding international requirements for addressing the impacts of invasive species in aquaculture or from hull fouling (Doelle et al. 2007). The following is a brief list of the major international coastal AIS conventions and protocols that could potentially apply to coastal AIS in California.

Box 2.2: Organizations and programs that coordinate international management and policy of coastal invasive species:

- International Union for the Conservation of Nature:
  - Global Marine Programme
  - Invasive Species Specialist Group
- International Maritime Organization (United Nations): Marine Environmental Protection Committee
- International Council for the Exploration of the Sea: Study Group on Ballast and Other Ship Vectors working group
- The Commission for Environmental Cooperation
- Global Invasive Species Threat Assessment by ConserveOnline, The Nature Conservancy
- Global Invasive Species Programme of the Commonwealth Agricultural Bureaux International, International Union for Conservation of Nature, The Nature Conservancy, and the South African Biodiversity Institute

International Plant Protection Convention, 1952:

The International Plant Protection Convention is an international agreement to prevent the spread and introduction of plant pests by an exchange of phytosanitary certificates between countries. Each country prevents invasions of

> pests of plants or plant products, any form of plant or animal life, or any pathogenic agent, injurious or potentially injurious to plants or plant products, and pests of potential national economic importance to the country endangered thereby and not yet present there, or present but not widely distributed and being actively controlled.

This is achieved by quarantine and risk assessment, or more specifically by "quarantine [of] pests involved with international trade, storage places, conveyances, containers and any other object or material capable of harboring or spreading plant pests, especially where international transportation is involved." This convention calls on countries to collaborate on the development of International Standards for Phytosanitary Measures.

Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention), 1971:

The Ramsar Convention, originally a treaty for the conservation of wetlands, was amended in 1999 to include invasive species concerns (Resolution VII.14, 1999). This amendment urged parties to establish eradication and control programs, review existing

legal and institutional measures relating to invasive species control, and where necessary, adopt legislation and programs to prevent the introduction of "new or environmentally dangerous alien species." In 2002, Resolution VIII.18 urged parties to undertake risk assessment of nonnative species which may pose a threat to the wetland habitats and to cooperate in preventing and controlling invasions across borders, including shared coastal zones (Doelle et al. 2007).

The Ramsar Convention is a treaty without a regulatory framework and has no penalties for violations or defaulting on treaty commitments. The United States is a contracting party with 23 listed wetlands of international importance, three of which are located along the California coast.

Convention on International Trade in Endangered Species (CITES), 1975:

CITES is intended to regulate the international trade of endangered species. By agreeing to regulate trade, members of the International Union for Conservation of Nature are legally bound to limit their trade of endangered and threatened species. CITES also can be applied to the international trade of invasive species if an endangered species from an exporting country is considered invasive in the importing country.

United Nations Convention on the Law of the Sea (UNCLOS), 1982:

This international policy agreement addresses the issue of nations' obligations to protect and preserve the marine habitat from pollution from both land and the ocean-based activities. After going into effect in 1994, UNCLOS provided the legal framework for addressing marine invasive species. Article 196(1) states that signatories need to "take all measures necessary to prevent, reduce, and control ... the intentional or accidental introduction of species, alien or new, to a particular part of the marine habitat, which may cause significant and harmful changes thereto." UNCLOS is the only legally binding international protocol concerning marine invasive species. The United States is not a signatory (Lodge et al. 2006).

Convention on Biological Diversity (CBD), 1992:

The CBD was developed in accordance with the Jakarta Mandate on Marine and Coastal Biological Diversity (Conference of Parties [COP] Decision II/10, 1995). In general, the CBD addresses the introduction and impacts of nonnative species in the context of broad biodiversity protection (MacPhee 2006). The section titled "Precautionary Approach to Species Introductions" urges countries to prevent both intentional and unintentional introductions of invasive species (Meliane and Hewitt 2005). Article 8 requires parties to "prevent the introduction, control or eradication of those alien species which threaten ecosystems, habitats, or species."

This convention provides goals for actions, but participating countries have broad discretion over how they will achieve the CBD goals (van den Bergh et al. 2002). The CBD also created "Guiding Principles for the Prevention, Introduction, and Mitigation of impacts of Alien Species that threaten Ecosystems" as a nonbinding set of principles to

guide these decisions (2001). The United States is a signatory to the CBD but is not bound by its provisions (MacPhee 2006).

Code of Conduct for Responsible Fisheries, 1995:

The Code of Conduct for Responsible Fisheries is a voluntary set of principles and standards for aquaculture that was accepted by the international Food and Agriculture Organization (FAO) of the United Nations. These guidelines include recommendations for evaluating the risk of importing and culturing nonnative aquaculture species (Hewitt et al. 2006). Article 9.3.1 urges the minimization of harmful effects of introducing nonnative species stocks used for aquaculture, and Article 9.2.3 proposes consultation with neighboring nations before introducing nonnative species into transboundary aquatic ecosystems. In 1996, the FAO developed "Technical Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions" that suggests introductions be controlled and in accordance with the nonbinding International Council for the Exploration of the Sea (ICES) Code of Practice on the Introduction and Transfer of Marine Organisms (Doelle et al. 2007). The guidelines also suggest the development of a database of known ballast or hull-fouling invasive species and the development of methods to reduce hull fouling.

Control of Harmful Anti-Fouling Systems on Ships (Anti-Fouling Convention), 2001:

The Anti-Fouling Convention was aimed at eliminating harmful biocide paints used for anti-fouling (anti-fouling paints are used to coat ship hulls in order to prevent organisms from attaching to the hull and being transported by the boats during their voyages). A chemical once effective for invasive species prevention was recently banned to protect water quality. Presently, there is no equally effective anti-fouling agent available that prevents the attachment of organisms to ship hulls. Adoption of the Anti-Fouling Convention has caused a recent urgency to put in place international regulations on hull fouling (Meliane and Hewitt 2005).

Jakarta Mandate on Marine and Coastal Biological Diversity (Jakarta Mandate), 2002:

The Jakarta Mandate followed the CBD by providing a method for attaining CBD standards. The Jakarta Mandate on Marine and Coastal Biological Diversity was adopted by the COP through an Annex "Guiding Principles for the Prevention, Introduction, and Mitigation of Impacts of Alien Species That Threaten Ecosystems, Habitats, or Species" (van den Berg et al. 2002). These 15 guidelines for the prevention and mitigation of impacts of alien species are in accordance with the precautionary principle. Decision VI/23 urges parties to develop national invasive species strategies and action plans and to develop regional strategies where appropriate.

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), 2004:

The BWM is an international attempt to manage the discharge of ballast water through ballast water exchange and ballast water treatment. The BWM attempts to achieve this by

a combination of initial and ongoing compliance inspections, management plans, certifications, coastal zoning and alternative discharge options (Doelle et al. 2007). The BWM set a uniform global standard for the minimum amount and size of organisms permissible in ballast water discharged by large shipping vessels. The BWM sets the standards to be met, but does not provide implementation guidelines (e.g., either ballast water exchange or ballast water treatment). In order for the BWM to be implemented, each country must legally adopt the BWM's standards or standards that are more stringent (MacPhee 2006).

The BWM was adopted in 2004 by a diplomatic conference of the International Maritime Organization (IMO), with input from the United States after 13 years of negotiations (Meliane and Hewitt 2005, MacPhee 2007). The convention has the potential to be a powerful legal instrument, but will not enter into force until after it is ratified by at least 30 nations, whose combined merchant fleets constitutes at least 35 percent of the gross tonnage of the world's merchant shipping fleet. Although its support is encouraged by the International Union for Conservation of Nature, the convention has been ratified by only 22 states representing 22.65 percent of tonnage.[*] The United States, home to the largest global shipping fleet, has not yet signed the convention because many states have their own ballast water management policies and because of concerns over ballast water treatment technology and testing.

A main reason for the delay in the convention's ratification has been the slow development of ballast water treatment technology needed to meet the rigorous standards of the convention. The process for ratification and technology development has been stalled by both supply and demand. Investors are hesitant to invest in new technology development without clearer specifications by the BWM and without enough demand by countries participating in the convention. Meanwhile, some countries are hesitant to enter into the convention without a clear set of specifications by the BWM and a reliable supply of treatment systems. Some claim that the delay in technology development is linked to the absence of the United States in the convention. The United States is seen as a driving force in the market for ballast water treatment systems (Lantz 2009).

Code of Practice on the Introduction and Transfers of Marine Organisms, 2005:

The ICES, through their Working Group on Introductions and Transfers of Marine Organisms, has developed the Code of Practice on the Introduction and Transfers of Marine Organisms. This code of practice suggests that any proposed intentional release of a marine or estuarine species should be brought before ICES for discussion and sanction. ICES Member Countries are required to submit a detailed prospectus on the rationale and plans for new species introductions (Gollasch 2007). This Code of Practice is voluntary, does not have any signatories, and is thus not legally binding (Lodge et al. 2006).

[*] See the IMO's "Status of Convention" table at http://www.imo.org/Conventions/mainframe.asp?topic_id=247. The cited figures were current as of February 28, 2010.

North American Free Trade Agreement (NAFTA), 1994; World Trade Organization (WTO), 1995:

International efforts constantly balance between safeguards that prevent invasive species and not hindering the international movement of goods and products (Jenkins 1996). The NAFTA and the WTO address invasion vectors and the amount of imports entering a country by either quarantine bans and tariffs, or customs and port inspections.

NAFTA encourages international trade, which can be a vector for invasive species. There is now greater potential for NAFTA trade to introduce invasive species to California because regional and global trade has increased, while the capacity to inspect for invasive species has remained constant (Perrault et al. 2003). The NAFTA partner countries have the authority to regulate certain aspects of trade in potentially invasive species.

There has been a call for NAFTA provisions to be expanded to include prevention of invasive species introductions and spread (Jenkins 1996, McNeely 2002, Meliane and Hewitt 2005). NAFTA countries agreed on an environmental accord, the North American Agreement on Environmental Cooperation (NAAEC), which established the Commission for Environmental Cooperation (CEC) to implement the accord. The CEC aims to foster cooperation for the protection of the North American environment, including management of invasive species (CEC 2005). The 2003-2005 CEC management plan included the objective to manage AIS in coastal waters through a tri-national policy. In addition, the CEC sought to create an information network, direct legal frameworks, identify vectors, and raise awareness (CEC 2002). CEC efforts are ongoing, but there has been limited implementation of this plan (Doelle et al. 2007).

Within the WTO's legal framework, the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement, 1995) and the Technical Barriers to Trade Agreement (TBT Agreement, 1979) are supplementary agreements with potential bearing on AIS. The SPS Agreement specifically relates to human, animal, and plant health. It sets guidelines for international trade of animal pests and diseases and for other animal health issues by providing a uniform interpretation of measures applied to prevent introduction, establishment, or spread of animals or plants with pests and disease. Under the SPS Agreement, the International Plant Protection Convention has begun developing plant pest risk assessment standards for environmental hazards using certain guidelines (Article 5.3) that consider loss of production or sales, costs of control or eradication, and the cost-effectiveness of alternative approaches.

These requirements can limit domestic policy for management of invasive species by placing the burden of proof on countries through a requirement of a risk assessment justification of quarantine measures in terms of scientific risk. It also requires that trade measures be "not more trade restrictive than required to achieve their appropriate level of protection." This standard is difficult to prove, therefore domestic bans might be challenged under the WTO (ELI 2004a).

The TBT Agreement exists to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles to trade. The WTO's TBT Agreement

specifically relates to coordination of product regulations and technical standards for imports based on risk assessment with "zero risk" considered a reasonable goal for a country to pursue. The TBT Agreement aims to do this with the recognition of each country's rights to adopt its own individual for environmental protection.

Conclusion of International Policy

Within existing international policies and guidelines, several gaps and shortcomings remain in the current policy environment. Many of the inadequacies of international policies have been pointed out by experts in invasive species policy. First and foremost, international efforts on invasive species are fragmented (Doelle et al. 2007). The existing international conventions and protocols generally focus on preventing introductions and do not address the other stages of invasion that demand comprehensive management (Williams and Grosholz 2008). Moreover, many vectors of aquatic species introductions have not been thoroughly addressed. For example, the BWM attends to ballast water from large shipping vessels in great detail, but equal attention is needed for hull fouling, as well as for other vessels used in scientific research, tourism, and the aquarium trade (Doelle et al. 2007). The many international organizations working in this area are not well coordinated, which has led to overlap among their efforts (Stoett 2007).

Despite the range of policies, programs and agreements reflected above, no international authority possesses strong enforcement capacity. Most policies are voluntary and leave national governments to implement specific law and policy measures that follow general global principles (Sandlund et al. 1999, Doelle et al. 2007, Stoett 2007). The United States has not signed the few international policies that are legally binding, but it has created many of its own. Therefore, although some of the international policies pertain to the management of invasive species along the California coast, federal policy provides a stronger framework for efforts in California.

2.2: Federal Policy: Major Coastal Aquatic Invasive Species Laws

Many United States federal policies touch on invasive species in some fashion, with some governing the management of coastal aquatic invasions directly. At least 20 federal government agencies have policies directing the research, use, prevention, and control of nonnative species. These authorities are intended to manage the estimated 4,300 invasive species already introduced, and to prevent further introductions (Corn et al. 1999).

Lacey Act 1900, amended 1998, 2008:

The Lacey Act was originally adopted in 1900 to authorize the Department of the Interior (DOI) to restore game and birds and to regulate the introduction of animals into the country. A 1998 amendment made the Lacey Act the first federal attempt to manage the intentional introduction of nonnative animals; it remains a primary piece of invasive species legislation (Dentler 1993). The Lacey Act prohibits the importation of "injurious wildlife," species that are designated and listed by the Fish and Wildlife Service (USFWS) as vertebrates, mollusks, and crustaceans "injurious to human beings, to the

interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States" (Lodge et al. 2006).

The listing process places the burden of proof on the government to justify the ban of a nonnative species, which can be difficult to prove even in instances where the invasive species damage is already very widespread (Whalin, 1998). The act is reactive in that a species must have already demonstrated economic harm before it can be listed, evidence which is not often apparent for new invasions. In 1973, the DOI proposed to use a "clean list" approach to give the burden of proof to the party seeking to import species, but the proposal was dropped after the pet trade industry and the zoological and scientific communities, fearing a burdensome permit procedure, exerted intense lobbying pressure (Kurdila 1988, Dentler 1993). In 2009, the federal government began considering a bill that proposed risk analysis for imports of nonnative species. At this time, there are very few California coastal AIS listed by the federal government.

Implementation of the Lacey Act involves the Customs Service and the USFWS Division of Law Enforcement at 13 ports of entry, where agents enforce civil and criminal penalties on people who knowingly import prohibited species (Brown 2006). States can use the Lacey Act to restrict introductions of invasive species into their territories. However, the U.S. Commerce Clause may mute those efforts if restrictions affect interstate commerce, a federal domain. State restrictions can be constitutionally permissible if the goal to prevent ecological harm is nondiscriminatory (Whalin 1998). The federal government relies on states, such as California, to help pursue the goals of the Lacey Act (Gorjanc 2004).

Animal Damage Control Act, 1931, amended 2000:

The Animal Damage Control Act, originally enacted in 1931, is the primary statute under which the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) operates a Wildlife Services program that controls wildlife damage on federal, state, or private land and includes protecting wildlife damage to marine species. APHIS is mandated to control invasive animal species on both public and private lands, not to dictate their importation (ELI 2004a). This is done by providing advice to individuals and municipal, state or federal agencies on a wide variety of preventive, nonlethal, damage control methods.

APHIS has cooperative agreements with the USFWS, the National Park Service, and state natural resource agencies to protect natural resources, including wildlife and threatened or endangered species, from loss of life, habitat, or food supply due to the activities of other species.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 1947:

The FIFRA gives the Environmental Protection Agency (EPA) authority over the use of chemicals to control invasive species. The EPA may require an environmental assessment for invasive species control activities involving chemicals. FIFRA also allows EPA to regulate the importation of substances, including organisms that are used as pesticides.

National Environmental Policy Act (NEPA), 1970:

The NEPA is a broad environmental protection act with application to invasive species. It requires federal agencies to consider the environmental consequences of their actions, including actions that could serve to introduce or spread invasive species. NEPA requires environmental impact statements to analyze the environmental, economic and social effects of proposed actions and alternatives.

Clean Water Act (CWA), 1972:

The CWA was intended to "restore and maintain the biological integrity (a condition in which the natural structure and function of ecosystems is maintained; a return to the condition which existed prior to man-invoked perturbations) of the nation's waters." As of 2006, invasive species are interpreted under the CWA as a type of water pollution. The EPA has the authority to enforce the CWA for invasive species regulations and is currently responsible for developing regulatory permits for ballast water discharges. The EPA now requires a Vessel General Permit through the National Pollutant Discharge Elimination System for large commercial and recreational vessels in waters that support the United States Coast Guard (USCG) rules and regulations (Copeland 2008, EPA 2009). Additionally, the CWA authorizes states to adopt water quality standards that include criteria to protect water bodies from AIS.

Endangered Species Act (ESA), 1973:

The ESA is a broad act that protects listed endangered and threatened species and has implications for invasive species management. The ESA regulates the taking (including harming, wounding, or killing) of species that are listed under the act. The ESA also recognizes invasive species as a threat to endangered and threatened species, in which case the ESA calls for their management. This law can limit the management options available when trying to control an invasive species if the methods are likely to harm an endangered or threatened species or their habitat. The ESA also provides funding for research or management actions that assist in the recovery of species listed under the act.

Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA), 1990; National Invasive Species Act (NISA), 1996

The NANPCA and the NISA are two of the primary pieces of federal legislation addressing coastal AIS (Lodge et al. 2006). Created in 1990, the NANPCA originally mandated that the USCG regulate the ballast water management of ships entering the Saint Lawrence River-Great Lakes by issuing regulations for ballast water on commercial ships through a national Ballast Water Management program. Because the NANPCA was not comprehensive in managing ballast water, the NISA expanded ballast water discharge restrictions developed by the USCG to all vessels entering United States waters.

The NANPCA created the Aquatic Invasive Species Program and the Aquatic Nuisance Species Task Force (ANSTF), an interagency federal advisory committee charged with developing and implementing "a program for waters to prevent introduction and dispersal of aquatic nuisance species; to monitor, control and study such species; and to

disseminate related information." The ANSTF coordinates federal agencies, conducts coordinated research, and controls AIS. The ANSTF has promoted cooperative efforts to control established aquatic nuisance species and is mandated to assist states with the preparation of AIS management plans (ELI 2004a). The ANSTF formed regional panels on aquatic nuisance species, including the Western Regional Panel that represents California. NISA also created the National Ballast Water Information Clearinghouse to collect data on ballast water management, which is led by the Smithsonian Environmental Research Center and the USCG.

The NISA gives the USCG the authority to enact policies deemed necessary to stop the spread of invasive species. The USCG has recognized that ballast water exchange is not solely effective at removing the threat of invasive species introductions. Further, ballast water exchange has variable efficiency and not all ships can perform the maneuver. For example, cargo ships are too unstable for suggested methods of mid-ocean ballast water exchange (Buck 2007, Copeland 2008, GLPANS 2001, Moore 2009).

As of 2004, the USCG's ballast water regulations required mandatory management practices for most vessels entering waters after operating beyond the exclusive economic zone (EEZ, 200 miles). Vessels entering from outside of the EEZ must conduct mid-ocean ballast water exchange, retain ballast water, or use an approved ballast water treatment. Certain vessels are exempt from these practices, e.g., vessels with safety concerns, crude oil tankers traveling along the coast, and vessels of the Armed Services (USCG 2009). In addition, all vessels must subscribe to certain management practices, including: avoiding ballast water operations near marine preserves, cleaning ballast water sediment, removing fouling organisms, training crew on ballast water management, and maintaining a ballast water management plan. The Aquatic Nuisance Species Project and the Western Association of Fish and Wildlife, among others, offer training programs for ballast water management inspectors and law enforcement personnel.

Under the NISA, the USCG has begun a rule-making process to propose the following changes to current regulations: a mandatory ballast water discharge standard, criteria for ballast water treatment equipment, and compliance with EPA and FIFRA regulations when necessary. The Coast Guard has proposed to implement its changes in two steps: a first phase to require ballast water exchange and a second phase to require ships to meet specific standards similar to those in place in California. These proposed rules would continue to exempt certain vessels and do not set enforcement or compliance procedures. The proposed rules were, as of December 2009, undergoing public review (USCG 2009).

In order to meet USCG standards, on-board ballast water treatment technology must be approved by the USCG, pass testing by a USCG-approved laboratory, meet all needs of the NEPA, ESA, CWA, FIFRA, be registered with state water quality units, and have an Environmental Impact Statement on record (Patnaik 2009). To promote this standard, the USCG has created the Shipboard Technology Evaluation Program (STEP), a pilot program to encourage the use of ballast water treatment systems technology by installing experimental equipment on vessels. Vessels participating in the STEP will be grandfathered in with this technology even if it does not meet future requirements. In order to be included in the STEP, ballast water treatment systems must meet all

environmental water standards. There are currently two active ships in the STEP on the west coast, the Coral Princess (running from Alaska to the Caribbean) and the Moku Pahu (running from San Francisco to Hawaii) (Dyer 2009, Moore 2009).

Alien Species Prevention Enforcement Act, 1992:

Under the Alien Species Prevention Enforcement Act, it is unlawful to knowingly send any prohibited animal species listed under the Lacey Act or any plant species listed under plant pest acts (replaced by the Plant Protection Act in 2000) through the postal service. The Postal Service has authority to dispose of these materials, referred to as "nonmailable matter," if they reach the office of delivery.

Executive Order 13112, 1999:

President Clinton issued Executive Order (EO) 13112 in response to congressional findings on the inadequacies in federal invasive species management. The order promotes coherence in federal actions regarding invasive species and provides national leadership on the issue (OTA 1993). EO 13112 directs agencies to use existing national and regional programs to prevent introductions of invasive species, detect and respond to invasive species, monitor invasive species, restore invaded ecosystems, research invasive species prevention and control, and to educate the public on invasive species. In addition, EO 13112 prohibits the funding or implementation of actions by federal agencies that are likely to cause an invasion unless the benefits outweigh the costs.

EO 13112 also established the National Invasive Species Council (NISC), to coordinate federal programs and activities that prevent and control invasive species. The NISC is co-chaired by the secretaries of the Departments of Interior, Commerce, and Agriculture, respectively, and includes representatives from all relevant federal agencies. The NISC is charged with ensuring that invasive species control measures "are coordinated, complementary, cost-efficient, and effective, relying to the extent feasible and appropriate on existing organizations addressing invasive species." It also publishes the National Invasive Species Management Plan (NISMP) (NISC 2001, 2008). The NISC is intended to carry out its mission with the participation of the Invasive Species Advisory Committee (ISAC), a group of scientific advisors representing diverse interest groups.

Plant Protection Act (PPA), 2000:

The PPA is intended to prevent the unintentional and intentional introductions of plants and plant pests deemed harmful by APHIS. The PPA consolidates all major plant pest and protection acts, and extends the authority given to APHIS for these purposes. To reduce the risk of invasive plants reaching an unacceptable level, the PPA gives the Secretary of Agriculture authority to prohibit or restrict imports, exports, and interstate movement of certain plant products. APHIS is required to use emergency powers when necessary, to "prohibit or restrict the importation, entry, exportation, and interstate movement of any plant, plant product, biological control organism, noxious weed, article, or means of conveyance if the Secretary of Agriculture determines that the prohibition or

restrictions is necessary to prevent the introductions into the United States, or dissemination of a plant pest or noxious weed within the United States."

In short, the PPA authorizes the federal noxious weed list and gives clear authority to regulate importation and interstate transportation (ELI 2004a). The PPA is unique as it is the only federal act designed to combat a developing invasion based on perceived risk (Lodge et al. 2006). In order to enforce the PPA, APHIS has Customs and Border Protection officers intercept prohibited species at major ports of entry. Under emergency conditions, APHIS can seize, quarantine, or destroy any item that may become a plant pest or noxious weed. The PPA also prohibits unauthorized interstate and foreign mailing of listed plants and plant pests.

The PPA specifically preempts state and local plant protection regulations that are more stringent than the federal requirements unless the state can demonstrate a "special need" for additional restrictions based on "sound scientific data or through risk assessment." It also gives emergency remedial power within the state (when interstate movement is not involved) if "the measures being taken by the state are inadequate to eradicate the plant pest or noxious weed" (ELI 2004a). As of 2003, border inspection and enforcement duties of the PPA became the responsibility of the Department of Homeland Security, Customs and Border Protection, Agriculture Quarantine Inspection.

APHIS had previously pursued a more precautionary approach to preventing the importation of potentially invasive species. In 1973, a "clean" list of species deemed safe for importation was proposed in rulemaking. This was abandoned after APHIS received opposition by the pet trade and the zoological and scientific communities on the grounds that all nonnative fish and wildlife were presumed harmful and banned from importation unless they were on a proposed list. In 1975, APHIS attempted to create a clean list once again with a longer proposed list of approved species, but again, due to adverse comments, the attempt was abandoned. In 1995, APHIS sought middle ground by listing certain taxonomic groups that contained known pest species. APHIS also proposed to establish a clean list of organisms within the regulated taxonomic groups and to give APHIS the authority to take any "remedial measures" that would prevent dissemination of a regulated species into or within the United States. This attempt at a proposed rule was withdrawn after just five months (Whalin 1998). In 2009, APHIS proposed several changes to the regulations governing the importation and interstate movement of noxious weeds including the use of risk assessment for certain species (USDA 2009).

United States Regional Efforts:

The NISA and the ANSTF created the Western Regional Panel on Aquatic Nuisance Species (WRPANS) (WRPANS 2009). The panel has established an annual work plan with suggested actions to improve AIS management in the western United States. The WRPANS has a coastal committee to address coastal AIS issues.

The governors of California, Oregon, and Washington entered into the West Coast Governors' Agreement on Ocean Health (WCGA) in 2006, an agreement that acknowledges the need for greater coordination among these states (along with Canada

and Mexico) to preserve the ecosystem. A WCGA Action Plan, released in 2008, calls for two actions that address aquatic invasive species: (1) prevent the future introduction of marine invasive species (Action 2.3.), and (2) focus efforts on eradicating nonnative cordgrasses (*Spartina*) as a pilot coastwide eradication (Action 2.4.) by a WCGA *Spartina* Action Coordination Team.

Federal Programs:

Invasive species prevention, education, research, and funding also take place through a diverse set of federal programs, national, and nongovernmental organizations, such as the Federal Interagency Committee on Environment and Natural Resources and the National Exotic Marine and Estuarine Species Information System. Several groups also coordinate information and education on this topic, such as the efforts of the ANSTF and the National Oceanic and Atmospheric Administration Sea Grant programs.

Conclusion of Federal Policy

United States federal policy regarding invasive species, and coastal AIS in particular, remains inadequate to address new introductions and to control existing invasions (USCOP 2004). In general, legislation and enforcement are not comprehensive. Because of a lack of cohesive policy on nonnative species importation and a lack of enforcement, the number of invasive species introduced has continued to increase (Ricciardi 2001, Levine and D'Antonio 2003, Lodge et al. 2006). It has been widely stated that existing laws and regulations in the United States comprise a patchwork of policy (ISAC 2000, ELI 2004a, Lodge et al. 2006). More specifically, experts cite a lack of strong importation restrictions, early detection and rapid response programs, and effective leadership (Keller and Lodge 2007). Furthermore, existing policies are poorly implemented because of a lack of standards, enforcement procedures, and mandates for prevention (Reeves 1999, Schmitz and Simberloff 2001). In large part, these challenges are tied to inadequate funding to meet needs (USCOP 2004, Lodge et al. 2006).

In respect to vectors of coastal AIS, federal policy is intended to reduce the risk of future introductions from trade, but federal policy lacks a coherent strategy to meet that goal (NISC 2001, 2008, Williams and Grosholz 2008). Major federal aquatic legislation is narrowly focused on a few invasive species and invasion pathways and lacks attention on broader and future threats (Lodge et al. 2006). Most federal attention is focused on ballast water, while largely ignoring other sources of invasive species that also threaten the coastal ecosystem (Ruiz et al. 1997, van den Bergh et al. 2002, Padilla and Williams 2004). Federal ballast water regulations were initially intended to prevent introductions of invasive species into the Great Lakes through the Saint Lawrence Seaway, a passage much more easily managed than the open ocean along the coast of California. Application of these prevention tactics to the coast is possible, but insufficient (Lodge et al. 2006). The legal tools and practical methods to prevent the transport of a species introduced into one state to another state are few and rarely used (Kolar and Lodge 2002).

We find that current federal regulation of AIS is woefully incomplete (Nadol 1999), especially for the coastal ecosystem. Many of the gaps in federal policy have hindered

protection of California's coast against aquatic invasions. Some suggest that one broad-sweeping federal law would solve California's AIS problem because state-by-state policy and regulation can be inconsistent and conflicting (Gorjanc 2004, Brown 2006). Others have argued that in the absence of comprehensive federal policies, aggressive California regulation of coastal AIS is necessary (Nadol 1999, Lodge et al. 2006). Given the current federal approach to invasive species, it is left to state governments to implement specific law and policy measures that follow the general principles developed on a global and federal level. Lessons learned from federal invasive species policy could be helpful in guiding California's approach to coastal AIS management.

2.3: Major California Coastal Aquatic Invasive Species Laws and Regulations

Given the gaps and inadequacies of international and federal policies, state regulation of invasive species is necessary (O'Shea and Cangelosi 1996, Dentler 1993, Nadol 1999). Many states have drafted and implemented their own policies and programs to prevent or respond to invasions (Williams and Grosholz 2008).

State regulation of invasive species is not ideal, but it is considered the main alternative strategy for several reasons (O'Shea and Cangelosi 1996). Some argue that states are more capable of effectively regulating invasive species than the federal government because states have firsthand knowledge of local invasive species and their vectors of introduction (Boothe 2008). Others suggest that state responses to invasions are more immediate and that the state process is less cumbersome, allowing for more flexibility and efficiency than the federal or international processes (Gorjanc 2004). Yet states must recognize that invasive species are interjurisdictional and certain prevention policies invoke the federal Commerce Clause and other federal preemptions. Federal hurdles to state regulation are avoidable, provided that states regulate invasive species with constitutional requirements in mind (Nadol 1999). Despite the critical role of federal regulations, they do not preempt many innovative state and local strategies, especially in states like California with its unique coastal concerns (ELI 2004a). This section will provide information on California policies that apply to coastal AIS via all known vectors. Policies that pertain to individual vectors are addressed in Sect. 2.4.

Porter-Cologne Water Quality Control Act (Porter-Cologne Act), 1969:

The Porter-Cologne Act is intended to preserve, enhance and restore California's water resources by establishing water quality standards and water discharge regulations. It establishes a comprehensive program and gives authority to the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCB) to achieve this goal. The SWRCB and RWQCBs have established water quality principles and guidelines that regulate chemicals for AIS control. The SWRCB is responsible for developing statewide water quality plans, including the Ocean Plan and total maximum daily loads (TMDLs) for water bodies listed under Section 303(d) of the CWA.

Recently, the legal interpretation of AIS as water pollution has caused the involvement of AIS in 303(d) water quality listings and TMDLs. Water bodies are listed under this

system when data indicate a correlation between an increase in invasive species and an accompanying decline in water quality over time. As of 2006, 11 new water segments were listed as 303(d) due to invasive species (ELI 2008).

California Environmental Quality Act (CEQA), 1970:

CEQA provides a framework to develop and maintain environmental protection by identifying environmental effects of projects and the measures that can avoid and mitigate the negative effects of those projects. Activities, including AIS control that will potentially impact the environment, must comply with CEQA's environmental review and public disclosure procedures.

California Endangered Species Act (CESA), 1997:

Similar to the federal ESA, the CESA establishes general protection and preservation for native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats that are threatened with extinction. Protection and preservation activities are managed by the Department of Fish and Game and the California Fish and Game Commission.

California Clean Coast Act (CCCA), 2005:

The CCCA regulates the release of graywater, sewage, sewage sludge, oily bilgewater, hazardous waste, or other waste into the marine waters of the state and marine sanctuaries by oceangoing ships and large passenger vessels. Authority under the CCCA is primarily given to the SWRCB in coordination with the State Lands Commission (SLC) to regulate those releases. If there is a release of these substances, the State Water Resources Control Board must be notified within 24 hours. The CCCA directs the SWRCB to obtain permission from the EPA to impose sewage discharge prohibitions on cruise ships and other oceangoing vessels in California waters; approval is still pending. In 2006, vessel operators were required to provide information on their releases to the SLC. In 2007, the SLC gave the data to the SWRCB to prepare a legislatively mandated report on releases. As of mid-2009, that report had not been submitted to the California State Legislature or made public (M. Falkner, personal communication).

California Invasive Species Council (ISCC), 2009:

In early 2009, the ISCC was created as an interagency council to coordinate and ensure complementary, cost-effective, environmentally sound and effective state activities regarding invasive species. The goal of the ISCC is to guide efforts to keep invasive species out of the state, to find invasive species before they are well established, and to take steps to eradicate invasive species populations. ISCC members include the secretaries of the California Department of Food and Agriculture, California Natural Resources Agency, California Environmental Protection Agency, California Business, Transportation and Housing Agency, California Health and Human Services Agency, and the California Emergency Management Agency.

The ISCC bylaws direct state agencies and departments whose actions may cause introductions of invasions to prevent those introductions. The ISCC bylaws also direct state agencies to rapidly respond in a cost-effective and environmentally sound manner to new invasions, monitor invasive species populations, provide restoration for native species, conduct research on invasive species and develop technologies to prevent and control invasive species, and to promote public education. The ISCC aims for the highest level of leadership and authority in California regarding invasive species. However, because the ISCC was not created by legislation it does not have the authority to mandate compliance with its objectives.

The ISSC is guided by the California Invasive Species Advisory Committee (CISAC). The CISAC provides advice to the ISCC on a broad array of issues related to invasive species. Specifically, the ISSC intends that the CISAC will recommend steps to prevent introductions of invasive species, including efforts to coordinate and guide state agency and department activities, develop a list of invasive and potentially invasive species, interact with a diverse set of stakeholders, develop recommendations for interstate cooperation, develop a coordinated network, develop a system for reports of invasive species sightings, facilitate education and outreach, and develop a statewide Invasive Species Action Plan including a rapid response plan. To date, the list of invasive and potentially invasive species has been published by CISAC.[*]

An invasive species council had been previously proposed in California. In 2002, a statute created an executive-level aquatic invasive species council. The council was never assembled and its statute was repealed in 2005 (FGC § 6950-6957). The California State Assembly in 2004 proposed a council similar to the one recently established, but with a more inclusive membership, a rotating chairmanship, and an Invasive Species Management Fund upon appropriation (AB 2631, 2004). Citing a need for efficient use of current state programs Governor Arnold Schwarzenegger vetoed the bill.[†]

Guiding principles of environmental protection:

In addition to the specific acts listed above, environmental protection laws acknowledge the value of the California coast as a natural resource and establish the need for its maintenance and restoration. Environmental protection for the coastal ecosystem is required by the Villaraigosa-Keeley Act, the California Coastal Act, the California Ocean Protection Act, and then California Park and Recreational Facilities Act. The marine ecosystem is protected in the Marine Life Protection Act as well as Fish and Game regulations and codes that recognize the need for long-term preservation of marine resources and protection through marine-protected areas.

Other environmental protection acts, such as CEQA and CESA, serve as statements of intent for the general preservation of California's native species and habitats, thereby

[*] The list of invasive species can be accessed at http://ice.ucdavis.edu/invasives/.
[†] Governor Schwarzenegger's veto statement may be found at http://www.gov.ca.gov/pdf/press/vetoes/AB_2631_veto.pdf.

defining the need for invasive species management. For example, the California Environmental Protection Act proclaims to

> encourage the preservation, conservation, and maintenance of wildlife resources … maintain sufficient populations of all species of wildlife and the habitat … alleviate economic losses or public health or safety problems caused by wildlife to the people of the state either individually or collectively ….

Environmental protection of the coastal ecosystem is also provided by NOAA, which manages invasive species in National Marine Sanctuaries, three of which are along the California coast.

The current invasive species laws enacted in California have resulted in many different regulations and programs that can best be understood when classified into policy categories. Current California policies are discussed in the context of these policy categories in the following section.

2.4: General California Coastal Aquatic Invasive Species Policy Categories

Authority

The primary state statutes governing management of coastal AIS lie within the Fish and Game Code, Title 14 of the California Code of Regulations (CCR), and the Public Resources Code (PRC), Division 7 of the Water Code (Porter-Cologne Water Quality Control Act) (see Sect. 2.5). There are seven primary California acts, accompanied by over 230 code sections in the California Code and over 50 sections in the California Code of Regulation that directly or indirectly address the management of coastal AIS.

Coastal AIS oversight is divided among several state agencies influenced by distinct legislative directions and historical orientations, including the California Department of Fish and Game (DFG), California Department of Boating and Waterways (DBW), SLC, California Department of Water Resources (DWR), California Department of Parks and Recreation, State Water Resources Control Board (SWRCB), California Coastal Commission (CCC), State Coastal Conservancy (SCC), and the Ocean Protection Council (OPC).

The DFG has general jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species (FGC § 1802). As a trustee agency of natural resources, and with oversight by the Fish and Game Commission (FGC), the DFG manages state ecological reserves through the Invasive Species Program (FGC §§ 1504, 1525, 1580, PRC § 21070, CCR Title 14 § 630).

Prevention: Risk Assessment Development

Risk assessments are valuable modeling tools that predict which nonnative species pose risks for becoming invasive and causing harm if unmanaged (Lodge et al. 2006). When performing risk assessments, predictive information is needed on the biology of the species, the environmental characteristics of its habitat, and its vectors of introduction (Gollasch 2007, Molnar et al. 2008, Lovell and Drake 2009). Risk assessments also can be applied to prioritizing control actions for different invasive species populations. Understanding the relative risk posed by various invasive species requires considerable scientific information, including the current distribution, the potential for spread, and available control tools. Risk from invasive species often differs by ecosystem, and can differ within California's regions, so one approach to risk analysis is not necessarily appropriate for all scenarios (Batabyal 2007, Meyers 2008). Risk assessments can be applied to individual species or to vectors; its application to risk analysis and importation restrictions of nonnative species is a key element of prevention (Riley 2009).

An ongoing risk assessment development program for six major coastal AIS vectors is being funded by the OPC and overseen by the Ocean Science Trust. These studies focus on the vectors that pose significant risk to the coastal environment but are poorly understood (recreational shipping, recreational boating, and the trade in live organisms). Results from the OPC research will provide crucial information to resource managers on the significance of these vectors and how they can be managed to prevent introductions of invasive species (D. Steinberg, personal communication). These assessments will be completed in early 2011 and will include recommendations to management programs for effectively and efficiently preventing introductions.

Prevention: Early Detection

Early detection programs aim to intercept invasive species when they are still in small, incipient populations. These efforts are dependent on monitoring and mapping programs. It is intended for early detection of an invasive species to be followed by subsequent rapid control to eradicate small, and still manageable population.

If invasive species are detected by any organization or individual, there are multiple ways to report this sighting, including calling or emailing the DFG Invasive Species Program and contacting the U.S. Geological Survey's Nonindigenous Aquatic Species Program. One early detection program, coordinated by the National Marine Fisheries Service and the DFG addresses the invasive marine alga *Caulerpa taxifolia*. This detection program includes a detailed surveying protocol for early detection, including a reporting form to use if *C. taxifolia* is found (NOAA, DFG 2008a). The DFG has the general authority to monitor facilities holding fish, amphibians, and aquatic plants (i.e., aquaculture facilities, aquaria, and water garden outlets) for early detection of disease (FGC § 6301).

These early detection programs are believed to be most successful when they target specific, easily identifiable species on a small scale. Therefore, they work best for brightly colored fish or conspicuous aquatic plants rather than for hard to detect invasive species such as those released from ballast water. These programs also benefit from

volunteer efforts and citizen participation although false positives can be a hazard of citizen monitoring (Lodge et al. 2006).

Early detection of coastal AIS is partly served by the Marine Invasive Species Monitoring Program of the DFG Office of Spill Prevention and Response (OSPR) whose researchers conduct monitoring. In addition, monitoring of invasive species is taking place by nongovernmental coastal research institutions with ongoing. Recent legislation requires that the DFA, with input from other state agencies, to develop a list of invasive pests ("species, both terrestrial and aquatic, whose introduction into California would likely cause economic or environmental harm") that are at high risk for entering and establishing in California and to identify management measures (FAC 5260-5261). The CISAC plans to develop the list and management measures required by the statute, which may include early detection actions.

Prevention: Importation and Release Restrictions

In addition to USFWS importation restrictions and border inspections, California has several policies restricting the importation and release of coastal AIS. The DFG manages the importation, exportation, release, sale, transportation, and possession of many nonnative animal and plant species (FGC §§ 2150, 2190, 2193). In a broad policy, DFG states "no person shall import into this state any live nonnative wild animal (any nonnative animal species, or hybrid thereof, that is not normally domesticated)" except pursuant to this chapter or regulations adopted pursuant thereto (FGC §§ 2189, 2190). The associated regulation (CCR Title 14 §236) explains which aquatic plants and animals require a permit for importation into California and which do not.

Lists of allowed and/or prohibited native and nonnative species is a prevention policy commonly used by state governments (ELI 2004a). The FGC is authorized to restrict the importation of listed species and add any species that are "undesirable and a menace to native wildlife or the agricultural interests of the state … or for the welfare of wild animals" in consultation with the DFA (FGC § 2118). This list includes less than 200 restricted taxa (species, genera, families, etc.). In addition to being included on this listing, certain species, such as alga species in the genus *Caulerpa*, also can be prohibited in their own species-specific regulations (FGC §§ 2300, 2301).

Based on both federal and California state regulations, there are approximately 24 coastal aquatic plants and animal taxa whose importation is prohibited into California by the DFG (DFG 2008a).[*] Subsection (b)(2) of this regulation states that an importation permit is *not* required for "live ornamental tropical marine or freshwater plants or animals that are not utilized for human consumption or bait purposes, are maintained in closed systems for personal, pet industry or hobby purposes and which will not be placed in waters of the state." In other words, a wide array of aquatic plants and animals can be brought into California without obtaining any kind of permit.

[*] Of the state regulated aquatic invasive animals listed in Appendix G of the CAISMP, 24 taxa are classified as occupying the marine habitat (DFG 2008a).

The FGC can modify the list of restricted species. Species can potentially be added quickly through emergency regulation procedures when justification exists (GC 11346.1).

The release (deposition, permission to pass, or placement) of most aquatic invasive species is prohibited because it is unlawful to place or plant a live aquatic animal or plant that is nonnative to California into state waters without the permission of the DFG (FGC §§ 2121, 6400, CCR Title 14 § 671.6). The DFG also prohibits the release of any wildlife or plants into ecological reserves, or any fish or wildlife into marine-protected areas and marine-managed areas, unless authorized (CCR Title 14 §§ 630, 632). Additional species, when diseased or parasitized, are restricted when they are going to be placed in state waters including mollusks, crustaceans, and ornamental marine or freshwater plants and animals that are not utilized for human consumption or bait purposes and are maintained in closed systems for personal, pet industry, or hobby purposes (FGC §§ 2270-2272).

Exceptions to almost all of these importation and release restrictions can be issued by permit. The vast majority of aquatic species may be legally imported into California with only an importation permit. The process to legally import restricted species with a standard importation permit is not rigorous and exists primarily to avoid entry by diseased or parasitized animals. In contrast, restricted animal permits are issued only for specific purposes (typically research or exhibition) and require measures to prevent escape or release of nonnative species, often with compliance reports.

The DFG may allow exceptions to many of the importation, release, and transport restrictions of nonnative and invasive species (FGC §§ 2270-2272, 2300, CCR Title 14 § 671). In general, these are intended for industrial, zoological, or research use (e.g., FGC § 2150). Conditions for importation or transport often require proper labeling to identify the species contained, labeling for the origin of the shipment, and conditions under which the species shall be kept after importation or during transportation (FGC §§ 2151, 2270-2272, CCR Title 14 § 671.1).

Prevention: Education and Outreach

Education and outreach campaigns are done to spread awareness of invasive species and their impacts. The California public is a very large constituency, comprised of people with strong and varied environmental opinions. A successful campaign against coastal AIS can target the industries and trades identified as vectors, the general public because of their influence on market dynamics, and decision makers. Education can also raise support for increased compliance and can reduce the need for regulations.

Education and outreach in California is presently handled by several different agencies and organizations. The OPC recently adopted the California Ocean and Coastal Information, Research, and Outreach Strategy that sets clear goals for California on education, including a media campaign to raise awareness of issues concerning the ocean. The DFG distributes brochures, posters, articles, and press releases to improve public awareness of AIS threats. To date, the DFG and the DBW have collaborated to provide outreach and education towards reducing the spread of quagga and zebra mussels.

There are several campaigns designed to educate California interest groups and general public about AIS. Examples of educational campaigns in California are the "Stop Ballast Water Invasions" (West Coast Ballast Water Outreach Program), "PlantRight" (California Horticultural Invasive Program), "Don't Plant a Pest" (California Invasive Plant Council), and California Weed Awareness Week. Education and outreach campaigns are also actively done by the University of California Cooperative Extension, University of California Division of Agriculture and Natural Resources, and California Sea Grant programs that receive federal funding for their efforts in California. Education programs are supported by the CALFED Bay-Delta Program, the San Francisco Estuary Project, the San Francisco Estuary Institute, the National Estuarine Research and Marine Sanctuaries, and the Pacific States Marine Fisheries Commission.

Research

Many agree that basic research on the science of invasive species is needed for better-informed management decisions and policymaking. Data is needed on the origins of invasive species, the time and location of their original introduction, the population size and growth rate, their impacts on native species and habitat, and other environmental, economic, and social factors. In addition, research is required on the efficacy of control techniques and the development on new control technologies.

These lines of inquiry are overseen by numerous governmental and non-governmental institutions along the California coast. Under the Marine Invasive Species Act, the Department of Fish and Game is required to conduct studies of AIS in the coastal and estuarine waters of the state, and to monitor for new introductions of nonnative species. To fulfill this requirement, the DFG OSPR, in collaboration with SLC, initiated several baseline field surveys of ports and bays along the California coast. OSPR maintains a database, (CANOD) with the following information: name and location of nonnative species on the California coast, native region of each species, vector of introduction, date of introduction, and locations found on the coast. CANOD is frequently updated and is made publicly available on the DFG Invasive Species Project website. Regular reports are prepared by the DFG per the requirements of the Marine Invasive Species Act.

A substantial amount of coastal AIS research is being conducted by interagency institutions and nongovernmental research institutions. These include the University of California (UC), NOAA Sea Grant, and USDA Agricultural Resources Service (ARS), Scripps Research Institute, Monterey Bay Aquarium, and the Smithsonian Environmental Research Center (SERC). Monitoring data on some coastal AIS are compiled by CANOD, the SERC's National Exotic Marine and Estuarine Species Information System, the United States Geological Survey (USGS) Nonindigenous Aquatic Species, and The Nature Conservancy Assessing the Global Threat of Invasive Species to Marine Biodiversity.

Research focused on control methods and options for invasive species is done by a variety of entities within California. The University of California Sea Grant Extension and ARS conduct ongoing research, much of it specifically focused on coastal AIS. In 2006, University of California-Davis researchers developed methods to eliminate the

invasive sabellid polychaete from parasitizing abalone and other shells. The university researchers have given the aquaculture industry easy-to-implement best-management practices that can eliminate risk of spreading this parasite into abalone populations. To widely disseminate their results, the UC Davis research group developed a DVD describing the invasive parasite, its impacts, and recommended techniques for its prevention (UC IPM 2006b).

Recently, to fulfill an objective of the CAISMP, the California Agencies Aquatic Invasive Species Team (CAAIST) was formed by a group of a senior scientist (DFG 2008a). The effectiveness of the CAAIST is yet to be seen, but it has begun developing an AIS agency directory, technical expert directory, and actions to improve early detection of AIS (J. Horenstein, personal communication). This team may function to coordinate and guide coastal AIS research and application to management and policy.

Control: General Guidelines and Tools Development

There is no requirement for DFG to address all infestations by coastal aquatic invasive species, or even infestation by species listed as restricted for import or possession. DFG is mandated to "destroy or confine" any aquatic species that is illegally transported or possessed and is determined to be deleterious, but these statutes are intended to apply to animals in captivity, or a recently escaped animal that is considered a public safety risk (FGC §§ 2189, 2190, 6303). Any other local, state, or federal governmental agency with public safety responsibilities also is authorized to enforce this control. For infected, diseased, or parasitized aquatic species, however, DFG is given specific guidelines for response (FGC § 6304).

Decisions on the control of coastal AIS by the DFG (i.e., which species to manage, where, when, and how) is largely unspecified in policy. The DFG uses its scientific expertise to determine where control efforts will be most effective considering available funding (S. Ellis, personal communication). Management of coastal AIS can be limited by the availability of effective control tools. The use of chemical biocides requires that the chemical be registered with the EPA or that a special permit is obtained from the California Environmental Protection Agency Department of Pesticide Registration. There is a lack of pre-approved chemicals to use in the coastal aquatic ecosystem; only two chemicals, imazapyr and glyphosate, are available under the current EPA regulations (CDPR Product Database). Experimental use of pesticide in certain areas is authorized by the California Department of Pesticide Use (FAC § 14006.6, CCR Title 3 § 6260).

Environmental protection of sensitive species and habitat often will require the management of harmful invasive species. Invasive species control can be both encouraged and restricted by environmental protection laws. Ideally, management of AIS finds a balance between the efficacy of control methods and the adverse side effects on native species and habitats (DFG 2008a). Environmental protection laws also restrict types of control methods in certain areas. For example, control of invasive species in ecological reserves is restricted by the DFG; unless authorized, the use of certain pesticides is prohibited on all ecological reserves. The DFG itself is allowed to use

pesticides on ecological reserves for management purposes, and must comply with state and federal environmental protection laws.

The DFG also is allowed to possess and take endangered, threatened, or candidate species for scientific, educational and management purposes, and for law enforcement, but must be permitted under CESA for any incidental take caused by its routine activities, (FGC § 2582, 2583, CCR Title 14 §§ 630, 786.0 - 786.8). In order to conduct control activities in compliance with these environmental protection laws, the DFG must analyze the impacts that control will have on any endangered, threatened, or candidate species, consider the possible impacts of its control actions, and plan for mitigation if needed (FGC § 2081, 2085, CCR Title 14 §§ 783.2-783.4). The taking of insects and other invertebrates is not prohibited (CCR Title 14 § 783.1).

Control: Emergency Powers, Rapid Response

Emergency powers, including the authority to enact quarantines and to rapidly respond to an invasion, are needed to contain and eradicate incipient invasions. Without a rapid response plan, quick eradication of an invasive species after early detection is unlikely. The use of rapid response plans for coastal AIS is limited. California has no policies or plans outlining emergency actions, including agency responsibility, or funding for coastal AIS control. One of the few regulations regarding emergency situations for coastal AIS control allows the use of quarantine and unregistered biocides by any state entity (HNC § 660, FAC § 14006.6, CCR Title 3 § 6260).

The CAISMP contains a preliminary draft rapid response plan that incorporates features of the National Incident Management System. This proposed rapid response relies on quick decision-making and subsequent action through pre-approved interagency agreements (DFG 2008a).

A very rapid response was taken to eradicate *Caulpera taxifolia* after this invasive alga was discovered in a Southern California lagoon in 2000. Because *C. taxifolia* was listed as a noxious species by the USDA, there was existing authority to treat the introduction as an emergency. Eradication was led by the self-appointed multi-organizational Southern California Caulerpa Action Team (Jenkins 2002). A fortuitous alignment of early detection, agency coordination, emergency funding, and expertise led to successful *C. taxifolia* eradiation (Anderson 2005). This spurred the creation of a control protocol for *C. taxifolia* to ensure eradication of any new infestations (NMFS DFG 2008a).

Control: Restoration

Restoration of California's coastal ecosystem is mentioned briefly in several policies, including the following excerpts. "It is the policy of the state to preserve, protect, and, where possible, restore coastal resources" (PRC § 5096.226). The Wildlife Conservation Board and the Department of Fish and Game are mandated to administer programs of "acquisition, enhancement, restoration, and protection of areas most in need of proper conservation to protect the state's rare native wildlife, fish, and plant species" (FGC § 2701). The SLC has the authority to protect and restore "coastal and marine habitat and

water quality…and living marine resources" (PRC § 31220). Coastal restoration occasionally takes place after invasive species management, but most restoration is performed in isolation from the state's invasive species programs (S. Ellis and J. Horenstein, personal communications).

Implementation: Enforcement and Funding

Policies and programs guiding invasive species management are not effective unless they are properly implemented. Implementation requires enforcement as well as adequate funding. It is not possible to assess if all California laws and regulations are enforced because many violations go unnoticed, and, as is common with invasive species, the party responsible for invasions or lack of management is often unknown.

Implementation of laws and regulations, as well as their enforcement, is largely guided by the amount of funding available. Incidentally, a portion of funding for invasive species management is collected during enforcement. State laws often stipulate fee collections and civil or monetary penalties for violations that are intended to affect those parties responsible for the importation or release of invasive species.

If any deleterious aquatic species is illegally transported or possessed, it is the responsibility of the owner to pay for disposal or confinement (FGC §§ 2189, 2190). The importation or possession of restricted species requires a permit fee that contributes to the Fish and Game Preservation Fund (FGC § 2150.1). In addition, in the case of escape or release, the permit holder must be financially responsible (by insurance bond or other financial guarantee) to cover expenses for recapture (CCR Title 14 § 671.1). The Fish and Game Preservation Fund is also maintained by civil penalties collected when pollution release laws are violated. The penalty is based on the volume of the discharge, the extent of harm caused by the violation, and whether the effects of the release may be reversed or mitigated (FGC §§ 5650, 5650.1).

Fines and penalties also are collected from violations of laws pertaining to the prevention of *Caulerpa taxifolia* introductions (FGC §§ 2300-2302). Border inspections conducted by DFA are funded by fees paid by the commercial shipping industry and penalty fees for noncompliance (FAC §§ 5352, 5353). Other funds for invasive species management include California's Harbors and Watercraft Revolving Fund managed by the DFG and DFA and the Native Species Conservation and Enhancement Account which funds restoration of native species and their habitats (HNC § 85.2, FGC § 1760). There also are sources of federal funding, including NOAA, which has recently funded coastal invasive species and restoration projects in California (NOAA 2009).

The Department of Fish and Game Invasive Species Program obtained grants from the ANSTF force for approximately $35,000 in 2008 and 2009 to implement the CAISMP. According to the National Invasive Species Information Center (NISIC) funding for other California invasive species management activities are available through numerous federal and state sources, including the USDA Cooperative State Research Education and Extension Service, ANSTF, National Fish and Wildlife Foundation, University of California (e.g., Statewide Integrated Pest Management Program, Riverside Center for

Invasive Species Research), ISCC, and the Ocean and Coastal Information, Research and Outreach Strategy.

Coordination: Institutional Coordination

Coordination of AIS management programs in California is seen as the responsibility of the DFG and is now one of the mandates of the new ISCC (DFG 2008a, ISCC 2009a,b). The DFG is taking a statewide and regional approach to conservation and now partners with many federal and other organizations to meet conservation goals. Coordination between state agencies (DFG, DFA, SLC, and SWRCB) for coastal AIS management is required by many California laws and regulations. There are state partnerships among certain NGOs, businesses, user groups, and local task forces. Consultation between organizations is often suggested, but is not legally mandated for the majority of actions.

Interstate and state-federal coordination for California is overseen by the NISC, the ANSTF, and the WRPANS. There is a very substantial amount of active invasive species management being done by diverse government and nongovernment organizations, the western United States, and the United States as a whole (Bunn et al. 2005).

Coordination: Councils

To help coordinate invasive species management, a collaborative state agency effort created the Invasive Species Council of California in 2009. The ISCC is intended to lead the coordination of state organizations for a more efficient use of time and money. In addition to the ISCC, statewide coastal AIS management is coordinated by the OPC and the Ocean Science Trust (OST). The OPC, created by the California Ocean Protection Act of 2004, coordinates ocean-related state agencies to improve effective use of funds for ocean conservation. The OST encourages multi-agency, multi-institution coordination for ocean science, management, and policy.

Coordination: Management Plan

In 2008 the California Aquatic Invasive Species Management Plan (CAISMP) was created through a collaborative effort by state agencies, state academic institutions, and the San Francisco Estuary Project. The CAISMP aims to coordinate state programs, create a decision-making structure for AIS management, and promote rapid response programs and data sharing. In total, CAISMP suggests over 160 different management actions and requires their annual evaluation and improvement. The CAISMP incorporates suggestions for AIS management from the WRPANS and the California Noxious and Invasive Weed Management Plan (Schoenig 2005). The CAISMP was drafted in accordance with federal guidelines from ANSTF under the NANPCA of 1990. Therefore, objectives and actions listed in the CAISMP are eligible to receive federal matching funds to achieve the CAISMP objectives. In addition to the CAISMP, it is the intention of the ISCC's Scientific Advisory Panel to draft a statewide management plan broadly addressing all invasive species.

2.5: VECTOR-SPECIFIC CALIFORNIA COASTAL AQUATIC INVASIVE SPECIES LAWS AND REGULATIONS

Through a greater understanding of the weaknesses in current policies, coastal AIS policy can be improved by concentrating on invasion vectors. Management specific to vectors involves identifying the transfer mechanisms and assessing how and when they operate and deliver new organisms (Ruiz and Carlton 2003). Because of a focus on intercepting introductions, vector management is a more effective approach to preventing coastal AIS and is more efficient than managing individual species (ELI 2007). Thorough management of invasive species should focus on prevention of introductions because prevention is sometimes the only line of defense (Nadol 1999). This is best done when regulatory schemes focus on vectors of introduction (Nadol 1999, ISAC 2003a, Carlton and Ruiz 2005).

This section discusses the laws and regulations of the main vectors of California costal aquatic invasions: commercial shipping (ballast water and hull fouling), recreational boating, and trade in live organisms (aquaculture, seafood, bait, and aquarium species and aquatic ornamental plants).

Commercial Shipping

Prevention of coastal AIS introductions via commercial shipping is critical because very few eradication or control methods are available if invasions were to occur through this vector. The vector of commercial shipping includes ballast water and hull fouling. For the purposes of these policies, “Vessels” are ships over 300 gross register tons. “Mid-ocean waters" refers to waters that are more than 200 nautical miles from land and at least 2,000 meters (6,560 feet, 1,093 fathoms) deep. The exclusive economic zone (EEZ) extends from the baseline of the territorial sea of the United States seaward for 200 nautical miles. "Coastal waters” are estuarine and ocean waters within 200 nautical miles of land or less than 2,000 meters deep, and rivers, lakes, or other water bodies navigably connected to the ocean. The greater "Pacific Coast Region" comprises all coastal waters on the Pacific Coast of North America, exclusive of the Gulf of California. California waters are all surface waters, including saline waters, within the boundaries of the state (PRC § 71200, CCR Title 2 § 2270).

Ballast water exchange is the emptying of water in ballast tanks, followed by the intake of surrounding water. Ballast water treatment refers to water treatment technology that treats the ballast water (usually by heat, chlorine, biocides, ultraviolet radiation, microwaves, filtration, or combinations of these tools, Cangelosi 2002, Nazzaro 2005, Boldor 2008) in order to remove possible invasive species.

Commercial Shipping: Ballast Water

The commercial shipping vector of ballast water is managed by the main laws of the Ballast Water Management for Control of Nonindigenous Species Act (BWMCNSA) of 1999, the Marine Invasive Species Act (MISA) of 2003, and the Coastal Ecosystems Protection Act (CEPA) of 2006 (PRC §§ 71204, 71207, 71211, 71216, 71271, 72421,

72423, 72440). The primary enforcement of these acts is given to the SLC to adopt any regulations necessary to implement these acts, and other regulations for ballast water management. The SLC manages California regulations for ballast water through its Marine Invasive Species Program in conjunction with the DFG and the State Water Resources Control Board and cooperates with the USCG for federal compliance.

Through these laws and regulations, California has established one of the most stringent and comprehensive ballast water management programs in the world. California was the first state to pass a mandatory ballast water regulation in 1999 and, over the past 10 years, the Marine Invasive Species Program has regulated ballast water exchange and reporting requirements. After different iterations, the current regulations require that if vessels do not intend to hold their ballast water, they must perform ballast water exchange 200 nautical miles from shore when arriving at a California port from outside of the Pacific Coast Region, or perform ballast water exchange 50 nautical miles from shore if arriving at a California port from within the Pacific Coast Region. Alternatively, vessels may perform ballast water treatment in accordance with the current standards.

Exemptions to these ballast water management requirements are given to vessels of the armed forces or a vessel traversing only the territorial sea of the United States and not entering or departing a United States port or internal waters, and not discharging ballast water (PRC § 71202). In addition, all vessels are exempt if ballast water management would be a safety risk to the vessel and its passengers (PRC § 71203). In the case of a safety exemption, all feasible prevention measures must still be taken, based on the best available and economically feasible technologies, that do not compromise the safety of the vessel (PRC § 71203). Exemptions are also given to vessels operating solely within San Francisco Bay or within the Long Beach/Los Angeles port complex.

In addition to ballast water exchange or retention, all vessels must adhere to the following best practices in order to minimize the uptake and the release of nonnative species: (1) discharge only the minimal amount of ballast water essential for vessel operations while in California waters, (2) minimize the discharge or uptake of ballast water in areas within, or that may directly affect, marine sanctuaries, marine preserves, marine parks, or coral reefs and (3) minimize or avoid uptake of ballast water: areas known to have infestations or populations of nonnative organisms and pathogens, areas near a sewage outfall, areas for which the vessel operator has been informed of the presence of toxic algal blooms, areas where tidal flushing is known to be poor or in turbid waters, in darkness when bottom-dwelling organisms may rise up in the water column, or in areas where sediment has been disturbed (PRC § 71204).

A vessel’s report on ballast water management must be given to the SLC at each California port of call containing detailed information about their ballast water management (PRC § 71205). The vessel operator is required to maintain a log of ballast water exchange for each ballast tank in a ballast water management plan, and make it available to the SLC upon request (PRC § 71204). Records must include: voyage ports of call, ballast water information (capacity, volume, number of ballast water tanks), and ballast water management information (tanks to be discharged or treated, management

plan, safety exemptions if any, origin of ballast, percentage exchanged at sea, expected next discharge) (PRC § 71205).

As of 2006, the SLC is required to adopt performance standards for the discharge of ballast water. The basic requirements for potential AIS in ballast water discharges are: "zero detectable" organisms greater than 50 micrometers, and fewer than 0.01 living organisms per milliliter for organisms between 10-50 micrometers. It is important to note that the California standards are 1,000 times more stringent than the international BWM standards. The SLC has developed a timeline for implementation of these standards that varies based on vessel size (PRC § 71205.3, CCR Title 2 § 2294). Originally, the standards were to be implemented starting in 2009 (PRC § 71205.3, CCR Title 2 § 2295).

The mandate for SLC to develop performance standards by CEPA was intended to spur the development for ballast water treatment technology that kills living organisms before the ballast water is discharged. Grants are available to system developers to fund the installation and testing of ballast water treatment systems (M. Falkner, personal communication). The SLC sponsors programs to evaluate treatment technologies for their efficacy, availability, and environmental impacts. Guidelines for evaluation have been developed by SLC with guidance from the EPA (Dobroski et al. 2009). Findings from this process and information on new treatment systems are to be publicly reported by the SLC (PRC § 71210). In addition, the SLC is required to submit a report to the California State Legislature on the efficacy, availability, and environmental impacts of currently available treatment systems (PRC § 71212). Because there were no treatment systems able to meet the California performance standards in 2007, the implementation of standards in legislation was pushed back from 2009 to 2010 (Falkner et al. 2007, Dobroski et al. 2009). As of 2009, two commercially available systems were likely to meet the California standards. Therefore, the implementation date for compliance with ballast water performance standards for newly constructed vessels with ballast water capacities less than 5,000 metric tons was January 2010.

To enforce current regulations and the impending implementation of performance standards, the SLC, in coordination with the USCG, must take samples of ballast water and sediment from at least 25 percent of vessels (PRC § 71206). The SLC marine safety inspectors conduct tests of ballast water tanks on board vessels and plans to start requiring vessels to report on their use of ballast water treatment systems. That information can help the SLC to make recommendations for testing ballast water (Dobroski et al. 2009).

Enforcement and funding for ballast water management is provided through fees and penalties. Each ship entering California ports from outside of the EEZ is required to pay an $850 adjustable fee per voyage (PRC § 71215, CCR Title 2 § 2271). Noncompliance with ballast water regulations results in civil penalties, fees, and a misdemeanor, and can require that the vessel depart California's waters to legally manage ballast water (PRC §§ 71207, 71216). Fees collected by the Marine Invasive Species Program are deposited into the Marine Invasive Species Control Fund and the Marine Invasive Species Fee Collection Law. Therefore, funds collected from vessel operators enters into a fund that

continues to pay for ballast water management and the usage of funds is reported to vessel operators (Faulker et al. 2009).

The biennial SLC report to the Legislature is required to include information about the rate of compliance (PRC § 71212). There is currently a very high rate of compliance achieved because the large majority (86 percent) of vessels discharge their ballast water. A majority of noncompliant vessels, those that exchanged in the wrong location or did not exchange at all, originate from the Baja Peninsula, central Mexico, Northern California, Southern Oregon, Central California, and San Francisco Bay. The SLC continues to research these patterns for risk management (Takata 2009).

Ballast water legislation also directs scientific research in coastal ecosystems. Scientific assessment of ballast water management is carried out by the DFG through research that compares the status and establishment of nonnative species populations through ecological surveys. The DFG conducts yearly monitoring of nonnative species populations in the coastal waters. The information is used to identify ballast water discharge zones, environmentally sensitive areas to be avoided, the long-term effectiveness of discharge control measures, potential risk zones and the rate and risk of establishment of nonnative species in the coastal waters of the state and the resulting impacts. DFG findings are made publicly available and are reported to the California State Legislature (PRC § 71211).

Education and outreach to prevent the introduction of AIS through ballast water was carried out by the Stop Ballast Water Invasions awareness campaign by the University of California Agriculture and Natural Resources West Coast Ballast Outreach Project, until December 2008, when it was put under a bond freeze due to California's budget crisis.[*]

Commercial Shipping: Hull Fouling

Hull husbandry is primarily used by vessel operators to improve the efficiency of their ships. Clean hulls move through the water more smoothly than hulls fouled with marine organisms and thus use less fuel. Statutes on ballast water management also contain regulations for hull fouling, but these are less extensive than ballast water measures.

As of 2007, removal of hull-fouling organisms from the submerged portions of ships must be performed at defined intervals (PRC § 71204). This process may require dry-docking or in-water cleaning. Vessel operators must maintain records of this process and provide SLC with the following information: voyage ports of call, dry-docking, in-water cleaning, and use of antifouling paints (PRC § 71205). In a forthcoming report, the SLC reports that "nearly the entire fleet (99.2%) has been either dry docked (and cleaned and treated with an antifouling coating) or delivered as new within the past five years" (Takata, et al. 2011, 76). In the meantime, the SLC supports research to reduce hull fouling. Current research is focusing on shipping traffic patterns, the extent of hull fouling and hull-management practices, and the viability of AIS that commonly attach to vessel hulls (M. Falker, personal communication).

[*] See http://ballast-outreach-uscgep.ucdavis.edu.

Ship owners use anti-fouling paints to prevent the attachment of fouling species. Some paints have been found to contaminate waters, such as the chemical tributyltin (commonly known as TBT). Copper is an alternative, but less effective (Dyer 2009) and also leaches into the water (L. Fernandez and L.T. Johnson, personal communications). The SLC found that 98.5 percent of vessels in the California commercial fleet had been cleaned and treated with biocide during 2003-2008 (C. Scianni, personal communication). Research and development to find effective anti-fouling paints is under way (J. Berge, personal communication).

The SLC continues to support research to reduce hull fouling. Current research is focusing on shipping traffic patterns, the extent of hull fouling and hull management practices, and the viability of AIS that commonly attach to vessel hulls (M. L. Falker, personal communication).

Recreational Boating

Recreational boating is believed to be a primary vector of invasive species as boats travel into California and among California ports. Invasive species can be transported on hulls, ropes, anchors, chains, and other areas of a boat (DFG 2008a, Fernandez and Johnson 2009).

The DBW regulates vessels operating in coastal waters weighing more than 300 gross register tons. This weight limit excludes recreational boaters and lighter vehicles. State laws on AIS do not apply to recreational boating. Although California has no formal policy addressing recreational boating as a vector of coastal AIS, under the authority of the Clean Water Act, the EPA could be directed to develop regulation to extend prevention measures to this important vector (Wickman 2007).

The DBW California Clean Boating Network, a collaboration between government, business, academic institutions, and recreational boaters, works to improve clean boating education across the state. The effectiveness of this program for coastal recreational boaters is unknown. Sea Grant has an educational program for coastal recreational boaters on anti-fouling paints and nontoxic alternatives. Their program has significantly influenced the behavior of some recreational boaters by promoting awareness of control methods. Sea Grant has shown that many recreational boats travel between Southern California and Baja California, and between San Francisco Bay and the San Joaquin Delta. However, nearly half of recreational boats rarely leave their marinas. These pose no significant risk of transporting coastal AIS (Fernandez and Johnson 2009).

Trade in Live Organisms

The trade in live organisms is diverse in California and includes subsistence and hobby industries. These trades must adhere to state regulations for the importation and sale of prohibited species (see Sect. 2.4). While many species are listed as prohibited, businesses can petition for exemptions from the DFG and receive a restricted animal permit. Yet the permit process does not cover all species that can become coastal AIS, or prevent their illegal importation.

The DFG has the authority to prohibit the possession of any species of fish that it considers a potential threat to California fisheries (FGC § 8462). The department also has the right to inspect all imported live aquatic plants and animals (CCR Title 14 § 236). General restrictions of imports and sales such as these apply to businesses conducting site-based, mail-order catalog, or Internet website transactions in California, other than the hobby aquarium or pet trade.

Trade in Live Organisms: Aquaculture

The aquaculture industry in California is regulated for the type of species that can be imported and used, the location of the facility, and disease and accidental escape management strategies. These laws apply to commercial aquaculture facilities that maintain species for human consumption or bait purposes (FGC § 15006). The industry is highly regulated for disease control. Many policies originally intended for disease control also address aquaculture as a vector of AIS. Aquaculture facilities also must comply with water quality requirements imposed by the SRWCB, and CCCA (Silvas and Caldwell 2008). Facilities also must obtain permits and those permits can be revoked for violations.

Aquaculture facilities are authorized to stock any native species and harvest wild aquatic plants, invertebrates, and fish (FGC § 15202). However, these wild harvest species require DFG inspection, separate holding facilities, identifiable markings, and cannot not be sold, bartered or traded without permission from the DFG (CCR Title 14 §§ 238, 240). Ocean facilities are not allowed to cultivate salmon species, transgenic finfish species, or certain exotic species of finfish (FGC § 15007). Permits can be obtained from the DFG to allow for the importation and farming of aquatic nonnative species that otherwise are restricted (FGC § 2150, CCR Title 14 § 671.7). These imports are subject to approval by the DFG (FGC §§ 15600, 15602, 15604, 15605, CCR Title 14 § 238).

The DFG restricts the locations where aquaculture facilities can be located (FGC § 15102). In general, aquaculture products may not be stocked directly into California waters (CCR Title 14 § 238). Fish cannot be stocked in an area if doing so is contrary to the fisheries management programs, or in any area where fish might escape to other areas where such species are not already present (CCR Title 14 § 238.5).

Aquaculture facilities are regulated by DFG to prevent the escape of farmed species and their establishment in the surrounding marine habitat. These facilities cannot stock fish in any waters where they might escape if they are not already established in those waters (CCR Title 14 § 238). A CEQA environmental impact statement for any coastal aquaculture facility must consider the possible effects of escaped fish on native marine species and habitats, as well as how to manage such an event (FGC § 15008). Each aquaculture facility must establish best management practices with regular monitoring, reporting, and site inspection for disease, escape, and environmental stewardship. However, facilities using marine water for artificial inlets and outlets do not require screens to prevent the entry or escape of aquatic plants or animals (CCR Title 14 § 235.1). In the case of escape or damage to the environment, subsequent restoration is the responsibility of facility owners (FGC § 15409).

In the event of more than minimal escape, the number of escaped fish and the circumstances surrounding the incident are to be reported immediately to the Fish and Game Commission (FGC § 15400). The aquaculture operation can be terminated by the DFG if the operation has damaged or is damaging the marine habitat. If the DFG decides an aquaculture operation is detrimental to native wildlife, it can shut down the operation (FGC §§ 15101, 15102, CCR Title 14 § 235).

Regulation of the aquaculture industry includes attention to disease control. It is illegal to stock or import species that are parasitized or diseased by unapproved pathogens (CCR Title 14 §§ 238, 238.5, 245). The DFG can inspect for disease at any other time (FGC §§ 1174, 15501, CCR Title 14 §§ 237, 238.5). If aquatic plants or animals are destroyed because of disease, the permittee will be reimbursed a portion the replacement value for diseased fish that had to be destroyed (FGC § 15512). If diseased fish, parasitized fish, or fish of an unauthorized species are found, they must be disposed of by the permittee; the permittee may be required to pay for disease eradication and the aquaculture permit may be revoked (FGC § 15516, CCR Title 14 §§ 236, 238). The DFG is given authority to establish quarantine areas and restrict movement of infected aquaculture stocks (FGC §§ 15505, 15509).

Trade in Live Organisms: Live Seafood

The live seafood trade is allowed to import live mollusks and crustaceans, but it is unknown which species are already for sale in California, which are being imported, and which may be contaminating packaging (DFG 2008a, E. Grosholz, personal communication). Authority to manage the trade in live seafood is geared mainly towards the prevention of disease spread. There are no regulations targeting this trade as a vector of AIS. However, live seafood may not be placed into the waters of the state or waters that discharge to waters of the state (FGC § 6400, CCR Title 14 § 236). Regulations can be enforced by inspections of seafood distributors. The existing black market of live seafood undermines the effectiveness of enforcement efforts (DFG 2008a).

Trade in Live Organisms: Live Bait

California currently seeks to prevent intentional and unintentional release of coastal AIS through live bait by regulating the culture, harvest, importation and sale of fish species sold as bait. But it is unknown how many bait dealers are active in California, which species are imported and sold, and how unwanted bait and packaging material is disposed (DFG 2008a, E. Grosholz, personal communication). Thus it is unclear if existing management strategies are effective.

Trade in Live Organisms: Aquarium Species and Aquatic Ornamental Plants

Trade in live aquatic animals and plants takes place via hundreds of aquarium stores, pet stores, nurseries, biology supply companies, and mail order and Internet businesses. Research facilities and public aquaria also maintain and transport aquarium species.

The aquatic pet species available for sale in California are regulated by the DFG general list of prohibited species and through a list of restricted species collected from the wild

and prohibited from marine aquarium pet trade. For example, DFG regulations specifically restrict the importation and sale of *Caulerpa* species (FGC §§ 8597, 8598). Proposals to increase import restrictions through legislation has been unsuccessful in the past because of the lobbying power from trade associations. These trade groups also have coordinated the distribution education and outreach materials for the prevention of invasive species introductions. The national Habitattitude education campaign of the Pet Industry Joint Advisory Council, and several federal agencies, is intended to prevent the release of unwanted aquatic pets.[*]

Aside from the general DFG listing, the state has no restrictions on nonnative or invasive live ornamental tropical marine animals intended for personal, pet industry or hobby purposes as long as those animals are maintained in closed systems and not placed in state waters (CCR Title 14 § 236). Any sale of live aquatic products at aquarium and aquatic ornamental plant nurseries may not be released into California waters either. (CCR Title 14 § 237).

Research facilities and public aquaria are subject to many of the same policies as the commercial live organism ventures. Facilities that use open seawater systems that intake and discharge seawater for the maintenance of nonnative species must monitor the water quality to ensure that they do not release any nonnative species into the ocean. However, the state does not mandate guidelines for wastewater discharge, or disposal of unwanted organisms (DFG 2008a). Some facilities, such as the Monterey Bay Aquarium, voluntarily monitor water quality in conjunction with the SWRCB and the DFG (R. Phillips, personal communication).

Conclusion of California Policy

At present, the risks posed by invasive species are addressed by a collection of policies with imperfect implementation and efficacy (ELI 2004a). Because international, federal, and state policies are numerous and lack coordination, California's coast remains at risk from AIS. As with federal policies, California's approaches have gaps, inconsistencies, and redundancies. Without a comprehensive, integrated state strategy that addresses invasive species in a proactive and comprehensive manner, a pattern of reactive government action has left scores of overlapping, disjointed legal authorities. To keep pace with the rate of invasive species introductions, experts have suggested that California's policies must establish a legal framework around prevention, control, coordination, and funding (Bunn et al. 2005).

In general, existing policies are broad, often with vague interpretation and limited enforcement. The suite of existing polices includes numerous minor provisions that result in fragmented authority. Miller and Fabian (2004) refer to this as "the paradox of invasive species law" – the abundance and, at the same time, essential absence of legal authority. Given that California needs to protect its rich coastal resources, strengthening invasive species policy is a necessary step and an opportunity for improvement.

[*] See http://www.habitattitude.net/.

Chapter 3: Policy Gaps and Options

3.1: Introduction and Methods

In an attempt to complement international and federal policy and to fulfill its unique policy needs, California has put in place several strategies to manage AIS. While California's efforts are both wide reaching and extensively praised by experts, gaps remain in the state's approach to invasive species policy. State policy is incomplete because it has yet to achieve a comprehensive prevention and management approach to coastal AIS (Nadol 1999). Supporters of policy reform cite gaps, inconsistencies, and redundancies in governing statutes and point out opportunities to improve coordination and efficiency. New legislation can fill those policy gaps. The state also must address how to best manage policies and programs to reduce the risks and costs of AIS.

This report presents options for improving coastal invasive species management. The focus of this report is on how existing and new legal authorities can be interpreted, amended, or applied to better address California's coastal AIS. This chapter identifies gaps, inconsistencies, and overlaps/redundancies in current policies that undermine statewide prevention and control of AIS in coastal ecosystems. The policy options described here are not new. Many appear in the CAISMP, in previously proposed policies, or in case studies from other regions facing similar challenges. Lessons learned from elsewhere can help guide California's effort to improve outcomes.

The federal ISAC recommends that effective invasive species policy include an assessment of current conditions against a measure of success (ISAC 2000) that relies on knowing the rate of invasions before and after policy implementation. Only then is it possible to attribute successful management to specific invasive species policies (Costello et al. 2007). In addition, ISAC recommends that a policy assessment include a vision, and principles and values to inform goals to be achieved. For example, vision and value statements can relate to the preservation of natural ecosystems while still sustaining economic growth and recreation with a measureable metric for invasive species presence, native species and ecosystems, and industrial growth. Currently, many of these key values and measureable objectives of invasive species law and policy have yet to be determined and agreed-upon.

There are numerous suggestions as to how invasive policy can be improved. The majority of these proposals focus on federal policy (ISAC 2000, Gorjanc 2004, Lodge et al. 2006, Box 3.1). Less attention has been paid to the states or California and specifically aquatic invasive species (for exceptions see Nadol 1999, ELI 2004a,b).

Methods to identify gaps, inconsistencies, and redundancies

Effective policy reform benefits from a clear and agreed upon understanding of the challenges to be addressed (Costello et al. 2007). One method to identify challenges is to

Box 3.1: Recommendations to the United States federal government for improving invasive species policy and management.

A) National Invasive Species Advisory Council, Policy and Regulation Working Group (NISC 2000)

A statement of general governing principles regarding invasive species enacted into statutory law recognizing the impacts of invasive species on human and economic activities, human and animal health, biodiversity, and natural and cultural resources.

Unification or harmonization of federal law and policy regarding invasive species issues, including definitions of critical terms.

Apply adaptive management principles of goal articulation, stakeholder involvement, continued data collection, and periodic reevaluations and revision.

Agencies should cooperate with local governments and stakeholders in the detection, control and eradication of invasive species.

Increase flexibility for local control of invasive species where local law is preempted.

Clear statutory authority enacted to support a systematic, effective and efficient clearance process for risk evaluation prior to approval of importation for all intentional introductions.

Under clear statutory authority, agencies should conduct science-based setting of priorities among all pathways based on risk, adopt effective and efficient methods and mechanisms to minimize risk of introductions, and establish a system to detect new introductions and new or changed pathways, and to respond appropriately.

Fully assess the threat from Internet sales and enacted law or policy immediately.

Establish systems to enable the federal government to more easily work with one or more states on specific invasive species problems.

Set safe minimum standards.

Congress should allow state officials to enforce lists of prohibited species in state court.

Enact new statutory authority to support and mandate early detection and rapid response to new invasions. Develop minimum processes and funding for early identification of, and rapid response to, invasions. The system should incorporate local, state or regional priorities into the response to invasions. Require use of the best available technologies in response to new and established invasions.

International cooperative efforts should be encouraged in response to widespread invasions. Designate an agency with the principle responsibility for assessing the collective and cumulative effects of control measures of invasive species to minimize those effects.

Where multiple agencies have authority, allocate responsibility to a lead agency with authorization and funding for resolving conflicts.

Policy or requirement for the development and maintenance of a sound and usable inventory of invasive species used for planning and setting priorities. Encourage and support efforts within and outside of the government. Regularly update lists in a transparent manner, make them readily accessible to the public, and link them to international databases. Publish biannual reports on the "state of nonnative species," including assessment of the impacts and effects of invasive species on the environment, agriculture, the economy, and human and animal health.

Expand and coordinate a public campaign regarding invasive species and assess the effectiveness and efficiency of education efforts.

Box 3.1 Recommendations to the United States federal government for improving invasive species policy and management. (cont.)

Expand user fees, especially in situations where the primary benefits of particular invasive species polices accrue to identifiable stakeholders. Calibrate user fees to reflect benefits and risks. Develop positive incentives, through direct support, tax incentives, or through other mechanisms. Authorize levels of expenditure for existing invasive species programs.

Support the use of native species through law and policy, including the development of markets for native species. Limit the use of nonnative invasive species by a screening or risk assessment.

B) Ecological Society of America (Lodge et al. 2006)

Use new information, technologies and best management practices to manage vectors to reduce the transport and release of potentially invasive species. Apply new cost-effective technologies now used for detection of transportation-related terrorist threats (i.e., microarrays, gene probes, and remote sensing) to nonnative species and more cost-effective ways to manage ballast water (i.e., prevent initial infection; remove or kill the entrained organisms before de-ballasting).

Agencies need to maintain and make available data on intercepted species

Educate consumers to understand that they are the proximate pathway of commercial introductions. An easy-to-understand message should accompany every purchase of a live organism. Have a cooperative effort between the industry, scientists, and government for all hobby trades. Industry should sponsor programs that fund risk assessments by authorized, independent organizations in order to certify that species for sale are not likely to be invasive. Partners should accept the results by removing those species for sale or removing them from areas where they are likely to be a problem.

Increase government oversight for species used as live or at least restricted to areas where they can be recollected. Manage live bait to prevent pathogen introduction.

Adopt quantitative procedures for risk analysis and apply them to every species proposed for importation into the country. The federal government (APHIS and the ANSTF) should approach this using the rigorous criteria involving peer-review, transparency, repeatability, specified uncertainties, and quantitative output whenever possible. Screening protocols must be adopted for all proposed new intros into the country so that no species is allowed entry unless the risk of invasiveness of it and its potential parasites is acceptably low.

Use new cost-effective diagnostic technologies to increase active surveillance and sharing of information about invasive species so that responses to new invasions can be more rapid and effective. Monitoring needs to be concentrated at points of entry like airport and seaports and where there is high human density or visitation.

Create new legal authority and provide emergency funding to support rapid responses to emerging invasions. Provide for a “categorical exclusion” for management of newly discovered potentially invasive species on federal lands. Provide for expedited review of rapid response to invasive species either through rule making or congressional action. All of these changes should happen through a process of broad stakeholder and scientific review of eradication and control plans and systematic monitoring and management efforts.

Provide funding and incentives for programs to slow the spread of existing invasions to protect yet uninvaded systems, social and industrial infrastructure and human welfare.

Under an invasive species council, establish a center for invasive species management to coordinate and lead improvement in federal, state, and international policies on invasive species.

compare current legislation to a model framework or to seek best practices. Several policy frameworks have been suggested, but there is no consensus on an optimal invasive species policy (ISAC 2000, Gren 2008, M. Miller, personal communication). ISAC suggests that a proper policy analysis is not feasible because there is no existing ideal policy in theory (e.g., a clear statement of principles and goals) or in practice (e.g., a comprehensive effort to evaluate federal invasive species law and policy) (ISAC 2000, Gren 2008).

Box 3.2: Three invasive species policy frameworks used to guide the policy review of this report.

A) United Nations Environmental Programme (UNEP 2000)

General: Precautionary approach, 3-tiered hierarchy approach (prevention > eradication > control), ecosystem approach, recognize each state as a provider of potential invasive species, research and monitoring, education and public awareness

Prevention: Border control and quarantine (authority, risk assessment), exchange of information between states, cooperation and capacity building between states

Introduction of species: Authority for intentional introductions (risk assessments), regulations to minimize unintentional introductions

Mitigation of Impacts: Cost-effective, safe to the environment, humans, and agriculture, culturally and ethically responsible, eradication (early-detection-rapid response), containment (monitor borders), control

B) International Union for the Conservation of Nature (Shine et al. 2000)

Understanding and Awareness: Information and communication with stakeholders, public education

Prevention and Introductions: Manage pathways, industry best management practices, quarantine and border control, penalties and compliance, risk assessment, rapid response, emergency powers

Eradication and Control: Authority, emergency resources, prioritization strategy

Re-introductions: Restoration of native species

Knowledge and research; Database, black-list

Laws and Institutions: National strategies and plans, authority, legislation for control of introductions, legislation for remediation

C) Environmental Law Institute (ELI 2004b)

Regulation: A statewide comprehensive piece of legislation

Control and Management: General control and management authority, emergency power, biological controls, restoration

Enforcement and Implementation: Enforcement authorities (including administrative and criminal penalties), funding (including dedicated funding sources)

Coordination: Invasive species council, Invasive species management plan

Funding: General source

Three of the most thorough frameworks for invasive species policy are available from the United Nations Environmental Programme (UNEP) Convention on Biological Diversity CBD (UNEP 2000), the International Union for the Conservation of Nature (Shine et al. 2000), and the Environmental Law Institute (ELI 2004b) (Box 3.2). The UNEP and IUCN frameworks are for international and federal jurisdictions and the ELI report is intended for state policy. Each of these comprehensive frameworks can help California to understand its available policy options. Similarities between the three frameworks include required decision-making protocols, prevention and control of invasions by early detection and rapid response programs, coordination of efforts and information, and restoration. Authors of the three model frameworks also acknowledge that the policies contain shortcomings and are not appropriate for all invasion scenarios. Indeed, the authors of most policy frameworks include discussions of their shortcomings. None of these frameworks, therefore, meet the criteria of being ideal for a strict policy analysis, especially for the purposes of analyzing state policy for coastal estuarine and marine habitats.

This report identified weaknesses in California's invasive species policy by using a multi-pronged analysis of published policy frameworks, scientific literature, newly developed databases and software, as well as discussions with numerous California invasive species experts. With each policy framework as a guide, an evaluative approach was developed based on California's existing policy structure. Attributes of each framework were combined with other missing criteria (i.e., a general goal and mission statement), and analyzed in the context of other factors (e.g., unique cultural aspects of California). This strategy provided a coherent backdrop for identifying gaps and developing options of each broad policy tool, as well as each coastal vector of introduction.

Guidance for this gap analysis came from the Management Identifying the Needs of Ocean Ecosystems (MINOE) software (Ekstrom 2009). The MINOE software program was designed to highlight gaps in coastal environmental policies for federal policies and the policies of states along the Pacific Ocean.

This work also included review of relevant published literature for guidance, such as the invasive species policy analysis questions posed by Batabyal (2007) and Gren (2008) (Box 3.3).

Policy gaps were also identified by examining bills that were proposed, but not enacted into law. This approach was used to understand how previously proposed changes were received and evaluated. Many policy and management weaknesses were identified during conversations with a wide range of the professionals and stakeholders who work on coastal AIS in California. Informal interviews were conducted with representatives from federal and state government agencies, non-government organizations, universities, as well as commercial and trade industries. These experts were asked to identify weaknesses in California's policy and management strategies for invasive species along the coast.

Take note that this listing of policy gaps may not be comprehensive.

Box 3.3: General questions (Batabyal 2007) and criteria (Gren 2008) considered in this review of invasive species policies in California.

When analyzing a biological invasion, is it more appropriate to focus on the likelihood or magnitude of the event?

Does the policy have precision and flexibility, such that actions are as close to the target as possible, while being flexible enough to give the opportunity of changing targets if found necessary in an environmental perspective (adaptive management)?

Are the policy enforcement and transaction costs as low as possible, including the costs of administrating the instrument and enforcing compliance?

Is the policy's cost effectiveness with determined targets at minimum costs in the short and long run so that it stimulates technological development?

Does the policy have equity and fairness, with equal relative cost burdens among the partners? Does the policy adopt the polluter pays principle?

What are some reasonable measures of the trade related risk from invasive species? How useful is strategic trade policy as an invasive species management tool?

When should the economic value of imports grant preferential treatment during the inspection process to a company?

When can one justify a trade ban as an effective regulatory policy?

Methods to identify options for strengthening policy

To identify policies, prior research and policy discussions, this work relied on database searches using multiple library and Internet sources, such as the Web of Science and LexusNexus. Search terms included variations of "invasive species policy," as well as each of the seven vectors. Guided searches also targeted: (1) the policies of other coastal states and countries (e.g., Maine, Florida, Australia, New Zealand) known for progressive strategies that could be implemented in California, (2) policies for addressing other types of emergencies, and (3) best management in other industries. Best management practices are given great weight by some industries as alternatives to regulations. International, federal, and regional management of invasive species are thought of as ideal in many respects, but this analysis focused on solely on coastal AIS in California and the development of a statewide policy framework. California's policy approach to managing costal invasions is similar to the approach of the federal government, thus many of the policy options identified here originate from research targeting gaps in federal policy.

Many options were revealed through conversations with experts representing a range of stakeholders working on coastal AIS. Informal interviews were conducted with representatives from federal and California state agencies, non-government organizations, academic universities, and industries. These experts were asked to identify options to fortify California's response to invasive species along the coast.

While accessing the policy options presented here, policymakers must recognize the option of not changing current strategies. It is also important to recognize that California is a recipient and an exporter of invasive species; some strategies intended to limit AIS may also impact the extent that species from California invade environments elsewhere.

For clarity of presentation in this report, options are presented to improve California's approach by policy category and then by vector.

3.2: Policy Gaps and Options for General California Aquatic Invasive Species Policy Categories

General weaknesses: goals and terminology

Gaps

As previously stated, California currently does not have a statement of its general values related to invasive species, nor does it have a strong vision of what it hopes to achieve through existing strategies for invasive species management. There is presently no shared, central goal for the management of invasive species, or measureable benchmarks to indicate what is being accomplished. Without a predetermined target for control measures, the estimates of damages and effectiveness of control strategies can be flawed (ISAC 2000, Windle 2005a, Gren 2008).

Experts have recommended a policy devoted to invasive species with clear criteria for creating, administering, and enforcing coastal AIS management, yet state policy lacks consistency in the terminology used to refer to nonnative and invasive species (Silvas and Caldwell 2008, S. Ellis, personal communication). Moreover, coastal AIS is not clearly defined in California policy, nor is there a definition that clearly delineates the coastal ecosystem for legal interpretation. The DFG, with large oversight over coastal AIS management California, lacks a guiding definition of invasive species in the FGC. Similarly, differing definitions for nonnative and invasive species are used in international, federal, and state policies (Box 3.4).

The meanings of "nonnative" and "invasive" lack agreed upon scientific definitions because interpretations change over time as we understand more about the origin, spread, and impacts of these species (Davis 2009). What makes a species native or nonnative often depends upon an ecosystem, not an established jurisdictional boundary. Given the constraints for interpreting ecosystems in policy, definitions of nonnative species tend to either use political boundaries or to leave the interpretation of nonnative up to the governing agency. The legal definition of "invasive" often requires that the species be nonnative and cause "harm" to an economic, natural, or societal resource. Definitions such as these lack clarity and are left open to value-laden interpretations (Whalin 1998, Davis 2009). Another weakness of current invasive species definitions is that they routinely claim to refer to all types of taxa (including insects, bacteria, and viruses), but management of invasive species rarely applies to microscopic species despite examples of these taxa as harmful invaders (i.e., viral hemorrhagic septicemia).

Box 3.4: Examples of definitions applied to aquatic nonnative and invasive species by various policies and institutions.

"Nonnative Species"

Marine Invasive Species Act, 2003: "the seeds, eggs, spores, or other biological material capable of reproducing that species, or any other viable biological material that enters an ecosystem beyond its historic range, including any of those organisms transferred from one country into another."

California Aquatic Invasive Species Management Plan (DFG 2008a): "species that enter an ecosystem beyond historic geographic range."

"Invasive Species"

Nonindigenous Aquatic Nuisance Prevention Control Act, 1990: nonnative 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."

Executive Order 13112, 1999: "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."

International Union for the Conservation of Nature (Shine et al. 2000): species that "become established in natural or semi-natural ecosystems or habitat, that is an agent of change and threatens native biological diversity."

California Food and Agricultural Code (FAC 5260.5): "animals, plants, insects, and plant and animal diseases or groups of those animals, plants, insects, and plant and animal diseases, including seeds, eggs, spores, or other matter capable of propagation, where introduction into California would or would likely cause economic or environmental harm.

Lack of a clear and consistent definition of invasive species, or aquatic or coastal invasive species, affects how the state manages its response. Jurisdictional definitions determine the application of each law; thus, inconsistent definitions can thwart interjurisdictional coordination (ELI 2004a, DFG 2008a, S. Ellis, personal communication). Depending on the phrase or definition in practice, different statutory codes, management tools, and enforcement options apply. In addition, definitions for nonnative and invasive species often guide how research is performed; datasets that are based on varying definitions are liable to be incompatible (Crall et al. 2006). The need for clear and standardized definitions for nonnative and invasive species has been recognized by the CAISMP (DFG 2008a).

There is no right definition of a nonnative or invasive species (Davis 2009). Nonetheless, comprehensive management of invasive species would benefit from a clear, scientific, and measurable definition (ELI 2004a).

Options

A measureable goal for the management of coastal AIS can be adapted from invasive species definitions and management objectives, such as those included in Executive Order 13112. The state could focus a statement on the coastal ecosystem and incorporate a main goal, such as the desire to maintain the preservation of the natural ecosystem while allowing for industrial prosperity and public recreation. In order to be measureable,

the statement could include: the acceptable levels of risk for new introductions occurring, the acceptable level of risk that intentional introductions or present nonnative species will become invasive, and the acceptable level of risk that ongoing invasions will spread further or cause harmful effects.

This statement would not only recognize California's environmental values, but give direction and unity to the wide set of stakeholders working in California on this shared issue. In addition, a statement of intent would serve to bring needed clarity to currently inconsistent policies (Windle 2005a). However, it should be noted that in order for California to establish certain measureable long-term goals, the gap in data and research would need to be filled (GAO 2002).

More authority is given to a goal statement when enacted into statutory law by the California State Legislature. Options for formalization include attaching this statement to the ISCC as part of their mission statement or, if the ISCC is to become authorized, as part of its authority statement. In addition, state agencies such as the DFG could put such a statement into their policies.

By committing to one invasive species definition, terminology for nonnative and invasive species can be given greater consistency for legal use in California's management of invasive species. Broad definitions have the advantage of allowing possible future application to invasions of unforeseen species from unforeseen origins and vectors. The guiding definition can be taken from existing state or federal definitions to help coordination and to unify statewide invasive species policies. For guidance on invasive species definitions, the Invasive Species Definition Clarification and Guidance White Paper by the NISC can be used as reference (ISAC 2006). The ISCC and the CISAC, if given authority, could adopt an over-riding definition that would pertain to all California state agencies. A standard definition could be created and distributed to all jurisdictions (DFG 2008a, Beck et al. 2008).

Authority

Gaps

The California approach to invasive species is not authorized by one, overarching law that covers the full spectrum of invasive species including coastal AIS. A large set of disjointed policies and procedures concerning invasive species exists, but California lacks a coordinated and effective program (Bunn et al. 2005). Regulators must use a series of laws that address different portions of this large, and growing, issue. (ELI 2004a).

Due to a fragmented legal framework, each state agency involved in the invasive species issue could be seen as having full authority over coastal invasive species (ELI 2004a). In practice, California agencies fulfill traditional roles and manage invasive species of a certain species group (e.g., plants) or geographic range (e.g., the coastal ecosystem).

The weakness of this policy approach leaves certain aspects of the invasive species managed in a redundant manner while others are undermanaged. Existing legislation for

the DFG is often more applicable to terrestrial and freshwater habitats rather than the coastal estuarine and marine habitats (E. Grosholz, personal communication).

Options

A comprehensive California approach to AIS would be improved by examining how California now manages the terrestrial invasive species that threaten its agriculture. The DFA has a comprehensive program and policy framework to manage terrestrial species with early detection monitoring, emergency eradication, enforcement, and funding (Bunn et al. 2005).

Building upon the structure of the DFA's terrestrial invasive species programs, policymakers could consider directing the California Natural Resources Agency to draft a comprehensive AIS response plan which would reflect California's holistic ecosystem (ELI 2004b, Brown 2006). Moreover, a general invasive species law may better protect California against future invasion pathways rather than individual policies for each pathway.

A comprehensive law could be informed by efforts in other countries such as Australia and New Zealand, recognized leaders in this area (Doelle et al. 2007, Williams and Grosholz 2008). Australia's main authority is the Commonwealth Environment Protection and Biodiversity Conservation Act of 1999, which is intended to reduce the introduction of nonnative species into marine habitats and to manage new and existing invasions. Australia also has a national system for the management of marine invasive species through its Quarantine Act of 1908. In general, Australian coastal AIS management operates on three tiers: prevention to reduce the risk of coastal AIS, emergency management to prepare for and respond to new introductions, and ongoing management and control of existing coastal AIS. New Zealand has enacted the Biosecurity Act of 1993 and the Hazardous Substances and New Organisms Act of 1996, rules that offer strict protection against the introduction of invasive species and potentially invasive nonnative species (Miller and Fabian 2004).

State resources for a comprehensive invasive species policy include a model invasive species state law by the ELI and the recent Oregon Aquatic Invasive Species Prevention Program (ELI 2004b). Some invasive species managers, however, have pointed out that a single piece of legislation may not adequately address all possible management situations and may be insufficient to address specific concerns, such as coastal AIS (Hill 2003). California, therefore, could draft a state law following this same model, or a comprehensive law could be drafted that applied solely to management of coastal aquatic invasive species, the coastal ecosystem, or aquatic invasive species. A comprehensive policy for coastal AIS could be drafted by a council, such as the OPC or the ISCC.

Prevention

California is not unique in the limited success of its prevention efforts. The historical approach to invasive species is the reactive mitigation of impacts. Scattered laws and regulations pertain to prevention, but do not provide clear authority to prevent invasions

from the numerous introduction pathways. There is no California authority for the broad prevention of invasions. In general, the need to formally prove that a species is highly invasive and damaging prevents California from deploying many cost-effective prevention strategies. Gaps in prevention are evident in the current progress and efficiency of risk assessment development, early detection, import restrictions, release requirements, and education and outreach.

Prevention: Risk Assessment Development

Gaps

California does not currently use formal risk assessments to inform species management efforts, which creates a weaker decision-making process. Ill-informed management decisions can lead to inadequate and ineffective prevention and eradication efforts (Williams and Grosholz 2008). Efficient management requires agencies to determine which species should be approached with rapid response, control and containment, or with no management at all (DFG 2008a). Ideally, well-informed management decisions would be made based on the utility of the activity, the availability of alternative methods, and the cost of implementation (Doelle et al. 2007).

Management decisions and use of risk assessments are currently at the discretion of state agencies. Available management tools, prioritization, and decision-making are left to the scientific expertise available to state agencies. Without a formalized decision-making process however, management decisions are often based on institutional mission or capacity rather than the relative risk posed by an invasion (Hulme et al. 2008).

State agencies currently recognize the need for a structured set of criteria to prioritize and guide management decisions and ask the following questions (Meliane and Hewitt 2005, Anderson 2007, S. Ellis and J. Horenstein, personal communications):

- Can a particular invasive species be eradicated?
- When is eradication preferable to control?
- What determines an emergency situation?
- Should access be allowed to the eradication site?
- Should research be conducted before eradication?
- How will success be measured?
- Which invasions deserve priority attention and limited funds?

California lacks a structured way to conduct risk assessments that analyze the magnitude of pathway, the survivability of organisms in transit, the likelihood of pathways to introduce organisms, environmental compatibility, ease of spread, and difficulty to control if established. Many of the factors comprising a risk assessment are subject to change over time, so predictions based on risk assessment models are more likely to be accurate only in the short-term (Ruiz and Carlton 2003). A well-applied risk assessment will ensure that invasion threats are not undermanaged. In order for risk assessments to

be incorporated into policy, they must be accurate, precise, generally applicable, and widely accepted (Lodge and Shrader-Frechette 2003).

According to the National Research Council, "there are currently no known broad scientific principles or reliable procedures for identifying the invasive potential of plants, plant pets, or biological control agents in new geographic ranges" (ELI 2004a). This is especially true for aquatic species in the estuarine and marine habitats for which a large amount of ecological and economic information is required (Lodge et al. 2006, Williams and Grosholz 2008, Davis 2009). The development of accurate risk assessments to protect California's coastal ecosystem requires input of further scientific information on all types of aquatic species and their broad range of impacts (Molnar et al. 2008). The CAISMP highlights research and development of risk assessments as a research priority and current efforts are underway (DFG 2008; see also Sect. 2.4).

Options

In the absence of currently available risk assessments, agencies still need better guidance for decision-making. Without formal tools, agencies can perform crude risk assessments that rely on the scientific advice of experts. Panels can be made through working groups recommended in the CAISMP, through coastal ecosystem specialists from the OPC, or through a Marine Invasive Species Clearinghouse. For example, an interdisciplinary panel of invasive species management experts can be made available on short notice to managers (Anderson 2005, S. Ellis, personal communication). The panel can shape management recommendations by using the proposed decision-tree in the CAISMP (2008). Regardless of its exact structure, experts suggest that this option could be useful in the short-term and require minimal investment (S. Ellis and E. Grosholz, personal communication).

Ongoing projects can seek guidance from the ISAC and IUCN, each of which has developed guidelines for risk assessment for different vectors (ISAC 2005, Hewitt et al. 2006). In addition, the CAISMP has a draft rapid response plan for AIS and is intended to set up a framework for individual species risk assessments (DFG 2008a). A model for coordinated risk assessment development is the National Center for Risk Assessment Development in Canada, a group of national labs and universities in the Canadian Aquatic Invasive Species Network.

Note that additional research is vital to these options. Successful risk assessments and invasive species research will depend upon coordination and sharing data. One coordination option is for a single state entity (e.g., ISCC) to take a leadership role in risk assessment development by implementing the research priorities laid out in the CAISMP (DFG 2008a).

Prevention: Early-Detection

Gaps

In general, early detection programs for invasive species are not well established in California. The lack of formalized and structured early detection of invasive species in California is a long-standing challenge and not an uncommon policy gap (ISAC 2000).

Early detection of coastal AIS in California, for the most part, takes place through a happenstance set of monitoring programs. Regular monitoring and mapping of the coastal ecosystem for native and nonnative species is performed by the DFG and various coastal research institutions. However, these monitoring programs are not comprehensive in species tracked or areas covered. It is rare for most early-detection programs to cover a large spatial area over a sufficient time span (Murray et al. 2005). Ideally, when unable to be widespread in scope, early-detection programs will at least concentrate monitoring efforts on high priority AIS (highly invasive species not yet established in California) and high priority coastal waters (ecologically sensitive and heavily-invaded areas).

Early detection of invasive species at California borders lacks sufficient monitoring by the USDA and USFWS, which inspect goods imported via cargo plane, commercial ships, and the mail (Lodge et al. 2006). These stations and services are often understaffed and operate less than full-time (DFG 2008a). Border inspections now take place by the Department of Homeland Security Customs and Border Protection, whose officers have a much broader homeland security mission than the former USDA APHIS staff and may not consider invasive species an enforcement priority (ELI 2004a).

Options

Options to improve early detection of coastal AIS include improving early detection programs in the coastal ecosystem and increasing inspections at borders as well as inspections of imported goods. Authority can be enacted to support and mandate early detection of invasive species through a core monitoring program of high priority invasive species and coastal waters (ISAC 2000, Meliane and Hewitt 2005, CSAP 2007).

Successful early detection programs involve partnerships between local government, NGOs, volunteers, and other stakeholders. These efforts require a strong network of monitoring and cooperation and should follow a systematic protocol. For certain projects, efforts can be increased by citizen participation with structured training for community groups, watershed councils, and diver associations. Ideally, programs would be ready to report species when found and elicit risk analysis and eradication from a rapid response team (DFG 2008a).

A statewide early detection program could be modeled on the ongoing *Caulerpa taxifolia* or quagga and zebra mussel (FGC § 2302, NOAA, DFG 2008a) programs, the early detection program proposed in the CAISMP (DFG 2008a Appendix A), or the proposal from ISAC based in part on early-detection systems of New Zealand and Australia (ISAC 2003b). California also can adopt a plan for early detection from other ongoing California and out-of-state programs. The new Bay Area Early Detection Program is a collaborative

partnership that aims to detect terrestrial invasive plants in the San Francisco Bay Area through species prioritization, detection protocols and reporting guidelines, and an Internet-based database with user-friendly maps (BAEDN 2007). The Reef Environmental Education Foundation in Florida successfully performs early detection of marine invasive species through participation by voluntary recreational scuba divers and a well-publicized centralized reporting location (Akins and Morris 2009). The Nature Conservancy also has created a centralized early detection program with coordinated, but separate, networks to monitor AIS within a system, nonnative aquatic species within a system, and AIS outside of a system (Smith 2009).

Inspections of imported goods and borders could prevent more invasions through increased vigilance and efforts by the federal government. California can collaborate with the federal government to support these efforts and can improve the enforcement of postal rules that deter foreign and interstate mail order and the Internet orders of invasive species from California-based companies (see Sect. 3.3). For example, California could provide education materials on invasive species to travelers entering California at state agricultural checkpoints (DFG 2008a).

Early detection monitoring in the coastal environment and at borders should be done with the best available technology. The National Aeronautic and Space Administration Office of Earth Science and the USGS are developing a National Invasive Species Forecasting System to detect invasive species with remote sensing technology (Davis 2009). Researchers also are developing methods to quickly detect invasive species in coastal waters using DNA (UC IPM 2007, Ficetola et al. 2008). Modern technology can also aid early detection monitoring through the use of smart phones and social Internet websites (e.g., Twitter) to help researchers quickly communicate information over long distances to dispersed audiences (National Geographic 2009).

Prevention: Importation Restrictions

Gaps

Current policies are not comprehensive for coastal AIS management. The state's DFG restricted species list, in the context of the federal USFWS list, does not adequately prevent introductions of many known invasive species and potentially invasive nonnative species into California. Although the regulation of intentional importation of invasive species is presumed to be straightforward (Hulme et al. 2008), it remains inadequate to prevent invasions of nonnative species. The DFG "dirty" list covers approximately 4 percent of California's known AIS (DFG 2008a)[*]. The DFG list does not include the vast majority of potentially invasive species that are not yet established in California. Species are often listed only after their invasive nature has been demonstrated, effectively preventing opportunities to regulate them before they have a chance to establish and spread. This reactive approach cannot prevent invasions, nor provide the opportunity to eradicate small populations before they become well-established.

[*] Of the state regulated aquatic invasive animals listed in Appendix G of the CAISMP, 24 taxa are classified as occupying the marine habitat of the 607 AIS (DFG 2008a).

Current listings also do not prevent the spread of invasive species that have become established in some parts of the state. Inclusion of widespread invasive species on restricted lists can provide legal justification of control efforts and prevent continued importation of additional species that could enhance existing populations (Cox 2004). The restricted import list also omits aquatic viruses, bacteria, and other pathogens as invasive species. For example, although pathogens cannot be managed in the same manner as other AIS, the simple listing status as invasive species may promote a more comprehensive and broad-based approach to coastal AIS management.

The DFG has expressed a desire to restructure their restricted species list to improve its clarity. According to the DFG, the current list can be confusing because of its structure and contents. AIS are listed by different taxonomic levels. Thus the list includes individual species as well as genus or family, which detracts from its utility for quick reference (S. Ellis and J. Horenstein, personal communications). Listings also can be confusing because aquatic invasive plants are found on multiple lists including in the DFA list of noxious weeds and the lists of the RWQCBs.

The process to amend the DFG restricted species "dirty list" lacks a formal structure and is time-consuming, which may deter new listings (ELI 2004a, Lodge et al. 2006). Decisions on whether a species will be proposed for listing is left to the scientific expertise of the DFG, but formal risk assessment is not required. Creating proposals for listings requires significant background research, time for public comment, and approval by the Office of Administrative Law. The DFG list was recently updated under urgent circumstances with additional listings, but this process took nearly one year to complete (S. Ellis and J. Horenstein, personal communications). The list amendment process is the same whether one or more species are proposed for listing, therefore, it is time-prohibitive to propose the listing of just one species (S. Ellis and J. Horenstein, personal communications).

Options

The state has several options to improve prevention efforts. An aggressive approach would ban all nonnative species. Some suggest that trade is the primary route for the introduction of invasive species and therefore bans and restrictions on trade are necessary to protect native habitats (Jenkins 1996). This approach would enhance prevention. However, a ban can create unfair restrictions on industries that rely on the sale of nonnative species, most of which are not harmful. Indeed, to some, less stringent regulations are preferable (GAO 2002). Further, bans on trade of all nonnative species can be considered unconstitutional by the federal government if it places restrictions on foreign and interstate commerce (Knowler and Barbier 2005, ELI 2004a).

Another option is to increase the number and type of prohibited species. Policies could prohibit the importation of any nonnative species that could not be eradicated in the event of an escape or release. Alternatively, importation could be limited until research could affirm that species are not invasive (Padilla and Williams 2004).

California also could adopt a strategy modeled on Florida's policies. Florida Fish and Wildlife Conservation Commission (FWCC) deems it unlawful to import or possess any nonnative marine plant or animals that "may endanger or infect the marine resources of the state or pose a threat to human health" (ELI 2004a).

California also could maintain its current list requirements, but streamline the listing process. The DFG could institute a regular review or form an interagency committee to spearhead the listing process (ELI 2004a). The current listings could also be improved by cross-referencing other legal restricted lists in place in California.

An advantage to any of these options that maintain the current black list is a maintained focus on species that are problematic. However, the disadvantage to this process is that all other species are in effect approved (Hill 2009).

The main alternative to black lists is a "white" or "clean" list of allowed species. White lists are often heralded as the ideal solution to preventing intentional introductions (e.g., Lodge et al. 2006, ELI 2007, Davis 2009). White lists aim for increased environmental protection by applying the precautionary principle and scientific screening alongside a shared burden of management between regulators and the regulated community (ELI 2004a, Williams and Grosholz 2008). The establishment of a white list can retroactively prohibit species that are currently traded or sold, or by covering only new species that are not yet available in trade (E. Grosholz, personal communication). Opposition to white lists is in part due to perceptions that restrictions would apply to species that are not invasive. Yet other jurisdictions, including Australia and New Zealand, have used clean lists without undue burden on industry and trade (ELI 2004b).

It is important to consider the costs of restricting commerce of certain species. It will typically be economically beneficial to remove the worst invasive species from trade. However, for any given species, consideration should be given to the benefits of having that species in trade, the degree to which removing it from trade would reduce its rate of spread, and the likely harm from additional introductions (Keller and Lodge 2007).

Another option is to create a combined list of both prohibited and allowed species for importation. These combined listings often include prohibited black-listed species, accepted white-listed species, and a "grey" list of species (Hill 2009). A combined list system represents a middle ground and evenly balances the burden of regulation. Increasingly, other states, such as Minnesota, Oregon, Hawaii, and Florida are using a combined listing approach. Minnesota blends two dirty lists (prohibited and regulated species) with a clean list into a four-tiered system that allows more flexibility compared to a binary choice. All nonnative species are classified on a four-tiered listing system that dictates their restrictions (Minnesota Administrative Rules Chapter 6216, ELI 2004a). Minnesota's approach to listing species is an example of a systematic, science-based listing process.

Listings of approved species and grey-listed species pending approval for importation require a risk analysis to assess the likelihood of a nonnative species becoming invasive if imported. Risk analyses are based on a relative assessment of a species' positive value

(e.g., social benefits, education, economic benefits) and its negative impacts (e.g., potential for escape and harm) (Larson 1995). These analyses require detailed information to establish quantifiable measures of positive value and negative impact (Pickering et al. 2007). Ideally, analysis would be based on an agreed-upon level of information for specific queries on risks and values (Brown 2006, Windle 2006). In order to prevent bias from influencing import restrictions, repeatable and quantitative analyses can be performed by an unbiased government entity (ISAC 2003b, Meyers 2008, E. Grosholz, personal communication). California could implement risk analysis for the importation of certain species by giving a legislative directive to the DFG to perform formal screenings (Windle 2009).

The application of risk analysis to the importation of nonnative species is not foolproof. Many experts have pointed out that it is difficult to *prove*, within reason and statistical probability, that a species will or will not cause harm (Windle 2006, Meyers 2008). Because this judgment is based in societal values, perhaps the public should participate in a transparent risk assessment process (ISAC 2003b, Meyers 2008, Davis 2009).

Guidance for implementing risk analysis into importation screenings can be sought from Wisconsin, the first state to implement risk and value-based screening after four years of stakeholder negotiation. Wisconsin's risk analysis is based on potential impacts, current abundance and distribution, potential for establishment and spread, control potential, and positive and negative socioeconomic impacts. Further information and guidance on best management practices for pre-import screening can be found from the Global Invasive Species Programme (Simons and DePoorter 2009).

Risk analyses can be expensive and time-consuming. In accordance with the "beneficiary pays" and the "polluter pays" principles, experts suggest that the importers should bear the cost for a risk analysis (Larson 1995, Lodge et al. 2006). Alternatively, consistent with a new USDA proposal, responsibility for regulating the cost burden of species importation can be placed on the government (USDA 2009).

Prevention: Release Requirements

Gaps

The issuance of permits for activities with restricted species is very defined (see Sect. 2.4). These permits never allow for release of the species and often include specific conditions to avoid accidental releases.

Nonetheless, there are gaps in California's prevention of invasions by intentional and unintentional release. State agencies that are given authority to intentionally release nonnative species or to conduct other activities rarely have specific guidance as to how this release or activity can be done safely to reduce the risk of an invasion.

Options

Intentional release of any species could require specific guidance to reduce the risk of escape. For example, release permits could require mandatory monitoring to ensure early

detection of an invasion (Doelle et al. 2007). In addition, a management plan for recapture of released species or stricter requirements could be implemented, along with prohibitions on the release of any species with a high likelihood of becoming invasive or the release of any species into coastal environments. All release permits could include a requirement for an insurance bond to cover recapture or management costs.

To prevent unintentional releases, a new item also could be added to the CEQA Guidelines for the Environmental Checklist Form, Biological Resources (CCR Title 14 Sections 15000-15387, Appendix G). This item would address preventing invasive species spread in California arising inadvertently from many types of projects. For example, the new checklist item could require consideration of how the project would result in the introduction or spread of an invasive species, or cause a substantial increase in the population of an existing invasive species.

Prevention: Education and Outreach

Gaps

There is a general lack of public education on invasive species and their associated impacts (DFG 2008a), which can lead to importation and introductions of coastal AIS that could have been prevented. Public awareness of invasive species issues may also create incentives for improved attention to risk within the pet, aquaculture and related industries. A "green is good" mentality can lead to ignorant release of unwanted pets into the wild and the introduction of invasive species. Burt et al. and Chang et al. indicated that nursery and aquarium store professionals who sell nonnative and potentially invasive species are not all aware of the risks posed by invasive species (Burt et al. 2009, Chang et al. 2009).

California has no requirement or strategy for promoting education to industries that transport or sell invasive species, to consumers of invasive species, or to the general public. Very little educational information is available or regularly offered to those who participate in activities that could introduce or promote invasive species. Of the many ongoing government and non-governmental education and outreach efforts, few target coastal AIS (but see the West Coast Ballast Water Outreach Program). Current education and outreach programs also often lack a mechanism to assess their effectiveness.

Options

Education can raise awareness of the impacts coastal aquatic invasive species by linking California-specific and coastal AIS-specific campaigns to national efforts and programs in other states (DFG 2008a). For example, California can link to and tailor a portion of the national "Habitattitude" or "Stop Aquatic Hitchhikers" campaigns to suit issues particular to California invasions. Coordination and improvement of education and outreach efforts can seek input from state agency staff and by incorporating recommendations from the NISMP, WRPANS, and the CAISMP. Current education and outreach campaigns also could be evaluated for their effectiveness and improved where necessary (ISAC 2000).

The target audience of these campaigns could be expanded to include the general public, government, industry, and stakeholders, and target specific populations such as public, importers, and sellers, hobbyists, pet store and restaurant owners, recreational boaters, vessel managers and crew, and divers (USCOP 2004).

Outreach efforts to the government can include briefings with policymakers and their staff or workshops aimed at educating invasive species managers on invasive species management and policy. Industry contact can be made via trade shows and conferences, trade newsletters and magazines, and management classes. In addition, information can be provided at the point of sale for the general public. Information on invasive species can also be disseminated through formal education (Bunn et al. 2005). Informational tools are available for the classroom from Sea Grant and the University of California Integrated Graduate Education and Research Traineeship program. Invasive species management can attempt to involve schools through hands-on, outdoors education and student participation in local monitoring and control efforts, programs similar to those coordinated by the Center for Land-based Learning. Lectures can be given at schools and information can be incorporated into school science curricula. However, implementation of invasive species education into California public schools can be challenging due to the strict California learning standards (Wells et al. 2007).

Expanded outreach on invasive species issues can take advantage of media coverage as a gateway of information to the public. Examples include the distribution of press kits or packaged television and radio features and easily referenced websites. For agricultural pests, California recently launched a new multimedia campaign (DFA 2009). Wisconsin expanded awareness of AIS through songs that include scientific information and recommendations for prevention (UWEX 2009). Several state and federal agencies are using social networking tools (i.e., facebook.com and twitter.com) to promote awareness of invasive species and the agencies' missions. For all of these media options, it is important that the information be distributed in languages commonly used by the target audience, such as Spanish and Chinese dialects, and that messages about invasive species are scientifically accurate and consistent (Wong 2009).

Issues surrounding coastal AIS can be promoted by coalitions of organizations. There is an annual California Weed Awareness Week and National Invasive Weed Awareness Week, but no equivalent that raises awareness of issues specific to coastal AIS. Guidance for coastal AIS awareness weeks can be taken from Michigan's Aquatic Invasive Species Awareness Week and Wisconsin's Invasive Species Awareness Month that includes workshops, field trips, and lectures throughout the states.

Research

Gaps

Gaps remain for the foundation of basic information about invasive species, economic impacts of invasive species, and best invasive species management practices. There has been a great wealth of research conducted on invasive species in California, but there is a need for more information to guide coastal AIS management. Successful invasive species

management, risk assessment, and rational policy will depend on ample high-quality data available (ISAC 2000, Meliane and Hewitt 2005, Costello et al. 2007). More research is needed on AIS in California's coastal environments, especially research aiding risk assessments (Lovell et al. 2006, Oregon Sea Grant 2009). In order to support risk assessment development, early detection, and eradication, data should be collected on: the abundance of nonnative species in California coastal waters, their locations, invasiveness, and rate of spread (Molnar et al. 2008). This requires broad datasets, including economic data, and communication between scientists, managers, and policymakers regarding research needs and priorities.

Accurate and useful research is also lacking on the economic impacts caused by invasive species (GAO 2002). There are no reliable economic estimates for invasions and current estimates are very flawed, especially for coastal AIS (Schmitz and Simberloff 2001, Lovell and Stone 2005, Lovell et al. 2006, Gren 2008). Economic analysis also relies on large, detailed datasets including information on: the value of the imports in question, the costs of invaders and the degree to which additional investment in risk reduction will actually reduce the future harm from invasive species (Shogren 2000, Batabyal and Lee 2006). Accurate economic analyses and predictions are notoriously complex because they ideally include societal values of the invasive species and environmental preservation (Rockwell 2003, Margolis et al. 2005, Lovell et al. 2006). Moreover, the time lag between the introduction and eventual control of an invasive species makes accurate information on damages very difficult (Costello and Solow 2003).

Ongoing research by government agencies and research institutions is rarely coordinated for sharing information on current projects, data, and results (S. Ellis, J. Horenstein, and E. Grosholz, personal communication). Data is collected by numerous institutions and is, for the most part, maintained solely by those institutions. Weak information-sharing practices lead to unstructured datasets that meet the priorities of neither state management agencies nor research institutions. California lacks a collection of standardized, repeated, quantitative scientific data in multiple locations. When data is published in peer-reviewed journals there is often a substantial time delay before that information reaches the rest of the scientific and management community. The lack of coordination among researchers can prevent the extraordinary wealth of information being generated in California from reaching managers and decision-makers (NECIS 2004).

Options

California can ensure that needed research is being performed by guided data collection through a comprehensive set of research priorities and guidelines that has consensus from state agencies and research institutions. Researchers, managers, and policymakers should negotiate to decide what research is needed, which research is a priority, and which will receive state funding. In addition, methods for data collection on coastal AIS should be broadly posted to generate data that is capable of being easily compiled and cross-referenced (see the National Institute of Invasive Species Science for an example). At minimum, one organization should be charged with oversight and coordination of research collection by editing a biannual report from all state agencies that manage invasive species (Ruiz 2009).

Research and data collection in California can be better coordinated by cooperation among the many entities that conduct research. A coordinated statewide research program would benefit each institution by encouraging communication and sharing of information (ISAC 2000, Lodge et. al 2006). Ideally, data would be exchanged and publicly accessible, and a transparent database would compile local information (ISAC 2000, DFG 2008a) and link to other databases, such as the DFG CANOD, SERC's National Exotic Marine and Estuarine Species Information System. California datasets for monitoring can be coordinated with the California Coastal Ocean Observing Systems, national databases like those maintained by the USGS and SERC, and international databases (Bunn et al. 2005, DFG 2008a). Examples of well-structured government websites that structure invasive species information can be found from the DFA (Encycloweedia) and the NISIC (Aquatic Species-Databases).

To increase coordination among research institutions, California can improve Internet-based informatics. For guidance on coordination of invasive species information in a publicly accessible web-based format, see the National Invasive Species Information Center. According to Graham et al. (2008), an effective webpage will have the following components: (1) collection of data on the location and characteristics of invasive or potentially invasive species, (2) watch lists of potential new invasive species by area, (3) e-mail alerts on early detection of new invasive species for managers and stakeholders, (4) models of the current range and predicted spread of invasive species and, (5) information on best management practices for control of invasive species. Reported information can be compiled by a lead agency and then published as an update.

Coordination of research can also be encouraged through individual researcher and institutional collaborations. Regular researcher meetings can help to build personal relationships between state agencies and research institutions and can facilitate informal information sharing when needed (E. Grosholz, personal communication). To help achieve this, postings can be made of ongoing state research projects, suggested data collection methods for certain species, listings of state expert researchers, and point-contacts for each research institution (DFG 2008a, S. Ellis, personal communication). Collaboration could also be fostered through a yearly California-focused conference, listserves, and a multidisciplinary invasive species research center with a subgroup focusing on coastal AIS research (Bunn et al. 2005).

Control: General Guidelines and Tools Development

Gaps

There is a lack of legal requirements to control newly established and widespread invasive species, an oversight which makes control of invasive species a lower priority for agencies (Hill 2003). Existing authorities do not specify which invasive species are to be controlled and in which locations. Further, the lack of a mandate for state agencies to control invasive species often means that there is little funding allocated for control (Nadol 1999). Often, the control of coastal AIS is overlooked when the coastal AIS is not affecting an economically valuable commodity or is not listed on the state invasive species lists. Ideally, the control of coastal AIS would take place through integrated

management. The DFA takes this integrated approach in an ecosystem-based strategy that focuses on long-term prevention through a combination of techniques that minimizes the risks to human health, nontargeted organisms, and the environment (FAC 7270.5).

Traditional control techniques such as mechanical and chemical methods present daunting logistical difficulties to a coastal ecosystem and may create considerable collateral damage. Further, dilution of biocides and the hardiness of many invasive species impede these methods (Thresher and Kuris 2004). Presently, there are no chemicals ready for off-the-shelf use on most AIS, especially aquatic species that are not in freshwater systems (L. Anderson, E. Grosholz, personal communications). For example, there are no chemicals available and EPA-registered for the control of marine algae species (L. Anderson, personal communication). More research is needed to develop control techniques for coastal AIS, especially tools for rapid response (ISAC 2000, Meliane and Hewitt 2005, Oregon Sea Grant 2009). A possible reason for the absence of environmentally-approved options for chemical control of AIS is the low awareness of the need for aquatic control tools, and the lack of incentive to develop them (GAO 2001).

Use of certain control methods, such as toxic chemical application, requires adherence to environmental protection policy. These procedures are not well tailored to invasive species management in the costal environment. Control of invasive species can also be thwarted by the difficulty of obtaining approval and permits from environmental protection agencies for use of certain chemicals in certain areas. In order to obtain permits, invasive species control projects may be required to conduct water quality monitoring. This is a very large expense and might deter some invasive species control from taking place (J. Horenstein, personal communication).

Decisions on how to control an invasion must balance effectiveness and social acceptability. Some believe that states should be prohibited from using pesticides and herbicides except in extreme cases (Nadol 1999). It can be hard to gain public acceptance and support for management of an invasion when the methods are perceived to cause more harm than the “natural” invasive species.

Options

In order to control coastal AIS, California could outline each agency’s strategic approach for different types of invasive species. Regulatory guidelines, like those given to the DFA for invasive plants, could be given to the DFG for general way to manage coastal AIS (FAC § 7270.5). This effort would rely on research, development, demonstration, and the verification of methods to eradicate and control AIS (Hill 2003).

To improve current control programs, laws could require the best available technology (ISAC 2000). In instances of socially unacceptable control methods, California can choose to increase acceptable and effective technologies. Better control laws would allow eradication and control efforts to be used as scientific experiments that teach which methods might work for future invasions of the same species or at the same location (Murray et al. 2005, E. Grosholz, personal communication).

Public acceptance and support for control methods can be increased through outreach efforts that inform the public of possible measures and allow the public to voice concern. The San Francisco Estuary Invasive Spartina Project, for example, is successful because of stakeholder buy-in *before* control efforts began (E. Grosholz, personal communication). Public involvement can also help to overcome a lack of funding designated for control projects because volunteers and other citizen groups can participate in control efforts when appropriate and safe (Lodge et al. 2006).

Control: Emergency Powers, Rapid Response

Gaps

California does not require state agencies to rapidly respond to coastal AIS, nor is rapid response facilitated by a statewide coordinated system for coastal invasions. Current rapid response programs may depend upon the agency mission rather than the risk posed by an invasion. Further, the DFG has no authority to mandate rapid response and emergency powers (i.e., quarantine and experimental use of chemical control) are rarely invoked. Rapid response to coastal AIS can also be hindered by a lengthy permitting process for site access and approval of control measures that can delay action (DFG 2008a). In addition, efforts can be delayed by disagreement over which institution should pay for and coordinate an emergency response (Anderson 2007).

Common hurdles for rapid response programs have been identified as a lack of understanding of the invasion risk, attention and early detection, agreement upon rapid response actions, adequate resources, and available control tools (GAO 2001). Interestingly, rapid response to invasive species in California can be undermined by public perception. A recent study by the DFG revealed that some people do not notify state agencies of invasive species because they doubt that notification will prompt a rapid response (S. Ellis and J. Horenstein, personal communications). Ineffective rapid response leads to mismanagement of invasive species populations when they are small and more easily managed (GAO 2001).

A coordinated rapid response plan is an ideal approach to eradication of a specific coastal AIS in a specific location (Wotton and Hewitt 2004, DFG 2008a). Essential components of rapid response have been identified as: knowledge of the biological, physical, and sociological properties of the invasive species; plans to guide response actions, tools and expertise with which to respond; and the capability and resources to carry out the response. This effort is often collaborative between government agencies, academic institutions, and private interest groups wherein each group has made an agreement to its participation role, responsibilities, and procedures. Rapid response to an invasion requires a formalized, preplanned procedure and a dedicated funding source (DFG 2008a). To enable quick management of new invasions, these activities should be well coordinated through an early detection-rapid response system (Anderson 2005, DFG 2008a). California has realized its need for rapid response and a streamlined decision-making process for improved AIS control.

Options

California can adopt a rapid response plan through the enactment of new authority that clearly mandates rapid response and emergency eradication with accompanied funding and coordination (Bunn et al. 2005). A rapid response plan can be adopted by increasing DFG authority to that of the DFA, adopting existing rapid response plans, or using frameworks proposed by the CAISMP (Appendix A, DFG 2008a). Rapid response can be statewide or can focus on certain habitats, such as the coastal ecosystem, or regions, such as the rapid response plan of the Florida Nonindigenous Aquatic Plant Control Act. Alternatively, rapid response programs can be developed for invasive species of high risk (ISAC 2000). Rapid response funding has been called for by the OPC and is featured in rapid response plans used in Oregon, Washington, and Wisconsin. Implementing options such as these can give Californians confidence that their state government will appropriately respond to potentially harmful invasions.

Current rapid response plans for high profile AIS and for other emergency situations can be adopted for coastal AIS threats. The DFG has established plans for rapid response to quagga and zebra mussels and to *Caulerpa taxifolia* (NMFS, DFG 2008a). The DFA has operated a rapid response plan for the aquatic weed Hydrilla for over 25 years (FGC § 2302, FAC § 6048, NMFS DFG 2008a). Other successful rapid response programs have been those for fires, disease outbreaks, and oil spills. California and federal examples include: National Fire Center and the California Department of Forestry and Fire Protection, Center for Disease Control Epidemic Intelligence Service, Environmental Protection Agency Office of Emergency Management, DFG Office of Spill Prevention and Response, California Emergency Management Agency, and California Coastal Commission. All of these agencies have programs that successfully manage large-scale emergencies through interagency coordination and emergency authority.

Control: Restoration

Gaps

Ongoing restoration for the coastal ecosystem very rarely takes place in conjunction with invasive species control efforts. This usually results in reinfestation by the same species, or, in some cases, invasion by a different invasive species. A variety of management activities, including native species restoration projects, lack plans to prevent the spread of invasive species between work sites (S. Ellis and J. Horenstein, personal communications). Integration of invasive species control and habitat restoration occurs infrequently because of insufficient coordination and funding. They also are often viewed as separate pursuits and are organized separately within agencies.

Ideally, control projects and other coastal activities would implement restoration projects as best management practices (J. Gerwein, personal communication). Integration between control and restoration efforts requires a large amount of dedicated funding beyond what is needed for initial control efforts. Sustained invasive species control and restoration needs dedicated long-term funding that is well beyond the term of most grants.

It should be noted that some invasive species control projects are followed by a natural recolonization of native species. Therefore, active restoration projects are not always necessary after invasive species control, but monitoring is still needed (J. Gerwein, personal communication).

Options

California could better integrate coastal AIS control and native species restoration. Including restoration in invasive species control could be a main goal of coastal management if the state were to adopt an invasive species goal statement. Institutional reorganization can coordinate disparate invasive species and restoration programs in the same locations. To ensure restoration is part of a control program, funding sources can require restoration as a stipulation for invasive species management funding. Guidance can be sought from ongoing invasive species management in California for other types of species and habitats, such as the Department of Parks and Recreation and its control and restoration of terrestrial habitats.

Implementation: Enforcement

Gaps

Though some current policies manage coastal AIS, they are ineffective unless they are enforced (ELI 2007). The extent to which policies are enforced is unknown because there is no mandatory reporting system or coordination of statewide information in California. Even when programs are being implemented well, the extent to which they are successful is unknown (DFG 2008a). There is no main invasive species oversight committee to make sure that management efforts are taking place as suggested through policy. The constant detection of new nonnative species that continue to arrive in California demonstrates that effective prevention of coastal AIS requires consistent and proactive enforcement (ELI 2004a).

Enforcement can be lacking at the institutional level. Enforcement of California's aquatic invasive species policies is thought to be understaffed and underfunded. Existing enforcement efforts are more likely to be geared towards programs supported by dedicated funding and towards emergency situations (S. Ellis and J. Horenstein, personal communications). Understandably, state agencies have funding and logistical limitations on what they can and cannot enforce at any given time. However, if state agencies fall below the needed management for invasive species, there is no mechanism in place to force them to comply with their mandates and there is no available penalty. California lacks a leadership framework to ensure that all agencies are carrying out their responsibilities. Lack of enforcement by any one agency is more pronounced when that agency oversees an invasive species vector and is unaccountable to a statewide system. In addition to a lack of funding, a lack of awareness of invasive species laws and regulations can lead to a lack of enforcement (DFG 2008a).

Invasive species prevention policies can be difficult to enforce because inspection officers are required to distinguish prohibited species from similar-looking or closely-

related permissible species (Lodge et al. 2006). For example, because enforcement officers fail to reliably distinguish prohibited *Caulerpa* species from permissible *Caulerpa* species, California now bans several species of the genus *Caulerpa* because of their resemblance to the invasive species *Caulerpa taxifolia* (ELI 2004a).

Another realm of invasive species management that is difficult to enforce is the importation and transport of invasive species through the mail. Almost every aquatic plant banned by the federal and state listings in the United States can be purchased over the Internet (Kay and Hoyle 2001). The Postal Service and APHIS have very little capacity to inspect and regulate the massive volume of mail. The growing use of Internet and mail order sales represents a rapidly expanding gap in AIS prevention (ELI 2004a).

Options

One of the main options available to improve enforcement of AIS laws and regulations is to maximize accountability at all levels (internationally, regionally, and nationally) and through all parts of society (industry, government, general public) (Doelle et al. 2007). California can create an oversight committee to assess the current rate of enforcement and to set-up a system of accountability for laws and regulations whose enforcement needs improvement (DFG 2008a). Such leadership can be done by an institution such as the ISCC.

Enforcement of imports into the United States, even those into California, is limited to federal jurisdiction and implementation (ISAC 2000). However, California can increase the enforcement of its import restrictions as well as support federal enforcement.

Comprehensive prevention includes high rates of inspection at all entry ports. For example, staffing and operating hours for border stations and ports can be increased to a 100 percent inspection rate of boats at all hours through coordination with the federal government (DFG 2008a). However, considering the limited capacity and funding for more inspections, the efficiency of current inspection levels may improve through reprioritization instead. Inspections can be focused on high-risk areas to ensure that the overall management of AIS is not jeopardized by a "weakest link" port entry (Perrings et al. 2002).

Enforcing mail order and Internet trade of prohibited species requires coordination between California and the federal government. For example, the USDA currently uses a WebCrawler software program to identify online distributors of prohibited species. California might use similar software for state trade. In addition, shipments and mailing inspection enforcement can be improved with more consistent and accurate package labeling of contents (see Sect. 3.3).

Implementation: Funding

Gaps

All management options, from border inspections to eradication and education, can carry significant costs. A lack of funding, even where legislative authority exists, leads to a

serious implementation problems and agencies competing for scarce resources (Lodge et al. 2006). Jenkins (2007) argued that a lack of sufficient funding is a problem because "when government agencies cannot afford to clean them up, our forests, waters, our other resources suffer long-term damage [and] taxpayers are subsidizing economic globalization by paying to clean up the biological messes it leaves behind."

California has no formal system in place to record funding and expenditure for AIS projects. Nonetheless, it is presumed that current resource allocation for coastal AIS management is not commensurate with the risk and harm posed by these species in California (Lodge et al. 2006). Funding for invasive species management is often allocated towards terrestrial invasive species or freshwater AIS rather than coastal AIS, because the former species groups affect a significant economic constituency (GAO 2001, NISC 2001, Jenkins 2002). Funding for coastal AIS also hasn't been consistent or dependable for critical management programs (ISAC 2000, Carlton 2001). Thus, even when agencies have the authority, will, and other resources to address an invasion, proposed projects can be stymied by a lack of funding (Lodge et al. 2006, Davis 2009). Indeed, a lack of funding was cited as the primary reason for poor implementation of the NISMP (GAO 2002).

Management of invasive species requires significant funding and often more than what is available (DFG 2008a). The current system of funding relies heavily on civil and criminal fees, but too often it is difficult to determine the precise cause of an invasion or who is responsible for damages (Jenkins 2002, Gren 2008). Even functioning liability payment systems do not deliver revenue in a timely manner (Jenkins 2002). Many other sources of funding rely on annual appropriations and grants, but these sources are unpredictable and not practical for invasive species management (Hill 2003, Lodge et al. 2006). Moreover, many funding sources do not require best practices, such as scientific data collection or restoration efforts. Without best practices information, limited funding resources are not always used wisely (Nadol 1999).

Coastal AIS management is best supported by long-term funding, as well as by emergency funds for rapid response programs (ISAC 2000, IAFWA 2006, DFG 2008a). Funding for invasive species management is required in perpetuity because long-term costs are needed to cover existing invasions and invasive species yet to arrive (Meliane and Hewitt 2005). Stopping funding in the middle of a management project can be likened to stopping an antibiotic regimen; without finishing all of the necessary steps, all previous progress might be reversed. For emergency control situations, resource needs can be specified ahead of time (ISAC 2000). Lack of adequate funding for rapid response programs has been considered "penny wise, pound foolish" by some invasive species managers (GAO 2001).

Funding Options

There are many options to fill gaps in funding, including better use of existing funding sources and increasing funds. Funds can be raised by increasing the amount of current fees and fines or through creative and modern funding mechanisms (ELI 2004a, Windle 2009).

Box 3.5: Payment options to generate invasive species management funds through market-based economic strategies.

Tariff adjustments: Unless management efforts are undertaken with such intensity that invasion risk is driven to zero, an external cost to trade still exists that would seem to call for policy, such as a tax (McAusland and Costello 2004). Tariffs could be levied on ships or boats that either arriving from certain destinations, carry certain goods (i.e., live nonnative aquatic species), or entering into certain ports. The optimal tariff level would be based on the damage of the associated marginal decrease in the risk of coastal aquatic invasive species introductions not accounted for in the markets for the goods. Tariff levels can be also be set by the importing country considering relative risks from different trading countries. However, such a discriminatory policy may be difficult to implement due to current World Trade Organization regulations on equal treatment of foreign and domestic goods. Economy-wide adjustments should be accounted for when designing tariffs on imports, otherwise counteractive results may actually increase the risk of invasive species damage. For example, increased tariffs prices on imported goods might cause an associated local increase in production and consumption costs which may counteract the intended effects on nonnative species introductions and make the country more susceptible to invasion. Or likewise, a company might respond to a tariff increase by hurrying the rate of introductions in order to exploit profits before invasions are detected (Gren 2008). Ultimately, businesses will pass on increased costs to consumers. Therefore an ideal fee will not function as a disincentive for trade and travel (Jenkins 2002).

Traveler's Tax: Taxes could be levied on international travelers arriving from certain global regions known to pose high risks of introducing invasive species (Jenkins 2002). Airport, harbor, port entry, dockage, and wharfage could be taxed as is done in Hawaii.

User fees: Fees could be placed upon activities that are vectors of coastal aquatic invasive species, such as commercial and recreational boating. This would allow stakeholders to still pursue their interests while accounting for the risk activities pose (ISAC 2000). User fees can be calibrated to reflect benefits and risks and future funding needed if damage occurs from release of an invasive species (ISAC 2000, Jenkins 2002). Similar fees have been placed by the government on oil shipments that can potentially trigger a spill and require massive clean-up. A charge on oil companies has raised industry awareness of oil spill risks and thus promotes the goal of reducing pollution. However, the oil shipping industry poses a more defined risk than the numerous import and travel vectors whose activities lead to coastal invasions, so implementation of user fees to prevent invasions requires a definite set of point sources (Jenkins 2002).

California can manage coastal AIS by using funds available within California and from the federal government. Efficient use of current spending on invasive species management can be improved through authorizing state agencies to spend funds on cooperative actions that benefit the coast (ISAC 2000). California can also shift some current funding for AIS management into an emergency fund for rapid response needs.

Another option for use of current funding is to use federal government-funding programs more creatively. For example, the ELI recommends turning to the Corps of Engineers Continuing Authorities Program authorities, National Resource Conservation Service Conservation Programs, USFWS's Partners for Fish and Wildlife Program, the Estuaries and Clean Waters Act of 2000, and NISA for funding (ELI 2004a). Also, the newly

Box 3.5: Payment options to generate invasive species management funds through market-based economic strategies (cont.).

Consumer taxes: A tax imposed on buying goods that have the potential to be invasive, such as all nonnative fish or water garden plants. Corrective taxes are thought to be some of the best solutions to the invasive species problem (Jenkins 2002).

Insurance bonds: Thomas and Randall (2000) suggest a damage liability scheme where companies post an insurance bond in order to offset larger damage costs in the case of an invasion. Economic and management efficiency can be achieved by this method if bond payments correspond to possible environmental damage (Gren 2008, Padilla and Williams 2004) and are at least equal the estimated cost of repairing any future damage that could occur in the worst-case scenario. The success of this strategy depends on setting the appropriate bond level and balancing the true cost of dealing with worst-case disasters when they arise, as well as the profit level of the proposed business and the ability of a business enterprise to absorb the costs and risks of negative outcomes (Padilla and Williams 2004).

Risk trading: Vessels can trade their risk for introducing invasive species by trading invasion risk quotients (based on environmental matching); permits can be traded among businesses from areas of different risk, such that shipments from areas of minimal risk can offset the risk of shipments from other areas. A trade market system achieves a certain probabilistic risk target and is always less costly than other systems since it allows companies to choose the least costly option (Gren 2008). However, applying traditional emission-based trading approaches (standards and incentives) to invasive species is difficult because of the inherent complications of biological invasions (Horan and Lupi 2005).

Compensation: Industries may be willing to self regulate if they are compensated for sound management actions. It is a lot easier to identify which companies are implementing management as compared to those who are not responsible for introducing invasive species (Gren 2008). Different types of compensation may include: direct support, technical assistance, tax breaks, reimbursements for private control work, competitive grants, and federal cost-share programs (ISAC 2000, ELI 2004).

established ISCC and publication of the CAISMP might give California greater access to federal funds (see Sect. 2.4).

If California plans to increase the amount of funds available, estimates of current spending and needed funding would help the state effort. The CAISMP has estimated funding needs for many proposed activities. Estimates for how much funding is required should rely on record keeping for how much is currently being spent on management (DFG 2008a). A statewide, standardized reporting system is needed that would coordinate funding data in a central repository.

Creative payment options to increase funding are economic instruments that thrive off of market forces and incentives (Doelle et al. 2007) (see Box 3.5; see Murray et al. 2005 for more information on these types of funding options). The majority of these instruments

are based on the "polluter-pays principle" which forces the industries and travelers responsible for invasive species introductions to pay for their actions. This is a shift from the current system funded by tax payers via government spending (Doelle et al. 2007) which some view as unfair because the invasion sources do not bearing the invasion costs. They also think it a smart trading agenda to have those parties that benefit from their actions, to pay fees (Jenkins 2002). Economic instruments that rely on the "polluter-pays principle" are often cost-effective because companies can adjust to balance projected costs and benefits (Leung et al. 2002, Gren 2008).

Market strategies such as those listed in Box 3.5 can be considered for any invasive species vectors connected to economic trade (Doelle et al. 2007). Funds from these vector-specific sources can cover costs of invasive species management. A general invasive species fund from other sources of revenue could also be effective (Jenkins 2002). For example, fees paid on oil shipments currently raise revenue for emergency funds used in the event of an oil spill. Similar funding strategies have been implemented in other states. For example, Georgia requires a major insurance policy to cover potential damages by certain species; Vermont assesses treble damages against importers of illegal invasive species for expenses incurred; and Nevada has a compensation fund for private property and crop damage.

Applying the "polluter-pays" principle and new payment methods to invasions is not without its hurdles. In order for the burden to fall on the "polluter," businesses need to internalize costs and not pass them on to consumers (Doelle et al. 2007). The application of these fees can be difficult to enforce when a causal connection is often not apparent and baseline data for the native ecosystem might not be available (Doelle et al. 2007). It is also hard to implement these funding regulations because the lag time between the responsible party's release of the invasive species and the detected invasion makes it hard to identify the responsible party who also may have left the area (Jenkins 2002). Moreover, past efforts to implement this type of legislation has been difficult and the efficacy and the transaction costs of implementing these tools are unknown (Gren 2008, Hulme et al. 2008). These tools have been largely untested and are part of a contentious issue. In general, questions which rise from funding options are: Who decides which constituencies will pay? Which nonnative species will be taxed? How much they will pay? How will the funds generated be used? (J. Horenstein, personal communication).

All funding options can include long-term management and emergency use. This can be implemented by guaranteed funding for certain agencies and projects, or by stipulating specific periods of time needed to complete management objectives. Emergency funding can be quickly accessible like that for other environmental emergencies like oil spills (Windle 2009). It has been suggested that emergency funds be made accessible to all state agencies and private entities with a memorandum of understanding as to how these funds should be quickly transferred and reimbursed when needed (NECIS 2004, Anderson 2005).

Coordination: Institutional Coordination

Gaps

Adequate management and prevention of coastal AIS requires coordination among agencies (Schmitz and Simberloff 2001). The NISMP (NISC 2008) and the CAISMP (DFG 2008a) point out that the lack of coordination in the current system can lead to problems such as redundancy, conflict, and, ultimately, ongoing invasions (Schmitz and Simberloff 2001, Lodge et al. 2006). In general, without structured coordination between and within state agencies, "what is all agencies' responsibility, is no agencies' responsibility" and overall management is "only as good as the weakest provider" (Lodge et al. 2006, Lovell et al. 2006, S. Ellis, personal communication).

Within California, several state agencies have some legal authority to implement more ambitious coastal management, but they lack sufficient incentives and the coordination to do so (Silvas and Caldwell 2008). State agencies also lack a defined role in the process of coastal ecosystem management and in their efforts with other agencies and institutions. In addition, numerous nongovernmental institutions that practice coastal AIS management are very likely unaware of redundant state activities (S. Ellis, personal communication).

Because invasive species readily move across political boundaries, authorities, policies, and funding should also be coordinated on an international, federal, regional, and intrastate level (ISAC 2000, Lodge et al. 2006). Aquatic invasive species introductions from neighboring countries and states are more likely to occur if there is not a coordinated effort to prevent introductions into and from California which shares a coastline with Canada, Mexico, Oregon, and Washington. Currently, international, federal, and regional laws fail to provide for notice and cooperation between neighboring countries and states and existing interjurisdictional organizations have not been effective at coastal management. The CAISMP recognizes a lack of partnership with all of these entities (DFG 2008a). California and the federal government should coordinate so that California can address policy gaps that are a federal matter, such as interstate transport of invasive species (ISAC 2000, ELI 2004a, Lodge et al. 2006). Coordination between California and the federal government is essential because of state reliance on the federal government for large-scale invasive species management and policy enforcement. The state/federal relationship is coordinated by the NISC and the ANSTF. However, progress on these efforts has been slow (USCOP 2004, Williams and Grosholz 2008).

Effective management requires internal government coordination with nongovernmental stakeholders, such as industry and economic interests, universities, research institutions, non-governmental organizations, citizen groups, and user groups. Greater coordination of management efforts will increase the efficient use of limited funding and present a unified and capable government to its constituents (ELI 2004a).

Options

There are many ways for California to improve its institutional organization. One frequent suggestion for statewide coordination is the designation of a lead invasive

species agency or the creation of an invasive species center or council (Schmitz and Simberloff 2001, ELI 2004a, Lodge et al. 2006). This coordinating institution would lead the management effort in many areas now overseen by multiple agencies. Specific responsibilities would include: coordinating research and data collection, determining the best response to new and widespread invasions, and mediating disputes over agency jurisdiction (ISAC 2000, DFG 2008a, S. Ellis, personal communication)*.

Internal agency coordination can be improved by centralizing all invasive species management work into a single branch within each agency or department, a change that would facilitate activities and expedite responses to external requests and suggestions. In addition, each agency might designate a point-person who can brief other organizations of their on-going activities (S. Ellis, personal communication).

California can turn to the NISC and ANSTF for guidance to improve coordination between California and the federal government,. One option to heighten cooperation is to require states to work with the federal government and other jurisdictions to acquire approval for control plans, management plans, and so on. Coordination with the federal government can easily begin in-state because many federal agencies with an invested interest in coastal management have branches located within California and along its shoreline. Active participation with the federal government on invasive species management is likely to be more successful if the federal government is given equal status in decision-making (ELI 2004a). Ideally, a relationship with the federal government would give California the advantages of the larger federal system and the flexibility to address California's needs, while avoiding federal preemption (ISAC 2000).

California can improve coordination with neighboring states and countries through agreements that encourage early detection of species, cooperative control efforts, and complementary policies (ISAC 2000). This can be done through the International Joint Commission, CEC, and the West Coast Governors' Agreement. Management plans and information-sharing systems can be drafted to provide coordination between regions (Murray et al. 2005, Doelle et al. 2007, ELI 2007). Information from these regional entities can be linked to other international databases and improved through California's participation in international conferences and workshops (DFG 2008a).

General guidance on intergovernmental organization can be found from other systems, such as the Center for Disease Control (CDC) and the National Fire Center. The CDC's Epidemic Intelligence Service successfully prevents new disease, monitors existing outbreaks, and implements prevention strategies by coordinating with foreign governments, numerous federal agencies, at least 50 state agencies, and thousand of local governments and private organizations. The National Fire Center is composed of five federal agencies with an agreed-upon rotating directorship so that all agencies have leadership and no one agency's agenda dominates the overall mission (Schmitz and Simberloff 2001).

*See also National Invasive Species Information Center, http://www.invasivespeciesinfo.gov/, for more information.

It has been suggested that AIS management would benefit from coordination and integration with terrestrial species management. This could provide flexible responses to invasions requiring responses from more than one agency (Hill 2003). Possible weaknesses of this approach are the disruption of ongoing coastal AIS programs, and unequal funding (Hill 2003, S. Ellis, personal communication). These shortcomings can be prevented by active participation from OST and OPC representatives in the coordinating center or council.

Coordination: Council

Gaps

The Invasive Species Council of California was only recently created. It is too soon to judge the effectiveness of this council and whether it will be the "go-to place" in California for invasive species issues. The ISCC appears to have been structured after the NISC. Many of the shortcomings of the federal council may apply to the ISCC as well.

In order to effectively coordinate management of coastal AIS in California, the ISCC will need both active participation from state agencies and sufficient funding. However, ISCC appointees representing coastal AIS issues are very few. Since the ISCC was not created by the California legislature, it can neither mandate state agency participation nor make its agenda a state priority (ELI 2004a). The extent to which state agencies will be mandated, staffed, or funded to carry out ISCC objectives is unclear. The DFA currently funds the ISCC, but long-term funding remains unclear. Without the structure, resources, and mechanisms to support managing California's coastal AIS the ISCC is not likely to be more effective than other state interagency groups (Schmitz and Simberloff 2001).

The new CAAIST has initiated action on goals that have been previously recommended for statewide AIS coordination. The CAAIST's effectiveness is as yet unknown.

Options

The ISCC could benefit by learning from the problems of the NISC. Giving legal authority to the ISCC can improve the implementation rate of its objectives by state agencies. For example, the ANSTF, an interagency council established in law, is effective at commanding attention, resources, and compliance unlike the NISC that was established by an executive order (Windle 2002). The California State Legislature can grant the ISCC authority by establishing it in either statute or regulation. This could clarify the responsibility of participating agencies, increase agency coordination, provide oversight for the implementation of management plans, and provide funding for ISCC actions (ELI 2004a, NECIS 2004). Alternatively, decision-making authority could be given to the OPC (Silvas and Caldwell 2008).

The ISCC could be established as a coordinating leader of state invasive species issues if it filled many of the coordination gaps of the state mentioned throughout this chapter. For example, the ISCC could act as a repository for dispersed datasets then issue a report on the status of invasive species along the California coast and then ecological, economic, and societal impacts. In addition, the ISCC could mediate cooperation among state

agencies and councils, and serve as the state-public interface for information on California invasive species.

Coordination: Management Plan

Gaps

Implementation of the state's CAISMP is hard to assess because the plan is new. However, the CAISMP content can be examined and compared to content in other management plans, like the NISMP and ANSTF.

Successful implementation of the CAISMP objectives is likely to happen if they are implemented by state agencies and other entities, and given adequate funding. The great amount of stakeholder input and buy-in that created the CAISMP increases the likelihood that its objectives will be fulfilled. There are no clear consequences if the plan is not followed and if participation does not occur by state agencies and other entities.

CAISMP is intended to be updated annually through an adaptive management strategy of systematic monitoring and evaluation. However, this evaluation will be difficult because the plan lacks a way to measure progress towards its goal to "minimize the harmful ecological, economic, and human health impacts of AIS." Without a more specific management plan, CAISMP lacks performance-based criteria by which to monitor its overall success in AIS management (GAO 2002, Hill 2003, Brown 2006).

Options

In order to measure the implementation of the state management plans, priority should be given to establishing a transparent oversight mechanism that state agencies can use for reporting on their implementations. Reporting of these activities could go to the ISCC, or another coordinating body, as a central location (GAO 2002, Hill 2003). Consequences could be set for any state agencies and entities that do not actively work to achieve the goals of the management plan.

Measuring the success of the management plan will require quantitative measures associated with a performance-oriented goal. The plan can be revised such that it calls for actions that develop much-needed data collection that is regularly analyzed towards a performance-oriented goal with measured success (Hill 2003).

3.3: POLICY GAPS AND OPTIONS IN CALIFORNIA'S VECTOR-SPECIFIC COASTAL AQUATIC INVASIVE SPECIES POLICY

California has some of the most progressive vector-specific policies, yet, considering the great number of active AIS vectors along the coast, there is a lot of progress to be made in order to manage coastal AIS vectors comprehensively.

Vector management will sometimes require different policies because of the vectors' inherent differences. For example, some vectors cause unintentional introductions of coastal AIS while others are more intentional. Patterns of coastal AIS are now better

understood on a vector-by-vector basis that can guide management and policy. For example, the trade in live organisms differentially sells bait primarily through retail stores, biological supplies through mail and Internet business, and aquatic plants and animals through stores, the mail, and the Internet (Keller and Lodge 2007). Dissemination characteristics of invasion species movement such as these should be taken into consideration when designing policy because the success of management will be highly dependent upon its appropriateness for the type of invasion. Hulme et al. (2008) propose general policy approaches to different types of vectors (Box 3.6).

Box 3.6: Recommended regulations that depend upon species introduced intentionally or unintentionally, by a commodity, transport vector, or natural dispersal, and by different general pathway.

Intentional, commodity, release (e.g., game animal): responsible party is the permit applicant; permits should be required, national regulations should apply

Intentional, commodity, escape (e.g., pets, garden plants, live bait): responsible party is the importer; screening risk analysis should be required, national regulations should apply

Intentional, commodity, contaminant (e.g., parasites, pests): responsible party is the exporter; quarantine procedures should be required, international regulations should apply

Vector, stowaway (e.g., hull fouling, ballast): responsible party is the carrier; quarantine procedures should be required, international regulations should apply

Unintentional, dispersal, corridor (e.g., migrant species): responsible party is the developer; environmental impact laws should be required, international regulations should apply

Unintentional, dispersal, unaided: responsibility party is the polluter; international regulations should apply

*Source: Hulme. et al. 2008.

As much as possible, California state law should respond appropriately to coastal AIS vectors by adopting methods that best address each as a separate pathway with individual needs (ISAC 2000, Bax et al. 2003). In this section the gaps in the management of each of the major coastal vectors of AIS are identified. This is done using the same method used for our general assessment of California's approach to coastal AIS management and policy. Suggestions are also offered to fill those gaps based on examples from other states and countries, as well as alternative policies that have been proposed by various experts (see Sect. 3.1).

For many of the vectors discussed below there is a lack of information available to accurately determine the risk each vector poses to the California coast. Other than the well-studied ballast water vector, all other vectors lack basic scientific information about the species that they transport: Which species are being transported? How many of each species is being transported? Where do the species originate? Where are they being introduced into California? How are they stored by the industries and facilities involved? How are water and unwanted species disposed? Accordingly, there is a lack of existing policies for many of these vectors, especially policy directed at preventing coastal AIS invasions (Ruiz 2009). Research on these vectors is prerequisite for risk assessments and appropriate policy. The OPC is supporting a risk assessment project for various coastal

vectors in hopes of recommending legislative improvements (ELI 2007, DFG 2008a, OST 2008, Ruiz 2009, A. Doherty, personal communication). Nonetheless, management of coastal AIS from these poorly studied vectors needs immediate attention and management and policy options should be considered while basic information is still being collected (Lodge et al. 2006).

Commercial Shipping: Ballast water

Gaps

California has some of the most stringent and comprehensive ballast water management in the world. Similarly strict ballast water management programs in the Saint Lawrence Seaway and the Great Lakes have successfully reduced the risk posed by this vector. Nonetheless, ballast water is still difficult to manage because it is very difficult to predict which ships are introducing coastal AIS and what actions can prevent coastal AIS introductions. The risk of infested ballast water depends on many factors, including the type of ship, ship source region, and survival of aquatic species during transport (Verling et al. 2005). Indeed, the chance of invasions occurring from certain ships is "invasion roulette" because of risk and uncertainty (NRC 1995, Murray et al. 2005).

The development of effective and environmentally safe ballast water treatment technology is lagging behind the legal implementation schedule of California's policies (J. Berge, personal communication). In general, the new field of treatment systems is not yet capable of reducing concentrations of aquatic organisms according to California's performance standards. Several different systems options are needed because of differences between vessels of varying models and size. Research and development on these systems is ongoing throughout the world. More than 80 different manufacturing firms, water treatment companies and maritime businesses have undertaken technology development, but only six are currently ready for sale (WWF 2009). The expense of purchasing and installing a treatment system is significant. Potential investors are hesitant to support research and development without more universal performance standards that will allow global compliance (Hill 2003). The uncertainty of ballast water treatment technology's ability to provide compliance with standards is a major roadblock to developing successful legislation (Cangelosi 2002, Bergeron 2009). Federal and California ballast water policies lack incentives for ship owners to try new ballast water treatment technologies (Lodge et al. 2006).

As research and development of treatment systems advances, there is not an agreed-upon method for testing compliance of these systems against regulations. Sound methods are under development but it is still unclear what volume of ballast water needs to be sampled in order to be accurate. Therefore, even if 100 percent of vessels were inspected for ballast water management compliance, at present it would be difficult to ensure that inspected ships pose no risk of introducing an invasive species (Carlton 2001, Dobroski et al. 2009, Edwards 2009). Research on this topic is also ongoing from institutions, such as SERC (Noble 2009). The SLC is currently working on protocols to verify vessel compliance with the performance standards, but it is likely that these protocols will be modified over time as the standards are implemented and the SLC gathers new

information on treatment system performance on operational vessels (Dobroski et al. 2009).

Ballast water oversight is generally well coordinated within California. Ballast water is managed by the SLC through coordination with state and federal agencies. Ballast water, recently given legal interpretation as water pollution, can also be regulated by the EPA and the SWRCB (see Sect. 2.2). It remains to be seen how these agencies will regulate ballast water and coordinate with the current agencies and regulations.

Coordination of regional, federal, and international ballast water management is insufficient. There is an inconsistency between ballast water requirements and standards for management at these different levels of jurisdiction (see the West Coast Ballast Water Outreach Project for more information). California's neighboring coastal states maintain have ballast water management regulations, but the regulations are less stringent than those of California. Canada has requirements similar to the international BWM, whereas Mexico lacks any regulations focused on ballast water management (WCBOP 2007). This lack of coordinated agreements among international, federal, and state regulations increases the potential for invasions entering California from neighboring states and countries (Bergeron 2009). Inconsistent standards and procedures are also a weakness from the standpoint of the shipping industry. When operating under different jurisdictions and authorities, a vessel must adhere to varied standards and schedules, impairing its ability to comply with local regulations at each port of entry (GLSBWWG 2008, WWF 2009).

Options

California can support the development of ballast water treatment technology and testing. This can be done by participating in research, or by assisting already existing new facilities, or helping to test and approve new treatment systems (USCG 2009). Support for research can also be given through other types of guidance, such as a scientific interpretation of the current standards and needed testing parameters. Alternatively, California can work to encourage support for ballast water treatment by the shipping industry. This can be done researching policy tools that increase incentives, such as 'green' certification, good ratings, tax deductions, or expedited port processing for ships with approved treatment systems and a good ballast water management track record.

The implementation of performance standards can be improved by allowing the SLC more flexibility. Concrete regulations that do not allow for easy changes overlook the steep learning curve that is taking place as ballast water laws are being implemented on the ground. A flexible process would authorize SLC to revisit the performance standards, incorporate new technology, adjust the implementation timeline and consult with other agencies as needed (USCOP 2004).

To address the inconsistency experienced by ships traveling to areas that are managed under different jurisdictions, it has been recommended that the commercial shipping industry, being so global in its nature, should be regulated based on the IMO Guidelines and the BWM Convention (Doelle et al. 2007). Others have suggested that guidelines

should be adopted on federal, regional, or local regulatory schemes (NRC 1996, USCOP 2004, Meliane and Hewitt 2005). Regardless of which jurisdiction dominates ballast water management, coordination can be improved and port inspections can be made more consistent for vessels. Coordinated efforts can be made through existing channels, such as the West Coast Governors' Agreement or the International Joint Commission, or through a new council that would represent the jurisdictions overseeing ballast water management.

Commercial Shipping: Hull Fouling

Gaps

In general, there is agreement that hull fouling is an undermanaged vector of coastal AIS. In comparison to ballast water, there is a lack of information about this commercial shipping vector and, thus, far fewer laws and regulations for hull fouling introductions. Although hull fouling on commercial ships is managed by the SLC, more basic information is needed for the creation of specific hull fouling regulations and is likely to develop from ongoing research.

There is a need for the development of effective hull fouling prevention methods. Anti-fouling paints that provide effective prevention of fouling are not currently EPA approved for usage. Without the availability of highly effective, yet non-leaching anti-fouling paints, fouling is more likely to occur. Research and development are needed for a wider selection of approved paints for regular use.

Hull husbandry also needs better coordination among regulations. The SLC program encourages hull cleaning, but this is discouraged by SWRCB (J. Berge, personal communication). As previously mentioned, compliance with hull fouling regulations is incentivized for some ships because regular cleanings will lead to less drag on hulls and faster movement. However, this incentive only translates into hull management for certain fleets (E. Grosholz, personal communication). Those ships that do perform regular hull cleaning lack direction from the state as to where they should dispose of the fouling organisms.

Options

Better regulation of hull fouling depends on more information about the risk of this vector to California's coast. In the absence of further information, measures to prevent hull fouling can still be implemented. Policy guidelines can be found by referring to the IUCN regulatory guidelines (Meliane and Hewitt 2005) or to the more developed federal policies of Australia and New Zealand. In addition, guidance can be sought from the Pacific Merchant Shipping Association.

Prevention of hull fouling can be improved through better anti-fouling paints and more regular boat cleaning and dry-docking (Hewitt et al. 2007). These activities can be encouraged through tax incentives similar to those for ballast water, cleaning subsidies, and preferential port reception for vessels that adhere to a frequent cleaning schedule. In

conjunction with ship harbors, the state can develop best management practices for hull husbandry including direction for proper disposal of fouling organisms.

Recreational Boating

Gaps

Not much is known about which coastal AIS are introduced through this vector, their abundance, where they originate, and where they are being introduced (DFG 2008a). Of particular interest is a better understanding the role of recreational boats that travel exclusively along the California coast as a vector of spreading coastal AIS (see Sect. 2.5).

Currently, there is no California law or regulation overseeing the activities of recreational boaters that will manage the introductions of AIS along the California coast and between California and other states and countries. A complete absence of legal oversight has resulted in large gaps in the prevention of this vector.

Methods currently available for the management of hull fouling on recreational boats are not conducive to broad participation by boaters. Boat washing stations can be used to remove fouling species that attach to hulls and various parts of recreational boats. The extent to which these stations are used is unknown since use is not mandated and there is no record-keeping system to track what percentage of boats are regularly cleaned. Boat washing stations can be ineffective when they aren't used, are not accepted by the public, have a large expense associated with them, have limited space for boats, or compromise user safety (Jensen et al. 2009). Anti-fouling paints to prevent hull fouling on recreational boats face challenges as well. Copper-based antifouling paints are widely used because of their affordability, but can leach into the water. Other legal alternatives and regular antifouling maintenance are relatively more economically prohibitive along the California coast relative to the Baja California coast of Mexico (Fernandez and Johnson 2009).

Education and outreach to recreational boaters can also prevent the transport of coastal AIS via recreational boats. The CAISMP cites a need for greater public information on the risks of spreading AIS via this vector (DFG 2008a).

Options

Basic information about recreational boaters must be collected in order to determine the best AIS management options for this vector. The need for a monitoring program has been cited in the CAISMP (DFG 2008a). Harbormasters can help to fulfill this research need by collecting information, such as the last port of call or last boat cleaning, for resident and visiting boats (E. Grosholz, personal communication).

Authority for recreational boaters can be made similar to that for commercial shipping vessels. Boaters can be required to record and report ports visited, time spent in each marina, and records of regular boat cleaning. Boat cleaning stations can be made easily accessible at each marina and part of mandatory cleaning, bilge pumping, and inspection programs before boats enter or leave the marinas or high priority areas (ecologically

sensitive or highly invaded estuarine and marine habitats) (CSAP 2007, ELI 2007). Additionally, authority could require state agencies to perform inspections of boats on a regular basis to ensure proper cleaning and to issue violations when necessary. Funding for programs such as this could be generated from boating permits or from marina use fees. California's Tahoe Regional Planning Agency charges recreational boaters a nominal fee to fund an inspection program for quagga and zebra mussels.

Further guidance on options for managing this vector can be found in other countries and states. The Northern Territory of Australia has recently implemented mandatory hull fouling checks on recreational and fishing vessels entering into any enclosed marinas. These guidelines are being evaluated by the National Introduced Marine Pest Coordination Group for implementation in either a voluntary or regulatory framework (Doelle et al. 2007). Maine, where AIS control efforts are funded partly by recreational boaters, requires inland water boaters to purchase and display stickers reading "Stop Aquatic Hitchhikers – Preserve Maine Waters" on their boats. This method has helped them to enforcing boating laws and to fund boat inspections (Maine Bureau of Land and Water Quality). A similar system could be established in California and could include a mandatory seminar or workshop on recreational boating as a vector of coastal AIS.

Education and outreach can be done at marinas and at high traffic areas where messages can reach recreational boaters. For example, guidelines for boat cleaning and prevention strategies can be made available at coastal marinas (ELI 2007, DFG 2008a). Educational programs can expand on the existing DBW California Clean Boating Network and the national "Protect Your Waters" and "Stop Aquatic Hitchhikers" campaign for workshops specific to needs of the coastal ecosystem. The collaborative education program between the DFG and DBW for the spread of quagga and zebra mussels by recreational boaters can be used as a guide for interagency education programs for coastal AIS.

New research from Sea Grant has shown that many boats transit between Southern California and Baja California (Fernandez and Johnson 2009). Therefore, coordination with Mexico will be critical to managing recreational boaters in Southern California.

Trade in Live Organisms: General

Gaps

In general, there is a lack of legislative authority for coordinated prevention of invasive species through the trade in live organisms. In addition, these vectors lack sources of funding for management (Smith et al. 2009).

The main preventative strategy of the trade in live organisms relies on the lists of species prohibited for importation. Currently, the vast majority of nonnative species, in addition to invasive species, are available for legal importation (for a further discussion of listings see Sect. 3.2). Permits can be issued to bypass these regulations and are easily issued for certain trades in live organisms more so than others (see Sect. 3.3). The management of the trade in live organisms is also dependent upon preventing the unintentional

introduction of invasive species (including viruses and disease) as contaminants and preventing the release of invasive species through maintenance and sales.

Another gap in the management of the trade in live organisms is the inconsistent, and often incorrect, labeling of the species being transported. Any efforts to reduce invasion risk from the trades in live aquatic organisms will require that border inspectors, retailers, and informed consumers have the ability to accurately identify the contents of packages and species being sold. Labeling is specifically required for the California aquaculture trade, but does not specify the level of taxonomic (i.e., scientific name, common name, genus, species, subspecies) or geographic origin (i.e., country, water body, hatchery) required. Other trades are required to follow the general provisions for labeling associated with shipment records. However, the majority of labels are insufficient or inaccurate. Recent studies have shown that none of the animals for sale in the aquarium, live seafood, and live bait trade are labeled with a scientific name; only 20 percent are labeled in the aquatic ornamental plant and biological supplies industry (Keller and Lodge 2007). Labels contain vague information, such as “marine fish” or “live invertebrate” (Smith et al. 2009). Labeling for live plants is more likely to contain scientific information, but is still very rare (Keller and Lodge 2007). In the San Francisco Bay region, Chang et al. found inconsistent and incorrect labeling of aquatic species available for sale (Chang et al. 2009).

Enforcement of restricted imports from the trades in live organisms is weakened by mail order and Internet sales (Padilla and Williams 2004). These sale options are under-regulated due to a lack of regulations insuring that prohibited nonnative species are not imported into the United States or to states with individual restricted lists. Some Internet sites voluntarily identify species that cannot to be sold and shipped to consumers in certain countries and states, but these lists are inconsistent and voluntary on the part of the individual business. Without enforced restrictions, mail order and Internet sales present a huge gap in the trade in live organisms. As Internet sales have increased, it has been suggested that this gap be addressed by policy as soon as possible (ISAC 2000).

Coordination of trades in live organism varies by specific sector. Some are well organized under California or national trade organizations, a fact that increases the likelihood of established best management practices, voluntary codes of regulation, and facilitated dialogue with policymakers. Individual trades without any formal organization make it harder to understand the risk they pose to introducing invasive species and harder to negotiate in matters of management and policy.

Options

Of late, there have been many suggested options for better managing the trade in live organisms. Yet, few of these have ever been implemented, so there is little evidence to suggest which options have the chance of succeeding.

Preventing the risk posed by the trades in live organisms can be done through tightening the restrictions on nonnative species allowed for importation into the United States and into California. Some have suggested that a comprehensive invasive species management

plan would remove all invasive species as available for importation and sale by these trades (Keller and Lodge 2007). Listing options can be changed to extreme precaution and exclude all nonnative species or more moderate restriction of only those species suspected to be invasive based on risk assessment. Preventing the importation and sale of nonnative and potentially invasive species, a contentious issue, can be seen as unfair to the trade industries. Some have argued that trade industries are dependent upon the importation of nonnative species (Meyers 2008). Very recently, the Ministry for Primary Industries, Fisheries and Rural and Regional Queensland in Australia has banned many nonnative ornamental fishes and now bans more than 70 species. A more balanced option for listing is to restrict the importation of any potentially nonnative species not yet sold in trade and still allow for the continued importation and trade of those species on which industries already rely for business (E. Grosholz, personal communication). In order to guide the importation of aquaculture species, Illinois has an aquaculture advisory committee of government, university, and private industry representative that makes recommendations regarding importation. For more information on listing options, see Sect. 3.2, and legislation and associated comments currently being considered by the United States Congress (H.R. 669) and by the USDA.

For the many nonnative species that the live organisms trade imports, implementing policies will require a more accurate labeling system. Specifically requirements could require that the scientific name (subspecies or variety when necessary), common names, and foreign origin (native range, country or region of origin, farming or collection location when appropriate) be included. Labeling regulations would be most effective if they targeted distributors of live organisms (e.g., wholesaler and growers) because they, rather than individual retailers, apply labels (Burt et al. 2007, Keller and Lodge 2007). Packages with insufficient information could be rejected and fined (Windle, N.d.). Guidance for labeling restrictions can be taken from the Federal Seed Act that requires accurate labels for foreign and interstate shipments.

Management of coastal AIS through these trades also relies on enforcing restrictions of mail order and Internet sales. Certain companies self-regulate sales by denying shipments of prohibited species to certain states, or by instituting blocks on websites for sales to certain states. This mechanism can expand to all companies by providing them with software to easily implement this on websites. USDA APHIS has developed an Internet surveillance application for monitoring the sale of invasive species (Padilla and Williams 2004); California can collaborate and tailor this effort to California trade.

Regulations can also be implemented by imposing fees or insurance bonds on companies trading potentially invasive species or by imposing taxes on invasive species at the point of purchase. In both cases, a fund designated for control of these species in case of release or accidental escape would be effective. This can be done in conjunction with modern micro-chipping technology used to tag animals and link individuals with their owners (ELI 2007).

Preventing the importation and sale of invasive species can also be done by creating incentives for trade in noninvasive alternatives to invasive species. Incentives can come in the form of a ‘green’ or ‘environmentally-responsible’ label to those distributors and

retailers that do not sell invasive species. An international system could certify that products are “non-invasive” or “invasive-free” (Padilla and Williams 2004). A program such as this has been recently proposed for the aquarium trade by the Marine Aquarium Council (MAC) as a way to promote sustainable harvest of coral reef fish. MAC has done this through affiliation with companies trained in certification programs. A similar MAC certification program could be effective if used in trades where individual consumers make direct purchases and can influence the sale of invasive species.

Preventing the risk posed by the trades in live organisms can be done through voluntary regulations, and, indeed, many of the trades have developed a guideline. However, some suggest that self-regulation may be insufficient unless stakeholders and policymakers recognize the threat of these trades (Padilla and Williams 2004). A California study on the nursery trade showed that voluntary regulations are ineffective for preventing sales of horticulture plants when the trade is not aware of the invasive species problem, is not aware of the voluntary codes, or does not have the means with which to implement the recommended best management practices (Burt et al. 2007).

Better management of the risk posed by these trades can be done through education and outreach. Educational programs can aim to reach both industry representatives and consumers. There are many options for education and outreach, from mandatory or voluntary classes and workshops to informal awareness campaigns. In many cases, education and outreach will reach a broader audience if efforts are coordinated with trades associations when possible.

Trade in Live Organisms: Aquaculture

Gaps:

An understanding of the risk posed to the coastal ecosystem from the aquaculture vector requires additional information about the species stocked at aquaculture facilities and the diseases associated with these species. Diseases are a well understood risk from the aquaculture trade. Thus, disease prevention is highly regulated in California and has led to management and oversight. However, the risk aquaculture poses to the California coast is poorly understood. Data are needed to monitor risk from aquaculture facilities, including their stocked species and water and disposal procedures (DFG 2008a).

Aquaculture authority requires a permitting and record keeping process geared to preventing escape and managing disease. The import sources of stocked shellfish culture are regulated, but not for possible disease (DFG 2008a). Escape prevention of stocked species and associated disease is not supported by an education program or strong enforcement. In general, California has an incomplete system for regulating the aquaculture industry because regulations vary based on species inventories (Silvas and Caldwell 2008).

The aquaculture industry is well coordinated through the National Aquaculture Association and the California Aquaculture Association. Each of these organizations

understands their possible role in the introduction of AIS and informs their constituents about these issues.

In addition to traditional aquaculture, private fish stocking for consumption may be taking place on residential properties (S. Ellis, personal communication). There is little information available on how this practice may lead to introductions of invasive species. In addition, there are few enforcement options for laws against private fish stocking.

Options:

Increased information about the aquaculture industry as a coastal AIS vector might include permit reviews for approved imported species. This would contribute to baseline information about which species are being stocked and in which locations. Survey measures, such as early detection programs can use this information for prioritization of monitoring efforts (E. Grosholz, personal communication).

New restrictions might specify which aquatic species can be imported and stocked for aquaculture along the California coast. The Marine Aquaculture Task Force has suggested that importation and release decisions be made with reference to a database of the distributions of marine parasites (MATF 2007). Alternatively, the stocking of nonnative species can be restricted to those that are sterilized and unable to reproduce and spread in the case of escape. However, this option has been shown to lack effectiveness and does not give equal consideration to the productivity of the aquaculture industry (Naylor et al. 2001). Intentional release of stocked organisms can be regulated more strictly statewide, as is already done for aquaculture facilities on Davenport Landing Creek in Santa Cruz County (CCR Title 14 § 235.2).

Increasing regulation of the aquaculture industry can also be done through self-regulation. Best management practices, such as monitoring for early detection of AIS and rapid response to infested facilities, are available through the DFG (for quagga and zebra mussels) and are being developed by the California Aquaculture Association (Bartley 2008, Tucker and Hargreaves 2008). However, some think that voluntary regulation of the aquaculture industry is likely to be ineffective because a) the costs of control are relatively high; b) it is difficult to trace an invasive species to a specific source; and c) the negative consequences of an introduction are shared by habitats outside of the aquaculture facilities (USCOP 2004).

More education and outreach in conjunction with the National and California Aquaculture Associations can help to prevent introductions of coastal AIS. In addition, training for aquaculturalists can be adopted from the Aquatic Nuisance Species Hazard Analysis Critical Control Point planning process that serves to direct fish hatcheries (USFWS, DFG 2008a).

Trade in Live Organisms: Live Seafood

Gaps:

Very little is known about the risks that the trade in live seafood poses from its packaging, maintenance, disposal, and release. There is not a full understanding of which species are already for sale in California, which are being imported, their geographic origin and California point of sale, and which are contaminating live packaging (DFG 2008a, E. Grosholz, personal communication). Authority to manage the trade in live seafood is geared towards the prevention of disease and lacks regulation of live seafood as a vector of invasive species. In part, our understanding of the risk posed by the seafood trade is limited because of black market trade and private stocking. Enforcement of regulations is very difficult because trade is often unknown or undetected.

There is a large gap in education and outreach for live seafood as an invasive species vector. Education and outreach is lacking for wholesalers, restaurants, and seafood markets. However, the seafood trade is well organized through the Seafood Network Information Center and the California Seafood Council.

Options:

Options for the management of the live seafood trade will require comprehensive research to increase the basic knowledge about this trade as a vector of invasive species (DFG 2008a). The California Seafood Council can assist in this investigative effort by helping to gather information about which species are being imported and where they are being sold (E. Grosholz, personal communication). Unique research methods will be required to assess the extent and risk posed by the more clandestine black market trade and private stocking of live seafood.

Authority can be enacted to increase prevention and enforcement in the live seafood trade. For example, guidelines can be developed for stringent management practices that specify nonorganic packaging materials use, record keeping, onsite maintenance, and proper disposal practices (DFG 2008a). Regular inspections can take place to survey species and to sample the water in which they are maintained.

The effort devoted to education and outreach about the risks posed by this vector can be greatly expanded (DFG 2008a). Educating both distributors and consumers of live seafood will help prevent possible introductions of aquatic invasive species. The California Seafood Council can help disseminate information to these interest groups, offer classes, and collaborate on possible prevention strategies (DFG 2008a, E. Grosholz, personal communication).

Trade in Live Organisms: Bait

Gaps:

The risk posed by the live bait vector is not well understood because of a lack of scientific data detailing which species are imported, how many are imported, their

geographic origin and point of sale in California, and maintenance and disposal procedures (DFG 2008a, E. Grosholz, personal communication). Nonetheless, the live packaging material (often seaweed) used for bait shipments and the live bait themselves have been shown to cause invasions on other coasts and are suspected to pose a risk to the coastal ecosystem of California (Yarish 2009). Frozen bait may also be a vector of coastal AIS because of possible disease contamination, but the risk posed from this specific source is unknown.

Shipping bait, maintaining live bait, and disposing of unwanted stock all remain largely unregulated, mainly because they are under-studied (DFG 2008a, E. Grosholz, personal communication). There is no legal requirement for import permitting, record-keeping, or routine inspection. Few jurisdictions manage live bait through established record keeping or inspection of bait dealers to ensure that prohibited species are not introduced (Reeves 1999).

The extent to which the general public and bait industry are aware of the threat live bait poses to the coastal ecosystem of California is unclear. Anglers often release unused live bait without considering that the bait and its live packaging can be invasive (Fuller 2003). Further, Weigle et al. reported that half of bait business owners were not aware of invasive species (Weigle et al. 2005). However, in California there is no coordinated network of bait dealers and organizations through which information about education can be disseminated or information about management practices can be collected. Each California bait dealer is a separate entity, an "individual cowboy" that makes the management of live bait more difficult (E. Grosholz, personal communication).

Options:

Options for managing the bait trade rely on research assessing the risk posed by this vector (DFG 2008a). However, there are many options to fill identified gaps. Prevention of AIS through the bait industry can be done with tighter regulations, such as requiring permits for all imports (DFG 2008a). Strict guidelines can be made to ban the importation of all live bait as Maine has done in its inland waters, or, the state can create lists of permitted and restricted bait species (Reaser et al. 2003). Similar regulations can be made to require the use of packaging material that is not live and uses synthetic or biodegradable material (DFG 2008a, E. Grosholz, personal communication).

Codes can be drafted similar to freshwater bait codes that require DFG licenses in order to sell marine bait (FGC § 8460). States, such as New York, require a license to sell bait. California can follow Canada's requirement of classes for bait dealers about the prevention of introducing live bait. The Ontario Ministry of Natural Resources Hazard Analysis and Critical Control Point requires the completion of this class in order for bait dealer licenses to be distributed.

Enforcement of bait laws can help to prevent introductions from this vector. Inspections at bait dealerships and at common fishing marinas could be increased to enforce any new regulations and guidelines. Compliance with these practices can be encouraged through the use of incentive programs. Bait dealers might take the active step to prevent sales of

invasive species and contaminated bait if there were a certification system that guaranteed wholesalers and retailers classification as "invasive-free" (USGS 2003).

Education and outreach campaigns can target fishermen, as well as bait dealers. Messages can outline steps that reduce the risk of AIS through live bait and can have an immediate impact (Padilla and Williams 2004). Under NOAA's "Don't Dump Bait" campaign, people are encouraged to throw unwanted bait, packaging, and boxes into the trash rather than into the water. Connecticut Sea Grant has developed an education program in which bait shops receive warning stickers to place on boxes of bait and posters to display in bait shops (Yarish 2009).

Trade in Live Organisms: Aquaria and Aquatic Ornamental Plants

Gaps:

As a vector of invasive species, the aquaria (including the aquarium plant and animal trade, public educational aquaria, and coastal research facilities) and aquatic ornamental plant industries have received little attention (Padilla and Williams 2004). Not until recently has research in California illuminated the greater possibility of invasive species introductions through this vector (Chang et al. 2009). There is still a gap in our understanding of these vectors in California and a need for a risk assessment; information is lacking for species types, abundance, geographic origin, and maintenance and disposal. It is presumed that aquaria stores rarely do maintenance and oversight through best management practices and record keeping. In addition, we lack sales information to determine if invasive and nonnative species profit these trades.

Regulations to guide the management practices of these trades and facilities are lacking. Lists of species prohibited from importation and sale do not include AIS sold through these trades. Further, trade in many invasive aquarium species continues intentionally and unintentionally and lacks regulations for certain species, like live rock (coral skeleton colonized by aquatic species) (DFG 2008a).

Comprehensive enforcement of the species sold by these trades is impeded by the large mail-order trade in marine bio-supplies and Internet commerce.

Aquaria also include public aquaria and coastal research facilities. These facilities transport and maintain live aquatic species and require invasive species management. Because these facilities do not sell aquatic species, they are not associated with many of the same activities that make aquaria retailers a risk factor for introducing AIS. Maintenance and oversight is done with some frequency by public aquaria and research facilities, presumably more so than with the aquatic ornamental plant businesses.

Options:

To understand the risk posed by the aquarium trade, further information should be gathered from surveying aquarium species and aquatic ornamental plant nurseries located in California, as well as mail order and Internet sites connected to California. Information

about sales may be available through trade organizations, so research coordination with them will be beneficial (E. Grosholz, personal communication).

Increased regulation of the aquarium and aquatic ornamental plant industry can include authority for inspections, seizures, and fines. These could be based off the stricter DFG and DFA guidelines for aquaculture and nurseries.

In addition to regulation, many best management practices have been proposed for this trade. Best management practices can be required as guidelines for legal sale of species without associated AIS and proper disposal of water and unwanted aquatic species (Keller and Lodge 2007). Alternatively, a permitting system can be instituted that would require dealers complete an educational course on live aquatic animal and plant species. The course would give information on best management practices for maintaining species, preventing escape, and effective disposal of unwanted species (Brown 2006). Disposal or release of unwanted and illegal aquatic species into the waters of the states also could be avoided through the creation of a statewide amnesty day during which unwanted aquaria pets and aquatic ornamental plants are collected humanely (Meyers 2008). Such programs are successful for unwanted pets in Hawaii (Hawaii Department of Agriculture) and Florida (Florida Fish and Wildlife Conservation Commission's Nonnative Amnesty Day).

In addition to trade dealers, education and outreach also can target consumers (Meliane and Hewitt 2005) who could be required to take classes on proper maintenance and disposal of aquarium species (Brown 2006). Alternatively a warning statement can be provided at the point of purchase to promote awareness of AIS and to guide hobbyists to not release these species into natural waters or sewer systems (Padilla and Williams 2004).

Campaigns would be most successful if they were formed in collaboration with organized trade associations and public aquaria (Padilla and Williams 2004). The DFG can collaborate with the existing Habitattitude campaign by becoming a member state agency as has been done for agencies in many other states. Public aquaria can assist in the prevention of invasive species through educational displays and exhibits and by providing outreach materials to discourage the use of invasive species such as the "PlantRight" campaign and the California Invasive Plant Council's "Don't Plant a Pest" campaign from the horticulture trade (McNeely 2002).

3.4: CONCLUSION

Coastal AIS have always existed, but introduction rates, negative impacts, anthropogenic causes, and progressive management options are relatively new. Like other environmental policies, advancement on this issue will require continuous effort over time. This report lays out many possible options for filling policy gaps by reorganization, consolidation, and reinvention of California's approach to management of coastal AIS. A number of different options are possible because invasive species policy is still an emerging field. Progress can come in many forms, including those options listed herein, but implementation and management decisions will be limited by California's capacity.

At the time of publication, California's budget and overall economy are severely suffering. Though many of the options presented in this report require a long-term funding investment, reducing spending on less effective invasive species management will balance these new management suggestions. Therefore, consideration of these options is encouraged, especially those that carry small fiscal outlays. By considering the options presented in this report for coastal AIS management, California has a chance to remain a progressive leader in environmental policy.

As demonstrated throughout this report, the state of California and the federal government both have an important role to play. Many of the identified options for improving policy may be implemented at either the state or federal level, or both. There are legal limits to the options that California can implement without federal guidance. The federal Commerce Clause prevents California from imposing a limit on the importation of certain species and products from another state because of possible discrimination or unreasonable burden on interstate commerce. In addition, the Supremacy Clause requires California to defer to the federal government in policies that concern coastal AIS so as to avoid conflict. Trade policies and federal preemption mean that efforts by California alone will not sufficiently address coastal AIS (Nadol 1999). California is encouraged to work with the federal government and to form policies that align with a federal framework (Nadol 1999, ISAC 2000).

Regardless of which management and policy options California pursues for coastal AIS, it is important to regularly reevaluate policies and to allow for changes. Which management options are successful depends upon a variety of factors, such as funding, political will, and the appropriate timing of policy. Biological invasions are dynamic and ever changing; new vectors and species will increase while established vectors may decrease in risk (Carlton 2001). New vectors may start to play larger roles in the introduction of coastal aquatic species in California (ELI 2007). For example, additional vectors should not be overlooked for coastal AIS management, such as: commercial and recreational fishing (hull fouling, sea chests), construction (dry docks, oil drilling platforms, desalination plants), and marine debris (Carlton 2001, DFG 2008a). Moreover, certain invasive species will soon receive more scientific and societal attention (e.g., microorganisms, bacteria, and viruses) and California's coastal ecosystem will experience other significant changes that might affect the resilience of the coastal ecosystem (e.g., ocean temperature warming and increased storm frequency from climate change) (Silvas and Caldwell 2008). These systems are all subject to inevitable change, both gradual, and sudden. Policies that are efficient and effective at a particular time and place may be inefficient and ineffective at another (ISAC 2000). For example, decades ago the Internet was unforeseen to be a large vector of AIS, but now this pathway poses a great risk to invasive species management and is under-regulated.

In conclusion, California needs a flexible policy framework open to reevaluation in order to handle future pressures from coastal AIS while still meeting specified management goals. Management and policy options adopted in response to current invasion scenarios may not be effective in addressing future threats (Hulme et al. 2008). Ideally, each stage of invasive species management would apply adaptive management principles to reformulate laws and regulations in accordance with newly articulated harms, benefits,

and goals. This approach could include the identification of significant goals that integrate directly back into a policy framework for adjustment when needed. Regular assessments, such as the policy review presented in this study, of the impact and efficiency of policy will help improve policies (ISAC 2000, Silvas and Caldwell 2008).

REFERENCES

Akins, J. L. and J. A. Morris. 2009. “Volunteer-Based Early Detection and Rapid Response; Examples of Successful Partnerships Addressing Non-Native Finfish in the Tropical Western Atlantic.” Paper prepared for presentation at the16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Anderson, Lars W.J. 2009. Plant Physiologist, Agricultural Research Service, United States Department of Agriculture, personal communication.

Anderson, L. W. J. 2005. "California's Reaction to *Caulerpa taxifolia*: A Model for Invasive Species Rapid Response." Biological Invasions Vol. 7: pp. 1003-1016.

Anderson, L. W. J. 2007. "Control of Invasive Seaweeds." Botanica Marina Vol. 50: pp. 418-437.

Ayers, D. R., D. L. Smith, K. Zaremba, S. Klohr, and D. R. Strong. 2004. "Spread of Exotic Cordgrasses and Hybrids (*Spartina* sp.) in the Tidal Marshes of San Francisco Bay, California, USA." Biological Invasions Vol. 6: pp. 221-231.

Bartley, D. M., H. McIntire, and M. Volkoff. 2008. “Draft Guidelines to Reduce the Risk of Quagga/Zebra Mussels in California Aquaculture.” Workshop Report, Sacramento: California Department of Fish and Game (DFG). http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=9938, accessed April 8, 2010.

Batabyal, A. A. 2007. "International Aspects of Invasive Species Management: a Research Agenda." Stochastic Environmental Research and Risk Assessment Vol. 21: pp. 717-727.

Batabyal, A. A., and D. M. Lee. 2006. "The Infinitesimal, the Deterministic and the Probabilistic: Alternative Container Inspection Policies in Invasive Species Management." Biological Invasions Vol. 8: pp. 1663-1671.

Bax, N., J. T. Carlton, A. Mathews-Amos, R. L. Haedricj, F. G. Howarth, J. E. Purcell, A. Rieser, and A. Gray. 2001. "The Control of Biological Invasions in the World's Oceans." Conservation Biology Vol. 15: pp.1234-1246.

Bax, N., A. Williamson, M. Aguero, E. Gonzalez, W. Geeves. 2003. "Marine Invasive Alien Species: a Threat to Global Biodiversity." Marine Policy Vol. 27: pp.313-323.

Bay Area Early Detection Network (BAEDN). 2007. “Bay Area Early Detection Network 2007 Annual Report”. http://baedn.org/images/stories/baedn2007annualreport20080519.pdf, accessed December 22, 2010.

Beck, K. G., K. Zimmerman, J. D. Schardt, J. Stone, R. R. Lukens, S. Reichard, J. Randall, A. Cangelosi, D. Cooper, and J. P. Thompson. 2008. "Invasive Species

Defined in a Policy Context: Recommendations from the Federal Invasive Species Advisory Committee." Invasive Plant Science and Management Vol. 1: pp. 414-421.

Berge, John. 2009. Vice President, Pacific Merchant Shipping Association, personal communication.

Bergeron, D. B. April 2009. "Timelines for Implementing Commercial Ballast Water Treatment Systems." Presented at the 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Boldor, D., S. Balasubramaniam, S. Purohit, and K. A. Rusch. 2008. "Design and Implementation of a Continuous Microwave Heating System for Ballast Water Treatment." Environmental Science and Technology Vol. 42(11): pp.4121-4127.

Boothe, J. A. 2008. "Defending the Homeland: A Call to Action in the War Against Aquatic Invasive Species." Tulane Environmental Law Journal Vol. 21: pp. 407-426.

Brown, R. 2006. "Exotic Pets Invade United States Ecosystems: Legislative Failure and a Proposed Solution." Indiana Law Journal Vol. 81: pp. 713-731.

Buck, E. H. 2007. "Ballast Water Management to Combat Invasive Species." Congressional Research Service Report RL32344. Washington, D.C. http://www.ncseonline.org/NLE/CRSreports/07Jul/RL32344.pdf, accessed April 9, 2010.

Bunn, D., A. Mummert, M. Hoshovsky, K. Gilardi, and S. Shanks. 2005. "Controlling Invasive Species That Affect Native Wildlife." Reprinted in Bunn, et al., 2007. California Wildlife: Conservation Challenges. California's Wildlife Action Plan. (CWCC). http://www.dfg.ca.gov/wildlife/WAP/docs/report/full-report.pdf, accessed April 8, 2010.

Burt, J. W., A. A. Muir, J. Piovia-Scott, K. E. Veblen, A. L. Chang, J. D. Grossman, and H. W. Weiskel. 2007. "Preventing Horticultural Introductions of Invasive Plants: Potential Efficacy of Voluntary Initiatives." Biological Invasions Vol. 9: pp. 909-923.

California Science Advisory Panel (CSAP) 2007. "California's Response to the Zebra/Quagga Mussel Invasion in the West." http://www.nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3871, accessed April 8, 2010.

Cangelosi, A. 2002. "Blocking Invasive Aquatic Species." Issues in Science and Technology.Vol. 19 (Winter 2002). http://www.issues.org/19.2/cangelosi.htm, accessed April 12, 2010.

Carlton, J. T. 1996. "Biological Invasions and Cryptogenic Species." Ecology Vol. 77: pp. 1653-1655.

Carlton, J. T. 1999. "The Scale and Ecological Consequences of Biological Invasions in

the World's Oceans." In O. Sandlund, P. J. Schei, and A. Viken, eds. Invasive Species and Biodiversity Management. Dordrecht, The Netherlands, Kluwer.

Carlton, J. T. 2001. "Introduced Species in the U.S. Coastal Waters: Environmental Impacts and Management Priorities." Arlington, VA, Pew Oceans Commission. http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/env_oceans_species.pdf, accessed April 12, 2010.

Carlton, J. T. and G. M. Ruiz. 2005. "Vector Science and Integrated Vector Management in Bioinvasion Ecology: Conceptual Frameworks." In H. A. Mooney, R. N. Mack, J. A. McNeely, et al, eds. Invasive Alien Species. Washington, D.C., Island Press.

Chang, A. L., J. D. Grossman, T. Sabol Spezio, H. W. Weiskel, J. C. Blum, J. W. Burt, A. A. Muir, J. Piovia-Scott, K. E. Veblen, and E. D. Grosholz. 2009. "Tackling Aquatic Invasions: Risk and Opportunities for the Aquarium Fish Industry." Biological Invasions Vol. 11: pp. 773-785.

Cohen, A. N. and J. T. Carlton. 1995. "Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta." United States Fish and Wildlife Service, National Sea Grant College Program, Connecticut Sea Grant. Washington, D.C., University of California at Berkeley, Williams College – Mystic Seaport. http://nas.er.usgs.gov/Publications/SFBay/sfinvade.html, accessed April 12, 2010.

Cohen, A. N. and J. T. Carlton. 1997. "Transoceanic Transport Mechanisms: Introduction of the Chinese Mitten Crab, *Eriocheir sinensis*, to California." Pacific Science Vol. 51(1): pp. 1-11.

Cohen, A. N. and J. T. Carlton. 1998. "Accelerating Invasion Rate in a Highly Invaded Estuary." Science Vol. 279: pp. 555-558.

Commission for Environmental Cooperation (CEC). 2002. "North America Agenda for Action: 2003-2005." http://www.cec.org/Storage/32/2381_operationalPlan03-05_en.pdf, accessed April 12, 2010.

Commission for Environmental Cooperation (CEC). 2005. "Looking To the Future. Strategic Plan of the Commission for Environmental Cooperation 2005-2010." Montreal, Canada. http://www.cec.org/Storage/84/8020_2005-2010-Strategic-plan_en.pdf, accessed April 12, 2010.

Copeland, C. 2008. "Regulating Ballast Water Discharges: Current Legislative Issues." R. Congressional Research Service Report RL34640. Washington, D.C. http://opencrs.com/document/RL34640/2008-08-28/download/1013/, accessed April 12, 2010.

Costello, C., J. M. Drake, and D. M. Lodge. 2007. "Evaluating an Invasive Species

Policy: Ballast Water Exchange in the Great Lakes." Ecological Applications Vol. 17: pp. 655-662.

Costello, C. and A. Solow. 2003. "On the Pattern of Discovery of Introduced Species." Proceedings of the National Academy of Sciences (USA) Vol. 100: pp. 3321-3323.

Corn, L. C., E. H. Buck, J. Rawson, and E. Fischer. 1999. "Harmful Non-Native Species: Issues for Congress." Congressional Research Service Report RL30123. http://ncseonline.org/NLE/CRSreports/Biodiversity/biodv-26.cfm, accessed April 12, 2010.

Cox, G. W. 2004. Alien Species and Evolution. Washington, D.C., Island Press.

Crall, A. W., L. A. Meyerson, T. J. Stohlgren, C. S. Jarnevich, G. J. Newman, and J. Graham. 2006. "Show Me the Numbers: What Data Currently Exist for Non-Native Species in the USA?" Frontiers in Ecology and the Environment Vol. 4: pp. 414-418.

Crawford, S. E. 1999. "Live rockweed (*Ascophyllum*) used as a shipping medium for the live transport of marine baitworms from Maine. Marketing and shipping live aquatic products: Proceedings of the Second International Conference and Exhibition, Seattle, WA, pp. 95-97. http://nsgl.gso.uri.edu/aku/akuw99003.pdf, accessed April 12, 2010.

Davis, M. A. 2009. Invasion Biology. New York City, Oxford.

Dentler, J. L. 1993. "Noah's Farce: The Regulation and Control of Exotic Fish and Wildlife." University of Puget Sound Law Review Vol. 17: pp.191-210.

Department of Fish and Game, California (DFG), Resources Agency. 2008a. California Aquatic Invasive Species Management Plan. Sacramento, CA. http://www.nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3868, accessed April 12, 2010.

Department of Fish and Game, California (DFG), Resources Agency. 2008b. "Regulations Governing Capture, Possession, Transportation and Sale of Live Freshwater Fish for Bait: Inland Fisheries – Informational Leaflet No. 7." Sacramento, CA. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=8371, accessed April 26, 2010.

Department of Food and Agriculture, California (DFA). 2009. "Invasive Pests." http://www.hungrypests.com/about.html, accessed August 15, 2009.

Dobroski, N. A., C. K. Scianni, L. Takata, and M. Falkner. 2009. "From Paper to Practice: Launching the World's Most Stringent Ballast Water Standards." Paper prepared for presentation at the Sixth International Conference on Marine Bioinvasions, August 24-27, 2009, Portland, OR.

Doelle, M., M. L. McConnell, and D. L. VanderZwaag. 2007. "Invasive Seaweeds: Global and Regional Law and Policy Responses." Botanica Marina Vol. 50:pp. 438-

450.

Doherty, Abe. 2009. Project Specialist, Ocean Protection Council, personal communication

Dyer, M. G. 2009. “Testing and Evaluation of Experimental Shipboard Ballast Water Treatment Systems for STEP: Experience and Lessons Learned.” Presentation prepared for the 16th International Conference on Aquatic Invasive Species, April 19-23, 2009, Montreal, Canada.

Edwards, M. 2009. “Joint US/Canadian Ballast Water Inspection Program: A Binational Approach to Securing the Great Lakes and St. Lawrence River.” Presentation prepared for the 16th International Conference on Aquatic Invasive Species, April 19-23, 2009, Montreal, Canada.

Ekstrom, J. 2009. “Management Identifying the Needs of Ocean Ecosystems” (MINOE). Software package. Palo Alto, CA: Stanford University. http://minoe.stanford.edu/index.php, accessed April 12, 2010.

Ellis, Susan. 2009. Invasive Species Coordinator, California Department of Fish and Game, personal communication.

Environmental Law Institute (ELI). 2002. Halting the Invasion: State Tools for Invasive Species Management. Washington, D.C., Environmental Law Institute.

Environmental Law Institute (ELI). 2004a. Filling the Gaps: Ten Strategies to Strengthen Invasive Species Management in Florida. Washington, D.C., Environmental Law Institute.

Environmental Law Institute (ELI). 2004b. Invasive Species Control: A Comprehensive Model State Law. Washington, D.C., Environmental Law Institute.

Environmental Law Institute (ELI). 2007. Halting the Invasion in the Chesapeake Bay: Preventing Aquatic Invasive Species Introduction through Regional Cooperation. Washington, D.C., Environmental Law Institute.

Environmental Law Institute (ELI). 2008. The Role of Aquatic Invasive Species in State Listing of Impaired Waters and the TMDL Program: Seven Case Studies. Washington, D.C.

Environmental Protection Agency (EPA). 2008. “Effects of Climate Change for Aquatic Invasive Species and Implications for Management and Research.” National Center for Environmental Assessment, Washington, D.C. EPA/600/R-08/014. http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=472114, accessed April 12, 2010.

Environmental Protection Agency (EPA). 2009. "Vessel Discharges | NPDES | US EPA." http://cfpub.epa.gov/npdes/home.cfm?program_id=350, accessed June 10, 2009.

Falkner, Maurya. 2009. Environmental Program Manager, Marine Invasive Species Program, California State Lands Commission, personal communication.

Falkner, M., L. Takata, S. Gilmore, and N. Dobroski. 2007. 2007 Biennial Report on the California Marine Invasive Species Program. Sacramento, CA: California State Lands Commission, Marine Facilities Division. http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Documents/2007FinalBiennialReport.pdf, accessed April 12, 2010.

Fernandez, Linda, Ph.D., Associate Professor, Department of Environmental Sciences, University of California, Riverside, CA, personal communication.

Fernandez, L., and L. Taylor Johnson. 2009. "Economic and environmental considerations in controlling invasive species on hulls of recreational boats in saltwater." Paper prepared for presentation at the Sixth International Conference on Marine Bioinvasions, Portland, OR.

Ficetola, G. F., C. Miaud, F. Pompanon, and P. Taberlet. 2008. "Species Detection Using Environmental DNA from Water Samples." Biology Letters Vol. 4: pp. 423-425.

Fimrite, P. 2009. "Snails Threaten Tomales Bay Olympia Oysters." San Francisco Chronicle, August 14, 2009. http://articles.sfgate.com/2009-08-14/bay-area/17176913_1_crabs-habitat-predators, accessed April 12, 2010.

Fuller, P. 2003. "Freshwater Aquatic Invertebrate Introductions in the United States: Patterns and Pathways." In G. M. Ruiz, J. T. Carlton, eds. Invasive Species: Vectors and Management Strategies. Washington, D.C., Island Press.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous Fishes Introduced into Inland Water of the United States. American Fisheries Society, Special Publication 27. Bethesda, MD.

General Accounting Office, United States (GAO). 2001. "Invasive Species: Obstacles Hinder Federal Rapid Response to Growing Threat."

General Accountability Office, United States (GAO). 2002. "Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem." Report to Executive Agency Officials.

Gerwein, Joel. 2009. Environmental Project Manager, California Coastal Conservancy, personal communication.

Global Invasive Species Programme (GISP). 2008. "Tackling Invasive Species Globally." Global Strategy 2008-2010.

Gollasch, S. 2007. "International Collaboration on Marine Bioinvasions – The ICES Response." Marine Pollution Bulletin Vol. 55: pp. 353-359.

Gorjanc, L. T. 2004. "Combating Harmful Invasive Species under the Lacey Act: Removing the Dormant Commerce Clause Barrier to State and Federal Cooperation." Fordham Environmental Law Review Vol. 16.

Graham, J., A. Simpson, A. W. Crall, C. S. Jarnevich, G. J. Newman, T. J. Stohlgren. 2008. "Vision of a Cyberinfrastructure for Nonnative, Invasive Species Management." BioScience Vol. 58(3): pp. 263-268.

Great Lakes Panel on Aquatic Nuisance Species (GLPANS). 2001. Policy Statement on Ballast Water Management, Adopted by the Great Lakes Panel on Aquatic Nuisance Species. G. L. Commission.

Great Lakes Seaway Ballast Water Working Group (GLSBWWG). 2008. 2008 Summary of Great Lakes Seaway Ballast Water Working Group. N. D. U.S. Coast Guard.

Gren, I. M. 2008. "Economics of Alien Invasive Species Management – Choices of Targets and Policies." Boreal Environment Research Vol. 13: pp. 17-32.

Grosholz, E. D. 2002. "Ecological and Evolutionary Consequences of Coastal Invasions." Trends in Ecology and Evolution Vol. 17: pp. 22-27.

Grosholz, Edwin D. 2009. Professor and Swantz Chair in Cooperative Extension, University of California, Davis, personal communication.

Grosholz, E. D., G. M. Ruiz, C. A. Dean, K. A. Shirley, J. L. Maron, P. G. Connors. 2000. "The Impacts of a Nonindigenous Marine Predator in a California Bay." Ecology Vol. 81: pp. 1206-1224.

Grosholz, E. D., G. M. Ruiz.1995. "Spread and Potential Impact of the Recently Introduced European Green Crab, *Carcinus maenas*, in Central California." Marine Biology Vol. 122: pp. 239-247.

Hewitt, C. L., M. L. Campbell 2007. "Mechanisms for the Prevention of Marine Bioinvasions for Better Biosecurity." Marine Pollution Bulletin Vol. 55: pp. 395-401.

Hewitt, C. L., M. L. Campbell, S. Gollasch. 2006. "Alien Species in Aquaculture: Considerations for Responsible Use." The World Conservation Union (IUCN). Gland, Switzerland and Cambridge, United Kingdom.

Hewitt, C. L., M. L. Campbell, B. Schaffelke. 2007. "Introductions of Seaweeds: Accidental Transfer Pathways and Mechanisms." Botanica Marina Vol. 50: pp. 326-337.

(Hill) Invasive Species: Federal Efforts and State Perspectives on Challenges and National Leadership, 108th Cong., 1st Sess., pp. 1-20 (2003) (testimony of Barry T. Hill).

Hill, J. 2009. "Hearing Statement: Threats to Native Species." Subcommittee on

Oversight and Water and Wildlife, Committee on Environmental and Public Works. Washington, D.C.

Horan, R., F. Lupi. 2005. "Tradable Risk Permits to Prevent Future Introductions of Invasive Alien Species into the Great Lakes." Ecological Economics Vol. 52: pp. 289-304.

Horenstein, Julie. 2009. Ecological Reserve and Lands Acquisition Coordinator, California Department of Fish and Game, personal communication.

Hulme, P. E., S. Bacher, M. Kenis, S. Klotz, I. Kuhn, D. Minchin, W. Nentwig, S. Olenin, V. Panov, J. Pergl, P. Pysek, A. Roques, D. Sol, W. Solarz, M. Vila. 2008. "Grasping at the Routes of Biological Invasions: a Framework for Integrating Pathways into Policy." Journal of Applied Ecology Vol. 45: pp. 403-414.

Interagency Ocean Policy Task Force. 2009. "Interim Report of the Interagency Ocean Policy Task Force." The White House Council on Environmental Quality, Executive Office of the President of the United States. http://www.whitehouse.gov/assets/documents/09_17_09_Interim_Report_of_Task_Force_FINAL2.pdf, accessed June 2, 2010.

International Association of Fish and Wildlife Agencies (IAFWA) Aquatic Nuisance Species (ANS) Regional Workshop. 2006. Appendix D. Recommendations for Federal Legislation.

Invasive Species Advisory Committee (ISAC). 2000. Draft Interim Report. Policy and Regulation Working Group.

Invasive Species Advisory Committee (ISAC). 2003a. "Invasive Species Pathways Team Final Report." Invasive Species Pathways Team.

Invasive Species Advisory Committee (ISAC). 2003b. "General Guidelines for the Establishment and Evaluation of Invasive Species Early Detection and Rapid Response Systems." Early Detection and Rapid Response Subcommittee. Vol. 1.

Invasive Species Advisory Committee (ISAC). 2005. "Focus Group Conference Report and Pathways Ranking Guide." Pathways Work Team.

Invasive Species Council of California (ISCC). 2009a. ISCC By-Laws. Sacramento, CA.

Invasive Species Council of California (ISCC). 2009b. ISCC Charter. Sacramento, CA.

Jenkins, P. T. 1996. "Free Trade and Exotic Species Introductions." Conservation Biology Vol. 10: pp. 300-302.

Jenkins, P. T. 2002. "Paying for Protection from Invasive Species." Issues in Science and Technology, Online Vol. 19.

Jensen, D., D. Henkel-Johnson, L. Stewart, M. E. Zhuikov, J. Rendall, S. Balgie, K. Bogenschutz, R. Martin, P. Moy. 2009. “Stop Aquatic Hitchhikers! – A Successful Campaign Preventing the Spread of AIS.” 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Johnson, Laura T. Faculty, School of Public and Environmental Affairs, Indiana University- Bloomington, Bloomington, IN, personal communication.

Kappel, C. V. 2005. "Losing Pieces of the Puzzle: Threats to Marine, Estuarine, and Diadromous Species." Frontiers in Ecology and the Environment Vol. 3: pp. 275-282.

Kay, S., S. Hoyle. 2001. "Mail Order, the Internet, and Invasive Aquatic Weeds." Journal of Aquatic Plant Management Vol. 39:pp. 88-91.

Keller, R. P., D. M. Lodge. 2007. "Species Invasions from Commerce in Live Aquatic Organisms: Problems and Possible Solutions." BioScience Vol. 57(5): pp. 428-436.

Kimbro, D. L., E. D. Grosholz, A. J. Baukus, N. J. Nesbitt, N. M. Travis, S. Attoe, C. Coleman-Hulbert. 2009. "Invasive Species Cause Large-Scale Loss of Native California Oyster Habitat by Disrupting Trophic Cascades." Oecologia Vol. 160: pp. 563-575.

Knowler, D., E. Barbier. 2005. "Importing Exotic Plants and the Risk of Invasion: Are Market-Based Instruments Adequate?" Ecological Economics Vol. 52: pp. 341-354.

Kolar, C. S., D. M. Lodge. 2002. "Ecological Predictions and Risk Assessment for Alien Fishes in North America." Science Vol. 298: pp. 1233-1236.

Kurdila, J. 1988. "The Introduction of Exotic Species into the United States: There Goes the Neighborhood!" Boston College Environmental Affairs Law Review Vol. 16(95): pp. 103-104.

Kuris, A. M., C. S. Culver. 1999. "An Introduced Sabellid Polychaete Pest Infesting Cultured Abalones and its Potential Spread to other California Gastropods." Invertebrate Biology Vol. 118: pp. 391-403.

Lafferty, K. D., A. M. Kuris. 1996. "Biological Control of Marine Pests." Ecology Vol. 77: pp. 1989-2000.

Lantz, I. 2009. “Does Increased Regulation Effectively Prevent New Introductions of AIS?” Presented at the 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Larson, D. P. 1995. "Combating the Exotic Species Invasion: the Role of Tort Liability." Duke Environmental Law and Policy Forum Vol. 5: pp. 21-34.

Legislative Analyst's Office (LAO). 2004. “California's Economy and Budget in Perspective.” 2004 Cal Facts. Sacramento, CA.

Leprieur, F., S. Brosse, E. Garcia-Berthou, T. Oberdorff, J. D. Olden, C. R. Townsend. 2009. "Scientific Uncertainty and the Assessment of Risks Posed by Non-Native Freshwater Fishes." Fish and Fisheries Vol. 10: pp. 88-97.

Leung, B., D. Lodge, M., J. F. Finnoff, J. F. Shogren, M. A. Lewis, G. Lambetti. 2002. "An Ounce of Prevention of a Pound of Cure: Bioeconomic Risk Analysis of Invasive Species." Proceedings of the Royal Society of London, Biological Sciences Vol. 269(1508): pp. 2407-2413.

Levin, L. A., C. Niera, E. D. Grosholz. 2006. "Invasive Cordgrass Modifies Wetland Trophic Function." Ecology Vol. 87: pp. 419-432.

Levine, J. M., C. M. D'Antonio. 2003. "Forecasting Biological Invasions with Increasing International Trade." Conservation Biology Vol. 17: pp. 322-326.

Lindström Battle, J. "Alien Invaders in Our Seas". World Wildlife Federation International (WWF).

Lodge, D. M., K. Shrader-Frechette. 2003. "Nonindigenous Species: Ecological Explanation, Environmental Ethics, and Public Policy." Conservation Biology Vol. 17(1): pp. 31-37.

Lodge, D. M., S. Williams, H. J. MacIsacc, K. R. Hayes, B. Leung, S. Reichard, R. N. Mack, P. B. Moyle, M. Smith, D. A. Andow, J. T. Carlton, A. McMichael. 2006. "Biological Invasions: Recommendations for U.S. Policy and Management." Ecological Applications Vol.16(6): pp. 2035-2054.

Lovell, S. J., L. A. Drake. 2009. "Analyzing the Economic Benefits of Regulating Ships' Ballast Water Discharges." Presented at the 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Lovell, S. J., S. F. Stone. 2005. "The Economic Impacts of Aquatic Invasive Species: A Review of the Literature: NCEE Working Paper Series", U.S. Environmental Protection Agency, National Center for Environmental Economics, Washington, D.C.

Lovell, S. J., S. F. Stone, L. Fernandez. 2006. "The Economic Impacts of Aquatic Invasive Species: A Review of the Literature." Agricultural and Resources Economics Review Vol. 35(1): pp. 195-208.

Mack, R. N., W. M. Lonsdale. 2002. "Eradication Invasive Plants: Hard-Won Lessons for Islands." Turing the Tide: The Eradication of Invasive Species. C. R. Veitch, M. N. Clout. Gland, Switzerland, IUCN Invasive Species Specialty Group.

MacPhee, B. 2006. "Alien Flotillas: The Expansion of Invasive Species through Ship Ballast Water." Earth Trends, World Resources Institute, Washington, D.C.

MacPhee, B. 2007. "Hitchhikers' Guide to the Ballast Water Management Convention: An Analysis of Legal Mechanisms to Address the Issue of Alien Invasive Species."

Journal of International Wildlife Law and Policy Vol. 10(1): pp. 29-54.

Maki, K., S. Galatowitsch. 2004. "Movement of Invasive Aquatic Plants into Minnesota (USA) Through Horticulture Trade." Biological Conservation Vol. 118: pp. 389-396.

Margolis, M., J. F. Shogren, C. Fischer. 2005. "How Trade Politics Affect Invasive Species Control." Ecological Economics Vol. 52: pp. 305-313.

Marine Aquaculture Task Force (MATF). 2007. "Sustainable Marine Aquaculture: Fulfilling the Promise: Managing the Risks." http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/Sustainable_Marine_Aquaculture_final_1_07.pdf accessed on April 23, 2010.

McAusland, C., C. Costello. 2004. "Avoiding Invasives: Trade-Related Policies for Controlling Unintentional Exotic Species Introduction." Journal of Environmental Economics and Management Vol. 48: pp. 954-977.

McNeely, J. A. 2002. "The Great Reshuffling: How Alien Species Help Feed the Global Economy." IUCN Biodiversity Policy Coordination Division. IUCN, Gland, Switzerland and Cambridge, UK.

Meliane, I., C. Hewitt. 2005. "Gaps and Priorities in Addressing Marine Invasive Species." IUCN, Gland, Switzerland and Cambridge, UK.

(Meyers) Testimony of Marshall Meyers Pet Industry Joint Advisory Council before the Subcommittee on Fisheries, Wildlife and Oceans, House Natural Resources Committee. 110 Cong., 2nd Sess., (2008).

Miller, Marc L. 2009. Ralph W. Bilby Professor of Law, University of Arizona, personal communication.

Miller, M. L., R. N. Fabian, Eds. 2004. Harmful Invasive Species: Legal Responses. Washington D.C., Environmental Law Institute.

Minton, M. S., E. Verlig, A. W. Miller, G. M. Ruiz. 2005. "Reducing the Propagule Supply and Coast Invasions via Ships: Effects of Emerging Strategies." Frontiers in Ecology and the Environment Vol 3: pp. 304-308.

Molnar, J. L., R. L. Gamboa, C. Revenga, M. D. Spalding. 2008. "Assessing the Global Threat of Invasive Species to Marine Biodiversity." Frontiers in Ecology and the Environment Vol. 6(9): pp. 485-492.

Moore, B. 2009. U.S. Coast Guard Experience with Implementation of a Prototype Ballast Water Management Equipment Evaluation Program. 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Mueller, J. M., J. J. Hellmann. 2008. "An Assessment of Invasion Risk from Assisted Migration." Conservation Biology Vol.22(3): pp. 562-567.

Murray, S. N., L. Fernandez, J. A. Zertuche-Gonzalez. 2005. “Status, Environmental Threats, and Policy Considerations for Invasive Seaweeds for the Pacific Coast of North America.” Commission for Environmental Cooperation, Montreal, Canada..

Myers, J. H., D. Simberloff, A. M. Kuris, J. R. Carey. 2000. "Eradication Revisited: Dealing with Exotic Species." Trends in Ecology & Evolution. Vol.15: pp. 316-320.

Nadol, V. 1999. "Aquatic Invasive Species in the Coastal West: An Analysis of State Regulation within a Federal Framework." Environmental Law Vol. 29.

National Environmental Coalition on Invasive Species (NECIS). 2004. “Invasive Species: Federal Actions the Nation Deserves” fact sheet. http://www.necis.ws/wp-content/uploads/2010/11/fsfederal_action_0204.pdf.

National Geographic. 2009. “Tracking Alien Species with Smart Phones.” National Geographic News. http://news.nationalgeographic.com/news/2009/07/090730-survey-video-ap.html.

National Invasive Species Council (NISC). 2001. “Meeting the Invasive Species Challenge: National Invasive Species Management Plan.” http://www.invasivespeciesinfo.gov/docs/council/mpfinal.pdf.

National Invasive Species Council (NISC). 2008. 2008-2012 “National Invasive Species Management Plan.”

National Marine Fisheries Service (NMFS), California Department of Fish and Game (DFG). 2008. “*Caulerpa* Control Protocol.” Vol. 4.

National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce (DOC). 2009. "Commerce Secretary Gary Locke Announces $167 Million in Recovery Act Funding for 50 Coastal Restoration Projects." NOAA News.

National Research Council (NRC). 1995. Understanding Marine Biodiversity. Washington, D.C.

Naylor, R. L., S. L. Williams, D. R. Strong. 2001. "Aquaculture – A Gateway for Exotic Species." Science. Vol. 294: pp. 1655-1656.

Nazzaro, R. M. 2005. “Progress and Challenges in Preventing Introduction into U.S. Waters via the Ballast Water in Ships.” Natural Resources and Environment, United States Government Accountability Office (GAO).

Niera, C., E. D. Grosholz, L. A. Levin, R. Blake. 2006. "Mechanisms Generating Modifications of Benthos Following Tidal Flat Invasion by a *Spartina* Hybrid." Ecological Applications Vol.16: pp. 1391-1404.

Noble, M. 2009. “Testing Chemical Tracers and the BEAM as a Method to Verify Ballast

Water Exchange." Presented at the Sixth International Conference on Marine Bioinvasions, Portland, OR.

O'Shea, S., A. Cangelosi. 1996. "Trojan Horses in our Harbors: Biological Contamination from Ballast Water Discharge." University of Toledo Law Review. Vol. 381: pp. 388-394.

Ocean Science Trust, California (OST). 2008. Aquatic Invasive Species Vector Risk Assessments: Request for Proposals."

Office of Technology Assessment (OTA). 1993. "Harmful Non-Indigenous Species in the United States."

Olson, L., S. Roy. 2002. "The Economics of Controlling a Stochastic Biological Invasion." American Journal of Agricultural Economics Vol. 84: pp. 1311-1316.

Oregon Sea Grant. 2009. "West Coast Regional Marine Research and Information Needs." J. Risien. Corvalis, OR.

Padilla, D. K., S. L. Williams. 2004. "Beyond Ballast Water: Aquarium and Ornamental Trades as Sources of Invasive Species in Aquatic Ecosystems." Frontiers in Ecology and the Environment Vol. 2(3): pp. 131-138.

Patnaik, B. R. 2009. "U.S. Coast Guard's Proposed Ballast Water Discharge Standard Rulemaking." Presented at the16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Perrault, A. M., S. Burgiel, A. Delach, C. Muffett. 2003. "Invasive Species, Agriculture and Trade: Case Studies from the NAFTA Context". Montreal, Canada, Center for International Environmental Law, Defenders of Wildlife for the North American Commission for Environmental Cooperation (CEC). http://www.cec.org/Storage/49/4117_Perrault-etal_en.pdf, accessed May 26, 2010.

Perrings, C., M. Williamson, E. Barbier, D. Delfino, S. Dalmazzone, J. F. Shogren, P. Simmons, A. Watkinson. 2002. "Biological Invasion Risks and the Public Good: An Economic Perspective." Conservation Ecology Vol. 6(1).

Phillips, Roger. 2009. Applied Research Manager, Monterey Bay Aquarium, personal communication.

Pickering, T., D., P. Skelton, R. J. Sulu. 2007. "Intentional Introductions of Commercially Harvested Alien Seaweeds." Botanica Marina Vol. 50: pp. 338-350.

Pimentel, D. 2003. "Economic and Ecological Costs Associated with Aquatic Invasive Species." Presented at the Aquatic Invaders of the Delaware Estuary Symposium, Malvern, PA.

Reaser, J. K., B. B. Yeager, P. R. Phifer, A. K. Hancock, A. T. Gutierrez. 2003.

"Environmental Diplomacy and the Global Movement of Invasive Alien Species: A U.S. Perspective." In Invasive Species: Vector and Management Strategies, G. M. Ruiz, J. T. Carlton, eds., pp.362-381. Washington, D.C., Island Press.

Reeves, R. 1999. "Analysis of Laws and Policies Concerning Exotic Invasions of the Great Lakes," Office of the Great Lakes, Michigan Department of Environmental Quality.

Reichard, S., P. White. 2001. "Horticulture as a Pathway of Invasive Plant Introductions in the United States." BioScience Vol. 51: pp. 103-113.

Rejmanek, M., M. J. Pitcairn. 2002. "When is Eradication of Exotic Plants a Realistic Goal?" In Turning the Tide: the Eradication of Invasive Species, C. R. Veitch, M. N. Clout, eds. Gland, Switzerland, IUCN SSC Invasive Species Specialist Group. http://www.issg.org/database/species/reference_files/onoaca/Rejmanek.pdf.

Ricciardi, A. 2001. "Facilitative Interactions Among Aquatic Invaders: Is an 'invasion meltdown' Occurring in the Great Lakes?" Canadian Journal of Fisheries and Aquatic Sciences Vol. 58: pp. 2513-2525.

Ricciardi, A. 2009. "Can We Predict the Impacts of Aquatic Invasions?" Presented at the 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

(Riley) Subcommittee On Insular Affairs, Oceans And Wildlife Legislative Hearing On The Nonnative Wildlife Invasion Prevention Act H.R. 669. Cong. 111, 1st Sess., (testimony by Lawrence M. Riley).

Rixon, C. A. M., I. C. Duggan, N. M. N. Bergeron, A. Ricciardi, H. J. MacIsacc. 2005. "Invasion Risks Posed by the Aquarium Trade and Live Fish Markets on the Laurentian Great Lakes." Biodiversity and Conservation Vol. 14: pp. 1365-1381.

Rockwell, H. W. 2003. Summary of the Survey of the Literature on the Economic Impact of Aquatic Weeds, Aquatic Ecosystem Restoration Foundation. http://www.aquatics.org/pubs/economic_impact.pdf.

(Ruiz) Threats to Native Wildlife Species: Subcommittee on Water and Wildlife and Subcommittee on Oversight joint hearing. Cong. 11, 1st Sess., pp. 1-6, (2009) (testimony by Gregory M.Ruiz). http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=180af368-7dac-4c60-b85d-e9addae2578c.

Ruiz, G. M., J. T. Carlton, Eds. 2003. Invasive Species: Vectors and Management Strategies. Washington, D.C., Island Press.

Ruiz, G. M., J. T. Carlton, E. D. Grosholz, A. H. Hines. 1997. "Global Invasions of Marine and Estuarine Habitats by Non-indigenous Species: Mechanisms, Extent, and Consequences." American Zoologist. Vol. 37: pp. 621-632.

Ruiz, G. M., P. W. Fofonoff, J. T. Carlton, M. J. Wonham, A. H. Hines. 2000. "Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases." Annual Review of Ecology and Systematics. Vol. 31: 481-531.

Sandlund, O., P. J. Schei, A. Viken. 1999. Invasive Species and Biodiversity Management. Dordrecth, Netherlands, Kluwer.

Schmitz, D. C., D. Simberloff .2001. "Needed: A National Center for Biological Invasions." Issues in Science and Technology, Online. Vol. 17: pp. 57-62.

Schoenig, S., ed. 2005. "California Noxious and Invasive Weed Management Plan." Sacramento, CA: Department of Food and Agriculture, California (DFA) and the California Invasive Weed Awareness Coalition (CALIWAC). http://www.cdfa.ca.gov/phpps/ipc/noxweedinfo/pdfs/noxious_weed_plan.pdf, accessed April 12, 2010.

Scianni, C. K., N. Dobroski, L. Takata, M. Falkner. 2009. "What the Hull is Going on: An Analysis of the Fouling-Related Practices of Commercial Vessels in California." Presented at the Sixth International Conference on Marine Bioinvasions, Portland, OR. http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/Scianni_Reduced.pdf.

Severinghaus, L., L. Chi. 1999. "Prayer Animal Release in Taiwan." Biological Conservation Vol. 89:pp. 301-304.

Shine, C., N. Williams, L. Gundling. 2000. A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species. Gland, Switzerland, The World Conservation Union (IUCN).

Shogren, J. F. 2000. "Risk Reduction Strategies Against the 'Explosive Invader' "In The Economics of Biological Invasions, pp. 56-69, C. Perrings, M. Williamson, S. Dalmazzone, eds. Edward Elgar: Cheltenham, UK.

Silvas, D. A., M. R. Caldwell. 2008. "A New Vision for California Ocean Governance: Comprehensive Ecosystem-Based Marine Zoning." Stanford Environmental Law Journal. Vol. 27.

Simons, S. A., M. De Poorter, eds. 2009. Best Practices in Pre-Import Risk Screening for Species of Live Animals in International Trade: Proceedings of an Expert Workshop on Preventing Biological Invasions, University of Notre Dame, Indiana, 9-11 April 2008, Global Invasive Species Programme, Nairobi, Kenya. http://www.gisp.org/publications/policy/workshop-riskscreening-pettrade.pdf, accessed June 7, 2010.

Smith, H. A. 2009. The Adirondack Park: A Region of Opportunities for Successful Aquatic Invasive Species Spread Prevention and Management. 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Smith, K. F., M. Behrens, L. M. Schloegel, N. Marano, S. Burgiel, P. Daszak. 2009. "Reducing the Risks of the Wildlife Trade." Science Vol. 324(5927): pp. 594-595.

Steinberg, Darrell. 2008. Chairman, California State Senate Committee on Natural Resources and Water, personal communication.

Stoett, P., J. 2007. "Counter-Bioinvasion: Conceptual and Governance Challenges." Environmental Politics Vol. 16(3): pp. 433-452.

Takata, L., N. Dobroski, C. Scianni and M. Falkner. January 2011. "2011 Biennial Report on the California Marine Invasive Species Program." California State Lands Commission, Marine Facilities Division. http://www.slc.ca.gov/Meeting_Summaries/12-10-10/Items_and_Exhibits/C45ExhA.pdf.

Takata, L., M. Falkner, N. Dobroski, C. Scianni 2009. Geographic and Quantitative Patterns of Ballast Water Management in California: 2002-2009. Sixth International Conference on Marine Bioinvasions, Portland, OR.

Thomas, M., A. Randall. 2000. "Intentional Introduction of Nonindigenous Species: A Principal-Agent Model and Protocol for Revocable Decisions." Ecological Economics. Vol. 34: pp. 333-345.

Thornber, C. S., B. P. Kinlan, M. H. Graham, J. Stachowicz. 2004. "Population Ecology of the Invasive kelp *Undaria pinnatifida* in California: Environmental and Biological Controls on Demography." Marine Ecology - Progress Series. Vol. 268: pp. 69-80.

Thresher, R. E., A. M. Kuris. 2004. "Options for Managing Invasive Marine Species." Biological Invasions Vol. 6: pp. 295-300.

Tucker, C. S., J. A. Hargreaves, eds. 2008. Environmental Best Management Practices for Aquaculture. Ames, Iowa: Blackwell.

United Nations Environmental Programme (UNEP). 1992. Rio Declaration on Environment and Development. United Nations Conference on Environment and Development. Rio de Janiero, Brazil.

United National Environmental Programme (UNEP) Conference of the Parties (COP) to the Convention on Biological Diversity (CBD). 2000. Report of the Fifth Meeting of the Conference of the Parties to the Convention on Biological Diversity. 5/23: pp. 111-119 (V/8). http://cdn.www.cbd.int/doc/meetings/cop/cop-05/official/cop-05-23-en.pdf accessed May 27, 2010.

United States Coast Guard (USCG). 2009. “Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters; Draft Programmatic Environmental Impact Statement”; Proposed Rule and Notice. Vol. 74: pp. 44631-44672.

United States Commission on Ocean Policy (USCOP). 2004. Chapter 17: “Preventing the Spread of Invasive Species.” An Ocean Blueprint for the 21st Century.

United States Department of Agriculture (USDA), Animal and Plant Health Protection Service (APHIS). 2009. “Importation of Plants for Planting; Establishing a Category of Plants for Planting Not Authorized for Importation Pending Pest Risk Analysis,” Federal Register. Vol. 74: pp. 36403-36414.

University of California, Integrated Pest Management Program (UC IPM). 2006a. “Scientists Untangle Seaweed's Effect on Other Species,” University of California, Agriculture and Natural Resources.

University of California, Integrated Pest Management Program (UC IPM). 2006b. “What a Difference a Day Makes – Abalone Pest is in the Dunk Tank.” University of California Agriculture and Natural Resources.

University of California, Integrated Pest Management Program (UC IPM). 2007. “Scientists Propose New Warning System for Invasive Marine Species.” University of California Agriculture and Natural Resources.

University of Wisconsin Extension (UWEX). 2009. "Environmental Music: Aquatic Invasive Species." http://www.uwex.edu/erc/music/index.html, accessed June 10, 2009.

Van den Bergh, J. C. J. M., P. A. L. D. Nunes, H. M. Dotinga, W. H. C. F. Kooistra, E. G. Vrieling, L. Peperzak. 2002. "Exotic Harmful Algae in Marine Ecosystems: An Integrated Biological-Economic-Legal Analysis of Impacts and Policies." Marine Policy . Vol. 26: pp. 59-74.

Venter, O., N. N. Brodeur, B. Belland, I. J. Dolinsek, J. W. A. Grant. 2006. "Threats to Endangered Species in Canada." BioScience Vol. 56: pp. 903-910.

Verling, E., G. M. Ruiz, D. L. Smith, B. Galil, A. Whitman Miller, K. R. Murphy. 2005. "Suppy-Side Invasion Ecology: Characterizing Propagule Pressure in Coastal Ecosystems." Proceedings of the Royal Society of London, Biological Sciences. Vol. 272: pp.1249-1257.

Wabinitz, C., M. Taylor, E. Green. 2003. From Oceans to Aquarium. Cambridge, UK: UNEP-WCMC.

Watson-Wright, W. 2009. “Aquatic Invasive Species: Closing the Science-Policy Gap.” Presented at the 16th International Conference on Aquatic Invasive Species, Montreal, Canada.

Weigle, S. M., L. D. Smith, J. T. Carlton, J. Pederson. 2005. "Assessing the Risk of Introducing Exotic Species via the Live Marine Species Trade." Conservation Biology. Vol. 19: pp. 213-223.

Wells, E. H., T. M. Mata, A. P. Wintzer. 2007. “Filling an empty niche: How academia can help find educational solutions to environmental problems.” Presented at the Ecological Society of America/Society of Ecological Restoration Joint Meeting, San

Jose, CA.

West, D. 1997. “Buddhists Release Animals, Dismaying Wildlife Experts.” The New York Times. New York, N.Y.: p. 27, p. 31.

West Coast Ballast Outreach Project (WCBOP). 2009. "West Coast Ballast Outreach Project - Ballast Management: Laws and Regulations." http://groups.ucanr.org/Ballast_Outreach/Laws_and_Regulations, accessed May 10, 2009.

Western Regional Panel on Aquatic Nuisance Species (WRPANS). 2009. "The Western Regional Panel on Aquatic Nuisance Species." http://www.fws.gov/answest/index.htm, accessed March 15, 2009.

Whalin, D. M. 1998. "The Control of Aquatic Nuisance Nonindigenous Species." The Environmental Lawyer. Vol. 5.

Wickman, T. W. 2007. "The Battle against Invasive Species: The Clean Water Act and Environmental Protection Agency Regulation of Recreational Boats." Marquette Law Review. Vol. 91.

Williams, S. L. 2007. "Introduced Species in Seagrass Ecosystems: Status and Concerns." Journal of Experimental Marine Biology and Ecology. Vol. 350: pp. 89-110.

Williams, S. L., E. D. Grosholz. 2008. "The Invasive Species Challenge in Estuarine and Coastal Environments: Marrying Management and Science." Estuaries and Coasts. Vol. 31: 3-20.

Williams, S. L., J. E. Smith. 2007. "A Global Review of the Distribution, Taxonomy, and Impacts of Introduced Seaweeds." Annual Review of Ecology, Evolution, and Systematics. Vol. 38: 327-359.

Windle, P. N. Letter to USDA APHIS Quarantine 37 (undated). USDA Animal and Plant Health Inspection Service. Riverdale, MD: Union of Concerned Scientists (UCS).

Windle, P. N. 2002. The National Invasive Species Act. “An Information Update by the Union of Concerned Scientists,” Union of Concerned Scientists (UCS).

Windle, P. N. 2005a. National Environmental Coalition comments on Invasive Species on NAISA. U. S. Senate. Washington, D.C., Union of Concerned Scientists (UCS).

Windle, P. N. 2005b. “APHIS Should Strengthen Regulations on the Import of Plants for Planting.” USDA Animal and Plant Health Inspection Service. Riverdale, MD: Union of Concerned Scientists (UCS).

Windle, P. N. 2006. UCS Urges APHIS to Enable States to Respond Rapidly to Urgent Invasive Species Problems. A. USDA PPD, Regulatory Analysis and Development. Riverdale, MD, Union of Concerned Scientists (UCS).

Windle, P. N. 2009. Invasive Species Legislative Priorities for 2009, Union of Concerned Scientists (UCS).

Wong, W. Y. 2009. Is the Right Message Reaching the Audience? Presented at the Sixth International Conference on Marine Bioinvasions, Portland, OR.

World Wildlife Federation International (WWF). 2009. “Silent Invasion – The Spread of Marine Invasive Species via Ships' Ballast Water.” Ed. J. Battle. Gland, Switzerland.

Wotton, D. M., C. L. Hewitt. 2004. "Marine Biosecurity Post-Border Management: Developing Incursion Response Systems for New Zealand." New Zealand Journal of Marine and Freshwater Research. Vol. 38: pp. 553-559.

Yarish, C. 2009. “Don't Dump Bait: Marine Bait Worms as a Potential Vector of Non-Native Species: Long Island Sound Study: EPA assistance Award Final Report.” C. S. Grant, University of Connecticut.

Zaleski, S. F., S. N. Murray 2006. "Taxonomic Diversity and Geographic Distributions of Aquarium-Traded Species of Caulerpa (Chlorophyta: Caulerpaceae) in Southern California, USA." Marine Ecology - Progress Series Vol. 314: pp. 97-108.

ADDITIONAL INTERNET RESOURCES

Aquatic Nuisance Species Task Force: www.anstaskforce.gov

Bay Area Early Detection Network (2007). Bay Area Early Detection Network 2007 Annual Report: www.baedn.org

California Department of Food and Agriculture, Encycloweedia: www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm

California Science Advisory Panel (2007). California's Response to the Zebra/Quagga Mussel Invasion in the West: www.dfg.ca.gov/invasives/quaggamussel

California Department of Fish and Game Invasive Species Program: http://www.dfg.ca.gov/invasives/inv_reporting/sightingReport.html

California Department of Fish and Game CANOD: http://www.dfg.ca.gov/ospr/Science/invasive_species.aspx

California Department of Food and Agriculture, Encycloweedia: http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm

California Product/Label Database Queries & Lists product database: www.cdpr.ca.gov/docs/label/labelque.htm

Commission of Environmental Cooperation: www.cec.org

Convention on Biological Diversity: www.cbd.int

Environmental Protection Agency: www.epa.gov/owow/invasive_species/

Federal Interagency Committee on Environment and Natural Resources: www.ostp.gov/cs/nstc/committees#cenr

Global Invasive Species Programme: www.gisp.org

Global Invasive Species Information Network: www.gisinetwork.org

Global Invasive Species Threat Assessment:

http://conserveonline.org/workspaces/global.invasive.assessment

International Union for the Conservation of Nature: www.iucn.org

Global Marine Programme: www.iucn.org/about/work/programmes/business/bbp_morework/bbp_programmes/marine/

Invasive Species Specialist Group www.issg.org/index.html

International Maritime Organization: Marine Environmental Protection Committee: www.imo.org/Newsroom/mainframe.asp?topic_id=109

International Council for the Exploration of the Sea: Study Group on Ballast and Other Ship Vectors working group: www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=16

Legislative Analysts Office: www.lao.ca.gov/2004/cal_facts/2004_calfacts_econ.htm

Management Identifying the Needs of Ocean Ecosystems (MINOE): http://minoe.stanford.edu/

Marine Aquarium Council certification program: www.aquariumcouncil.org/default.aspx

National Exotic Marine and Estuarine Species Information System (NEMESIS): http://invasions.si.edu/nemesis/

National Environmental Coalition on Invasive Species (NECIS): www.necis.net/

National Institute of Invasive Species Science: www.niiss.org/cwis438/websites/niiss/Home.php?WebSiteID=1

National Invasive Species Information Center (NISIC): www.invasivespeciesinfo.gov/laws/main.shtml

National Invasive Species Awareness Week: http://www.nisaw.org/

National Oceanic and Atmospheric Administration (NOAA) Aquaculture Program: http://aquaculture.noaa.gov/

Ocean Protection Council (OPC): www.opc.ca.gov/about/

Ocean Science Trust (OST): http://www.calost.org/

Global Invasive Species Database (2009): IUCN Invasive Species Specialist Group "List of the 100 Worst Invaders": www.issg.org/database/welcome/

Habitattitude: www.habitattitude.net

Ramsar Convention: www.ramsar.org

West Coast Governors' Agreement on Ocean Health, Spartina Eradication Action Coordination Team Work Plan: www.westcoastoceans.gov/Docs/SpartinaACT_Draftworkplan_May09.pdf

Western Regional Panel on Aquatic Nuisance Species (WRPANS): www.fws.gov/answest/index.htm

Wisconsin Invasive Species Awareness Week: http://invasivespecies.wi.gov/awareness/index.asp

World Trade Organization (WTO): www.wto.org

World Wildlife Foundation, Conservation Science: http://www.worldwildlife.org/science/ecoregions/marine/item1863.html#

United States Coast Guard (USCG): www.uscg.mil/hq/cg5/cg522/cg5224/bwm.asp

United States Geological Survey (USGS) Nonindigenous Aquatic Species Program http://nas.er.usgs.gov/SightingReport.aspx

APPENDIX 1: AIS POLICY MATRIX

INTERNATIONAL, UNITED STATES FEDERAL, AND CALIFORNIA STATE POLICIES REGARDING THE MANAGEMENT OF CALIFORNIA COASTAL AIS

Table of Abbreviations*	
Federal Policy Acronyms	**Meaning**
CFR	Code of Federal Regulations
Fed. Reg.	Federal Register
P.L.	Public Law
USC	United States Code
USCA	United States Code Annotated
California Policy Acronyms	**Meaning**
FAC	Food and Agriculture Code
FCG	Fish and Game Code
PRC	Public Resources Code

* Other Acronyms and their meanings can be found within the California Policies chart on page 136.

International Conventions

Title or Common Use Name	Year Enacted
Plant Protection Convention	1952
International Convention on Wetlands of International Importance	1971
Convention on International Trade in Endangered Species	1975
Technical Barrier to Trade Agreement	1975
United Nations Convention on the Law of the Sea	1982
Convention on Biological Diversity	1993
Code of Conduct for Responsible Fisheries	1995
North American Agreement on Environmental Cooperation	1995
Agreement on the Application of Sanitary and Phytosanitary Measures	1995
Control of Harmful Anti-Fouling Systems on Ships	2001
Jakarta Mandate on Marine and Coastal Biological Diversity	2002
International Convention for the Control and Management of Ships' Ballast Water and Sediment	2004
Code of Practice on the Introduction and Transfers of Maine Organisms	2005

United States Federal Policies

Title or Common Use Name	Year Enacted (Amended)	Authorizing Code, Law, or Register
Lacey Act	1900 (1998, 2008)	18 USC 42; 50 CFR 16
Animal Damage Control Act	1931	7 USC 426
Federal Insecticide, Fungicide, and Rodenticide Act	1947	7 USC 136 et seq.
National Environmental Policy Act	1970	P.L. 91-190; 42 USCA 4321-4370e
Clean Water Act	1972 (1977, 1987)	P.L. 92-500; 33 USC 1251
Endangered Species Act	1973	16 USCA 1531-1544 (1531 et seq.)
Nonindigenous Aquatic Nuisance Prevention and Control Act	1990	P.L. 101-646; 16 USC 4701 et seq.
Alien Species Prevention and Enforcement Act	1992	P.L. 102-393
National Invasive Species Act	1996	P.L. 104-332
Executive Order 13112	1999	64 Fed. Reg. 6183
Plant Protection Act	2000	P.L. 106-224; 7 USC 7701

California Policies

Title or Common Use Name	Year Enacted	Authorizing Code/Entity
The Porter-Cologne Water Quality Control Act	1969	Water Code, §§13000-14958
California Environmental Quality Act (CEQA)	1970	Public Resources Code, Division 13
California Park and Recreational Facilities Act (CPRFA)	1984	Public Resources Code, Division 5, Chapter 1.691
California Endangered Species Act (CESA)	1997	Fish and Game Code, Division 3, Chapter 1.5

California Policies (cont.)

Title or Common Use Name	Year Enacted	Authorizing Code/Entity
Ballast Water Management for Control of Nonindigenous Species Act (BWMCNSA)	1999	Public Resources Code, §§71203-71210.5
Marine Invasive Species Act (MISA)	2003	Public Resources Code, Division 36; Revenue and Taxation Code §§44000-44007
California Clean Coast Act (CCCA)	2005	Public Resources Code, Division 38; Health and Safety Code §§39630-39632
Coastal Ecosystems Protection Act (CESPA)	2006	Public Resources Code §§71204.7, 71205.3, 71207, 71211, 71216, 71271, 72421, 72423, and 72440.
Invasive Species Council of California	2009	Created via multiple interagency agreements.

California Code Sections

FISH AND GAME CODE		
Division 2. Department of Fish and Game		
Code Section	**Provision**	**Related Policy**
§1174	Private Nonprofit Hatcheries	
§§1501.5 (a), (b), (d); 1504	Fish and Game Management, Generally	
§1525	Wildlife Management Areas and Game Farms	
§1580	Ecological Reserves	
§1760	Native Species Conservation and Enhancement Account	
§§1801, 1802	Conservation of Wildlife Resources; Policy	CEQA

California Code Sections (cont.)

FISH AND GAME CODE (cont.)		
Division 3. Fish and Game Generally		
Code Section	**Provision**	**Related Policy**
§§2081, 2085	Endangered Species; Taking, Importation, Exportation, or Sale	
§§2118, 2121	Importation, Transportation, and Sheltering of Restricted Live Wild Animals; Generally	CCR Title 14: 236, 671
§§2150-2157	Importation, Transportation, and Sheltering of Restricted Live Wild Animals; Permits	
§§2189, 2190, 2193	Importation, Transportation, and Sheltering of Restricted Live Wild Animals; Regulation and Enforcement	CCR Title 14: 671, 671.1, 676
§§2270–2272	Importation and Transportation of Live Plants; Aquatic Plants and Animals	CCR Title 14: 171
§§2300-2302	Aquatic Invasive Species	
§§2582 (a)(1)-(4); (b), (c); 2583	Control of Illegally Taken Fish and Wildlife	
§2701	Wildlife and Natural Areas Conservation Program; General Provisions	
Division 3. Chapter 10.5 Marine Life Protection Act (MLPA)		
Code Section	**Provision**	**Related Policy**
§§2851, 2853	Findings and Declarations	
Division 6. Fish		
Code Section	**Provision**	**Related Policy**
§§5501, 5515	Miscellaneous	
§§5650 (a)(6), (b)-(e), (f), 5650.1	Pollution; General	
§§6301, 6303, 6304	Infected or Diseased Fish	
§6400	Fish and Planting and Propagation; General Provisions	CCR Title 14: 171, 238, 238.5
§§7055-7059	Conservation and Management of Marine Living Resources; Marine Fisheries Generally	

California Code Sections (cont.)

FISH AND GAME CODE (cont.)		
Division 6. Fish (cont.)		
Code Section	**Provision**	**Related Policy**
§8462	Commercial Fishing; Fresh-Water Fish for Bait	
§8500	Commercial Fishing; Tidal invertebrates	CCR Title 14: 632
§§8597, 8598	Commercial Fishing; Marine aquaria pets	
Division 9. Fines and Penalties		
Code Section	**Provision**	**Related Policy**
§§12000-12026	General Provisions	
§12159	Forfeitures, Revocation, and Seizures	
§§15006-15008	General Provisions	
§§15101, 15102	Aquaculture Development Section	
§§15200, 15202	Stocking Aquatic Organisms	CCR Title 14: 227, 235, 235.1, 235.2, 237, 238, 238.5
§§15400(b)(4), (9);15409(b),(c)	Leasing of State Water Bottoms	CCR Title 14:§§ 235.1, 237, 238, 671.1
§§15500-15516	Disease Control	CCR Title 14:§§ 245, 238.5
§§15600-15605	Importation of Aquatic Plants and Animals	CCR Title 14: §§236, 235.2

FOOD AND AGRICULTURE CODE		
Code Section	**Provision**	**Related Policy**
§§5352, 5353	**Division 4.** Plant Quarantine and Pest Control; Plant Quarantine Inspection Stations	
§§14006.6	**Division 7.** Agriculture Chemicals, Livestock Remedies, and Commercial Feeds; Restricted Materials	

California Code Sections (cont.)

HARBORS AND NAVIGATION CODE		
Code Section	**Provision**	**Related Policy**
§§85.2 (d), (e)	**Division 1.** Department of Boating and Waterways and the Boating and Waterways Commission; Harbors and Watercraft Revolving Fund	
§660	**Division 3.** Vessels; Operation and Equipment	

GOVERNMENT CODE		
Code Section	**Provision**	**Related Policy**
§11346.1	**Division 3.** Executive Department; Public Participation: Procedure for Adoption of Regulations	

PUBLIC RESOURCES CODE		
Code Section	**Provision**	**Related Policy**
§5001.4	**Division 5.** Parks and Monuments; State Park System	
Chapter 1.691 California Park and Recreational Facilities Act of 1984		
Code Section	**Provision**	**Related Policy**
§§5096.225-5096.227	General Provisions	CPRFA, BWMCNSA, MISA, CESPA
Chapter 1.692 Safe Neighborhood Parks, Clean Water, Clean Air, and Coastal Protection Bond Act of 2000		
Code Section	**Provision**	**Related Policy**
§§5096.300, 5096.301, 5096.302, 5096.308 (j)(1), (3); (k)	General Provisions	BWMCNSA, CESPA, MISA

California Code Sections (cont.)

PUBLIC RESOURCES CODE (cont.)		
Division 5.8. California Wildlife, Coastal, and Park Land Conservation Act		
Code Section	**Provision**	**Related Policy**
§§5900-5902 (k), (l)	General Provisions	BWMCNSA, CESPA, MISA
§§5905-5907	California Wildlife, Coastal, and Park Land Conservation Program	BWMCNSA, CESPA, MISA
§§5910-5929	Miscellaneous Provisions	BWMCNSA, CESPA, MISA
§§5930-5938	Fiscal Provisions	BWMCNSA, CESPA, MISA
Division 13. California Environmental Quality Act (CEQA)		
Code Section	**Provision**	**Related Policy**
§§21000 et seq.	Environmental Quality	BWMCNSA, CESPA, MISA, numerous cross-references
Division 20. California Coastal Act (CCA)		
Code Section	**Provision**	**Related Policy**
§§30001	Findings	
§§30230, 30231, 30233, 30236	Coastal Resources Planning and Management Policies; Marine Environment	
Division 21. State Coastal Conservancy		
Code Section	**Provision**	**Related Policy**
§§31220	Integrated Coastal and Marine Resources Protection	

California Code Sections (cont.)

PUBLIC RESOURCES CODE (cont.)		
Division 26.5. California Ocean Protection Act (COPA)		
Code Section	**Provision**	**Related Policy**
§§35500-35515	General Provisions	BWMCNSA, MISA, CESPA
§§35600-35625	Ocean Protection Council	BWMCNSA, MISA, CESPA
§35650	California Ocean Protection Trust Fund	BWMCNSA, MISA, CESPA
Division 36. Marine Invasive Species Act (MISA)		
Chapter 2 Ballast Water Management for Control of Nonindigenous Species Act (BWMCNSA)		
Code Section	**Provision**	**Related Policy**
§§71200-71202	General Provisions	MISA; CCR Title 2:§§2270, 2271, 2280-2284
§§71203-71210.5	Ballast Water Management Requirements	CESPA, MISA; CCR Title 2:§§2280-2284
§§71211-71213	Research and Program Evaluation	CESPA, MISA
§71215	Marine Invasive Species Control Fund	MISA; CCR Title 2:§§2270, 2271
§§71216-71217	Civil and Criminal Penalties and Liability	CESPA, MISA
§71271	Repeal: Contingent on Implementation of Federal Program	CESPA, MISA
Division 38. California Clean Coast Act (CCCA)		
Code Section	**Provision**	**Related Policy**
§72400, 72401	Findings and Declarations	
§72421, 72423	Prohibited releases	CESPA
§72440	Miscellaneous	CESPA

California Code Sections (cont.)

WATER CODE		
Code Section	**Provision**	**Related Policy**
§229	General State Powers Over Water; Surveys, Investigations, and Distribution of Water	
Division 7. Porter-Cologne Water Quality Control Act		
Code Section	**Provision**	**Related Policy**
§§13000-14958	Water Quality	

California Code of Regulations

TITLE 2 – ADMINISTRATION		
Division 3. Chapter 1. Article 4.5 Marine Invasive Species Control Fund Fee		
CCR Sections	**Provision**	**Related Policy**
§2270 (a), (b)	Definitions	PRC §§71200(m), (o); 71215(b)
§2271	Fee Schedule for Marine Invasive Species Control Fund	PRC §§71200, 71215(b)
Division 3. Chapter 1. Article 4.6 Ballast Water Regulations for Vessels Arriving at California Ports or Places After Departing from Ports or Places Within the Pacific Coast Region		
CCR Sections	**Provision**	**Related Policy**
§§2280 (a)-(d)	Purpose, Applicability, and Date of Implementation	PRC §§71201.7, 71204.5
§§2281 (b)(1), (2)	Safety of Ballasting Operations	PRC §§71201.7, 71203, 71204.5

California Code of Regulations (cont.)

TITLE 2 – ADMINISTRATION (cont.)		
Division 3. Chapter 1. Article 4.6 Ballast Water Regulations for Vessels Arriving at California Ports or Places After Departing from Ports or Places Within the Pacific Coast Region		
Related Policy		
§2282	Definitions	PRC §§71201.7, 71204, 71204.5, 71200(e), (j), (n); 71201
§2283	Alternatives	PRC §§71201, 71201.7, 71204.5
§§2284 (a)(1)-(5)	Ballast Water Management Requirements	PRC §§71200, 71201.7, 71204, 71204.5
Division 3. Chapter 1. Article 4.7 Performance Standards for the Discharge of Ballast Water for Vessels Operating in California Waters		
CCR Sections	**Provision**	**Related Policy**
§§2291 (a)-(c)	Purpose, Applicability, and Date of Implementation	PRC §§71201.7, 71205.3
§§2292 (a)-(d); (e)(1)-(4); (f)(1)-(4); (g)	Definitions	PRC §§71200, 71201.7, 71205.3
§§2293 (a), (b), (c)(1)-(3), (A)-(C)	Interim Performance Standards for Ballast Water Discharges	PRC §§71201.7, 71205.3
§§2294 (a)-(d)	Implementation Schedule for Interim Performance Standards for Ballast Water Discharges	PRC §§71201.7, 71205.3

California Code of Regulations (cont.)

TITLE 2 – ADMINISTRATION (cont.)		
Division 3. Chapter 1. Article 4.7 Performance Standards for the Discharge of Ballast Water for Vessels Operating in California Waters (cont.)		
CCR Sections	**Provision**	**Related Policy**
§2295	Implementation Schedule for Final Performance Standards for Ballast Water Discharges.	PRC §§71201.7, 71205.3
§2296 (a)	Delay of Application for Vessels Participating in Promising Technology Evaluations	PRC §§71201.7, 71204.7, 71205.3
Division 3. Chapter 1. Article 4.8 The Collection of Information Relating to Hull Husbandry Practices of Vessels for Control of Marine Invasive Species in Waters of California		
CCR Sections	**Provision**	**Related Policy**
§2298 (a), (b)	Hull Husbandry Reporting Form	PRC §§71201.7, 71204.6, 71205(e), (f)

TITLE 3 – FOOD AND AGRICULTURE		
Division 6. Chapter 2. Subchapter 1. Article 13. Research Authorization		
CCR Sections	**Provision**	**Related Policy**
§6260	Authorization for Research	FAC §§12781, 12976, 12995, 14006.6

California Code of Regulations (cont.)

TITLE 14 – NATURAL RESOURCES		
Division 1. Subdivision 1. Chapter 9. Aquaculture		
CCR Sections	**Provision**	**Related Policy**
§§227 (a), (d)	Sale of Live Aquaculture Products by Aquarium or Pet Stores	FGC §§1050, 8371, 15005, 15200, 15202
§§235, 235.1, 235.2	Screening Requirements for Aquaculture Facilities	FGC §§17, 15200, 15102, 15202, 15400
§§236 (a), (b) (c)(4),(5),(7)	Importation of Live Aquatic Plants and Animals	FGC 1050, 2118,2116-2191, 2270-2272, 3201-3204, 6401, 15004, 15600, 15601
§236.1	Importation and Planting of Live Bivalve Mollusks	FGC 1050, 15004, 15005, 15200-15202, 15400, 15600
§§237 (e)(2)	Leasing of State Water Bottoms for Aquaculture	FGC §§1050, 8500, 15003, 15101, 15200, 15400, 15408
§§238 (b)(2); (d)(1), (4); (f)(1), (2), (4)	Sale and Transportation of Aquatic Plants and Animals	FGC §§17, 1050, 6400-6401, 7701-7708, 8040, 8304, 8371, 8435, 8436, 15005, 15200, 15202, 15400-15415

California Code of Regulations (cont.)

TITLE 14 – NATURAL RESOURCES (cont.)		
Division 1. Subdivision 1. Chapter 9. Aquaculture (cont.)		
CCR Sections	**Provision**	**Related Policy**
§§238.5 (a), (c), (d)(3), (4)	Stocking of Aquaculture Products	FGC §§17, 45, 1050, 6400-6401, 7701-7708, 8371, 8435, 8436, 15005, 15200, 15202, 15501, 15504
§240	Transportation, Possession and Sale of Sturgeon, Striped Bass, Hybrid Striped Bass (Striped Bass Crossed with White Bass), Abalone and Steelhead Trout Produced or Imported by Registered Aquaculturists for Aquaculture Purposes	FGC §§1050, 2348, 7700-7703, 7708, 8371, 8431 and 15505, 15102, 15200, 15202, 1560
§243 (g)	Take of Aquatic Plants, Invertebrates, Fishes and Bullfrogs from the Wild for Use as Broodstock for Aquaculture Purposes	FGC §§1050, 1907, 5503, 2000, 2052, 2273, 5503, 8430, 8433, 8435, 8436, 8460, 15001, 15004, 15300
§245 (a)(6)	Aquaculture Disease Control Regulations	FGC §§200, 15500, 15504, 15505, 15506, 15508, 15509

California Code of Regulations (cont.)

TITLE 14 – NATURAL RESOURCES (cont.)		
Division 1. Subdivision 2. Chapter 11. Ecological Reserves		
CCR Sections	**Provision**	**Related Policy**
§§630 (a)(11), (13); (b)(1)(A), (10)(B), (14)(D), (17)(H), (21)(A), (23)(A), (32)(B), (36)(A), (37)(A), (42)(H), (44)(B), (54)(E), (56)(G), (65)(E), (73)(B), (87)(D), (105)(D), (106)(B), (108)(B), (F), (120)(A), (122)(A), (124)(E)	Ecological Reserves	FGC §§1526, 1528, 1530, 1580-1585,1907
§630.5	Marine Resources Protection Act Ecological Reserves	California Constitution Article XB, §14; FGC §§1580, 1581, 1582, 1583, 1584, 1585, 8610.9, 8610.14
§632 (a)(5), (76)(F), (92)(D), (93)(C), (94)(D), (97)(D), (98)(F)	Marine Protected Areas (MPAs), Marine Managed Areas (MMAs), and Special Closures.	FGC §§200, 202, 203.1, 205(c), 219, 220, 1590, 1591, 2860, 2861, 6750; PRC 36725(a), 36725(e)

California Code of Regulations (cont.)

TITLE 14 - NATURAL RESOURCES (cont.)		
Division 1. Subdivision 3. Chapter 3. Miscellaneous		
CCR Sections	**Provision**	**Related Policy**
§671 (a)-(c)	Importation, Transportation and Possession of Live Restricted Animals.	FGC §§1002, 2116, 2118, 2118.2, 2118.4, 2119, 2120, 2122, 2123, 2124, 2125, 2126, 2127, 2150, 2190, 2271, 3005.9, 3005.92
§§671.1 (a)(1), (5), (7), (9)(A)-(H); (b)(8)(A)(2)	Permits for Restricted Species	FGC §§1002, 2116-2118, 2120, 2122, 2150, 2150.2, 2190, 2271
§§671.6 (a)(1),(4) (3)	Release of Animals into the Wild	FGC §§2116, 2116.5, 2118, 2118.2, 2118.3, 2118.4, 2120, 2121
§671.7	Permits for Aquaculture Purposes	FGC §§1050, 2116-2118, 2118.5-2123, 2125, 2150-2190, 15200-15202, 15400, 15600
Division 1. Subdivision 3. Chapter 6. Article 1. Take Prohibition…		
CCR Sections	**Provision**	**Related Policy**
§783.0	Purpose and Scope of Regulations.	FGC §§702, 2080, 2081
§783.1	Prohibitions	FGC §§702, 1001, 2080, 2081(a), (d); 2085, 2062, 2067

California Code of Regulations (cont.)

TITLE 14 - NATURAL RESOURCES (cont.)		
Division 1. Subdivision 3. Chapter 6. Article 1. Take Prohibition… (cont.)		
CCR Sections	**Provision**	**Related Policy**
§783.2	Incidental take permit applications	FGC §§702, 2081(b)-(d)
§783.3	Compliance with the California Environmental Quality Act	FGC §§702, 2081(d); PRC §§21002.1, 21069, 21080.1, 21080.3, 21080.4, 21080.5, 21165
§783.4	Incidental Take Permit Review Standards	FGC §§702, 2081(b)-(d)
§783.5	Incidental Take Permit Process	FGC §§702, 2081(b), (d); PRC §§21002.1, 21069, 21080.1, 21080.3, 21080.4, 21080.5, 21165
§783.6	General Permit Conditions	FGC §§702, 2081(b), (d)
§§783.7-783.8	Permit Suspension and Revocation	FGC §§702, 2081(b), (d)
Division 1. Subdivision 3. Chapter 6. Article 2. Take Incidental to Routine and Ongoing Agricultural Activities		
CCR Sections	**Provision**	**Related Policy**
§§786.0-786.8	Purposes	FGC §§700, 702, 704, 2062, 2067, 2068, 2080, 2086, 2087, 2088, 2089, 2835

APPENDIX 2 LIST OF ACRONYMS USED

AIS: aquatic invasive species

ANSTF: Aquatic Nuisance Species Task Force

APHIS: Animal and Plant Health Inspection Service

ARS: Agricultural Resources Service

BWM: International Convention for the Control and Management of Ships' Ballast Water and Sediments

BWMCNSA: Ballast Water Management for Control of Nonindigenous Species Act

CAISMP: California Aquatic Invasive Species Management Plan

CAAIST: California Agencies Aquatic Invasive Species Team

CANOD: California Aquatic Non-native Organism Database

CBD: Convention on Biological Diversity

CESA: California Endangered Species Act

CEQA: California Environmental Quality Act

CCC: California Coastal Commission

CCCA: California Clean Coast Act

CDC: Centers for Disease Control and Prevention

DFA: California Department of Food and Agriculture

DFG: California Department of Fish and Game

CEPA: Coastal Ecosystems Protection Act

CISAC: California Invasive Species Advisory Committee

CITES: Convention on International Trade in Endangered Species

CWA: Clean Water Act

DBW: Department of Boating and Waterways

DOI: Department of the Interior

DWR: Department of Water Resources

EIS: Environmental Impact Statement

ELI: Environmental Law Institute

EO13112: Executive Order 13112

EPA: Environmental Protection Agency

ESA: Endangered Species Act

EEZ: Exclusive Economic Zone

FAO: Food and Agriculture Organization

FAC: Food and Agriculture Code

FGC: Fish and Game Code

FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act

FWCC: (Florida) Fish and Wildlife Conservation Commission

GC: Government Code

HNC: Harbors and Navigation Code

ICES: International Council on Exploration of the Seas

IMO: International Maritime Organization

ISAC: Invasive Species Advisory Committee

ISCC: Invasive Species Council of California

IUCN: The World Conservation Union

MAC: Marine Aquarium Council

MATF: Marine Aquaculture Task Force

MINOE: Management Identifying the Needs of Ocean Ecosystems

MISA: Marine Invasive Species Act

NAFTA: North American Free Trade Agreement

NANPCA: Nonindigenous Aquatic Nuisance Prevention and Control Act

NEPA: National Environmental Policy Act

NISA: National Invasive Species Act

NISC: National Invasive Species Council

NISIC: National Invasive Species Information Center

NOAA: National Oceanic and Atmospheric Administration

OPC: Ocean Protection Council

OSPR: Office of Spill Prevention and Response

OST: Ocean Science Trust

PPA: Plant Protection Act

PRC: Public Resource Code

RWQCB: Regional Water Quality Control Board

SCC: State Coastal Conservancy

SERC: Smithsonian Environmental Research Center

SLC: State Lands Commission

STEP: Shipboard Technology Evaluation Program

SPS: Application of Sanitary and Phytosanitary Measures

SWRCB: State Water Resources Control Board

TBT: tributyl tin

TBT Agreement: Technical Barriers to Trade Agreement

TMDL: Total Maximum Daily Load

UC: University of California

UNEP: United National Environmental Programme

USCG: United States Coast Guard

USDA: United States Department of Agriculture

USFWS: United States Fish and Wildlife Service

USGS: United States Geological Survey

VGP: Vessel General Permit

WCGA: West Coast Governors' Agreement

WRPANS: Western Regional Panel on Aquatic Nuisance Species

WTO: World Trade Organization