

California Aquatic Invasive Species Management Plan

**State of California
Resources Agency
Department of Fish and Game
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TABLE OF CONTENTS

ACKNOWLEDGMENTS	IV
ACRONYM GLOSSARY	V
EXECUTIVE SUMMARY	XI
1. INTRODUCTION	1
2. AIS ECOLOGICAL & ECONOMIC IMPACTS	7
3. VECTORS OF AIS	16
Vector 1. Commercial Shipping.....	19
Vector 2. Commercial Fishing	21
Vector 3. Recreational Equipment & Activities	22
Vector 4. Trade in Live Organisms.....	23
Vector 5. Construction in Aquatic Environments	27
Vector 6. Water Delivery & Diversion System	27
4. MANAGEMENT FRAMEWORK	29
General Framework	29
An Overview of Current AIS Management Activities in California	35
Gaps & Challenges	45
5. SUMMARY OF AIS LAWS, REGULATIONS & AUTHORITIES	46
6. MANAGEMENT OBJECTIVES, STRATEGIES & ACTIONS	50
OBJECTIVE 1: COORDINATION & COLLABORATION.....	53
OBJECTIVE 2: PREVENTION	63
OBJECTIVE 3: EARLY DETECTION & MONITORING	75
OBJECTIVE 4: RAPID RESPONSE & ERADICATION.....	79
OBJECTIVE 5: LONG-TERM CONTROL & MANAGEMENT	82
OBJECTIVE 6: EDUCATION & OUTREACH.....	86
OBJECTIVE 7: RESEARCH	93
OBJECTIVE 8: LAWS & REGULATIONS	96
7. PRIORITIES, IMPLEMENTATION & PLAN EVALUATION	98
8. CASE STUDIES IN ERADICATION & CONTROL	117
1. CAULERPA.....	117
2. SMOOTH CORDGRASS	119
3. BRAZILIAN ELODEA	123

4. EURASIAN WATERMILFOIL	127
5. OTHER AIS SPECIES OF CONCERN	129
9. LITERATURE CITED	132
FIGURES	
1: Nonindigenous Species Surveys from California Harbors & Bays....	4
2: AIS Invasion Progression, Management and Cost.....	15
3: Wetted Surface Area	21
4: Ballast Water Reporting and Discharge Rates	42
5: AIS Coordinating Structure.....	58
TABLES	
1: CAISMP Action Summary	xi
2: Common Bioinvasion Vectors	17
3: Species Management Types.....	31
4: Lead AIS Agency Contacts in California.....	37
5: CAISMP Implementation Table	100
6: Funds Spent on Ongoing AIS Programs and Activities	114
APPENDICES	
A: Draft California Rapid Response Plan	2
B: Federal Authorities, Legislation & Agencies.....	26
C: State Authorities, Legislation & Agencies	37
D: Other AIS Interests: Coordinating Committees, Educational Initiatives & Special Interest Groups	46
E: AIS Plan Development & Process	53
F: Executive Summary of <i>Biological Invasions:</i> <i>Recommendations for U.S. Policy and Management,</i> Position Paper of Ecological Society of America	71
G: List of Regulated Species in California	74

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2007 Plan

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ACRONYM GLOSSARY

This section describes acronyms and other terms concerning entities involved in AIS management, species names used in this plan and a brief glossary.

Acronyms*

AE	Agency Executives (Upper management of state agencies and departments)
AISWG	Aquatic Invasive Species Working Group (see Action 1A3)
ANSTF	Aquatic Nuisance Species Task Force
BML	Bodega Marine Lab
BOE	Board of Equalization
CAAIST	California Agencies Aquatic Invasive Species Team (see Action 1A2)
CAC	County Agricultural Commissioners
CACASA	California Agricultural Commissioners and Sealers Association
CAISMP	California Aquatic Invasive Species Management Plan
CALFED	CALFED Bay-Delta Program
CBC	California Biodiversity Council
CCC	California Coastal Conservancy
CDF	California Department of Forestry and Fire Protection
CeNCOOS	Central and Northern California Ocean Observing System
DBW	California Department of Boating and Waterways
DESP-UCD	Department of Environmental Science and Policy, University of California, Davis
DFG	California Department of Fish and Game
/OSPR	/Office of Spill Prevention and Response
DFA	California Department of Food and Agriculture
DHS	California Department of Health Services
DOE	California Department of Education
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
FA	Federal Agencies
FY	State fiscal year (July 1 through June 30)
ISAC	United States Invasive Species Advisory Committee
ISP	San Francisco Estuary Invasive <i>Spartina</i> Project
NGOs	Non-governmental Organizations
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NPDES	National Pollutant Discharge Elimination System
OPC	California Ocean Protection Council
PARKS	California Department of Parks and Recreation
PBWG	Pacific Ballast Water Group
PSMFC	Pacific States Marine Fisheries Commission
RCD	Resource Conservation District
RI	Research Institutions, universities and affiliated programs
RWQCB	Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCCOOS	Southern California Coastal Ocean Observing System
Sea Grant	California Sea Grant College Program
SFEP	San Francisco Estuary Project
SH	Stakeholders
SLC	California State Lands Commission
SWRCB	State Water Resources Control Board
TRPA	Tahoe Regional Planning Agency
TRCD	Tahoe Resource Conservation District
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture

/ARS	/Agricultural Research Service
/APHIS	/Animal and Plant Health Inspection Service
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WRP	Western Regional Panel

** Acronyms are used largely after the first appearance of an agency name within a chapter. Full names are often spelled out again in subsequent chapters if it has been many pages since the prior mention or if the full name is central to the information presented.*

Important Terms

These terms are used throughout, but especially in Chapter 6 and in the Table 5: CAISMP Implementation Matrix.

Implementing Entity: Since this is a state plan, these are state agencies, programs within state agencies, or groups that include state agencies that fund and have primary accountability and authority for an action being carried out. In Chapter 6, the Implementing Entity appears in **BOLD**. This term is also used in the Implementation Table in Chapter 7.

Cooperating Organizations: Entities whose participation is needed or may be needed to conduct an action. In Chapter 6, cooperating organizations appear in regular, non-bold, type.

Non-governmental Organizations (NGOs): Non-profit organizations directly involved in AIS research or control activities.

Stakeholders: Relevant recreation, industry, local government, landowner representatives and special interest groups.

Plan Implementation and Science Advisory Panels: Panels created per Action 1A5 to help the work of the CAAIST and AISWG.

Species Names

All species names mentioned in this document appear below in full, with their scientific names for reference. Common names are used throughout the document, except in those cases where the scientific name has become the preference for common use (*Arundo*, *Egeria*, *Hydrilla*, *Caulerpa*, etc.). All names appear in full in Appendix G, the Regulated Species List, for the purposes of regulatory clarity.

Invasive Species

1. African clawed frog, *Xenopus laevis*
2. Alligatorweed, *Alternanthera philoxeroides*
3. Asian overbite clam, *Corbula amurensis**
4. Asian swamp eel, *Monopterus albus*
5. Atlantic salmon, *Salmo salar*
6. *Botrylloides diegensis*
7. Brazilian elodea, *Egeria densa* (most commonly called *Egeria*)
8. Bullfrog, *Rana catesbeiana*
9. *Caulerpa taxifolia* (most commonly called *Caulerpa*)
10. Channeled apple snail, *Pomacea canaliculata*
11. Chinese mitten crab, *Eriocheir sinensis*
12. Curly pondweed, *Potamogeton crispus*
13. Dwarf eelgrass, *Nanozostera japonica*
14. English cordgrass, *Spartina anglica*
15. Eurasian watermilfoil, *Myriophyllum spicatum*
16. European frogbit, *Hydrocharis morsus-ranae*
17. European green crab, *Carcinus maenas*
18. Giant reed, *Arundo donax* (most commonly called *Arundo*)
19. Giant salvinia, *Salvinia molesta*
20. Golden mussel, *Limnoperna fortunei*
21. Green sunfish, *Lepomis cyanellus*
22. *Hydrilla verticillata* (most commonly called *Hydrilla*)
23. Japanese seaweed, *Sargassum muticum*
24. Knotted wrack, *Ascophyllum nodosum*
25. Melaleuca, *Melaleuca quinquenervia*
26. *Microcystis* spp.
27. Mosquitofish, *poeciliids*
28. New Zealand mudsnail, *Potamopyrgus antipodarum*
29. Northern Pacific seastar, *Asterias amurensis*
30. Northern pike, *Esox lucius*
31. Northern snakehead, *Channa argus*
32. Paleyellow iris, *Iris pseudacorus*
33. Parrot feather milfoil, *Myriophyllum aquaticum*
34. Perennial pepperweed, *Lepidium latifolium*
35. Purple loosestrife, *Lythrum salicaria*
36. Quagga mussel, *Dreissena bugensis*
37. Sabellid polychaete, *Terebrasabella heterouncinata*
38. Sacramento pikeminnow, *Ptychocheilus grandis*
39. Saltcedar, *Tamarix ramosissima*
40. Saltmeadow cordgrass, *Spartina patens*
41. Sea lamprey, *Petromyzon marinus*
42. Shimofuri goby, *Tridentiger bifasciatus*
43. Shipworm, *Teredo navalis*
44. Small cordgrass, *Spartina maritima*
45. Smooth cordgrass, *Spartina alterniflora*
46. Wakame, *Undaria pinnatifida*
47. Water hyacinth, *Eichhornia crassipes*
48. Water lettuce, *Pistia stratiotes*
49. Yellowfin goby, *Acanthogobius flavimanus*

50. Yellow floating heart, *Nymphoides peltata*
51. Zebra mussel, *Dreissena polymorpha*

Native Species

1. Brown turban snails, *Tegula brunnea*
2. California clapper rail, *Rallus longirostris obsoletus*
3. Chinook salmon, *Oncorhynchus tshawytscha*
4. Dungeness crabs, *Cancer magister*
5. Delta smelt, *Hypomesus transpacificus*
6. Giant kelp, *Macrocystis pyrifera*
7. Green sturgeon, *Acipenser medirostris*
8. Pickleweed, *Salicornia* spp
9. Salt marsh harvest mouse, *Reithrodontomys raviventris*
10. Soft bird's-beak, *Cordylanthus mollis* ssp. *mollis*
11. Steelhead trout, *Oncorhynchus mykiss*

* This document refers to the locally known "Asian clam" as the "Asian overbite clam." Many scientists have begun to call it the "overbite" clam to distinguish it from other invasive clams from the Far East. The species' scientific name is due to be officially modified from *Potamocorbula amurensis* to *Corbula amurensis* in the forthcoming *Light's Manual* and many scientists have begun to use the shorter species name. Other literature citations for the name change can be found on page 5 of the following:

http://www.iep.ca.gov/report/newsletter/2005_newsletters/IEPNews_spring2005final.pdf

Glossary

Accidental introduction: An introduction of nonindigenous species that occurs as the result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast water or in water used to transport fish, mollusks or crustaceans for aquaculture or other purposes.

Biocontrol: The use of living organisms, such as predators, parasites and pathogens, to control pest animals (e.g. insects), weeds or diseases.

Ballast water: Any water and associated sediments used onboard a ship to increase the draft, change the trim, regulate the stability or maintain the stress loads of the vessel.

Control: Eradicating, suppressing, reducing or managing invasive species populations, preventing spread of invasive species from areas where they are present and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

Cryptogenic species: An organism of unknown origin; may be introduced or native.

Ecological integrity: The extent to which an ecosystem has been altered by human behavior; an ecosystem with minimal impact from human activity has a high level of integrity; an ecosystem that has been substantially altered by human activity has a low level of integrity.

Eradicate: For the purpose of this plan, eradication is the complete elimination of an invasive species from a specific part of California or the entire state.

Established: An introduced organism with a permanent population(s), i.e., one that has the ability to reproduce and is not likely to be eliminated by humans or natural causes.

Exotic: Any species or other variable biological material that enters an ecosystem beyond its historic range, including such organisms transferred from one country to another. Also known as nonindigenous or non-native.

Fouling: An accumulation of organisms that attaches to naturally occurring and manmade submerged hard surfaces such as rocks, shells, ships, intake pipes, and other submerged equipment or machinery. Mobile organisms that may be tucked in nooks created by the larger animals are also considered part of the "fouling community".

Genetic dilution: Genetic dilution occurs when introduced organisms add their genetic material to native populations through hybridization. This can result in populations that are less well adapted to their environment, potentially leading to the decline of those populations.

Host: A living animal or plant that supports parasitic animals, plants or microbes, internally or on its surface.

Incipient infestation: A small colony of an invasive species that has spread to a new area.

Intentional introduction: All or part of the process by which a nonindigenous species is purposefully introduced into a new area.

Introduction: The intentional or unintentional escape, release, dissemination or placement of a species into a California ecosystem as a result of human activity.

Invasive species: For the purpose of this plan, the term refers to 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.

Keystone species: A species whose loss would have a disproportionately large effect on its ecosystem relative to its abundance.

Native species: A species within its natural range or natural zone of dispersal, i.e., within the range it would or could occupy without direct or indirect introduction and/or care by humans.

Non-native or Nonindigenous species: A species that enters an ecosystem beyond its historic geographic range. Also known as exotic or alien species. Other taxa can be considered non-native or nonindigenous, such as families, genera, subspecies or varieties.

Nuisance species: For the purpose of this plan, the term is synonymous with invasive species.

Pathogen: A microbe or other organism that causes disease.

Pathways: Natural and human connections that allow movement of species or their reproductive propagules from place to place.

Pioneer infestation: See incipient infestation.

Taxa: Taxa are groups used to classify organisms (e.g. kingdom, phylum, class, order, family, genus and species). Taxa is the plural form of taxon.

Vector: Vector is synonymous with “pathway,” see definition above. As such, vector is defined more broadly in this report than in its narrower more common definition as a pathway solely for pathogens.

Watershed: The geographic area that drains to a single water body or hydrographic unit such as a lake, stream reach or estuary.

EXECUTIVE SUMMARY

Invasion of California Waters

Californians have benefited from the introduction to this state of various fish, plants and other species necessary for food or other human pursuits; however, there are many other introduced species that can wreak havoc on the state's environment and economy. Those species that cause harm and spread quickly from their point of introduction are often called "invasive." For these species, a single individual may produce thousands of seeds, masses of larvae or reproduce from nothing bigger than bits of stems, roots or leaves. Those that live in or near the water – aquatic invasive species – can be easily dispersed to distant water bodies or new ecosystems by currents, tides, river flows, streams, floods and other water flows.

This plan proposes management actions for addressing **aquatic** invasive species (AIS) threats to the State of California. It focuses on the non-native algae, crabs, clams, fish, plants and other species that continue to invade California's creeks, wetlands, rivers, bays and coastal waters. State surveys indicate that at least 607 species of aquatic invaders can be found in California's estuarine waters. These invaders cause major impacts: disrupting agriculture, shipping, water delivery, recreational and commercial fishing; undermining levees, docks and environmental restoration activities; impeding navigation and enjoyment of the state's waterways; and damaging native habitats and the species that depend on them. As the ease of transporting organisms across the Americas and around the globe has increased, so has the rate of AIS introductions.

Vectors & Entry Points

Transoceanic shipping is a major source of AIS invaders. The state estimates that about 9.1 million metric tons of ballast water was discharged in California waters in 2005. Hull fouling may rival ballast water discharge as a leading historical cause of harmful AIS introductions. AIS can also be transported from place to place via other pathways or vectors. Invasive species can cling to recreational gear, fishing equipment, drilling platforms, floating debris and docks. They may escape or be released into state waters from aquaculture packing materials, ornamental ponds and aquariums. Shoreline restoration and construction projects, as well as water-based scientific research, also transport species. The threat of aquatic invasions poses major challenges to California's aquatic systems managers and policy makers. Resources must be devoted to preventing new introductions as well as to containing existing populations. Current state resources and programs are far from adequate to perform this task.

Need for Statewide Action

Though a number of state agencies have been individually addressing AIS concerns or coordinating on individual projects, the scope of the problem has now reached a scale, complexity and cost requiring a more comprehensive statewide approach. Thus, the main purpose of this new California plan is to coordinate state programs, create a statewide decision-making structure and provide a shared baseline of data and agreed-upon actions so that state agencies may work together more efficiently. While the plan recognizes and provides for coordination with the federal, regional, local, private and nonprofit efforts to manage AIS, its central actions concern internal state coordination. As such, the plan ensures state action on high priority activities, improves utilization of scarce state resources and helps bridge gaps in coverage. Plan development was directed by the California Department of Fish & Game and includes input from state agencies involved in AIS management, as well as from the public and stakeholders, over a period of five years.

Plan Goals & Chapters

The plan's overall goal is to identify the steps that need to be taken to minimize the harmful ecological, economic and human health impacts of AIS in California. The plan contains background chapters on AIS environmental and economic impacts. It describes vectors of AIS entry into the state including, but not limited to, commercial shipping, trade in live organisms, construction in aquatic habitats, and water deliveries and diversions. Subsequent chapters explain how AIS are managed in general and what the state has been doing to manage them to date. In addition, case studies for managing four specific AIS appear in the last chapter of this plan.

Beyond this background information and context, the heart of the plan lies in 163 different management actions organized under eight objectives (Table 1):

1. Coordination & Collaboration
2. Prevention
3. Early Detection & Monitoring
4. Rapid Response & Eradication
5. Long-term Control & Management
6. Education & Outreach
7. Research
8. Laws & Regulation

The interagency process of developing and discussing each of these actions, and deciding which entities will undertake them, provides a strong foundation for improving state management and coordination in the years ahead. It also supports the state's first rapid response process for high-risk invaders, which is detailed in Appendix A of this plan.

Current Priorities

The highest priorities among the 163 actions identified in this plan are as follows:

1. Formalize the creation of two major new coordinating entities, one entirely for state agencies and one for a broader range of AIS interests (Action 1A2 and 1A3).
2. Formalize a process for the team of state AIS managers to share information with and get input from agency executives (Action 1A1).
3. Secure funding for state AIS staff (Action 1C3).
4. Conduct a statewide assessment of the risk from four specific AIS vectors: commercial fishing, recreational boating, live bait, and live imported seafood (Actions 2B7, 2C1, 2D1, and 2D4).
5. Fund and launch early detection and rapid response actions, including efforts to coordinate various AIS monitoring programs and expand monitoring of freshwater systems (Strategies 3A and 4A, and Appendix A).

If these core actions can be accomplished, it will provide a basis for pursuing the larger list of AIS management priorities in the future.

Conclusion

Aquatic invasive species are already a serious problem for California. Invasions around the world suggest that environmental and economic impacts from AIS will soon become much greater. This plan provides the state's first comprehensive, coordinated effort to prevent new invasions, minimize impacts from established AIS and establish priorities for action statewide. In addition, it proposes a process for annual plan evaluation and improvement so that AIS can continue to be managed in the most efficient manner in the future.

Table 1: CAISMP Action Summary

The actions described in this table are abbreviated to provide a summary. See Chapter 6 for complete and accurate language of these actions.

OB1: COORDINATION & COLLABORATION	
Internal State Coordination	
1A1.	Develop an executive level consultation process.
1A2.	Formalize the California Agencies AIS Team (CAAIST).
1A3.	Establish, fund and staff an Aquatic Invasive Species Working Group (AISWG).
1A4.	Evaluate the need for an invasive species center.
1A5.	Form and fund technical advisory panels.
1A6.	Draft and update a list of AIS at high risk for introduction.
1A7.	Identify lead state agency for particular AIS, water bodies and invasion vectors.
1A8.	Identify agency personnel required for AIS management.
1A9.	Improve state websites related to AIS.
1A10.	Assess effectiveness of and gaps in state AIS programs.
1A11.	Coordinate AIS management with SWRCB & RWQCBs.
1A12.	Develop and update AIS expert list.
1A13.	Develop boilerplate AIS language for official agency comments.
Local, Nat'l & Int'l Coordination	
1B1.	Identify AIS reps in government agencies and NGOs.
1B2.	Identify conflicts and overlaps among government and NGO AIS programs.
1B3.	Invite community groups for AIS planning and education.
1B4.	Expand participation in local AIS efforts and task forces.
1B5.	Expand participation in regional, national and international AIS task forces.
1B6.	Partner with Mexico, Canada, Pacific Coast and Colorado River states.
1B7.	Participate in national and international conferences.
Funding	
1C1.	Identify and apply for state and national grant funding.
1C2.	Establish stable, long-term funding to help implement this plan.

1C3.	Provide state funding for AIS positions.
1C4.	Provide funding for AIS rapid response actions.
1C5.	Hire a funding development specialist.
1C6.	Provide new funding mechanisms.

OB2: PREVENTION

Regional Vector Assessment

2A1. Rank AIS vector importance in different regions of California.

Commercial Vessels & Maritime Activities

- 2B1. Quantify ballast water and hull fouling vectors and assess invasion risk.
- 2B2. Continue and improve state ballast water inspection and enforcement program.
- 2B3. Implement discharge standards for treated ballast water.
- 2B4. Identify and address gaps in Marine Invasive Species Act.
- 2B5. Develop a commercial vessel fouling outreach and management program.
- 2B6. Investigate how moving maritime structures can contribute to AIS dispersal.
- 2B7. Quantify and assess the role of commercial fishing vessels as AIS vectors.
- 2B8. Develop a commercial fishing outreach and management program.

Recreation

- 2C1. Quantify and assess recreational boating as an AIS vector.
- 2C2. Develop a recreational boating outreach and management program.
- 2C3. Develop a watercraft inspection program for high priority boat launch sites.
- 2C4. Quantify and assess recreational fishing as an AIS vector.
- 2C5. Develop a recreational fishing outreach and management program.
- 2C6. Develop guidelines for: disposal of invasive species at marinas; cleaning of fishing gear and equipment; disposal of live bait.

Bait, Seafood, Aquaculture & Aquarium

- 2D1. Quantify and assess bait as an AIS vector.
- 2D2. Work with the bait industry to develop prevention strategies.
- 2D3. Develop a bait outreach and management program.
- 2D4. Quantify and assess imported seafood as an AIS vector.
- 2D5. Work with the live seafood industry to develop preventative strategies.
- 2D6. Develop an imported seafood outreach and management program.
- 2D7. Assess risks posed by water handling systems.
- 2D8. Educate aquaculture industry on containment systems.
- 2D9. Develop an aquaculture outreach and management program.
- 2D10. Quantify and assess how aquarium and aquascaping introductions contribute to AIS introductions.
- 2D11. Work with aquarium, water garden and other industries on accessible disposal.
- 2D12. Implement an aquarium and aquascaping outreach and management program.

Fisheries Enhancement

- 2E1. Quantify and assess fisheries enhancement as an AIS vector.
- 2E2. Review DFG practice of intentional introductions of non-native species for recreational purposes.
- 2E3. Reduce unauthorized stocking of non-native species.
- 2E4. Weigh benefits of mosquito-fish introduction.

Research, Management & Education

- 2F1. Quantify and assess research, resource management and educational activities as AIS vectors.
- 2F2. Establish protocols to minimize spread of AIS by these activities.
- 2F3. Evaluate regulations and protocols for in-water research.
- 2F4. Quantify and assess live aquatic species shipments for research as an AIS vector.

Table 1: CAISMP Action Summary (continued)

Construction & Restoration

- 2G1. Quantify and assess construction activities as an AIS vector.
- 2G2. Work with industry to develop equipment decontamination guidelines.
- 2G3. Develop a construction outreach and management program.
- 2G4. Quantify and assess restoration activities as an AIS vector.
- 2G5. Encourage the use of native species.
- 2G6. Develop a restoration outreach program.

Water Diversion

- 2H1. Quantify and assess the water delivery and diversion system as an AIS vector.
- 2H2. Develop an outreach and management program for the system.

Enforcement & Inspection

- 2I1. Increase staffing and hours at DFA Border Protection Stations.
- 2I2. Develop guidelines for border inspections.
- 2I3. Increase DFG enforcement of current regulations on prohibited and restricted species.
- 2I4. Ensure adequate staffing and cargo inspection guidelines for port and airport enforcement.
- 2I5. Continue disease sampling for shipments and stocks of live aquatic species.
- 2I6. Identify mail order, online vendors selling California prohibited and restricted species.

OB3: EARLY DETECTION & MONITORING

Early Detection

- 3A1. Assess current monitoring of state waters for early detection opportunities.
- 3A2. Assess how the state's Marine Invasive Species Program monitoring can aid early detection.

- 3A3. Develop a statewide approach to early detection.
- 3A4. Outreach to those regularly sampling state waters.
- 3A5. Create and train a statewide citizen monitoring network.
- 3A6. Engage professional divers in early detection network.
- 3A7. Review efficacy of the state's AIS early detection systems.

Long-Term Monitoring

- 3B1. Assess long-term AIS monitoring of state waters.
- 3B2. Coordinate with ocean observing groups.
- 3B3. Monitor locations with a high invasion rate.
- 3B4. Monitor the population growth and dispersal of established AIS.
- 3B5. Fund the incorporation of DFG's historical stream surveys and report findings into a central database.
- 3B6. Include maps of existing AIS in California waters in the DFG BIOS system.
- 3B7. Review the efficacy of long-term monitoring systems.

OB4: RAPID RESPONSE & ERADICATION

Rapid Response

- 4A1. Develop and implement a statewide rapid response plan.
- 4A2. Evaluate and coordinate existing systems for reporting AIS sightings.
- 4A3. Develop species- and/or location-specific rapid response plans.
- 4A4. Explore permanent funding for rapid response.

Eradication

- 4B1. Review effectiveness of eradication programs.
- 4B2. Continue and complete current eradication efforts.
- 4B3. Standardize criteria for identifying priority species for eradication.
- 4B4. Develop a method to prioritize sites of AIS invasion concern.
- 4B5. Identify ecologically sensitive waters requiring additional precautions.

OB5: LONG-TERM CONTROL & MANAGEMENT

Control

- 5A1. Develop a method or criteria to prioritize control actions.
- 5A2. Prioritize control efforts for existing and new organisms of concern.
- 5A3. Continue ongoing control programs.
- 5A4. Develop species- and site-specific control plans.
- 5A5. Provide technical assistance to watershed councils, irrigation districts and other groups.

Limit Dispersal to New Areas

- 5B1. Establish boat washing stations and disposal facilities at infested waters.
- 5B2. Install AIS warning and information signs in infested areas.
- 5B3. Use volunteer monitors to conduct AIS inspections.
- 5B4. Develop criteria for enforcing closures of infested areas.

Protect Natives

- 5C1. Prioritize ecologically sensitive areas at risk of AIS impacts.
- 5C2. Coordinate entities to meet AIS protection and restoration objectives.
- 5C3. Develop GIS maps showing coincidence of AIS and critical ecosystems.
- 5C4. Establish guidelines for when AIS eradication or control will occur in sensitive areas.
- 5C5. Adopt guidelines on best practices for timber, agricultural or livestock activities.
- 5C6. Assess guidelines for preventing AIS spread in habitat restoration and shoreline landscaping projects.

Table 1: CAISMP Action Summary (continued)

OB6: EDUCATION & OUTREACH	Resource Managers & Researchers	OB7: RESEARCH
<p>Outreach</p> <p>6A1. Inventory education and outreach efforts and develop a state AIS communication strategy.</p> <p>6A2. Partner with ongoing outreach campaigns.</p> <p>6A3. Develop a DFG Communications Plan.</p> <p>6A4. Develop posters, brochures and articles for industry sectors and user groups.</p> <p>6A5. Develop permanent interpretive displays at marinas, boat ramps and fishing sites.</p> <p>6A6. Work directly with industry trade shows to deliver the AIS message.</p> <p>6A7. Present AIS information at public gatherings.</p> <p>6A8. Include AIS information in state hunting, fishing and boating regulations and licenses.</p> <p>6A9. Include AIS information in local fishing and recreational publications.</p> <p>6A10. Develop and distribute AIS identification cards.</p> <p>6A11. Encourage industries to offer noninvasive alternatives to AIS.</p> <p>6A12. Partner with stakeholders and interest groups to broaden education efforts.</p> <p>6A13. Educate waterfront and shoreline property owners about AIS.</p> <p>6A14. Develop and offer AIS management classes for professional organizations.</p> <p>6A15. Continue state education measures concerning ballast water.</p>	<p>Schools</p> <p>6C1. Increase AIS awareness among scientific and natural resource managers.</p> <p>6C2. Educate researchers on AIS containment, disposal methods and legal restrictions.</p> <p>6C3. Develop an AIS regulatory handbook.</p> <p>6C4. Share information on current mechanical, chemical, biological and physical control methods.</p> <p>6C5. Disseminate guidelines to promote use of native plants.</p> <p>6C6. Encourage the training of more taxonomists.</p> <p>General Public</p> <p>6E1. Develop press kits.</p> <p>6E2. Increase local TV, radio and newspaper media coverage.</p> <p>6E3. Identify state publications and websites to add AIS information.</p> <p>6E4. Develop multicultural educational materials.</p> <p>6E5. Develop AIS traveling trunks and portable presentation boards.</p>	<p>Baseline Biology</p> <p>7A1. Host workshops to develop AIS research priorities and identify gaps.</p> <p>7A2. Assess, continue and complete current studies.</p> <p>7A3. Develop a strategy to communicate and support research needs.</p> <p>Economics</p> <p>7B1. Perform economic impact studies on AIS effects.</p> <p>7B2. Assess and compare costs of different management techniques.</p> <p>Management Options</p> <p>7C1. Evaluate efficacy of AIS management methods.</p> <p>7C2. Investigate the efficacy of invasion prevention techniques.</p> <p>7C3. Consider shipboard ballast water treatment testing center.</p> <p>7C4. Identify opportunities for interagency funding of AIS management research.</p>
<p>Policymakers</p> <p>6B1. Brief decision makers and legislators on AIS management progress.</p> <p>6B2. Brief the Fish and Game Commission, SLC, OPC, SCC and CCC.</p>		<p>OB8: LAWS & REGULATIONS</p> <p>Laws & Regulations</p> <p>8A1. Establish a regulatory review committee.</p> <p>8A2. Identify the potential for improved regulatory coordination.</p> <p>8A3. Pursue the authority to establish an interagency rapid response program.</p> <p>8A4. Explore the need for additional state authority for AIS management.</p> <p>8A5. Develop and pursue the adoption of new AIS legislation.</p> <p>8A6. Explore how new or modified regulations can bridge authority gaps.</p> <p>8A7. Develop and pursue the adoption of new regulations.</p>

1. INTRODUCTION

What are Invasive Species?

An invasive species is “a species that is non-native to the ecosystem under consideration, and whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human health,” according to the National Invasive Species Management Plan (National Invasive Species Council 2001). The characteristic of causing, or potentially causing, harm is central to the federal definition because it produces policy and management consequences. In other literature and in legislation, such invaders are also sometimes referred to as “nuisance” species.

From a technical point of view, “invasive” refers to species that rapidly reproduce and spread outside their point of origin. The term “invasive species” is distinct from “non-native,” “nonindigenous,” “alien” or “exotic” species – the latter terms refer only to the origin of the species and not their rate of reproduction, dispersal or potential to cause harm (see Glossary for further definitions).

This management plan focuses on **aquatic** invasive species – algae, insects, crabs, clams, fish, plants and other invaders to California’s creeks, wetlands, rivers, bays and coastal waters. Aquatic invasive species (AIS) threaten the diversity and abundance of native species and natural communities, the ecological stability and water quality of infested waters, and the commercial, agricultural, aquacultural and recreational activities dependent on these waters. The economic consequences of AIS impacts can be substantial, from decreased productivity of commercial fisheries to lowered property values and the expenditure of billions of dollars to alleviate AIS impacts in water bodies after they have already become infested (Pimentel et al. 2000).

Geographic Scope

This report proposes AIS management actions and a rapid response plan for the State of California. The diversity of California waters is extensive and includes: the rich coastal waters and estuaries of the Pacific Ocean (approximately 3,500 miles of tidal shoreline); over 210,000 miles of rivers and streams; over two million acres of freshwater wetlands, lakes, ponds and reservoirs; over 400,000 acres of saline lakes; and more than 22,000 miles of ditches and canals (RF3 computerized database; USGS Digital Line Graph traces; SWRCB’s 2002 WBS database).

These diverse aquatic resources provide habitat for native marine and freshwater animals and plants including invertebrates, fish, and other aquatic or riparian-dependent species, aesthetic enjoyment, hydropower, irrigation, municipal and industrial water supplies and countless recreational and commercial opportunities.

The authorities and programs outlined in this plan are generally limited to the political boundaries of California; however, it is recognized that there is a need for interstate and international cooperation to prevent the introduction and spread of AIS. The plan prescribes increased coordination with all Western states, Mexico and Canada, as rivers, water delivery systems, and water-based commerce and recreation cross state or national boundaries.

History of Invasions

The introduction of non-native species into the United States has been occurring for centuries, probably beginning with the introduction of human diseases and pests as a result of European settlement. The broad scale introduction of species into California waters most clearly begins with the shipment of tens of thousands of barrels of oysters from the East Coast after the establishment of the transcontinental railway (Barrett 1963). The huge influx of settlers, the establishment of maritime commerce and a multitude of other human activities through the 1900s contributed to continued invasions.

Since then, hundreds of AIS have found their way into California waters, not only via transoceanic ships, but also by other vectors such as aquaculture, the aquarium trade, the bait industry, recreational activities, biological research, environmental restoration projects and even freshwater deliveries up and down the state. Statewide, researchers have now identified 607 introduced, or likely introduced, species in California's estuarine waters (DFG/OSPR 2002 – see Figure 1). In San Francisco Bay, the rate at which AIS are becoming established increased from an average of one new species every 55 weeks prior to 1960, to one new species every 14 weeks between 1961 and 1995 (Cohen and Carlton 1998). To date more than 250 non-native species have been found in the San Francisco Bay-Delta Estuary (Cohen, Pers. Comm. 2006).

Some of the most problematic AIS that have become established in California include the European green crab, the Chinese mitten crab, the Asian overbite clam, and a plethora of aquatic plants with origins as far away as Brazil and Japan (for full scientific references see Acronym Glossary, Species Names page 7). More information on these invasions appears in subsequent chapters. Perhaps the most important issue is not the species that have already invaded but those that might invade in the future, such as the notorious zebra mussel. Quagga mussel, which poses a threat similar to the closely related zebra mussel, was found in Lake Mead, Nevada on January 7, 2007 and subsequently in Lake Havasu in California. Based on the damage caused in the Great Lakes region by zebra and quagga mussels, these European freshwater invertebrates could threaten California's entire water delivery system, irrigation network and freshwater ecosystems.

In general, it is extremely difficult to predict the impacts that most AIS may have on natural resources, human health, infrastructure and the economy. It is clear, however, that biological invasions of California are likely to continue, as global movements of goods and services continue to increase.

In the United States, the number of non-native plant pathogens, insects, and mollusks discovered since 1920 strongly correlates with importation of goods over the same time period, and is forecast to increase by 16-24% over the next 20 years. As the world's largest economy and home to many of the world's richest ecosystems, the United States is particularly vulnerable to additional biological invasions (Lodge et al. 2006). California is equally vulnerable as a Pacific Coast trade hub, immigration and recreation destination and major engine of the American economy.

Figure 1: Nonindigenous Species Surveys from California Harbors and Bays

These graphs compile information from surveys that included coastal harbors, bays and estuaries along the length of the state and the Sacramento/San Joaquin Delta (up to Sacramento and Stockton). *Source: DFG-OSPR 2002*. A very small introduction status category in the source document graphs is not shown here for simplification. That category represents the number of species that may have been introduced from one region of California to another.

Outer coastal waters were not included in the surveys that generated the graphs shown here, however a new report on nonindigenous species surveys for outer coastal waters is available at www.dfg.ca.gov/ospr/organizational/scientific/exotic/MISMP.htm

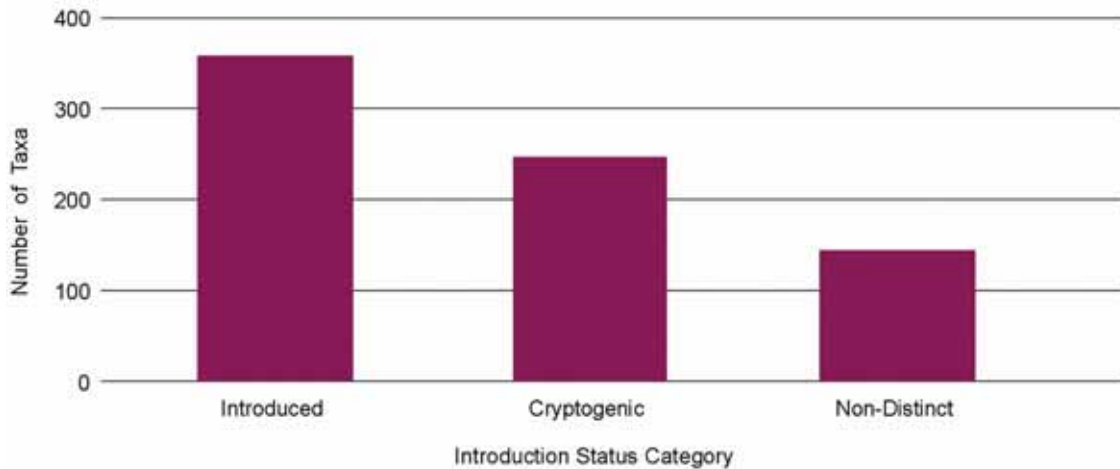
Introduction Status Categories

Introduced = Organisms identified to species. Introduced to California.

Cryptogenic = Organisms identified to species. Possibly introduced to California.

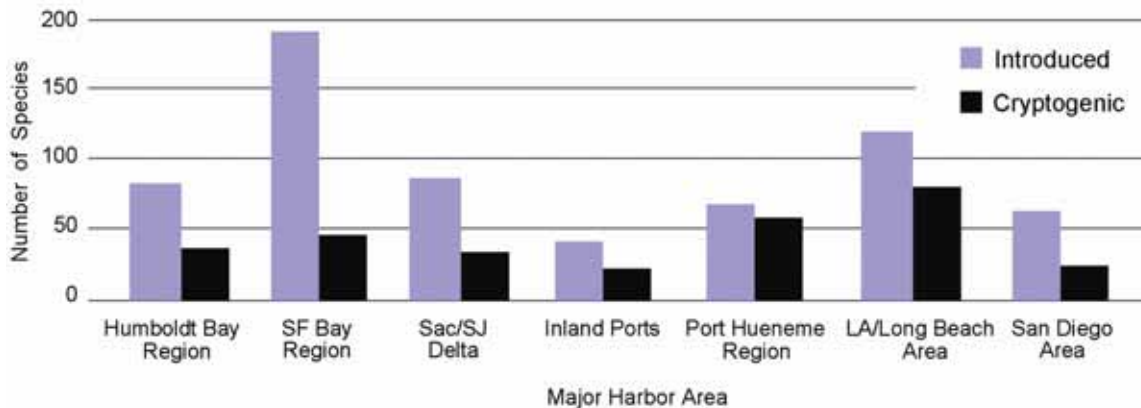
Non-Distinct = Organisms not identified to the level of species. Possibly introduced to California.

Numbers of Nonindigenous taxa by introduction status category



Number of Nonindigenous species in 7 major ports of California

This graph shows the number of introduced and cryptogenic species for each major harbor area. Species found in multiple harbor areas are represented more than once on the graph.



Benefits of a Statewide Plan

AIS pose unique challenges to California's water and resource managers, as well as to those developing policies affecting aquatic environments. Unlike other sources of pollution, established AIS populations can reproduce and spread. As a result, resources must be devoted to both the prevention of new introductions and the control of existing ones. The introduction of only a few organisms, or in the case of aquatic plants and algae, a tiny portion of an organism, can result in the infestation of an entire water body or watershed. These introductions can occur through a variety of vectors, further complicating preventative measures.

California's past efforts to address AIS focused on control of those species that most directly impacted boating, agriculture and other human activities. More recently, California's focus has shifted toward prevention, with programs aimed at excluding plant pests and managing AIS-laden ballast water on ships. Current AIS activities involve prevention, eradication, management and education. These activities are not adequately coordinated throughout the state and do not comprehensively manage current established AIS or adequately prepare for new invasions.

The vital importance of California's aquatic resources requires the creation of a more comprehensive management plan for responding to AIS. This management plan targets both marine and freshwater environments and highlights the need for aggressive action on many fronts. Although these pages describe the significant need for AIS management, there is currently no statutory mandate in California for the preparation of this management plan.

The plan meets federal requirements to develop statewide Nonindigenous Aquatic Nuisance Species Management Plans under Section 1204 of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (amended as the National Invasive Species Act of 1996 – see Appendix B). This Act authorizes a 75:25 federal to state match of funds required to achieve objectives and actions outlined in plans approved by the federal Aquatic Nuisance Species Task Force (ANSTF, also established by the 1990 act). In developing this plan, the State of California has closely followed the *Guidance for State and Interstate Aquatic Nuisance Species Management Plans* developed by the ANSTF in 2000. Suggested actions contained in the Western Regional Panel's *Recommendations on State Actions to Improve Our Regional Capacity for Managing Aquatic Invasive Species* (revised June 2003) were also incorporated.

California Plan Goal & Objectives

The California Aquatic Invasive Species Management Plan (CAISMP) provides a common platform of background information from which state agencies and other entities can work together to address the problem of aquatic invasive species. Beyond providing information, the goal of this planning process has been to identify the major objectives and associated actions that need to be attained in order to minimize the harmful ecological, economic and

human health impacts of aquatic invasive species in California.

Eight major objectives have been identified:

1. Improve coordination and collaboration among the people, agencies, and activities involved with AIS.
2. Minimize and prevent the introduction and spread of AIS into and throughout the waters of California.
3. Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.
4. Establish and manage systems for rapid response and eradication.
5. Control the spread of AIS and minimize their impacts on native habitats and species.
6. Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.
7. Increase research on the baseline biology of AIS, the ecological and economic impacts of invasions and control options to improve management.
8. Ensure state laws and regulations promote the prevention and management of AIS introductions.

Each objective is supported by a series of strategic actions with the implementing entities and cooperating organizations identified, and costs included where appropriate. Detailed actions can be found in Chapter 6: Management Actions, Strategies and Objectives and in Table 5: CAISMP Implementation Matrix.

The plan goal, objectives, strategies, and specific actions were developed with input from a series of stakeholder scoping meetings, interagency staff communications and public workshops held in 2002 and 2006 (see Appendix E). These meetings, as well as many individual conversations and extensive review, played a role in making the plan as comprehensive and responsive to AIS issues in California as possible.

2. AIS ECOLOGICAL & ECONOMIC IMPACTS

California currently faces a variety of significant and lasting impacts from aquatic invaders in both fresh and coastal waters. In general, these include:

- Reduced diversity and abundance of native plants and animals (due to competition, predation, parasitism, genetic dilution, introduction of pathogens, smothering and loss of habitat to invasive species).
- Degradation of wildlife habitat.
- Stresses on rare, threatened, and endangered species.
- Alteration of the native food web and declines in productivity.
- Changes in biogeochemical cycles (including nutrient cycling and energy flow).
- Losses in fisheries production.
- Impairment of recreational uses such as swimming, boating, diving and fishing.
- Impairment of agricultural infrastructure such as irrigation canals.
- Impairment of water delivery systems.
- Degradation of water quality.
- Threats to public health and safety (via parasites and disease).
- Diminished property values.
- Loss of coastal infrastructure due to fouling and boring organisms.
- Erosion and destabilization of shorelines, banks and levees.
- Increased costs to business, agriculture, landowners and government of invasive pest control, treatment and clean up.

Ecological Impacts

In terms of ecological impacts, the introduction of invasive species is thought to be second only to habitat loss in contributing to declining native biodiversity throughout the United States. Nationwide, non-native species have contributed to 68% of the fish extinctions in the past 100 years and the decline of 70% of the fish species listed under the Endangered Species Act (Wilcove et al. 1998).

California has been invaded by many aquatic plants and animals which have altered native ecosystems and taken a toll on recreation, commercial fishing and sensitive native species (i.e. species that are listed as endangered or threatened or otherwise considered rare or declining).

California Examples

- **European green crab** likely arrived in seaweed packed with bait worms shipped from the Atlantic to the Pacific Coast. They were first detected on the West Coast in San Francisco Bay in the late 1980s. By 1996 the crab had spread along 300 miles of coastal California (Lafferty and Kuris, 1996). Green crabs may prey upon juvenile Dungeness crabs as well as cultured oysters, clams and mussels (McDonald et al. 2001 & Grosholz and Ruiz, 1995). Clam and native shore crab populations in California have dropped significantly since the arrival of the green crab (Sea Grant 1998). Densities of native clams and shore crabs showed a five to ten-fold decline within three years of the green crab's arrival (Grosholz et al. 2000).
- **Arundo** is a plant native to the Mediterranean and tropical Asia. In California, it was planted as early as the late 1700s as a windbreak and for erosion control in flood channels. This reed grows in thick, bamboo-like stands that can reach a height of 30 feet. Its monotypic growth displaces native vegetation, increases flooding and siltation, increases water loss from underground aquifers and increases the susceptibility of riparian areas to fire. Despite its sizable height, it does little to shade in-stream habitat. The higher resulting water temperatures harm aquatic wildlife, including protected frogs, turtles and fish (see Appendix D, Team Arundo).
- **Asian overbite clam** was introduced into San Francisco Bay via ballast water discharge and first collected in 1986. This Asian species has since become the most abundant clam in the northern part of the bay, ultimately reaching densities of nearly 50,000 clams per square meter (Peterson 1996), and has radically altered food-web dynamics and augmented contaminant transfer up the food web (Stewart et al. 2004). It is estimated that clams in the northern portion of San Francisco Bay have the capacity to filter the entire water column at least once and possibly more than twice in a single day (Thompson 2005).
- **Wakame**, an Asian seaweed, arrived in Los Angeles Harbor in 2000 and has since spread as far north as Monterey Bay (Sanctuary Integrated Monitoring Network 2007). One plant can release millions of spores capable of remaining dormant for many years before sprouting (Fisheries Global Information System 2007). Biologists fear it will either disrupt or hybridize with native giant kelp, endangering a keystone species of the California coast (Chapman 2005).
- **Japanese eelgrass** first established itself in the Pacific Northwest in the 1950s, probably arriving as packing material for oysters. It has since colonized hundreds of acres of bays in Washington and Oregon, growing in dense mats on formerly unvegetated mudflats. Studies suggest that the eelgrass displaces native burrowing shrimp and reduces habitat quality for feeding shorebirds (Posey 1988). It was discovered in California in 2002 growing on the shores of Indian Island in Humboldt Bay.

Most of these species are not the only invader in their newfound habitats. In combination, invasive species can have even larger scale impacts on the environment. In the Sacramento-San Joaquin River Delta, for example, a clam and several plant species are all implicated in the sharp decline of endangered Delta smelt. In this small fish's habitat, the Asian overbite clam has recently increased in abundance, possibly due to seasonal changes in outflows and salinity. This invader's higher abundance and presence during more periods of the year than in the past, may be intensifying its impact on the pelagic food web which sustains Delta smelt. Young smelt, not to mention the popular sport fish, striped bass, may also be suffering from changes in habitat, water turbidity and predation levels caused by aquatic invasive weeds (Feyrer et al. in revision).

In sum, AIS may not only have direct ecological impacts on habitats, species and food webs, but can also confound efforts to restore and protect these resources. More details on specific AIS impacts and efforts to manage them can be found in the case studies in Chapters 4 and 8.

Economic Impacts: United States

Most of the environmental impacts described above have associated economic costs as managers invest time and money trying to minimize AIS impacts on native species and habitats. Other economic losses are incurred when AIS invasions hamper or jeopardize human activities. For example, in just three years in the early 20th century, the invasion of a single organism, the shipworm, caused \$615 million (1992 dollars) of structural damage to maritime facilities (Cohen, AN and JT Carlton 1995). On a national level, invasions are costing American taxpayers billions of dollars every year in environmental degradation, lost agricultural productivity, expensive prevention and eradication efforts and increased health problems. One nationwide estimate suggests that annual costs in environmental damage and losses, arising from the 50,000 invasive species now in the United States, exceed \$120 billion (Pimentel et al. 2005).

Invasives that spread into aquatic environments can be particularly costly to manage. The damage and costs associated with control of AIS in the United States are estimated to be \$9 billion annually (Pimentel 2003). A breakdown by type of invader suggests annual costs as follows:

Fish	\$5.4 billion
Zebra & quagga mussels	\$1 billion
Asiatic clams	\$1 billion
West Nile virus	\$1 billion
Aquatic plants	\$500 million
Shipworm	\$205 million
Green crab	\$100 million

In an earlier study for the U.S. Congress, the Office of Technology Assessment (OTA) attempted to quantify economic impacts of 111 species of invasive fish and 88 species of invasive mollusks. Of these only four fish species and 15 mollusk species resulted in major negative impacts—including the sea lamprey, zebra mussel, and Asian overbite clam. OTA estimated that the cumulative loss to the U.S. for the period 1906-1991 from three harmful fish species was \$467 million (1991 dollars) and \$1.3 billion from three aquatic invertebrates. Invasive aquatic and riparian plants can also have costly impacts. OTA reports that spending on aquatic plant control in the U.S. is \$100 million per year (Lovell and Stone 2005).

Another indicator of economic impacts is government spending. In 1999 and 2000, the federal government spent \$459 million and \$556 million, respectively on activities related to invasive species; however, federal funding to address fish and aquatic invertebrates was only \$20.4 million in 1999. In 2004, federal funding to the U.S. Coast Guard, largely for programs to limit invasions via ballast water on ships, was \$4.5 million (Lovell and Stone 2005). These numbers underscore how limited government spending on aquatic invasions is compared to spending on agricultural and forestry pests, despite the complexity and consequences of these invasions.

One of the most costly and well-studied North American invasions has been the introduction of zebra mussel to the Great Lakes. In 1988, zebra mussel was first discovered in Lake Saint Clair, a small water body connecting Lake Huron and Lake Erie. By 2006, zebra mussels inhabited the waters of at least 20 states. This prolific mussel colonizes pipes, constricting flow and thereby reducing water intake for heat exchangers, condensers, fire-fighting equipment and air conditioning and cooling systems. Zebra mussel densities were as high as 700,000 per square meter at one power plant in Michigan (Kovalak et al. 1993). One estimate puts the cost of scraping mussels from pipes in the Great Lakes region alone at \$50-100 million per year (Maryland Sea Grant 2003). Zebra mussels also attach to boat hulls, docks, locks, breakwaters and navigational aids, increasing maintenance costs, impeding transportation and increasing the likelihood of spread of the species.

Economic Impacts: California

AIS could threaten or undermine resources of great economic value to California. Recent statistics shed some light on the importance of California's water resources to residents and visitors alike.

- California has the largest ocean economy in the United States, ranking number one overall for both employment and gross state product. This economy (which includes coastal construction, living resources, offshore minerals, ship and boat building and repair, maritime transportation and ports, and coastal tourism and recreation) generated \$42.9 billion in 2000 and provided almost 700,000 jobs (Kildow and Colgan 2005).

- Commercial fish landed in California in 2005 had a value of over \$106 million (DFG Marine Fisheries Statistical Unit).
- Marine recreational fishing in California brought in an estimated \$768 million in expenditures in 2005 (NOAA Fisheries Service survey, formerly NMFS).
- Sport fishing licenses issued in 2005 were 1,978,143 (DFG License and Revenue Branch).
- In 2005, there were 965,892 boats registered in California. Recreational boating currently contributes \$17 billion annually to the California economy (DBW).
- California's travel industry and associated recreation contributes approximately \$55.2 billion annually to the state's economy. Much of this recreational activity is centered on water or water-based activities (California Trade and Commerce Agency, Division of Tourism).

AIS can have dramatic impacts on these important state resources and activities. Recreational boating and fishing, in particular, have long been hampered by aquatic weeds. The control of weeds to facilitate the public's enjoyment of these activities has required some of the state's longest-lived and most expensive management programs. Over the past three decades state agencies have spent more than \$60 million to keep a handful of aquatic weed species from impeding the navigation of rivers, lakes, bays and other waterways, not to mention their causing other problems for fish, wildlife, agriculture and water quality.

- **Water hyacinth** was introduced into the United States in 1884 as an ornamental plant for water gardens, where its floating showy, lavender-blue flowers attracted many admirers. Water hyacinth can double its size every ten days in hot weather. By 1904, the water hyacinth had made its way into a Yolo County, California slough. Surveys in recent years indicate that by early summer, the infestation can cover up to approximately 4,000 acres of the Sacramento-San Joaquin Delta. At present, aquatic herbicides remain the primary tools available to control water hyacinth. Two weevils and a moth have been introduced as biological controls but have not demonstrated much success. Programs to manage water hyacinth in the Sacramento-San Joaquin Delta, its tributaries and the Suisun Marsh have been the responsibility of the state's Department of Boating and Waterways (DBW). Over the program's 22-year history, DBW's costs for water hyacinth control have mounted to approximately \$25 million dollars, with annual spending currently around \$2.5 million.
- **Hydrilla** was imported into the United States from Asia in the late 1950s for aquarium aficionados. The plant, which grows in dense mats, is most likely to spread when fragments are carried into new habitat by recreational watercraft. Hydrilla has been found in 17 of California's 58 counties. Working to eradicate hydrilla – as well as managing other aquatic weeds and wetland plants such as purple loosestrife, giant salvinia, and alligatorweed – is the responsibility of the state's Department of Food and Agriculture (DFA). Since the 1970s, DFA has spent approximately \$30 million dollars on aquatic weed control, with most of that money being focused on hydrilla eradication, which costs about \$1.5 million per year. Such expenditures have enabled DFA to eradicate the plant from 19 sites in 12 counties, but much work remains to be done.

DBW and DFA expenditures on aquatic weed control are just the tip of the iceberg (see side bar). The two budgets described in the water hyacinth and *Hydrilla* programs do not take into account the cost of control efforts by other public agencies and private landowners, lost revenue due to decreased property values, impacts on fisheries or decreased use of water for swimming, boating, fishing and other recreational activities. Other costly current infestations of aquatic or riparian plants in California include saltcedar (tamarisk), purple loosestrife, perennial pepperweed, Brazilian elodea, and smooth cordgrass.

Fish, clams, crabs and other AIS can be more costly to control than plants, and in many cases, they cannot be controlled once they become established. The troublesome zebra mussel has yet to be documented in California; however, it has been detected at border inspection stations on dozens of occasions. Research suggests the zebra mussel has a broad potential range in California. Of 160 sites assessed, 44% had a high potential for colonization due to sufficient calcium level, appropriate pH, temperature, salinity range, and constant submersion (Cohen and Weinstein 1998). Most coastal watersheds, the western portion of the Sacramento Valley, the San Joaquin River and the southern Delta, offer conditions suitable for zebra mussel proliferation. Areas with a high potential for colonization encompass many of the state's most important water delivery facilities, including the Delta-Mendota Canal, the California and South Bay Aqueducts, the Los Angeles Aqueduct, the Colorado River Aqueduct, the All American Canal and their reservoirs (Cohen and Weinstein 1998).

In January 2007, quagga mussel, a close relative of zebra mussel, was found in Lake Havasu in the Colorado River in California. Quagga mussel prefers deeper, cooler water than zebra mussel but poses the same serious threat to California's entire water delivery system and irrigation network. Prevention programs for these two species would be almost identical. Until there is time to develop species specific analysis, the economic analyses and potential distribution created for zebra mussel is being used as a guideline for quagga mussel.

Damage to the water delivery system that provides drinking water to millions of southern Californians, or damage to the irrigation network that supports a \$30 billion per year agricultural industry, could produce extraordinary economic and social consequences. A recent risk analysis, based on lakes in Michigan, compared optimal spending on zebra mussel prevention to estimated costs of reducing the impacts to local power plants, if it were to become established. The analysis suggests that it would be beneficial to spend up to \$324,000 per year to obtain a modest reduction in the probability of a zebra mussel invasion into a single lake with a power plant (Leung et al. 2002).

In spite of the warnings from states already battling zebra mussels and quantitative analyses such as those described above, relatively few resources were directed towards the pending threat to California posed by these and similar organisms. Indeed the first line of defense, border protection stations, where

trailer boats arrive from infested states, were far below adequate staffing and operational hours for consistent inspection and interception, and provided little in the way of AIS information to travelers (see Management Examples, Chapter 5). After the quagga mussel was discovered in Lake Mead and the lower Colorado River, short-term emergency funding was provided to state agencies responding to the incident, and permanent funding was later authorized to provide additional staff for an ongoing program. These measures are a positive step, but additional long-term funding is needed to increase intervention at all border protection stations and provide staff to prevent further introductions.

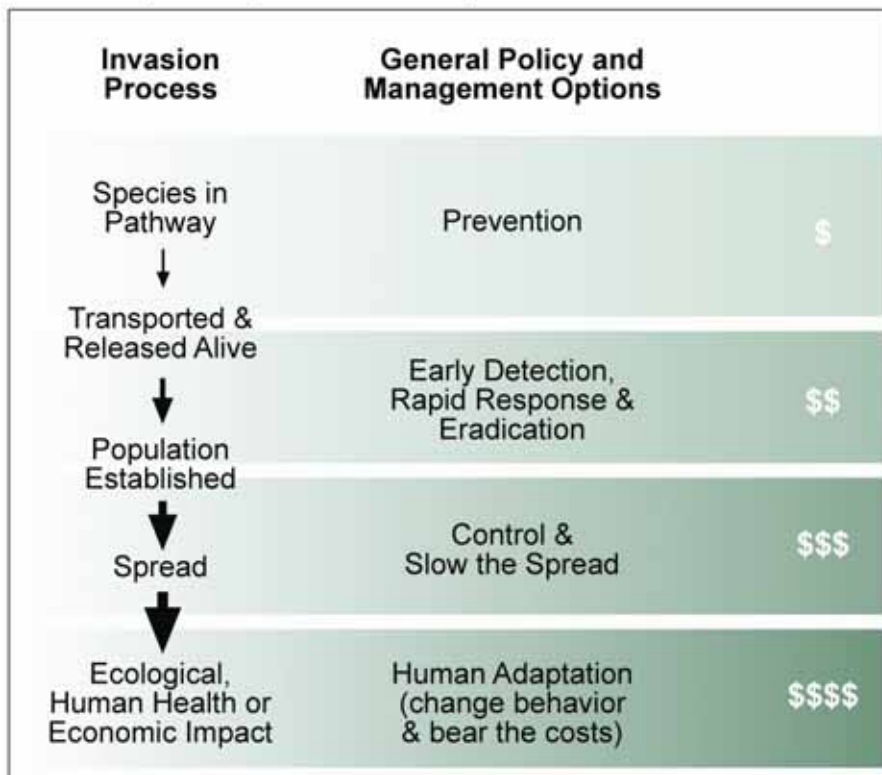
Conclusion

The harm done by invasives is a challenge to quantify. Environmental economists have been struggling to find a systematic method of quantifying human health values, use values, existence values and ecosystem values for decades. Invasive species add a level of complexity to the task that increases difficulties involved in such valuations. Rates of biological propagation, for example, do not always conform neatly with economic variables. Nor do assessments of the level of risk from invasives. Equally challenging can be attempting to quantify the benefits of preventing or controlling invasives (Lovell and Stone 2005).

Whatever the species or impacts, experts agree that the most costly response of all is inaction. Costs mount as management activities shift from prevention to rapid response to eradication to control (see Figure 2) and as invasions spread and become irreversible. While some control programs have been highly successful, many more have not even been attempted due to the perceived challenges and expense. On most management levels, the default response is adaptation – passively adjusting to the damages caused by new species – even when eradication or control would be more cost-effective. Even when the initial funding, the tools, and the political will to launch an AIS control program exists, resources must be made available in perpetuity – not an easy task in the context of government funding cycles (Lodge et al. 2006). California managers have attempted to address some of these challenges as they developed the state AIS action plan described in Chapter 6.

Figure 2: AIS Invasion Progression, Management and Cost

As AIS invasions progress, the cost of management options tends to increase. This is one of the reasons why the California Aquatic Invasive Species Management Plan places an emphasis on prevention and early detection.



Source: Adapted from Lodge et al. 2006.

3. VECTORS OF AIS

Invasive species arrive in California via vectors – the means or agents that transport species from one place to the next. Vectors, also referred to as pathways, include ships, fishing vessels, recreational boats and gear, sea planes, diving gear, drilling platforms, dry docks, and industries that grow and sell fish, plants and other organisms for food, bait, aquariums, pets and water gardens (see Table 2). Shoreline restoration or construction projects and water-based scientific research or monitoring can also inadvertently move organisms from one place to another. Invasive species cling to boat bottoms and recreational or research gear, construction equipment, floating debris and docks. They inhabit ballast water on ships, and escape or are released from aquaculture packing materials, ornamental ponds, and aquariums into the state's waters.

Once a highly invasive species arrives, preventing its rapid spread can be difficult if not impossible. Plants can produce thousands of seeds, which may be carried by wind, water, animals or human activities to distant water bodies. Some aquatic plants can reproduce vegetatively, with small bits of leaves, stems or roots resulting in new plants. Water flows and currents may also deliver these AIS to new ecosystems. Chinese mitten crabs hatch into larvae that spend one to two months drifting as plankton. During this period, the tide can carry these invaders deep into vulnerable estuary systems. Quagga mussels traveled, most likely in their larval form, on trailered recreational boats from the Great Lakes to the Colorado River system. In the past, efforts to control such invasions have focused on managing individual problem species. More recently, however, the concept of focusing on vectors, rather than species, has begun to gain support as a more effective approach for addressing aquatic invaders.

Table 2: Common Bioinvasion Vectors
Invasion Vectors and Types of Organisms Transported

Ships

- Planktonic and nektonic organisms in ballast water
- Attached and free-living fouling organisms on hull, on rudder, on propeller and propeller shaft, in seawater systems, seachests, in ballast tanks, and in ballasted cargo holds
- Organisms associated with anchors, anchor chains, and anchor chain lockers
- Organisms associated with cargo, such as logs that have been floated for loading

Drilling Platforms

- Attached and free-living fouling organisms
- Planktonic and nektonic organisms in ballast water

Dry Docks

- Attached and free-living fouling organisms
- Planktonic and nektonic organisms in ballast water

Navigation Buoys and Marina Floats

- Attached and free-living fouling organisms

Amphibious Planes, Seaplanes

- Attached and free-living fouling organisms
- Organisms in pontoon water

Canals

- Movement of species through sea level, lock, or irrigation canals

Public Aquaria

- Accidental or intentional release of organisms on display
- Accidental or intentional release of organisms accidentally transported with target display species

Research

- Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in research (intentional or accidental escape)
- Organisms associated with research and sampling equipment, including SCUBA and other diving or swimming gear

Floating Marine Debris

- Transport of species on human-generated debris, such as floating nets and plastic detritus

Recreational Equipment

- Movement of small recreational craft, snorkeling and SCUBA gear, fins, wetsuits, jet skis, and similar materials

Fisheries, Including Marine Aquaculture (Mariculture)

- Transplantation or holding of shellfish, such as oysters, mussels, clams, crabs, lobsters, and other organisms; fish; or seaweed (algae) in the open sea for growth or freshening (rejuvenation); and other organisms associated with dunnage and containers
- Intentional release of shellfish, fish, and seaweed (algae) species, either as part of an official governmental introduction attempt, or as an illegal private release
- Stock enhancement, often ongoing, as well as accidentally transported associated organisms
- Movement of live seafood intended for sale but then released into the wild
- Processing of fresh or frozen seafood and subsequent discharge of waste materials to environment, which may include associated living or encysted organisms
- Movement of live bait subsequently released into the wild
- Discarding of packing materials—such as seaweed and associated organisms—used with live bait and seafood
- Movement, relocation, or drifting of fisheries gear, such as nets, floats, traps, trawls, and dredges
- Release of organisms as forage food for other species
- Organisms transported intentionally or accidentally in “live well” water, vessel scuppers, or other deck basins
- Release of transgenic stocks—genetically modified organisms (GMOs)
- Movement of algae and associated organisms as substrate for fish egg deposition

Aquarium Pet Industry

- Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in the aquarium industry (intentional or accidental escape)

Restoration

- Movement of marsh, dune, or seagrasses as well as associated organisms
- Reestablishment of locally extinct or decimated populations of native species, and accidentally transported associated organisms

Education

- Release of species from schools, colleges, and universities following classroom use

Source: Carlton 2001

Analyzing the risk of specific AIS vectors to the environment, human health and the economy represents a critical first step in preventing invasions. Many factors contribute to the invasion risk posed by a given vector. These include:

- number of nonindigenous species transported;
- number of individuals of each species transported;
- characteristics of the species (including their environmental tolerances);
- number and characteristics of their hitchhiking species (including parasites, pathogens and other associated organisms);
- likelihood and frequency of a species and its hitchhikers reaching suitable habitat;
- feasibility and cost of eradication or control if a species becomes invasive (Lodge et al. 2006).

Any quantitative analysis of invasion risks will not only examine these factors, but also seek the point source of invasions and evaluate opportunities for management of each vector.

Large vectors, such as commercial shipping, are not the only source of large-scale invasions. Seemingly minor vectors can lead to major invasions. For example, the use of seaweed to pack bait worms from the U.S. Atlantic Coast brought the European green crab to the Pacific Coast (Carlton 2001). Preventing introductions from smaller vectors can therefore provide significant ecological and economic benefits.

The live trade, including the pet, aquaculture and horticulture industries, introduces far fewer exotic species than ships and other transportation vectors; however, prevention efforts aimed at this sector are well worth their cost. Providing education and oversight to these purveyors tends to cost less than comparable efforts aimed at transportation vectors and can preclude the far larger costs of stopping an invasion. The burgeoning mail order/Internet trade has only increased the risk from these pathways. Meanwhile, the water garden and live food industries are growing rapidly and will likely become the source of more invasions in the future. These trades frequently put non-native species of plants and animals in close proximity to natural waterways where they are more likely to find conditions suitable for establishment (Lodge et al. 2006).

Raising awareness of the invasion risks from ballast water discharge and hull fouling, as well as among aquarium, pet, nursery, aquaculture and seafood industry groups, has great potential to change public behavior and develop cooperative guidelines for industry practices. In the end, these measures may significantly reduce the likelihood of AIS introductions (Lodge et al. 2006).

California's initial focus may have to be on vectors currently thought to pose the highest risk of invasion. The ultimate goal, however, is to assess all potential vectors and to manage those that present the highest risk of new

invasions. The sections that follow seek to provide general information on some of the diverse vectors by which AIS enter California. Details on the regulation control and management of these vectors appears in subsequent chapters. The general vector categories described below are:

- Vector 1: Commercial Shipping
- Vector 2: Commercial Fishing
- Vector 3: Recreational Equipment & Activities
- Vector 4: Trade in Live Organisms
- Vector 5: Construction in Aquatic Environments
- Vector 6: Water Delivery & Diversion Systems

Vector 1. Commercial Shipping

In coastal environments, commercial shipping is the most important vector for the introduction of AIS (Ruiz et al. 2000, Hewitt et al. 2004). In one study, commercial shipping accounted for one half to three-quarters of nonindigenous introductions to North America (Fofonoff et al. 2003). The steady rise of global commerce, increased shipping activities and shorter transport times suggests that the threat of introductions through this vector is increasing.

California, as a coastal state engaged in significant Pacific Rim trade, cruise-line tourism and commercial fishing, is vulnerable to the global rise in invasions. California hosts 11 major seaports: Hueneme, Humboldt Bay, Long Beach, Los Angeles, Oakland, Redwood City, Richmond, Sacramento, San Diego, San Francisco and Stockton. Three of these ports are among the top four busiest ports in the United States. Two of these ports are located a significant distance inland and are slated for expansion, potentially importing more AIS deeper into the state. These 11 seaports handled 23% of the United State's waterborne trade in 2003. Almost 95% of containerized Asian cargo destined for central and mountain states entered through West Coast ports – highlighting California as a first national line of defense against AIS (PMSA 2004).

Ballast Water

Shipping vessels commonly fill their ballast tanks with water from harbors after unloading cargo and discharge it in another harbor when loading more goods. The added mass of ballast water improves stability, trim, maneuverability and propulsion in large, otherwise empty cargo vessels. Vessels may take on, discharge, or redistribute ballast water during cargo loading and unloading, in rough seas, or while moving through shallow waterways. Live marine organisms ranging from plankton to adult fish are regularly transported from source to destination ports when ballast water is discharged (Carlton and Geller 1993, Cohen and Carlton 1995). Estimates suggest that more than 7,000 species are moved around the world daily in ballast water alone (Carlton 2001).

Ballast water teeming with a wide array of non-native organisms is discharged into U. S. waters at the rate of about two million gallons per hour. In 2005, 9.1 million metric tons were reported to have been discharged in state

waters (Falkner et al. 2006). California requires vessels arriving from outside the United States Exclusive Economic Zone (U.S. EEZ), or engaged in coastal travel, to manage their ballast water. Federal regulations (USCG) also require ballast water management. See Chapters 4 and 5, and Appendices B and C for more information on state and federal regulations and programs. Actions in this AIS management plan recognize and support these ballast water management activities.

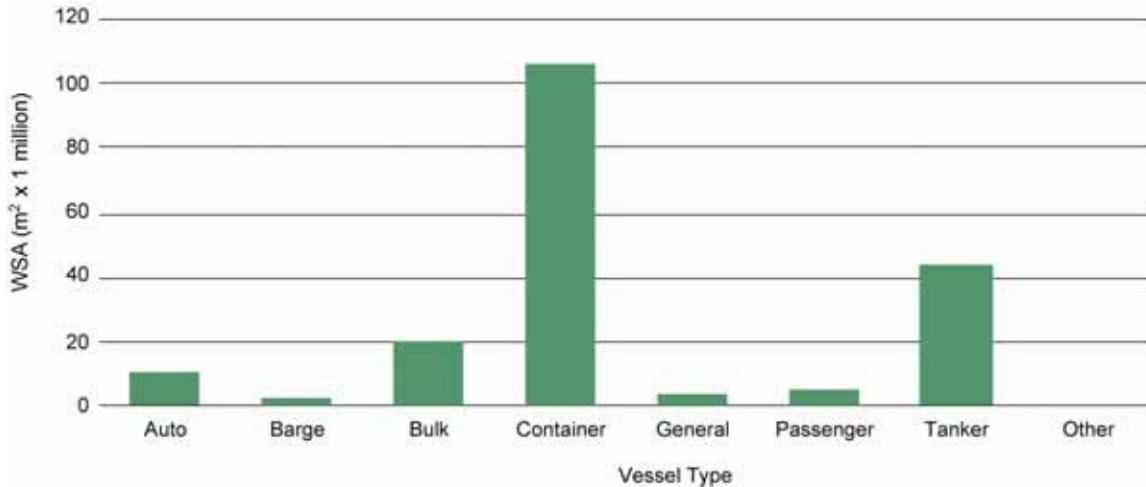
Hull Fouling

Hull fouling may rival ballast water discharge as the leading cause of harmful AIS introductions (Thresher 1999, Hewitt 2002). Organisms such as mussels, seaweed, anemones and sea squirts with sedentary life stages can attach themselves to the hulls of commercial vessels or become entangled in nets, anchors, and other gear. Barnacles, other seaweeds and bryozoans may in turn attach to mussel shells and seaweed fronds, while more mobile species such as shrimps, worms and sea snails may hide in crannies created by larger fouling species (Takata et al. 2006). These organisms can survive for extended periods of time once secured to a vessel. Fouling organisms may then be transferred from the vessel to coastal waters and ports via spawning or egg release, detachment (simply dropping off into the water) or mechanical removal (via scraping, in-the-water cleaning or blasting in dry dock depending on clean up procedures).

Fouling organisms live on wet surface areas such as vessel hulls. One study analyzed the total "wetted surface area" (WSA) of all vessel hulls arriving on the West Coast between July 2003-June 2005 (Takata et al. 2006 – See Figure 3). The goal was to provide some indication of the rate and pattern with which individual organisms may arrive (propagule pressure), and how they may contribute to AIS establishment. The resulting two-year total of WSA entering California waters was 189.5 million square meters, which is 1.5 times the area of San Francisco County.

Figure 3: Wetted Surface Area

Total wetted surface area (WSA) is the estimated total of submerged surface area for each type of commercial vessel shown on this graph, that arrived in California ports between July 2003 and June 2005. Wetted surface area represents potential for fouling accumulation. The potential magnitude of the threat from hull fouling is significant, however, without reliable data on the extent of fouling found on commercial vessels, the ability to determine this risk is limited.



Data courtesy of Ian Davidson, Aquatic Bioinvasion Research and Policy Institute.

Source: Takata et al. 2006

In an expansion of California's ballast water management program, recent legislation directed a team of technical advisors to formulate recommendations to prevent introductions through vessel fouling, among other non-ballast shipping vectors. The team's report documents several factors concerning this vector. For example, the degree of fouling may be affected by environmental conditions, vessel maintenance practices, types of shipping traffic and vessel movement patterns, all factors which may differ from region to region. (Takata et al. 2006). See Chapter 4 and Appendix C.

Vector 2. Commercial Fishing

While commercial fishing vessels do not usually carry ballast water, they can be an important AIS vector. As these vessels sit in harbors, docks, and berths during the off-season for long periods, they are more subject to the hull fouling described under Vector 1 than commercial ships (which travel so constantly through waters of widely varying temperature and salinity that their hulls remain relatively clean). Commercial fishing vessels can also carry AIS from one harbor to another via their fishing gear, lines, tackle, buoys, traps and nets. Researchers believe the Japanese marine algae, wakame, may have been introduced to Monterey Bay by fishing vessels from other California ports. Though the state currently regulates ballast water and may soon regulate hull-fouling, it has no authority over vessels under 300 gross register tons in size, such as commercial fishing vessels. More information is needed on the AIS risk from this vector. Actions in this management plan seek to address this need.

Vector 3. Recreational Equipment & Activities

Boating & Sea Planes

The lakes, ponds, rivers and coastal waters of California provide recreational opportunities for a large population of boaters. The movement of boats along the coast, as well as the overland transport of boats and their trailers between water bodies, can introduce AIS that foul hulls, become entangled on motor propellers, and are small enough to be discharged in bilge pump water. In addition, aquatic invasive plants and other AIS can also be transported from one body of water to another through entanglement on aircraft pontoons. Recreational boats and sea planes can be both the source of an initial introduction (bringing in a species from its native location, into California), or a source of spread of a species once it arrives via other vectors such as ballast water or aquarium releases. This is the case with zebra mussel and quagga mussel, which were thought to have originally entered the US via ballast water, and now have spread throughout many areas in the United States via recreational boats.

Fishing

Recreational fishing is another vector in the introduction and spread of AIS. Initial introductions can occur when bait buckets and live tank contents are dumped. Gear used for fishing (boats, nets, floats, anchors, wading boots, tackle, etc.) can spread AIS. For example, fly fishing gear used in waters infested with New Zealand mudsnails, may be the primary vector associated with the spread of this AIS into California's rivers.

Other Water Sports

Those engaged in California's diverse variety of other water sports – swimming, jet-skiing, windsurfing, parasailing, scuba diving, waterfowl hunting – can all also be potential carriers of hitchhiking AIS as sports gear is moved among coastal and inland recreational spots.

For all recreational water users, clear identification of AIS-infested waters through posted signs and by other means would reduce the risk of the transport of established invaders. This measure, along with vessel inspections and investigating the feasibility of installing washing stations for recreational watercraft, are actions in the management plan. Education of all recreational users – and for non-aquatic equestrians, hikers and cyclists crossing streams and rivers – is also recommended in this management plan.

Vector 4. Trade in Live Organisms

Live Bait Industry

The shipment of live, non-native fishes or invertebrates into California for use as bait may serve as another vector of AIS introduction. Packing materials are frequently comprised of live plants that have the potential to become invasive. Knotted wrack, a seaweed native to the North Atlantic, is the primary packing material for marine baitworms (blood worms and pile worms) and American lobsters shipped to California. This seaweed often harbors a substantial number and variety of non-native marine organisms. Of further concern is live bait that harbors parasites or pathogens that could endanger the health of human populations or native species. The state regulates the culture, import, harvest and sale of fish species sold as bait; however, the sources of invertebrate imports to California for recreational fishing purposes are largely unknown and unregulated. Actions in the plan address the need to evaluate, improve and enforce regulations designed to minimize the invasion threats from both live and frozen bait. Frozen bait has recently gained more attention as a potential vector for AIS because the virus that causes hemorrhagic septicemia, a disease that causes fish to bleed to death, has been found to survive in frozen bait (Bergquist 2007).

Live Imported Seafood

The import, sale and distribution of fresh, live seafood are important component of California's economy. The processing and sale of live fin and shellfish can result in the intentional or unintentional release of live organisms as well as their associated parasites and pathogens. Specific seafood-related introduction pathways include packing materials, as discussed in the prior section, and the following:

Shellfish waste disposal: Shells and other unwanted materials discarded following shellfish processing might harbor shellfish pathogens or live epiphytes (plants that grow on organisms or objects, rather than on the ground), as well as embryos or other developing stages of the shellfish species. Disposal of this material in or near a water body could result in unwanted introductions, as well as other types of water quality impairment.

Bivalve wet storage: Holding shellfish in flow-through systems subjects surrounding surface waters to pathogens and other organisms that may be discharged during tank flushing. Transporting shellfish in nests of algae or other plants also poses the risk of introductions when these packing materials are discarded.

Creation of new fisheries: Several aquatic invaders, such as the Chinese mitten crab, may have been released intentionally in hopes of founding a new and commercially valuable fishery (Whitlatch et al. 1995). Seafood suppliers and commercial and recreational fishers and anglers, who are unaware of the detrimental impacts resulting from these introductions,

may be tempted to release these species into local aquatic systems to establish a self-sustaining population that can be harvested for consumption.

Aquaculture

California has the most diverse aquaculture industry in the United States. Like the seafood industry, aquaculture is an important sector of the California economy and has the potential for significant growth as more limits are imposed on wild fish harvests. While intensive culture of both finfish and shellfish reduces the harvesting pressure on wild stocks, concerns related to water quality impairment, the growth and distribution of pathogens, the escape of non-native species, and genetic dilution indicate a need for careful planning in this industry. The following are examples of how non-native species introductions can occur through intensive aquaculture operations.

Shellfish seed import: Shellfish seed is commonly grown in hatcheries and imported to California for use in commercial operations such as oyster culture. While the state regulates the sources of seed for this industry, there is the potential for the import of shellfish pathogens and other organisms associated with shellfish, such as boring organisms, from outside of the state. An enhanced capacity to identify and manage shellfish diseases will be necessary to minimize the loss of shellfish due to these threats.

Abalone culture: Farmed commercial abalone is a small but productive industry that recently felt the sting of an introduced parasite. The industry's struggles with the South African sabellid worm offer a good example of what can happen when shellfish are transferred among hatcheries across state and national boundaries (see also Management Examples, Chapter 4). Although both abalone aquaculture and stock importations are regulated by the state, new guidelines for the movement of live organisms may be needed.

Shellfish waste: Several shellfish species cultured in California prefer clean, hard surfaces on which to settle and attach. Placement of shellfish waste as substrate in grow-out areas has raised concern over the source and proper disinfection of this waste material and the potential of this practice to transport shellfish pathogens or other associated non-native species.

Finfish culture: Raising finfish in open systems such as raceways, flow-through tanks and net pens exposes surrounding aquatic systems to pathogens commonly associated with cultured fish populations, and introduces the possibility of escape of the aquaculture species into adjacent waters. The state regulates this industry and requires that species cultured in watersheds where they are not already present be isolated from natural systems.

Genetic dilution: Strains of shellfish and finfish used in aquaculture are often imported or represent stocks that have been genetically altered or selected for particular traits such as large size or disease resistance. Cultured stocks are usually at a disadvantage in competition with wild populations in the natural environment; however, farmed Atlantic salmon have been documented to escape and survive in the wild in Pacific Coast waters.

California has addressed many of these concerns through existing laws and regulations; however, several actions related to the prevention of introductions through the shellfish and aquaculture industries have been included in the plan.

Recreational Fisheries Enhancement

It is common practice in the United States for federal and state agencies to import game fish to enhance recreational fishing. Private citizens have also illegally transported and released fish species into waterways in hopes that a viable population would survive. Non-native fish introductions in California peaked in the 1960s, when 13 new species were introduced (Moyle 2002). Illegal fish introductions, including species newly brought to the state and transfers of already-established species to new sites are of increasing concern in California. There are 51 non-native freshwater fishes currently found in California; the majority introduced deliberately, whether legally or illegally, in an attempt to enhance recreational fisheries (Moyle 2002). Non-native fish are now the most abundant fish in many waterways in California, raising concerns about increased competition, predation, habitat interference, disease and hybridization with native species.

Aquarium & Aquascaping (Water Gardens)

Non-native marine and freshwater organisms can be introduced accidentally or purposefully after being imported for use in aquaria and water gardens (Carlton 2001). Aquatic plants available through these industries are often native to temperate regions and are selected for their ability to thrive under adverse environmental conditions. Of additional concern is the mislabeling of imported organisms, particularly aquatic plants, which may then be confused with native or innocuous species and released by the consumer. Careful inspection of stock shipped and received is important; aquatic plants such as water lilies have reportedly been shipped from nurseries still entangled in fragments of invasive hydrilla plants.

Live rock – coral skeleton that has been colonized by marine plants, microorganisms, and algae – poses a similar threat as a means of invasive species transport. Imported from tropical reefs, live rock is becoming a favored means to decorate and improve water quality in aquaria. Live rock is currently not subject to quarantine or other biological regulations, and has the potential to

transport small invasive species ranging from algae to jellyfish (Bolton and Graham 2006).

The state monitors and regulates a limited number of aquarium and aquascaping species. Enforcement can be difficult, as California's nursery industry includes approximately 3,500 growers, 3,000 retail nurseries and 3,500 incidental dealers such as supermarkets, drugstores and other chain-store markets. Many species of concern, particularly freshwater aquatic plants, are also now readily available via the Internet and through mail order catalogs for water gardening. Some of the most popular AIS still commonly sold include water hyacinth, parrot feather milfoil, Brazilian elodea, water lettuce, yellow floating heart, paleyellow iris and European frogbit.

Widespread use of the Internet for commercial sales of non-native aquatic plants and animals is particularly troubling. Federal agencies have the authority to regulate sales of invasive plants and invertebrates through the aquarium and water garden trades; however, California's capacity to monitor and regulate the importation of species is limited to those restricted by statute. The state can play a more active role by encouraging providers to monitor their shipments and by providing recommendations for care and handling. Efforts can be made to provide information to Internet suppliers based in California about the risks of particular species. Educated consumers can provide an added level of security by carefully inspecting shipments, after they are received and prior to release, to make sure they are not contaminated by additional AIS.

For all types of AIS imports – whether into stores, through catalogs or via the Internet – more education and outreach, inspections and enforcement are needed at both the state and federal level. Such steps are among the actions recommended in this management plan.

Research & Educational Activities

Marine and freshwater species can be ordered from research and education supply companies around the world through catalogs or Internet websites. While these organisms are generally supplied for research purposes, many companies also sell species for use in home aquaria. Few suppliers of live organisms, among them marine labs and research facilities, provide guidelines documenting use and handling practices.

Once the organisms are delivered, improper handling techniques may result in the release of non-native species. Both lab and field practices routinely present the opportunity for AIS release through wastewater discharge, disposal of unwanted organisms, poorly contained studies, etc. The invasion of the colonial sea squirt, *Botrylloides diegensis*, in Massachusetts is believed to have occurred via this vector (Whitlatch et al. 1995).

Vector 5. Construction in Aquatic Environments

Many types of construction are conducted in aquatic environments, including the maintenance of canals and water delivery systems, the creation of shoreline parks and developments, the dredging of shipping channels and marinas, the control of riparian and levee-bank erosion, and the restoration of wetland, riparian and shallow water ecosystems. All of these activities, and the equipment used to accomplish them, can transfer or introduce AIS.

Construction Equipment: The use of contaminated construction equipment and the transport of sands and sediments during marine construction (building and installation of docks, platforms, bulkheads, breakwaters, artificial reefs, etc.) can lead to the introduction of unwanted AIS. Similarly, the use of heavy machinery, such as harvesters and dredges, to remove AIS and/or sediments from infested water bodies, can spread AIS from one site to another if the equipment is not properly cleaned between projects.

Canals, Channels, and Aqueducts: The building of canals, channels and aqueducts creates artificial connections between waterways, allowing the free movement of species across physical barriers. Increasingly in California, fish are being introduced into new areas by aqueducts that bridge drainages (see below).

Ecosystem Restoration and Erosion Control: Historical examples abound of non-native plants being introduced to California for habitat restoration and/or erosion control with disastrous results, including species of cordgrass, tamarisk and *Arundo*, to name a few. Awareness of this problem needs to be increased and alternative plant choices must be made available and encouraged or required. Equipment used during habitat restoration and subsequent monitoring should be cleaned to avoid transferring AIS from one site to another.

Vector 6. Water Delivery & Diversion System

The state's extensive water delivery, export, transfer and development system, which moves water not only from one watershed to another, but also from one end of the state to another, and even across state lines, can be an important vector of AIS. Water deliveries can spread freshwater-adapted AIS within and out-of-state, and carry species from infested areas to more pristine locales. For example, the yellowfin goby was first found in the San Francisco Estuary, and then in the Delta-Mendota Canal, a feature of the Central Valley Project. The yellowfin goby was later found further south, in the California Aqueduct, which is part of the State Water Project and transports water from northern and central California to the Los Angeles area. More recently, the yellowfin goby has been found in the San Luis Reservoir in the western San Joaquin Valley. The California Aqueduct has transported a number of species, both native and invasive. Scientists have already identified species they predict will travel to new locales on this waterway, such as the Shimofuri goby found in

the Suisun Marsh northeast of San Francisco, and more recently in Pyramid Reservoir, 39 miles from downtown Los Angeles.

A significant amount of water, and whatever AIS are in it, is moved around California each year to supply drinking, irrigation and other water supplies for human activities. The state's two largest water distribution systems, the State Water Project and the federal Central Valley Project, can move up to four and seven million-acre feet of water each year, respectively. At least 7,000 other users also have permits to divert water. During the period 1998 and 2001, approximately 30-37 million acre feet of water were diverted from their original courses annually in California. Of these transfers, between 3.9 and 4 million acre feet of water transfers came from the Colorado River (Messer 2007).

The likelihood of spreading aquatic invaders via water diversion is not proportional to the amount of water that is being transferred. Often, water is moved to a water treatment plant where it will be processed into safe drinking water or to agricultural fields inhospitable to aquatic species. Water turbines may be fatal to invasive species. When an invasive species arrives in a new location, it does not always establish. For instance, Chinese mitten crabs transported to an agricultural canal near Bakersfield, California by the Central Valley Project cannot establish a viable population because they need access to an estuary to complete their life cycle.

Water managers are working to better track AIS in their equipment and systems. State and federal project managers, for example, monitor AIS by counting mitten crabs which clog the fish screens at fish collection facilities in Tracy, California, where water is diverted from the Delta. Native and non-native fish are counted, collected, and salvaged, and new fish species have been noted at these facilities. Less extensive sampling, mostly to determine fish loss, is conducted at other regional water diversion facilities.

Intensive manipulation of natural water paths and flow rates, and other characteristics of the state's aquatic and adjacent ecosystems, make California particularly vulnerable to AIS. Not only can AIS be more easily transferred via these diversions but they can also find it easier to colonize areas where native species are already stressed by dams, water diversion, altered hydrology and development in their habitats.

Conclusion

The above is only a discussion of the primary vectors of aquatic species invasions. In the past 200 years, the number of vectors available to transport marine species has steadily increased. In the year 1800, ships and the materials carried for ballast were the major mechanisms of introduction. By 2000, there were at least 16 known human-related vectors (Carlton 2001). The increasing diversity of vectors makes the prevention of introductions an even greater challenge.

4. MANAGEMENT FRAMEWORK

Efforts to manage aquatic invasive species began more than a century ago when water hyacinth and alligatorweed began to clog navigable waterways. Early 1900s management efforts involved chemicals that generally proved either ineffective or poisonous to livestock and wildlife and mechanical removal, either by hand with a scythe or with the help of "crusher boats," which smashed floating vegetation between heavy rollers, and "saw boats" which shredded plants with rotating blades (Hoyer and Canfield 1997). Since then, management approaches have changed and become more diverse to include everything from hyperspectral remote sensing, ozone treatment and K-12 education curricula to herbicides, electro-fishing, Internet sales precautions, PowerPoint presentations and border inspections. Numerous international, federal and state laws have been passed aimed at preventing and controlling invasions, and numerous government agencies, NGOs, industry groups and other organizations have become involved in AIS management.

Most long-established programs – both state and federal – are targeted at managing terrestrial agricultural pests, which can spread easily by wind, fog and through the air. Many of these programs are species specific. Efforts to manage invaders living in and around water present a different set of challenges for containment and control and focus on preventing vectors from bringing in new species and on developing early detection networks. This chapter:

- explains the generally accepted management framework and control options for AIS;
- provides a brief overview of AIS programs operating in California;
- summarizes the responsibilities of California state agencies most involved in AIS work;
- lists gaps and challenges in state AIS management.

A summary of AIS-related state and federal laws and authorities can be found in Chapter 5, with a more comprehensive description and more extensive agency information appearing in Appendices B, C and D. A list of regulated AIS species can be found in Appendix G.

General Framework

On a general level, invasive species management involves five basic strategies, often in combination:

- Prevention
- Early Detection & Monitoring
- Rapid Response & Eradication
- Long-Term Control & Management
- Education & Outreach

This basic framework, well established on a national level, is also reflected in California's existing pest prevention programs and weeds management plans. It forms the foundation of management actions described in Chapter 6 of this plan.

In choosing management approaches within this framework, the nature of the invader itself comes into play (see Table 3). Some invaders (such as the zebra mussel) may be known troublemakers in other states or nations but have not yet arrived in California, suggesting a management response focused on monitoring, education and early detection. Other invaders (such as the water hyacinth choking boating channels and lakes) may be so well-established that eradication is infeasible and ongoing chemical and/or mechanical removal is selected to minimize the harmful effects of the infestations. Still others (such as the Asian overbite clam colonizing the floor of Suisun Bay) may present no management option whatsoever since there is no environmentally acceptable way to treat or remove widespread benthic invertebrates in open waters. Whatever the species, the possible human management responses generally narrow as any invasion progresses (Lodge et al. 2006).

Table 3: Species Management Types

SPECIES MANAGEMENT TYPE	REPRESENTATIVE SPECIES	MANAGEMENT RESPONSE
Type 1 Not yet detected in California or eradicated	<i>Caulerpa</i> Northern Pacific seastar South African sabellid polychaete snakehead zebra mussel	Monitoring Early detection
Type 2 Limited in extent	Hydrilla channeled apple snail <i>Salvinia</i> smooth cordgrass quagga mussel	Early detection Rapid response Eradication
Type 3 Established but manageable	African clawed frog <i>Egeria</i> Chinese mitten crab Eurasian watermilfoil European green crab purple loosestrife salt cedar water hyacinth	Localized eradication Impact mitigation Control of spread to other water bodies Research on control technologies
Type 4 Widespread but currently no large-scale control options	Asian overbite clam inland silverside New Zealand mudsnail bullfrog water lettuce pale yellow iris	Monitoring Prevent spread to new water bodies Research
Type 5 Unknown invasion potential	Asian swamp eel green sunfish salt meadowcordgrass	Research and evaluation

The Species Management Type (SMT) characterizes the distribution and degree of establishment of an AIS in California and could be assigned to any AIS species. This characteristic is useful to consider when setting management priorities or planning for a management response to a potential or actual AIS infestation. Representative species are merely examples, as this table is not meant to provide a comprehensive list of species sorted by SMT. Though valid at the time of publication, the status of the species mentioned is likely to change over time. For more examples see Chapter 8.

Prevention

Preventing AIS introductions is the single most cost-effective and environmentally beneficial management approach and is the first line of defense. This approach focuses on preventing the release of AIS into state waters via ballast water, fouled hulls, marine equipment movements, aquatic recreation and research activities, and by the producers and buyers of bait, aquariums, seafood and other live organisms. Pest prevention programs for noxious weeds often refer to this type of prevention as “exclusion” (keeping the species out of the state). Many prevention programs focus on minimizing the introduction of all species into the environment via specific vectors. This is because it is very difficult to predict which species will invade and cause significant impacts. It is also very difficult to identify the actual species of potential aquatic invaders (especially very small invertebrates, internal parasites, and unicellular organisms). Inspection programs, such as those for smaller boats and retail and wholesale businesses, are also part of prevention, but generally target specific species rather than the entire range of species that those vectors could potentially introduce.

Prevention programs may include everything from inspections of stores, industries or facilities that may be harboring or selling AIS to education and outreach. As prevention is the least expensive and most effective management response, every vector deserves state level consideration and coordination.

Monitoring, Early Detection & Rapid Response

Some species will evade prevention programs. A few of these will spread, after a certain lag time and become pests. The lag time between establishment and spread, which could be weeks to years, offers an opportunity for detection and eradication. Taking action while populations are small and localized is extremely important but the effort required to detect a species can be inversely proportional to its population size. Sound management must balance the high costs of surveys aimed at detecting small populations over a wide area against the high costs of eradication if a survey fails to catch an invasion early on. New surveillance technologies and web-based reporting and information networks may help increase the success of early detection efforts (Lodge et al. 2006). Enlisting the help of citizen monitors, watershed groups, professional diving associations, and others often in and out on the water may also prove effective.

Once detected, rapid response often involves an attempt to eradicate the invader by chemical, mechanical or other means. This works best when the invader appears in an isolated lake, creek or other water body where spread can be contained and the environmental impacts of chemicals used to kill the invader is minimized. Eradication may be possible in isolated areas of one part of the state while larger scale control programs may be necessary in others where infestations have spread. For this reason, it is sometimes hard to categorize existing response programs as either “eradication” or “control.” Such measures often go hand-in-hand on a statewide scale.

MANAGEMENT EXAMPLES: BALLAST WATER & HULL FOULING

California law began mandating ballast water management for ships arriving from foreign ports in 1999. During the ballast exchange process for vessels entering the state from outside the U.S. Exclusive Economic Zone (U.S. EEZ), biologically rich water loaded at the last port of call is flushed out of ballast tanks and replaced with the water from the open ocean, beyond 200 nautical miles (nm) from land. For vessels moving along the coast, the exchange is done outside of 50 nm. Organisms are generally less numerous in the open ocean and it is expected that they will be poorly adapted to survive once discharged in the very different environmental conditions of a near shore port. Scientific research indicates that offshore ballast exchange typically eliminates 70% - 95% of the organisms originally taken into a tank while at or near port (Zhang and Dickman 1999, Parsons 1998). Other studies suggest that exchange efficiency is inconsistent and ranges from 50-90% (U.S. Coast Guard 2001). Most experts view ballast water exchange as a short-term solution, with the final resolution being a combination of ship-board treatment technologies and management options such as ballast water retention or the use of freshwater as ballast, among others (Falkner et al. 2006).

Minimizing the release of invasive organisms growing on or clinging to the hulls of oceangoing ships and commercial fishing vessels is also an important frontier of AIS management. Commercial vessel operators have long endeavored to keep fouling to a minimum on their ships for other reasons. Fouling creates drag, increasing fuel consumption, and/or straining the engine; it can also block pipes bringing in seawater to cool machinery. To prevent such problems, commercial vessels periodically clean their hulls and utilize antifouling coatings designed to discourage the attachment of organisms. While these measures do reduce the amount of fouling on a ship, consequently reducing the potential for AIS to be moved to new locations, they can create water quality problems. Most antifouling coatings slowly release toxic substances. Vigorous scraping of a hull while a vessel remains in the water can exacerbate the quantity of toxins and toxic debris released into surrounding waters. Biocide-free anti-fouling alternatives are currently being researched (Anderson). Recommendations for a new state program targeted at reducing the risk of AIS release from hull fouling (including consideration of some of the water quality concerns) were completed in 2006 (Takata et al. 2006). For more information on current California ballast water and hull fouling management programs see SLC section later in this chapter.

In order to effectively respond to the early detection of an AIS occurrence, several states have developed formal interagency rapid response plans. California has recently begun this process and written a draft rapid response plan (Appendix A). The goal of such plans is for agencies and other interests to work together as effectively and efficiently as possible through prior agreements about: roles and responsibilities, chains of command and communications, criteria for initiating rapid response actions, public safety, funding, regulatory permit processes, public information, data collection, implementation and follow-up evaluation. In other words, a rapid response plan lays out how federal, state and local officials should respond if an AIS of particular concern (such as the zebra mussel, see below, or the marine algae *Caulerpa*, see Chapter 8) is detected. Response can be delayed by permitting processes developed for maximum public input and thorough review, rather than for emergency response timelines. Both federal and California agencies have recognized the need for special levels of coordination and cooperation to facilitate rapid response.

MANAGEMENT EXAMPLES: ERADICATION OF SABELLID WORMS & ZEBRA MUSSELS

The South African sabellid worm was imported to the United States in the 1980s in an abalone shipment from South Africa. By 1993, abalone growers in Cayucos, California began to notice defects such as misshapen, stunted and brittle shells in their stock. The worm causes shell lesions that compromise the abalone's overall health and marketability. The worm quickly spread to other abalone farms via seed stock and to rocky intertidal habitat nearby. The resulting infestation spread to native black turban snails. University of California, Santa Barbara researchers removed more than a million infected snails from the area, eradicating the worm from the wild in California. State agencies now closely regulate transfers of abalone between aquaculture facilities and have established a two-year certification program to ensure buyers that shellfish stocks are sabellid-free.

Though not in California, a 2006 success story in early detection marks the first successful extermination of zebra mussels. In 2002, the mollusks were discovered growing in a twelve-acre abandoned rock quarry in Virginia. With neither a native mollusk population nor any surface water outlets, the site was deemed ideal for mussel eradication. In 2006, the quarry was treated for three weeks with twice the concentration of potassium chloride found to be lethal to zebra mussels. Eradication was confirmed by a variety of measurements. Concentrations of potassium chloride in quarry water remained well below levels harmful to other wildlife; turtles, fish, aquatic insects, snails and other wildlife in the quarry do not appear to have been affected by the treatment. Unfortunately, the large volume of potassium chloride required makes the technique impractical to apply in large bodies of water.

Slow the Spread & On-Going Control

When eradication is not feasible, containment or at least a “slow the spread” strategy may be the best choice, particularly when management costs are likely to be exceeded by the environmental, public health or economic losses to businesses dependent on aquatic environments if an invasion is allowed to proceed unmanaged. Control programs often occur over many years, involve multiple sites and waterways, and present a daunting battle to manage the movements of small seeds, spores, larvae and specks of algae across huge landscapes and waterscapes.

Education & Outreach

Regardless of what the management response is, or the scale or type of invasion, it is critical to establish effective, ongoing communication with all those impacted, involved or potentially perpetrating the problem. Education and outreach – whether it is public service announcements and other media campaigns, species identity cards, volunteer training or school programs – play an important role. Education and outreach activities go hand-in-hand with all phases of AIS management, including prevention, early detection and monitoring, rapid response and eradication, and long-term control.

MANAGEMENT EXAMPLES: PURPLE LOOSESTRIFE AND CHINESE MITTEN CRAB IMPACTS

Purple Loosestrife is a wetland invader imported from Europe in the early 1800s for its medicinal value and beautiful purple flowers. A large plant can produce more than two million viable seeds in one season. Purple loosestrife is still sold as an ornamental in nurseries in some states, though at least 24 states, including California, have listed it as a noxious weed and prohibit its sale. In California, it is rapidly expanding its range. State agencies have undertaken an effort to survey state populations and develop management plans. Eradication is the goal where feasible; however, preventing the spread of established populations may be the only alternative in other places. The plant is extremely difficult to eradicate, although a suite of insects has provided effective biological control in some areas.

Although the Chinese mitten crab had previously been found elsewhere in the United States, San Francisco Bay was the first introduction that resulted in the establishment of a population. Burrows excavated by the crabs erode banks and could damage levees. The crab's sharp claws can cut through commercial fishing nets and reduce or damage catch. The mitten crab can also host a human parasite known as the lung fluke, which can cause tuberculosis-like symptoms (the parasite has not been found in California crabs to date). In fall of 1998, as many as 1 million mitten crabs were collected at the federal and state fish salvage facilities in the south delta, which are associated with the California Aqueduct and State Water Project. The crabs clogged the screens, holding tanks and transport trucks used to salvage fish from the pumping stations. The state built "Crabzilla", an 18-foot high traveling fish screen, at its Tracy fish collection facility to scoop up the crabs so they can be hauled off and ground up for fertilizer. Mitten crab numbers declined after 2001 and in 2005 were at very low numbers throughout the watershed (Hieb 2005 in press).

MANAGEMENT EXAMPLES: NATIONAL AWARENESS CAMPAIGNS

Numerous education campaigns seek to improve public awareness of AIS issues on a national level. Habitattitude, for example, was started by the U.S. Fish & Wildlife Service and the national Aquatic Nuisance Species Task Force and the pet industry. This campaign focuses on promoting consumer awareness and responsible behaviors for aquarium and water garden hobbyists and in the industries that serve them. Other national campaigns are already working to educate water users about how to prevent the spread of AIS: Protect Your Waters & Stop Aquatic Hitchhikers is an educational campaign aimed at all recreational users; the 100th Meridian Initiative is a campaign aimed at stopping the spread of the zebra mussel and other AIS into the West. For more information on these national campaigns see Appendices B and D.

An Overview of Current AIS Management Activities in California

Seven state agencies are actively involved in large-scale ongoing AIS management programs. Numerous other local, state and federal agencies, NGOs, universities, research institutions and stakeholder groups, also play a role. Some management programs focus on a specific vector (commercial shipping, aquaculture, etc.), some on specific nuisance species or a group of species (such as agricultural pests) and some on minimizing AIS impacts on protected uses of the state's waters (boating, fishing, wildlife habitat, etc.). More information about the activities of these diverse agencies appears later in this section and in Appendices B, C, and D.

The seven state agencies with lead AIS responsibilities are the California Department of Fish & Game (DFG), the California Department of Food and

Agriculture (DFA), the California Department of Boating and Waterways (DBW), the California State Lands Commission (SLC), the California Department of Water Resources (DWR), the State Coastal Conservancy (SCC), the State Water Resources Control Board (SWRCB) and nine regional water quality control boards (RWQCBs) – see Table 4.

At this time, DFG serves as the coordinating agency for AIS activities, represents the state on the Western Regional Panel (see Appendix D), and as such, has organized the development of this plan and other statewide initiatives to improve AIS management. State weed control programs are managed primarily by DFA, with federal help from the USDA and critical input and cooperation from research, education and related business organizations. As part of this program, DFA, with the help of County Agricultural Commissioners, also manages an exclusion program both at borders and at entry points. Other state agencies manage specific in-the-water and on-the-ground aquatic weed programs – including DBW and SCC.

SLC is the lead implementing agency for the state's ballast water management program. This program implements California regulations requiring vessels arriving from outside the U.S. EEZ and engaged in coastwise travel, to manage their ballast water. As part of this program, DFG/Office of Spill Prevention and Response (DFG/OSPR) conducts biological surveys in port/harbor areas and open coastal areas.

Other state agencies undertake invasive species management activities to enforce mandates such as the protection of commercial fisheries and sensitive wildlife by DFG, in cooperation with federal agencies such as USFWS, the maintenance of state water supplies and protection from flooding by DWR and the protection of the beneficial uses of state waters and water quality by SWRCB and RWQCBs. Across the state, local districts work to control mosquito populations to protect human and livestock health. All these state efforts to manage AIS are supported by the cooperative work and research provided by universities, NGOs, federal agencies, local agencies and stakeholder groups.

Table 4: Lead AIS Agency Contacts in California (as of April 2007)		Vectors	Invaders
California Department of Boating and Waterways (DBW)	Marcia Carlock mcarlock@dbw.ca.gov (916) 263-8142 http://www.dbw.ca.gov/	Recreational boating	water hyacinth Brazilian elodea
California Department of Fish and Game (DFG)	Susan Ellis sellis@dfg.ca.gov (916)653-8983 http://www.dfg.ca.gov/	Aquaculture Commercial Fishing Live fish and animal transportation and imports	fish aquatic organisms and plants algae (<i>Caulerpa</i>)
	Marian Ashe mashe@ospr.dfg.ca.gov (916)324-9803 http://www.dfg.ca.gov/ospr/	Ballast water (biological surveys)	estuarine and marine invasives
California Department of Food and Agriculture (DFA)	Patrick Akers pakers@cdfa.ca.gov (916)654-0768 http://www.cdfa.ca.gov/	Nurseries Agriculture	Hydrilla and other regulated aquatic weeds agricultural pests
California State Lands Commission (SLC)	Maurya Falkner falknem@slc.ca.gov (916)574-2568 http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Ballast_Water_Default.html	Commercial shipping: Ballast water Vessel fouling	estuarine and marine invasives
	Eric Gillies gilliee@slc.ca.gov (916)574-1897	Construction Restoration	freshwater, estuarine and marine invasives
California Department of Water Resources (DWR)	Jeff Janik jjanik@water.ca.gov (916) 653-5688 http://www.water.ca.gov/	Water supply and delivery systems Flooding	riparian weeds mitten crab aquatic food web
The State Coastal Conservancy (SCC)	Abe Doherty adoherty@scc.ca.gov (510)286-4183 http://www.coastalconservancy.ca.gov/	Coastal preservation Restoration	<i>Spartina</i> <i>Arundo</i> wetland invasives
State Water Resources Control Board (SWRCB)	Dominic Gregorio dgregorio@waterboards.ca.gov (916)341-5488 http://www.waterboards.ca.gov/	Discharges Runoff	general exotics

For detailed information on these and other state, federal and local agencies involved in AIS management see Appendices B, C & D.

As this plan is intended primarily for internal state coordination, the focus of the following sections of this chapter is on state agency activities. This section is intended as an overview. A more comprehensive description of state agency responsibilities appears in Appendix C and overlaps somewhat with the overview below.

Biological Surveys, Environmental Planning & Enforcement

DFG is the state trustee agency for fish, wildlife and native plants and plays a major role in managing invasive species that have negative impacts on these resources. Numerous programs and laboratories within DFG work on AIS detection and/or control, including DFG's Invasive Species Program which coordinates statewide AIS activities and undertook the development of this statewide AIS management plan and the associated rapid response plan. DFG is responsible for enforcement of regulations concerning: the aquaculture industry; recreational fishing; commercial fishing; the importation and transport of live wild animals, aquatic plants and fish into the state; and the placement of any such animals in state waters. Recent programs have focused on *Caulerpa* (see Chapter 8), northern pike (see below), quagga mussel, and New Zealand mudsnail, among others.

DFG is also responsible for conducting biological surveys to assess the amount and types of AIS present in state waters. Starting in 1999 with ballast management legislation, DFG/OSPR conducted biological surveys to determine the degree of success of ballast water management activities. The first survey of major ports, harbors and bays of California helped determine a baseline of nonindigenous aquatic species introduced from the ballast of ocean-going vessels. The survey revealed that all areas of the California coast have experienced some level of invasion by species not native to California. Since then, DFG/OSPR has revisited baseline monitoring sites and expanded monitoring to include intertidal and subtidal habitats at 22 outer coast sites. DFG/OSPR also manages the California Aquatic Non-Native Organism Database (CANOD) for marine and estuarine species and is working to establish consistency among the various major databases being used to analyze similar types of AIS-related information. Lastly, DFG has been an active manager or partner in numerous AIS eradication and control programs – especially those AIS that threaten or undermine the health of endangered species or the conservation and restoration of the aquatic ecosystem.

Aquatic Weed Control & Plant Pests

DFA has long regulated and managed aquatic and terrestrial weeds, with a particular emphasis on those that are agricultural pests or cause economic harm. DFA activities and regulatory authority include quarantine, exterior pest exclusion (border protection stations and inspections), interior pest exclusion (pet/aquaria stores, aquatic plant dealers, and nurseries), and detection and control/eradication programs. DFA maintains a rated list of noxious weed species, which, depending on the rating, require various levels of eradication,

containment or holding actions. For all plants, the DFA Plant Pest Diagnostic Center identifies plant species and assigns plant pest ratings. In 2005, DFA and the California Invasive Weed Awareness Coalition completed the state's first comprehensive *Noxious and Invasive Weed Action Plan* (CDFA and CALIWAC 2005), whose recommendations as they relate to aquatic weeds have been taken into account in this AIS plan. One of DFA's largest aquatic weed management programs is a statewide effort to eradicate the escaped aquarium plant *Hydrilla* (see Chapter 2). The County Agricultural Commissioners (CACs) work closely with the state's pest prevention program. In northern California, CACs carry out many quarantine inspections and manage a weed eradication program.

MANAGEMENT EXAMPLE: CONTROLLING NORTHERN PIKE

California's northern pike infestation is currently limited to just one lake. This native of northern waters from Asia to Europe and from Alaska to the Great Lakes Region, is a voracious predator that can grow up to 40 pounds in North America. It uses sharp teeth to eat creatures ranging from smaller fish such as juvenile salmonids to frogs, crayfish and even ducks. After introduction, it has the potential to dominate water bodies such as lakes, by both preying on and out-competing trout and other game fish. The northern pike poses a major threat to California's aquatic ecosystems, in particular the freshwater species of the Sacramento-San Joaquin Delta. The northern pike was introduced to California on at least two occasions, possibly by anglers hoping to establish a local population of this popular game fish. It was first found in Frenchman Lake, Plumas County, in 1988.

In 1991, Frenchman Lake and its tributaries were treated with rotenone; subsequent testing indicated no pike survived. In 1994, the pike was discovered again in nearby Lake Davis, another Sierra Nevada reservoir. In 1995, DFG proposed to treat Lake Davis with rotenone in order to protect the area's thriving trout fishery, as well as downstream aquatic resources, by eliminating the chance of pike escaping to other waters. Residents strenuously opposed the plan, citing contamination of their drinking water supply. By 1997, the lake's trout population had been virtually eliminated by pike predation. Local businesses, many of which depend on visiting fishermen, began to suffer. Despite the controversy surrounding the proposed project, a treatment occurred in October 1997. Over 55,000 dead pike were removed from the lake and the treatment was declared successful. In 1999, just 17 months after treatment, more pike were found in Lake Davis. It is unknown whether fish survived the treatment or pike were illegally introduced after the treatment. After the fish were rediscovered in Lake Davis, DFG commenced trapping, electrofishing, netting, and increased law enforcement and education on the dangers of pike introduction. Yet fish numbers in the lake have continued to rise. In 2005, DFG proposed a project to eradicate northern pike in Lake Davis. The proposed project includes application of rotenone in combination with a significant reservoir drawdown; the drawdown would reduce the amount of chemical needed to kill the pike. DFG, in cooperation with the U.S. Forest Service, Plumas National Forest, are currently engaged in a joint state and federal environmental review process for the proposed project and seven alternatives. Both agencies are working closely with the local community and local, state and federal agencies to avoid the controversial nature of the chemical treatment that occurred in 1997.

MANAGEMENT EXAMPLE: QUARANTINES & INSPECTIONS

California has a long history of state-imposed quarantines and exclusionary practices dating back over a century. These quarantines have prevented or limited the entry of many invasive species and diseases such as Mediterranean fruit fly and exotic diseases that developed from farmed salmon and other fish. At the height of California's quarantine and inspection programs, DFA operated 16 full-time Border Protection Stations (BPS), staffed by over 150 inspectors, to inspect all vehicles entering the state for quarantine compliance. Additionally, the CACs conducted enforcement activities at plant and produce import sites and aquaculture facilities. In recent years, funding for these programs has diminished and resources are not available to keep up with increases in invasions due to growth in U.S. and global travel and mail order and Internet sales of live organisms and plants. DFA funding for BPS alone dropped from \$11 million in 2002 to \$9.2 million in 2005 and private vehicle inspections (including trailered boats and other watercraft) had until recently been eliminated.

Zebra mussel infested watercraft were intercepted at the BPS 68 times between 1993 and 2006. Over half of these finds were from private vehicles, which are not being inspected today. DFA is in the process of conducting a pilot project at one station (Needles on I-40) to determine the pest introduction risk presented by private vehicles. Since this project began on July 5, 2006, zebra mussel has been intercepted four times on private vehicles. Hydrilla has also been intercepted from a private vehicle during this pilot. Increased levels of inspection and enforcement are critical to the prevention of new AIS introductions (Leslie, Pers. Comm. 2007). The discovery of quagga mussel in Lake Mead in January 2007 allowed state agencies to access emergency funds to increase staffing, and permanent funding became available July 1, 2007.

DBW manages the state's largest and oldest aquatic weed control program, working with other public agencies to control the widespread water hyacinth (see Chapter 2) – and more recently Brazilian elodea – in the Sacramento-San Joaquin Delta, its tributaries and the Suisun Marsh. In addition to managing these weed control programs and attempting to keep waterways free of the navigational problems they pose, DBW also manages the recreational boating vector of AIS in California (although currently there is not funding and staff for a comprehensive program). DBW leads the California Clean Boating Network – a collaboration of government, business, boating and academic organizations working to increase and improve clean boating education efforts, including invasive species education, across the state.

SCC has been involved for over twenty years in the control and eradication of aquatic invasives, particularly plants. Most recently, its management focus has been on developing, funding and operating the Invasive Spartina Project in San Francisco Bay (see Chapter 8 and Appendix B). The project's aim is to eradicate four invasive species of *Spartina* (and their hybrids), which threaten to destroy marsh and mudflats and clog drainage channels. SCC is also heavily involved in efforts to control *Arundo* in many coastal watersheds and has been a partner in developing this state AIS management plan.

Commercial Shipping Management (Ballast Water and Vessel Fouling)

SLC oversees management of AIS introductions through commercial shipping as directed by the 2003 Marine Invasive Species Act. This program implements regulations governing ballast water management for vessels arriving or operating on the West Coast of North America. Commission inspectors board approximately 25% of all vessels that arrive to California to verify compliance with regulations and to disseminate outreach materials to vessels and crews new to California (Falkner et al. 2007). Monitoring results suggest that vessel compliance with the requirement to report ballast management and discharge practices is very high (see Figure 4) and has risen dramatically since the inception of the program. The majority of non-compliant ballast water discharge originating from outside U.S. waters is from Mexico (Falkner et al. 2007).

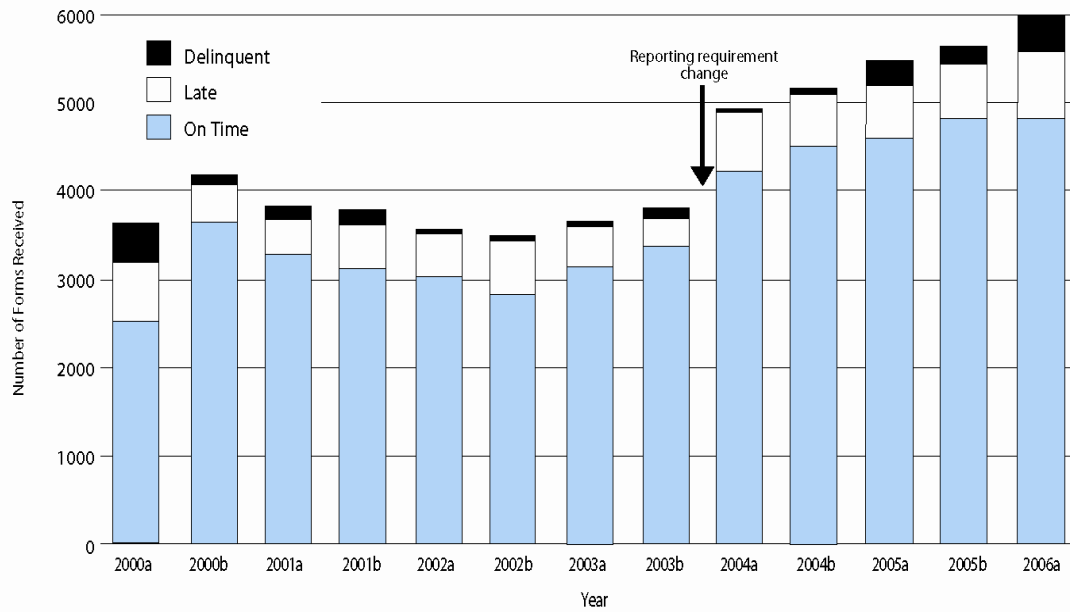
The high compliance rates are attributable to the multi-pronged outreach and communication activities undertaken by SLC. Inspectors distribute information about regulations verbally and in print to crews. Agents are notified monthly of their vessels' reporting compliance or non-compliance. Multi-agency, multi-interest advisory groups are regularly convened and consulted regarding evolving policy considerations. New legislation (2006) directs SLC to develop regulations requiring vessel owners and operators to implement certain interim and final performance standards for the discharge of ballast water. In addition to the regulatory activities described above, SLC facilitates scientific research and technology development to enhance management efforts of the ballast water program and to inform policymakers.

SLC has also developed recommendations for preventing AIS release from hull fouling on commercial vessels. In follow up to the Marine Invasive Species Act of 2003, which directed SLC to formulate these recommendations, SLC collaborated with the California Sea Grant Extension Program on a May 2005 workshop. This workshop was designed to discuss the vessel fouling issue with stakeholders from both the recreational boating and commercial shipping communities (Gonzalez and Johnson 2005). Information gathered from this workshop and from several additional advisory group meetings, was incorporated into a set of final recommendations presented to the state legislature in 2006 (Takata et al. 2006). In addition to its commercial shipping-related activities, SLC is also engaged in regional AIS projects that affect waters that fall under their jurisdiction, such as coordinating interagency efforts to manage Eurasian watermilfoil in Lake Tahoe (see Chapter 8).

Figure 4: Ballast Water Reporting and Discharge Rates

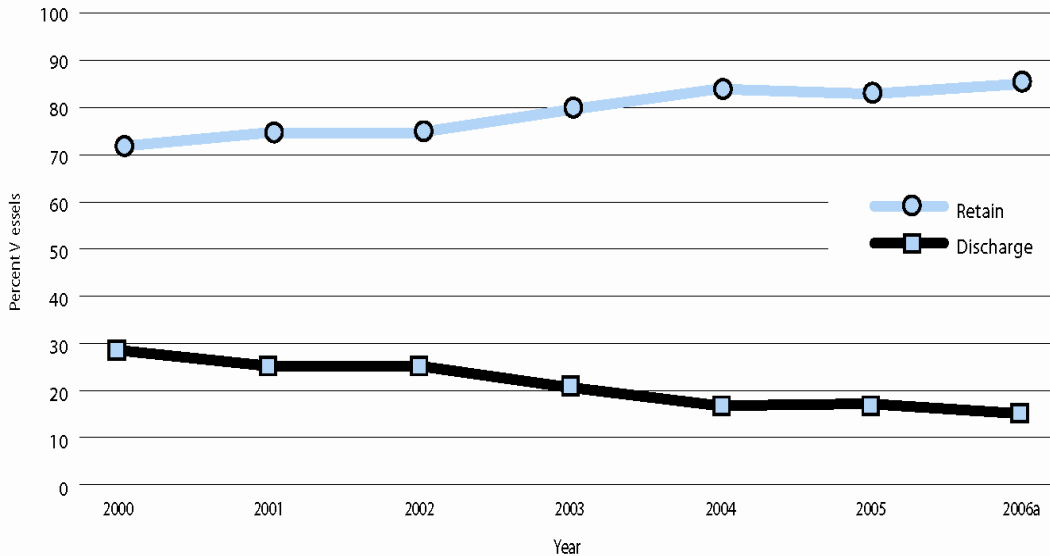
Ballast Water Reporting

Vessel compliance with requirement to submit information on ballast water management practices to the State Lands Commission. The x-axis is divided into 6-month intervals (a = January-June; b = July-December). Since 2004, compliance has remained above 94% with approximately 85% of vessels reporting on time (upon departure from port). (Source: Falkner et al. 2007)



Ballast Water Discharge vs. Retention

Percent of vessels discharging in CA waters (squares) compared to percent of vessels that retain ballast water (circles). Only the first 6 months of 2006 are represented in this graph. Since 2000, the percentage of vessels discharging has steadily decreased. Ballast water retention is currently the most protective management option available. (Source: Falkner et al. 2007)



Monitoring & Managing AIS Impacts on Water Quality & Supply

DWR addresses invasive species issues that impact water supply and delivery and flood control. Recent management activities have focused largely on monitoring AIS within the water column and food web, developing key early detection programs and undertaking structural improvements such as a barrier at Lake Davis (to prevent northern pike escape) and a screen at the State Water Project (to collect Chinese mitten crabs). In terms of monitoring, DWR conducts monthly monitoring of benthic (bottom-dwelling) invertebrates, zooplankton and phytoplankton throughout the upper San Francisco Estuary. DWR also documents the distribution of the invasive algal species *Microcystis* spp. (both toxic and non-toxic strains) in this estuarine region. DWR is also investigating the impacts of the Chinese mitten crab on the benthic invertebrate community in the Sacramento-San Joaquin Delta. On the early detection front, DWR was most recently responsible for implementing the California Zebra Mussel Watch Program (which included risk assessment, early detection, public outreach and the development of a rapid response plan for the Central Valley watershed and a centralized reporting system for mussel sightings). DWR also participates in programs aimed at controlling invasive weeds along eroding Sacramento River banks, within flood control and water conveyance structures and along urban streams. The agency coordinates its activities with other state and federal agencies as a member of the CALFED Non-Native Invasive Species Advisory Council.

The SWRCB, and the nine affiliated regional boards, have no specific policies and programs related to AIS but have been working in support of and in an advisory capacity to, other state agencies on various related activities such as hull fouling and ballast water management. AIS come under SWRCB purview as part of the state's responsibilities under the federal Clean Water Act (CWA, see Appendix B). A 2005 federal court ruling defined nonindigenous species as "pollutants" present in discharges from vessels and found that such discharges are not exempt from permitting requirements (see National Pollutant Discharge Elimination System (NPDES) permits in discussion of the CWA in Appendix B).

In terms of AIS management activities, some of the regional boards have also sought to place specific water bodies within their regions on the CWA's 303(d) list, as impaired by "exotics" (see Glossary). San Francisco Bay was listed in 1998. In 2006, the State Board also listed the Delta, the upper San Joaquin River and the Cosumnes River. Once on the 303(d) list, the regional boards are required to develop discharger/source based programs for managing pollutant loads (called Total Maximum Daily Loads or TMDLs), which in the case of AIS have proved somewhat difficult to develop. Trying to allocate loads or goals for zero loads, among dischargers, water users and municipalities is challenging when most of the water bodies in question are already heavily invaded. Despite the implementation challenges, the S.F. Bay RWQCB's work on the state's first exotics TMDL did widely publicize the problem and led to other successful AIS management and legislative programs.

Other regional boards have become involved in AIS-related water quality issues through watershed management projects, non-point source pollution management programs and wetland mitigation and restoration programs (raising issues about the use of non-native aquatic plant species for these programs, and the control of invasives, for example). The SWRCB has also participated in AIS management activities concerning the use of aquatic pesticides and the nine regional water quality control boards enforce the statewide NPDES permit for use of aquatic pesticides for weed and vector control.

Education & Outreach

Most of the AIS management programs described in this chapter involve some education and outreach. There are many other outreach activities, large and small, conducted by public and private organizations interested in the prevention and control of AIS infestations. The University of California Cooperative Extension (UCCE) and California Sea Grant Programs (Sea Grant), for example, are active and successful leaders in invasive species outreach and education. They have built substantial stakeholder networks and brought media attention to AIS concerns. Other groups engaged in AIS outreach and education include CALFED, the San Francisco Estuary Project, the San Francisco Estuary Institute, National Estuarine Research Reserves and Marine Sanctuaries, the Pacific States Marine Fisheries Commission and the California Invasive Plant Council, among others (see Appendix D).

Partnerships with NGOs, Business & User Groups

Many of the state's AIS management activities are undertaken through partnerships with local agencies, non-governmental organizations (NGOs), private landowners and various interest groups. Those currently active range from large environmental and land-holding organizations such as the Nature Conservancy to smaller county land trusts, Native American tribes, watershed management organizations, and special interest groups (fishing, hunting, boating, etc.). Business groups affected by AIS management activities (shippers, aquarium trade, habitat restoration companies, etc.) have also been active partners in AIS management. A number of task forces and projects are dedicated to very specific invaders (see Appendix D). Such groups and organizations can greatly help state and federal efforts to manage AIS.

Partnerships with Universities, Research Institutes, Industry & Consulting Firms

The management activities mentioned in the preceding sections were possible because of the research conducted by universities, relevant industries public/private research and resource management organizations. Increased knowledge of the biology of invasive species and associated control methods allows for the most effective management of AIS. Research is needed to quantify and clarify the effects that non-native species are having on native plants, animals and their habitats. It is also important to know what economic effects AIS are having and whether there are any human health and safety

concerns resulting from an infestation. These partnerships are necessary in order for agencies to develop their management programs with scientific input.

Gaps & Challenges

Factors such as the large size of the state, the number of organizations/constituencies involved and other geographic and water management issues complicate California's efforts to prevent AIS introduction and manage their spread. California, like other states, suffers from the following challenges to effective AIS management:

- Difficulty in balancing negative environmental impacts of chemical treatment with positive protection of native habitats and listed species
- Difficulty in timely permitting for rapid response, eradication and control
- Lack of adequate long-term funding
- Difficulty coordinating diverse state activities, agencies and programs, and ensuring communication and high-level priority setting to optimize limited management resources
- Lack of awareness of, and enforcement of, existing laws
- Limited detection and treatment technologies, and coordination among detection efforts
- Limited public awareness of the threats posed by AIS, and costs of managing AIS, versus the threats from pesticides used to control them

This management plan is a substantial step toward addressing these challenges. It emphasizes coordination, communication and prevention; suggests actions to fill management gaps and provides a foundation for California's first comprehensive state-wide approach to AIS.

5. SUMMARY OF AIS LAWS, REGULATIONS & AUTHORITIES

The primary authority for state efforts to prevent AIS introduction and manage the spread and impacts of AIS in state waters derives from California's Fish and Game Code, the Food and Agriculture Code, and the Public Resources Code. Other significant statutes discussed below are found in the California Water Code and the Harbors and Navigation Code. These codes are the actual state laws passed by the legislature. Relevant state commissions are charged with adopting regulations that are necessary to carry out the intent of these laws. The regulations are added to the relevant divisions within the California Code of Regulations. Various federal laws also impact management activities. For a more comprehensive description see Appendices B & C.

California Authorities

Fish and Game Code & Title 14 of the California Code of Regulations

At least five code sections and their associated regulations address or relate to AIS. The intent of these code sections are to regulate the importation and transportation of live wild animals and plants; restrict the placement of live aquatic animals or plants in state waters; and regulate the operation of aquaculture industries. DFG is the state agency responsible for implementing these statutes.

F & G Code §§ 2080–2089, 2118, 2270-2272, 2300, 6400-6403, 15000 et seq.
<http://www.fgc.ca.gov/html/regs.html>

California Food and Agriculture Code

Over 30 different code sections address the state's mandates to prevent the introduction and spread of injurious animal pests, plant diseases and noxious weeds. These codes describe procedures and regulations concerning, among other things: plant quarantines; emergency pest eradications to protect agriculture; pests as public nuisances; vectors of infestation and infection; the sale, transport and propagation of noxious weeds; and the protection of native species and forests from weeds. Most of these statutes and their associated regulations (Title 3 of the California Code of Regulations) are enforced by DFA.

F & A Code §§ 403, 461, 5004, 5021-5027, 5301-5310, 5321-5323, 5401-54204, 5421, 5430-5432, 5434, 5761-5763, 7201, 7206-7, 7501-2
www.leginfo.ca.gov

California Water Code

The Porter-Cologne Water Quality Control Act (California Water Code, Division 7) lists a number of types of pollutants that are subject to regulation. Section 13050, for example, specifically includes the regulation of "biological" pollutants by defining them as relevant characteristics of water quality subject to regulation by the SWRCB and the affiliated RWQCBs. AIS are an example of this kind of pollutant if they are discharged to receiving waters. The Water Code generally regulates more substances occurring in discharges and also defines discharges to receiving waters more broadly than the federal CWA.

Water Code §13050

Harbors & Navigation Code

This code authorizes DBW to manage aquatic weeds impeding the navigation and use of state waterways.

Article 2, Section 64

Public Resources Code

Sections of this code address the state's mandates to prevent nonindigenous species introductions through ballast water of commercial vessels. These sections were promulgated by the three laws described below. The SLC and the DFG have primary responsibility for carrying out these statutes and associated regulations.

The Ballast Management for Control of Nonindigenous Species Act of 1999 required that commercial vessels over 300 gross register tons (GRT) originating from outside the U.S. EEZ carry out mid-ocean exchange (at least 200 nautical miles offshore) or use an approved ballast water treatment method, before discharging in California state waters. State enforcement of the act took the form of monitoring ballast discharges and reports, inspecting vessels for compliance and assessing vessel reporting rates and compliance.

The Marine Invasive Species Act was passed in 2003, widening the scope of the original program. The 2003 act requires ballast water management for all vessels that intend to discharge ballast water in California waters, though the regulations differ depending on voyage origin. All qualifying vessels coming from ports within the Pacific Coast region must conduct an exchange (in waters at least 50 nautical miles offshore and 200 meters deep), or retain all ballast water and associated sediments. All vessels must complete and submit a ballast water report form upon departure from each port of call in California. They must also comply with good housekeeping practices, ranging from avoiding discharge near marine sanctuaries to rinsing anchors and removing fouling organisms from the hull. They must also keep logs of ballast management activities, conduct crew training and pay a fee for each qualifying voyage at their first port of call in California. To determine the effectiveness of the management provisions of the act, the legislation also requires state agencies to conduct a series of biological surveys to monitor new introductions to coastal and estuarine waters.

The Coastal Ecosystems Protection Act of 2006 deleted the sunset provision of the prior statute making the Marine Invasive Species Program permanent. The new law also requires adoption of regulations that will require vessel owners to implement certain interim and final performance standards for the discharge of ballast water and establishes an on-going coastal AIS monitoring program to be implemented by DFG.

PR Code §§ 71200-72423; CC 2271; RT 44008

Regulated Species

For a list of AIS plant and animal species regulated by the state see Appendix G.

Primary Federal Authorities & Agencies

California's AIS management efforts must also be coordinated with the federal government's extensive efforts on the same front. No single federal agency has comprehensive authority for all aspects of aquatic invasive species management. Federal agencies with regulatory authority over the introduction or transport of aquatic species that may be invasive or noxious include the U.S. Department of Agriculture, Animal Plant Health Inspection Service, the U.S. Department of Agriculture, Agricultural Marketing Service, the U.S. Fish and Wildlife Service (USFWS), the U.S. Department of Commerce and the U.S. Coast Guard (USCG). Additionally, many other agencies have programs and responsibilities that address components of AIS, such as importation, interstate transport, exclusion, control and eradication. One of the earliest authorities derives from the 19th-century Rivers & Harbors Act, which enables the U.S. Army Corps of Engineers to control aquatic weeds.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) established the first major federal program to prevent the introduction and control the spread of introduced aquatic nuisance species. The act provides an institutional framework that promotes and coordinates research, develops and applies prevention and control strategies, establishes national priorities, educates and informs citizens and coordinates public programs. The act also calls upon states to develop and implement comprehensive state AIS management plans, such as this California plan. In 1996, the National Invasive Species Act (NISA) amended the 1990 act to mandate ballast water exchange for vessels entering the Great Lakes and to implement voluntary ballast water exchange guidelines for all vessels with ballast on board that enter U.S. waters from outside the U.S. EEZ. The act also authorized the USCG to toughen requirements if compliance proved unsatisfactory, which it did in 2004. As a result, the USCG has since established mandatory ballast water management requirements for all ships entering U.S. waters and penalties for non-compliance.

The NANPCA/NISA does not affect state authority to adopt or enforce AIS control measures. Several states have elected to undertake such measures. In addition to reporting requirements, California, Oregon and Washington have ballast water exchange requirements. California law (2006) requires the state to adopt a ballast water discharge standard.

The Executive Order on Invasive Species signed by President William J. Clinton on February 3, 1999, expanded federal efforts to address AIS. The order intended to build upon existing laws, such as the National Environmental Policy Act, the Nonindigenous Aquatic Nuisance Prevention and Control Act, the Lacey Act, the Plant Pest Act, the Federal Noxious Weed Act and the Endangered Species Act. The order creates a National Invasive Species Council charged with developing a comprehensive plan to minimize the economic, ecological and human health impacts of invasive species and determine the steps necessary to prevent the introduction and spread of additional invasive species. Federal

activities are now coordinated through this council and through the National Aquatic Nuisance Species Task Force (ANSTF).

Beyond authorities and legislation, some of the other major federal activities related to AIS management in California include:

- USFWS' 100th Meridian Initiative to stop the zebra mussel from spreading west.
- NOAA's Sea Grant Program, and its support for the West Coast Ballast Outreach Project (which educates the maritime industry about the ecological impacts of aquatic invasive species), as well as funding research on key invasive species.
- USDA's federal noxious weed list, maintained through the APHIS Cooperative Agricultural Pest Survey, and its Agricultural Research Service (ARS) units at Davis and Albany, California, whose work includes improving management of invasive aquatic and riparian weeds affecting agriculture and natural resources.
- USEPA's recent commitment to providing federal coordination for AIS rapid response planning and associated permitting.
- USGS' ongoing research and data bases on invasive species.
- NPS inventories and monitors invasive species and, where feasible, strives to eradicate them.

For more detailed information on federal AIS authorities, agencies and programs, see Appendix B or visit <http://www.anstaskforce.gov> and www.invasivespecies.org.

6. MANAGEMENT OBJECTIVES, STRATEGIES & ACTIONS

PLAN GOAL: Minimize the harmful ecological, economic and human health impacts of aquatic invasive species.

To assist in attaining the goal of the California AIS Management Plan (CAISMP), eight major objectives have been identified:

1. **COORDINATION & COLLABORATION:** Improve coordination and collaboration among the people, agencies, and activities involved with AIS.
2. **PREVENTION:** Minimize and prevent the introduction and spread of AIS into and throughout the waters of California.
3. **EARLY DETECTION & MONITORING:** Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.
4. **RAPID RESPONSE & ERADICATION:** Establish and manage systems for rapid response and eradication.
5. **LONG-TERM CONTROL & MANAGEMENT:** Control the spread of AIS and minimize their impacts on native habitats and species.
6. **EDUCATION & OUTREACH:** Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.
7. **RESEARCH:** Increase research on the baseline biology of AIS, the ecological and economic impacts of invasions, and control options to improve management.
8. **LAWS & REGULATIONS:** Ensure state laws and regulations promote the prevention and management of AIS introductions.

Associated strategies and specific actions pertaining to each of the above objectives are presented in this chapter. These actions have been identified as being key tasks necessary to more effectively manage aquatic invasive species. The proposed objectives, strategies and actions in this plan should be regularly reviewed and incorporate annual opportunities for updates and adaptation to new knowledge and circumstances.

Plan Development Process

The plan goal, objectives, strategies, and specific actions were developed with input from a series of stakeholder scoping meetings, interagency staff communications and public workshops held in 2002 and 2006 (Appendix E).

Implementing Entities & Cooperating Organizations

The entities listed as acronyms, in bold type, in parentheses after each action represent the suggested key implementing entities (see the acronym list in the front material of this plan). In most cases, this refers to those state entities that have the responsibility and/or authority to implement the appropriate actions. Federal, regional and local agencies will, in most cases, not be listed as implementing agencies, since this is a state plan. The acronyms of cooperating organizations, who can participate in implementation efforts, are listed in normal type.

State agencies will coordinate with federal, regional, and local agencies whenever appropriate. The need for particular coordination with federal agencies is noted with an "FA" in the list of implementing entities and cooperating organizations. When an action requires input or products from universities, colleges, academic institutions or research organizations, the generic label "RI" (research institutions) will be used. These include the state government's primary research arms – California State Universities and the University of California – as well as the California Sea Grant program. Some of these entities are listed specifically after appropriate actions per their request, rather than being listed generically as RI. For many actions the Aquatic Invasive Species Working Group (AISWG) is included as a responsible entity. This implies that representatives of all AISWG entities will have the opportunity to be involved in these actions.

The CAISMP Implementation Matrix (Table 5, Chapter 7) lists implementing entities and cooperating organizations. The listings presented here are only a guideline, and as implementation progresses, the implementing entities may change.

Year & Funding

The year associated with each of the tasks indicates the suggested year in which to begin implementation. Year 1 indicates that funding and personnel resources are already available for FY 2007/2008, or that the action is a high priority for which resources need to be secured as quickly as possible. For some of these actions, suggested implementation years may seem overly optimistic, especially those that require funding beyond what is currently available. Like many other states across the nation, California is currently undergoing budgetary restrictions and financial support for many of these actions is uncertain. The purpose of this plan however, is to represent what should, rather than what is likely to, happen if California is to adequately address its aquatic invasive species problems on a statewide basis. Actions aimed at securing more funding appear under Objective 1.

Discussion

Many details are included with the following actions. "Discussion" statements are included with many of the following actions to provide more specific direction to implementing agencies.

OBJECTIVE 1: COORDINATION & COLLABORATION

Improve coordination and collaboration among the people, agencies and activities involved with AIS.

AIS management activities conducted by the state spread across multiple agencies. State managers coordinate specific AIS activities through a variety of venues and networks, but without the benefit of a formal coordinating framework. The actions under this objective seek to describe a new coordinating framework that will allow for the comprehensive assessment of AIS activities and ensure action on high priorities. This coordinating framework includes: an executive level consultation process through which state agencies may gain policy level direction and support for AIS management; the establishment of an Aquatic Invasive Species Working Group (AISWG) made up of representatives from various agencies, research institutions and stakeholder groups; and the formal creation of a California AIS Team (CAAIST) of lead AIS managers from each state agency and/or department. The work of the AISWG and the CAAIST will be assisted by the development of technical advisory panels. These panels will provide forums for federal agencies, local agencies, research institutions, NGOs, Native American organizations, and stakeholders to address questions within a specific topic (such as management techniques, specific species or particular geographic areas). In addition to these standing technical advisory committees, several ad hoc committees are likely to be formed.

STRATEGY 1A: INTERNAL STATE COORDINATION

Identify and coordinate agencies, programs and representatives within state government involved with AIS.

ACTIONS

1A1. Develop an executive level consultation process for state agencies involved with AIS management.

(AE, CAAIST, RI, NGOs, SH) Year 1

Discussion: Coordination and consultation at the executive level are central to statewide policy level direction and planning. This direction could include legislation, funding and program direction for all state departments responsible for addressing invasive species issues. This can be accomplished by regular briefings to agency and department directors by key state AIS managers. Alternatively, it could be accomplished by the formation of an AIS or Invasive Species Council made up of department and agency upper management. If such a council for executive level coordination and consultation were pursued, the costs and benefits should first be assessed. In the absence of an AIS or Invasive Species Council, coordination could be accomplished through the California Biodiversity Council. In addition, periodic briefings should be made to the Ocean Protection Council and Fish and Game Commission. Briefing agency and

department executives and involving them more routinely in decision making should improve statewide coordination.

1A2. Formalize the California Agencies AIS Team (CAAIST) made up of representatives from each state agency involved with AIS, and have the team meet regularly.

(AE) Year 1

Discussion: Each state agency and/or department has identified a lead representative for AIS work. This team will meet regularly to coordinate implementation of the state AIS plan. This team will report to executive level managers to implement actions in the plan (Action 1A1) and be led by DFG's State Invasive Species Coordinator.

1A3: Establish, fund and staff an Aquatic Invasive Species Working Group (AISWG) made up of representatives from state and federal agencies, NGOs, stakeholder groups and research institutions, and have the group meet regularly.

(AE, CAISST, RI, NGOs, SH) Year 2

Discussion: The complexity of aquatic invasive species management demands regular peer review to ensure that research, monitoring, prevention and management actions are using the best available approaches. It also demands some broader public and private involvement in forums in which the status of invasive species, control efforts, funding opportunities and criteria for setting priorities are discussed. Forming this new working group could increase the level of collaboration and coordination on AIS throughout the state by creating a regular venue to discuss priorities, pool expertise and reduce redundancies. Any such group would require staff to set up meetings, follow up on action items and handle time-sensitive inquiries and issues that need to be addressed between scheduled meetings. The AISWG is listed as an implementing entity or cooperating organization for many actions in this plan. If the AISWG is not formed, the CAAIST (see 1A2) will become the responsible entity and integrate input from research institutions, NGOs and stakeholder groups into appropriate actions.

1A4. Evaluate the need for an invasive species center.

(AE, NGOs, RI, SH, CAAIST) Year 1

Discussion: Statewide coordination of research and outreach activities could improve by establishing a research network which could incorporate an invasive species center. Defined goals and roles and dedicated funding would be essential to the success of any such entity.

1A5. Form and fund technical advisory panels to provide input to the AISWG and CAAIST and to address specific issues within the plan.

(CAAIST, AISWG) Year 2

Discussion: This plan proposes to convene technical advisory panels to address specific research, management and implementation issues. In addition to state agency staff, the panels will be made up of representatives from the following groups: federal agencies, local agencies, research institutions, NGOs, Native American organizations and stakeholders. It is anticipated that Plan Implementation and Science Advisory panels will be the first to be formed, with other panels created as necessary over time.

1A6. Draft and regularly review working lists of AIS of high-priority concern for early detection actions 3A1-6, rapid response action 4A3 (also see Appendix A, Section IV, Task 7) and control actions such as 5B4.

(CAAIST, FA, RI, Sea Grant, UCCE, NGOs, SH) Year 1 and ongoing

Discussion: One approach would be for the appropriate technical advisory panel (Action 1A5) to review existing national lists, filter these lists through state screening criteria and edit the list based on California-specific conditions and constraints. Draft lists could be circulated for peer review, subsequently finalized by the panel, and submitted to the CAAIST and the AISWG for approval. Lists could then be posted on state websites and updated biennially.

1A7. Clarify which state agencies have lead jurisdiction for more specific AIS issues related to particular species, habitats, water bodies or invasion vectors.

(AE, CAAIST) Year 1

Discussion: Current agency mandates and jurisdictions need to be reviewed, clarified and documented in the context of this statewide plan and discussed by the CAAIST, AISWG and Agency Executives. State AIS managers, local governments, NGOs, stakeholders and others involved in AIS activities, need to be clear about which state agency handles what and why. Such a clarification exercise is an important step in documenting different agency mandates, integrating the many different programs addressing diverse AIS issues, avoiding duplication and ensuring cost-effective use of limited resources. The results of this clarification exercise will be documented and distributed in a report.

1A8. Identify personnel needs within appropriate agencies. Employ needed personnel, to focus on high priority AIS issues and plan implementation.

(AE, CAAIST) Years 1-3

Discussion: This action is already underway. The Governor approved an allocation of \$5.7 million that includes the establishment of 16 new positions in DFG and a \$2.5 million allotment to DFA to work on aquatic invasive species, focusing on quagga mussel prevention, control, eradication, research and outreach.

1A9. Improve state websites to make information on AIS management activities, and research and data, more accessible.

(CAAIST) Year 2

Discussion: State websites and databases on AIS are diverse and reflect different agency mandates and capabilities. To the extent possible, state websites should be improved and linked to facilitate access to current information on management activities statewide, as well as on the latest AIS related technological improvements, data and research. Such accessibility improvements to websites and databases, and linkages among state and other AIS databases, will improve statewide coordination and assist managers and researchers with revisions of this plan and setting action priorities. Efforts under this action will be coordinated with early detection and monitoring actions under Objective 3 and with education and outreach actions under Objective 6, to the greatest extent possible. In addition, whenever possible and useful, biological surveys and other data collected in California databases should be provided, and or developed in compatible formats with, national AIS databases managed by USGS and the Smithsonian Environmental Research Center.

1A10. Assess the effectiveness of AIS programs and projects undertaken by state agencies. Identify and address any gaps in these activities.

(AISWG, Plan Implementation Panel) Year 2

Discussion: The Implementation Panel will review and assess the effectiveness of ongoing AIS management activities in the context of the plan, and in subsequent years (2 and 5) the effectiveness of the plan itself. This assessment will bring together the more program-specific assessments called for in Actions 3A1, 3B1, 4A2, 4B1, 5A1-3, 6A1, 7A1 and 7C1. The Implementation Panel will make recommendations to CAAIST and AISWG. The CAAIST or AISWG will forward the recommendations to the executive managers, the Biodiversity Council, the Ocean Protection Council, and the AIS or Invasive Species Council (if formed).

1A11. Coordinate state AIS management activities with the State Water Resources Control Board (SWRCB) and the Regional Water Quality (RWQCBs) Control Boards.

(CAAIST, SWRCB, RWQCBs) Year 2

Discussion: AIS often exacerbate or complicate pollution control and water quality management. State AIS management activities should be coordinated, through CAAIST, SWRCB and RWQCBs, with state Watershed and Basin Plans, TMDLs for water bodies on the 303 (d) list, and the NPDES permitting process.

1A12. Develop and annually or biennially update a list of AIS experts in California.

(CAAIST, Science Advisory Panel) Year 1

Discussion: The federal ANSTF, USGS, USFWS and NOAA are currently working on developing a list of experts. State agencies should collaborate with the federal agencies on developing and updating the list and making it available to AIS resource managers. Experts are needed in taxonomy, vector management, eradication techniques and ecological impacts.

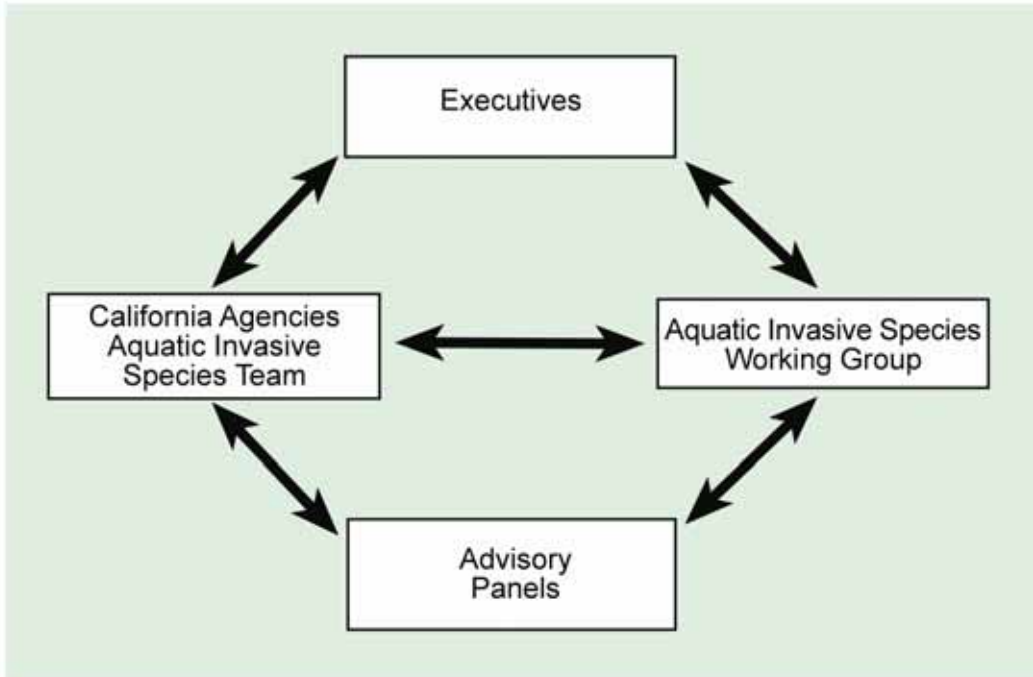
1A13: Develop boilerplate AIS language for agency comments on project plans and other activities.

(CAAIST) Year 2

Discussion: Boilerplate language addressing the need to prevent AIS introduction, or control AIS spread, should be available to agencies commenting on environmental documents, landscape plans, restoration plans and research proposals. Such language should be distributed to all appropriate state, federal and local agency staff.

Figure 5: AIS Coordinating Structure

This figure illustrates the flow of communication about coordination on AIS work. The entities in each box are defined below. As is evident from the definitions, this diagram emphasizes state agency participation. That is because the state has major responsibilities with regard to AIS, and because a primary purpose of the California Aquatic Invasive Species Management Plan is to provide information and guidance to state agencies. It is not meant to diminish the importance of the state's partners in dealing with this issue.



Definitions:

Executives – Representatives of upper level management of state agencies being reported to individually or as a group organized to address invasive species concerns.

California Agencies Aquatic Invasive Species Team (CAAIST) – Representatives from programs in state agencies that meet to coordinate their work on AIS.

Aquatic Invasive Species Working Group (AISWG) - Representatives from state and federal agencies, NGOs, stakeholder groups and research institutions that meet to coordinate efforts among the larger AIS community.

Advisory Panels – Panels that may include people both within and outside of the CAAIST and the AISWG, to help address specific issues or tasks being worked on by those groups.

STRATEGY 1B: LOCAL, NATIONAL & INTERNATIONAL COORDINATION

Continue and improve collaboration among local, regional, state and federal agencies addressing AIS issues; communication with non-governmental organizations, community groups and business interests affected by AIS management; and participation in local, national and international AIS task forces and conferences.

1B1. Identify AIS representatives within key regional agencies, federal agencies and NGOs and provide this information to state managers.

(CAAIST, RI, FA, NGOs, SH) Year 1

Discussion: This action should be completed in collaboration with regional agencies, federal agencies and NGOs. The resulting information should then be posted or distributed to facilitate greater federal, state and local coordination and to provide a springboard for 1B2.

1B2. Identify conflicts and overlaps between state programs and local and federal programs, and between state programs and NGOs, if any.

(CAAIST, RI, FA, NGOs, SH) Year 1

Discussion: This task should be completed in collaboration with regional and federal agencies, NGOs and local watershed management groups. Any significant conflicts and overlaps should be brought to the attention of agency executives and department managers.

1B3. Invite community groups (Native American organizations and industry, business, professional and other groups impacted by AIS management efforts) to participate in planning activities, and to learn more about their role in AIS introduction and dispersal.

(AISWG, SH) Year 2 and Ongoing

1B4. Continue and expand participation in localized efforts and task forces focusing on AIS issues.

(AISWG) Ongoing

Discussion: Participation should extend to the Southern California Caulerpa Action Team, the Lower Colorado River Giant Salvinia Task Force, Team Arundo, and the CALFED Bay-Delta Authority Non-native Invasive Species Program, among others (see Appendix D).

1B5. Continue and expand participation in regional, national and international efforts and task forces focusing on AIS issues.

(AE, CAAIST, RI) Ongoing

Discussion: Participation should extend to the federal ANSTF, the Western Regional Panel, federal ballast water and hull fouling activities, the Pacific Ballast Water Group, the Pacific States Marine Fisheries Commission, the Global Invasive Species Programme, the Invasive Species Advisory Council, the 100th Meridian Project, among others (see also Appendix D).

1B6. Form partnerships with Mexico, Canada, Oregon, Washington, Nevada, Arizona and Colorado River states and secure their input and assistance with AIS issues affecting the Pacific Coast.

(AE, RI, AISWG) Ongoing

1B7. Participate in national and international conferences concerning the management and control of AIS.

(AE, CAAIST, RI) Ongoing

Discussion: AIS conferences increase knowledge of efforts and successes elsewhere, as well as ensure out-of-state awareness of California's issues and activities. Authorization for key out-of-state and out-of-country travel should be promoted.

STRATEGY 1C: FUNDING

Increase funding sources for AIS management and obtain dedicated long-term funding to implement AIS Management Plan tasks and provide matching funds for federal grants.

1C1. Identify and apply for grant funding available in California and nationally.

(CAAIST, RI, NGOs) Year 1-5

Discussion: The federal Nonindigenous Aquatic Nuisance Prevention and Control Act enables state governors to request federal assistance for up to 75 percent of the cost incurred to implement state aquatic invasive species management plans. Currently, the USFWS has a limited budget for grants for this purpose. California should also identify other federal programs that can be used to address invasive species issues (Coastal Zone Management Act etc.), pursue diverse sources of state funding (State Bonds, Sea Grant, etc.) and NGO support (conservation organizations etc.).

1C2. Establish stable, long-term funding to assist in the implementation of the AIS management activities identified in this plan.

(AE, CAAIST) Year 1-3

Discussion: This action should be coordinated with the identification of gaps in 1A10 and 1B2.

1C3. Provide state funding for the AIS positions as detailed in Action 1A8.

(AE, CAAIST) Year 1

Discussion: As noted in 1A8, significant funding has already been allocated.

1C4. Provide funding for AIS rapid response actions when warranted.

(AE) Year 1

Discussion: In Year 1, the Governor approved the expenditure of money for the Quagga Mussel Incident Command. The state's proposed rapid response programs, and some funding issues, are described under Strategy 4A and in Appendix A.

1C5. Finance the hiring of a funding development specialist.

(AE, CAAIST) Year 2

Discussion: Hiring a specialist for 2-3 years to explore and develop funding sources would free up the AIS coordinator to focus on establishing the program necessary to carry out the plan.

1C6. Provide a mechanism to obtain funding to implement additional tasks referred to in this AIS Management Plan, including education, control, monitoring and research.

(AISWG) Years 2-5

Discussion: This mechanism could draw on user fees, visitor taxes, general funds, etc., and build on participation from industries that contribute to, and/or are impacted by, AIS.

The Case for Permanent Funding

Dedicated permanent funding to support permanent staff and agency programs will be a key to effectively addressing AIS issues in California. Though many AIS activities are currently underway throughout the state, almost all of these are operating on 'soft' (short-term/grant) money – a very inefficient approach in the long-term because so much time and effort must be spent soliciting grants rather than managing invasive species. Such grants also result in high staff turnover (including short-term hiring and rehiring); the need to write various status reports to comply with grant requirements; and gaps in eradication and control efforts between funding opportunities, allowing for the recovery of AIS. Thus while soft monies can be very effective for short-term projects such as research studies, they may compromise long-term program operations. There is a clear need for dedicated permanent funding to address aquatic invasive species issues in California.

OBJECTIVE 2: PREVENTION

Minimize and prevent the introduction and spread of AIS into and throughout California waters.

Prevention is the most cost effective and environmentally sensitive method of managing AIS. Prevention revolves around the interception of AIS at the point of entry or release. The movement of AIS into and within California not only takes place via transoceanic ships, but also via other vectors such as aquaculture, the aquarium trade, the bait industry, recreational activities, biological research, environmental restoration projects, and even freshwater diversions to farms and cities up and down the state. California management occurs on both the species and vector level. The actions suggested below seek to: identify high priority vectors and improve programs aimed at addressing them; strengthen enforcement and inspection at entry points; and sustain and expand the state's current ballast water management program and proposed hull-fouling control program. Prevention is a central focus of this plan and it is expected that universities, research institutions and stakeholder groups will be integrally involved in state activities. In addition, prevention efforts targeted at specific vectors will be coordinated with broader outreach and education efforts described under Objective 6.

STRATEGY 2A: REGIONAL VECTOR ASSESSMENT

Identify possible vectors and pathways of AIS introductions into and throughout California and assess the risks and impacts of each.

ACTIONS

2A1. Develop comprehensive regional vector assessments to rank the importance of different AIS vectors in different regions of California.

(RI, DFG) Year 3

Discussion: Some of the vectors California must manage are described in the "Pathways Report" developed by the Aquatic Nuisance Species Task Force and National Invasive Species Council (National Invasive Species Council 2005). The report not only provides a comprehensive vector list, but also criteria for ranking their importance. The information in this report will be used as a foundation for California's regional vector assessment. Comprehensive analysis of vectors in California have occurred for noxious weeds and in areas potentially impacted by ballast water discharges. DFG/OSPR conducts the biological surveys in port/harbor areas and in open coastal areas as directed by the Marine Invasive Species Act. The results of the biological surveys are analyzed for possible vectors of introduction so that high risk vectors can be identified and targeted by prevention programs. Surveys and assessments should be extended to include all waters of the state (i.e. lakes, rivers and streams) so that all potential high risk vectors can be identified. Once a high risk vector is

identified, a detailed assessment of that specific vector is usually needed to quantify the risks and identify potential management options.

STRATEGY 2B: COMMERCIAL VESSELS & MARITIME ACTIVITIES

Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment and hull fouling from commercial vessels and maritime structures.

2B1. Quantify the ballast water and hull fouling vectors, and assess the risk of introduction and dispersal of AIS throughout California from these vectors.

(SLC, RI) Ongoing

Discussion: In 2000, SLC began collecting ballast water report forms from all vessels coming into California from outside the U.S. EEZ. These reports include information about port of origin, how the ballast water was managed (e.g. open ocean exchange) and how much ballast water was discharged. In 2004, SLC expanded their program to require ballast water reports from all vessels, regardless of the last port of call. This comprehensive reporting program is essential to help quantify the extent of the ballast water problem and how it may change over time due to changes in trade routes and/or ballast water management requirements. In addition, in April 2006, SLC approved the following report: “Commercial Vessel Fouling in California: Analysis, Evaluation and Recommendations to Reduce Nonindigenous Species Release from the Non-Ballast Water Vector” (Takata et al. 2006). This report includes recommendations on how commercial vessel fouling should be managed. The recommendations in this report should be adopted. See also Chapter 3.

2B2. Continue to implement and improve California’s current ballast water inspection and enforcement program.

(SLC) Ongoing

Discussion: SLC should continue current ballast water inspection and enforcement program. Training for inspectors should be evaluated and updated as necessary. Technologies such as the handheld Ballast Exchange Assurance Meter, now being developed and tested by the USCG, may prove useful to California’s programs.

2B3. Implement performance standards for the discharge of treated ballast water.

(SLC) Ongoing

Discussion: In January 2006, the SLC approved the report titled “California State Lands Commission Report on Performance Standards for Ballast Water Discharges in California Water” (Falkner et al. 2006). This

report includes interim performance standards, an implementation schedule, final discharge standards and other programmatic recommendations. The report was forwarded to the California Legislature on January 30, 2006 for consideration. In September 2006, legislation based on the report, Senate Bill 497, became law and requires SLC to adopt the interim standards and implementation schedule outlined in the report. Regulations now need to be created and implemented based on the new legislation.

2B4. Identify and address gaps in the Marine Invasive Species Program not addressed by either federal or state law.

(AISWG, SLC, DFG) Ongoing

Discussion: The 2003 Marine Invasive Species Act charged SLC with oversight of the state's program to prevent nonindigenous species introductions through commercial shipping. In recognition of the uncertainties surrounding the development of an effective ballast water management program for the state, the law requires that on or before January 2005, and updated biennially, SLC submit to the legislature and make available to the public, a report that summarizes vessel ballast water activities as they relate to the act and put forward recommendations to improve the state's program. Likewise, DFG is charged with oversight of studies to determine the location and geographic range of AIS in California estuaries and coastal areas and to assess the effectiveness of the ballast water controls implemented pursuant to the law. DFG reports their study results to the public annually.

2B5. Develop a commercial vessel fouling outreach and management program based on results from action 2B1.

(SLC, Sea Grant) Year 1

Discussion: The recommendations of the fouling report described under 2B1 should be adopted and implemented. Options for resolving policy conflicts between efforts to control hull fouling with copper-based anti-fouling paints and efforts to protect water quality need to be explored. Such a resolution may also benefit the implementation of actions related to recreational boats under Strategy 2C.

2B6. Investigate the degree to which moving maritime industry structures, such as oil drilling platforms and barges, may contribute to AIS dispersal.

(DFG, SLC, RI, FA) Year 3

2B7. Quantify and assess the role of commercial fishing vessels as AIS vectors and identify potential management options.

(DFG, RI, NGOs, SH, FA) Year 1

2B8. Develop commercial fishing outreach and management program based on results from action 2B7.

(DFG, AISWG, FA) Year 2

STRATEGY 2C: RECREATION

Limit new AIS introductions through recreational boating, fishing, diving and other water-based activities.

2C1. Quantify and assess the role of recreational boating as an AIS vector and identify potential management options.

(DBW, DFG, RI, SH) Year 1

Discussion: The assessment should examine both the movement of boats over land (trailer boats) and the movement of boats in the water. The assessments should make use of existing data from border protection stations (DFA) and boater surveys (DBW and 100th Meridian Initiative); determine patterns and frequency of watercraft use and transport routes between waterways; and link boater survey results to hull fouling studies (amount of fouling, type of antifouling paint, etc). Information derived from DBW's Boating Facility Needs Assessment may also prove useful.

2C2. Develop a comprehensive recreational boating outreach and management program based on results from action 2C1.

(DBW, UCCE, Sea Grant) Year 2

2C3. Develop a watercraft inspection program for high priority boat launch sites.

(DBW, DFG, DPR, SH) Year 1

Discussion: Unless new funding for agency staff is provided, such a program may need to be volunteer- or NGO-based, or undertaken by a citizen monitoring network as described in 3A5.

2C4. Quantify and assess the role of recreational fishing as an AIS vector and identify potential management options.

(DFG, DBW, RI, SH) Year 3

2C5. Develop a recreational fishing outreach and management program based on results from action 2C4.

(DFG, UCCE, Sea Grant) Year 3

2C6. Develop and distribute guidelines for: disposal of invasive species removed from marina areas (including from hull cleaning); the cleaning of fishing gear and equipment; and disposal of bait.

(DFG, DBW, Sea Grant) Ongoing

Discussion: Collecting fouling organisms removed from larger vessels that are kept in the water poses significant infrastructure and economic challenges that this plan's commitment to statewide collaboration can help address (hauling boats for hull cleaning is nine times more expensive than in-water cleaning). In terms of fishing, contaminated recreational fishing gear and waders function as mechanisms for the introduction and dispersal of AIS throughout California. The angling community is particularly interested in curbing the dispersal of AIS. DFG and DBW will continue to work closely with these stakeholders to identify and publicize methods to decontaminate equipment.

STRATEGY 2D: BAIT, LIVE SEAFOOD, AQUACULTURE & AQUARIUM

Work with appropriate industry representatives to ensure awareness of the threats and prevent introductions.

Discussion: The definition of aquarium may include hobby aquarists, public aquaria (such as Monterey Bay Aquarium) and research aquaria (such as UC Davis Bodega Marine Lab)

2D1. Quantify and assess the role of bait as an AIS vector and identify potential management options.

(DFG, RI) Year 1

2D2. Work with the bait industry to develop preventative strategies, identify education needs and implement permitting of bait imports, collection and sales.

(DFG, UCCE, SH) Year 2

Discussion: Guidelines need to be developed on the use of packing materials for live bait transport. An implementation plan needs to be developed to facilitate permitting bait imports. Input from pathologists is needed to develop prevention strategies and the management program referred to in action 2D3.

2D3. Develop a bait outreach and management program based on results from actions 2D1 and 2D2.

(DFG, UCCE, SH) Year 3

2D4. Quantify and assess the role of live imported seafood as an AIS vector and identify potential management options.

(DFG, DFA) Year 1

2D5. Work with the live imported seafood industry to develop preventative strategies and identify education needs.

(DFG, DFA, UCCE, Sea Grant) Year 2

Discussion: Guidelines need to be developed for use of plants and other live packing materials for seafood transport and linked to education and outreach efforts under Objective 6. Input from pathologists is needed to develop prevention strategies and the management program referred to in action 2D6.

2D6. Develop a live imported seafood outreach and management program based on results from actions 2D4 and 2D5.

(DFG, DFA, UCCE, Sea Grant) Year 3

2D7. Perform an inventory and associated risk assessment of the discharge, overflow systems and storm/flood containment systems of aquaculture, public aquariums and research facilities to determine the potential risks of effluents and propose remedies for remediation and monitoring requirements.

(SWRCB, DFG, RI, SH) Year 3

Discussion: The level of risk currently posed by these facilities is not known and must be more accurately assessed. Though containment procedures must be outlined in the permit process of such facilities, follow-up has been inadequate to ensure procedures and systems are in place and effective. Methods already exist to evaluate the risks associated with this pathway such as those presented in the Aquatic Nuisance Species Hazard Analysis Critical Control Point (ANS-HACCP) planning process. USFWS has adopted ANS-HACCP as a national tool for use by federal fish hatcheries and developed guidance materials and training to facilitate its use.

2D8. Work with the aquaculture industry to ensure understanding of the importance of containment systems as well as the threat escapees may pose to native species and habitats.

(DFG, SH, UCCE) Year 2

Discussion: DFG should provide ANS-HACCP training and assist in development of ANS-HACCP plans.

2D9. Develop an aquaculture outreach and management program based on results from actions 2D7 and 2D8.

(DFG, UCCE) Year 4

2D10. Quantify and assess the ways the aquarium and aquascaping (water garden) trades contribute to AIS introductions in addition to the discharge issue addressed in 2D7 and evaluate potential management options.

(DFG, DFA, RI) Year 1

2D11. Work with aquarium, water garden, and other target industries to ensure that there are easily accessible, appropriate locations and methods for disposal of aquatic organisms.

(DFA, DFG, UCCE, FA) Year 1

2D12. Implement an aquarium and aquascaping outreach and management program based on results from action 2D10.

(DFA, DFG, UCCE, FA) Year 2

STRATEGY 2E: FISHERIES ENHANCEMENT

Assess and minimize activities related to planned, authorized introduction of non-native species into inland water systems.

2E1. Quantify and assess the role of fisheries enhancement as an AIS vector and identify potential management options.

(DFG, RI) Year 1-3

2E2. Review DFG's authorized practice of intentional introductions of non-native species into aquatic habitats for recreational purposes.

(DFG, RI) Year 1-3

Discussion: DFG is currently writing an Environmental Impact Report (EIR) that will examine DFG operated hatchery stocking throughout the State. The anticipated completion date is December 2008.

2E3. Explore ways to reduce the amount of unauthorized stocking of non-native species into aquatic habitats.

(DFG) Year 2

2E4. Assess the efficacy of, versus threats from, authorized introductions of *Poeciliids* into native habitats for mosquito control.

(DFG, RI) Year 2

Discussion: The practice of stocking streams, ditches and other inland waterways with *Poeciliids* (i.e. mosquitofish) to control mosquitoes should be evaluated. Though mosquito control to address human health concerns is certainly important, *Poeciliids* may not be the most effective method, harbor parasites and can be harmful to native insect and fish species.

STRATEGY 2F: RESEARCH, MANAGEMENT & EDUCATION

Minimize AIS introductions and transfers by researchers, resource managers and others involved in field activities.

2F1. Quantify and assess the role of research, resource management and educational activities as AIS vectors and identify potential management options.

(AISWG) Year 2

2F2. Establish and make available protocols to minimize the spread of AIS into the wild from research, monitoring and control activities, and incorporate protocols into permits and funding requests.

(DFG, AISWG, RI) Year 3

Discussion: With the rise in AIS work suggested by this plan, there will be a corresponding increase in the chance of transferring AIS during research or management activities. Protocols addressing this task have been developed by the ANSTF and could be adapted to meet the state's needs. Such protocols should be a standard component of all field activities that involve AIS or infested waters, as well as a required component of AIS grant proposals. Other protocols already exist such as those presented in the ANS-HACCP planning process.

- 2F3. Evaluate existing, or establish new, regulations and protocols for in-water (non-lab) based research experiments that could potentially introduce or involve the culture or movement of non-native species into areas where they do not currently exist.**

(DFG, SWRCB, RI) Year 4

Discussion: Information on gaps in existing protocols and any new protocols developed under this action should be distributed to researchers in coordination with 6C1 and 6C2. Researchers also need to understand that these activities are regulated by Private Stocking Permits. In addition, permit evaluation should include scrutiny of potential AIS issues.

- 2F4. Quantify and assess the role of the shipment of live aquatic species for use in research or educational activities as an AIS vector.**

(DFG, RI) Year 4

Discussion: Marine and freshwater species can be ordered from research and educational supply companies around the world through catalogs or the Internet. Once the organisms are delivered, improper handling techniques may result in the release of non-native species.

STRATEGY 2G: CONSTRUCTION & RESTORATION

Limit new introductions of AIS as a result of restoration, landscaping and construction activities.

- 2G1. Quantify and assess the role of construction activities as an AIS vector and identify potential management options.**

(DFG, RI) Year 3

- 2G2. Work with industry and consultants to develop guidelines for decontamination of construction equipment, tools and protective clothing.**

(DFG, SLC, DPR, FA) Year 2-3

- 2G3. Develop a construction outreach and management program based on results from actions 2G1 AND 2G2.**

(DFG, SLC, DPR, FA, UCCE) Year 4

- 2G4. Quantify and assess the role of restoration activities as an AIS vector and identify potential management options.**

(AISWG, RI) Year 2

Discussion: Construction equipment used for restoration work, as well as soil from nurseries and dredged material used for restoration, can be vectors for AIS.

2G5. Work with consultants and other groups conducting habitat restoration projects or landscaping projects to encourage the use of native species (with propagules from appropriately local stock) or noninvasive non-native species to minimize the transfer of AIS.

(DFG, SCC, AISWG) Year 2-3

Discussion: Non-native species should not be used in habitat restoration and mitigation projects. Approved mitigation and restoration projects should include a program for periodic site monitoring for non-native species and a program for control and, if appropriate and feasible, eradication if an introduction occurs. The use of non-native plant species in public access landscape improvements should be avoided where a potential exists for non-native plants to spread into waterbodies or transition zones between tidal and upland habitats.

2G6. Develop a restoration outreach and management program based on results from actions 2G4 and 2G5.

(AISWG, UCCE) Year 3

STRATEGY 2H: WATER DELIVERY & DIVERSION SYSTEM

Limit new introductions of AIS as a result of water delivery systems.

2H1. Quantify and assess the role of the water delivery and diversion system as an AIS vector and identify potential management options.

(DWR) Year 2

Discussion: The state's extensive water delivery, export, transfer and development system, which moves water not only from one watershed to another, but also from one end of the state to another, and even across state lines, can be an important vector of AIS. Water deliveries can spread freshwater-adapted AIS within and out of state, and carry species from infested areas to more pristine locales. Intensive manipulation of natural water paths and flows in support of these water diversions and deliveries, and of the aquatic ecosystem in general, makes California particularly vulnerable to AIS. Not only can AIS be more easily transferred via all these diversions, but they may also find it easier to colonize areas where native species are already stressed by the loss of habitat caused by dams, water diversion, altered hydrology and development.

2H2. Develop an outreach and management program for the water delivery and diversion system based on results from actions 2H1.

(DWR, UCCE, Sea Grant) Year 3

STRATEGY 2I: ENFORCEMENT & INSPECTION

Increase enforcement of existing regulations controlling the transport, propagation, sale, collection, possession, importation, purchase, cultivation, distribution and introduction of AIS.

Discussion: State resources directed toward interdiction and inspections at major points of entry for invasive species are inadequate. This plan seeks to improve inspections at both interior and coastal borders and increase monitoring efforts to ensure compliance with current regulations.

2I1. Increase staffing and hours of operation at DFA Border Protection Stations.

(DFA, SH) Year 1

Discussion: DFA operates 16 border protection stations (BPS) on major highways entering California. When BPS stations perform boat inspections, they remove any quagga or zebra mussels found on infested boats, place the boat under quarantine and coordinate with DFG personnel to supervise final cleaning at destination points. Before 2003, DFA inspectors checked all watercraft entering California through these stations for AIS, including zebra mussel and *Hydrilla*. However, in 2003, the program was subject to severe budget cuts and the ability to inspect small, privately transported watercraft was lost. At 15 of the 16 BPS, only watercraft transported by commercial vehicles were inspected from 2003 through the end of 2006. At the end of December, 2006, only nine of the stations were open 24/7, while the other seven were open only eight hours a day. DFA suggests that in order to prevent AIS invasions, all boats should be inspected, all check stations should be open 24 hours a day and all staff (and the CHP) should be trained in zebra mussel, quagga mussel, aquatic weed and other AIS identification, disposal and reporting to other state agencies. The recent quagga mussel discovery in January 2007 in Lake Mead allowed state agencies to get funds to increase staffing in southern California. Additional funding and staff are needed to reopen all stations and inspect private vehicles.

2I2. Develop and distribute comprehensive guidelines for border inspections of boats, boat trailers and water-based equipment entering California.

(DFA, DFG) Year 1

- 213. Increase DFG staffing to more effectively enforce current regulations on prohibited and restricted species, and on movement of aquatic species.**

(DFG, SH) Year 1-2

Discussion: Various regulations exist to protect valuable resources against the introduction of prohibited and restricted species. In Year 1, the Governor approved additional staffing for enforcement laws related to quarantine of vessels infested with prohibited species.

- 214. Ensure adequate staffing and clear cargo inspection guidelines for inspectors and enforcement officers at maritime ports and at airports.**

(FA, AISWG, SLC) Year 3-5

Discussion: Inspecting cargo is a critical step in preventing unwanted species from entering the state. Adequate staffing and clear guidelines are needed for inspectors to be effective. Close coordination and collaboration with federal inspectors (including USCG, USFWS, USDA, and DHS) will be required. Training for inspectors should be evaluated and updated as necessary.

- 215. Continue disease sampling for shipments and stocks of live fish and other species. Assess whether current systems are adequate to keep contaminated stocks from being distributed via aquaculture, the aquarium and bait trade, terminal food markets, research activities and government stocking programs.**

(DFG) Ongoing

- 216. Develop a program to identify mail order and online vendors who are selling California prohibited and restricted species, and work with these vendors to keep AIS from being imported into the state.**

(AISWG, RI) Year 2

Discussion: There are multiple cases of restricted and prohibited stocks being sold without detection by government regulators, not only in local venues, but also through mail order or from on-line sources. Any California enforcement should integrate with efforts such as USDA's current development of a WebCrawler designed to identify online vendors of federally listed noxious weeds and regulated plant species.

OBJECTIVE 3: EARLY DETECTION & MONITORING

Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.

Early detection of introductions and quick, coordinated responses can eradicate or contain invasive species at much lower cost than long-term control. In many cases, control may not only be prohibitively expensive but also infeasible. Thus detection of non-native arrivals, before they become established, should be a priority for any AIS management effort. The purpose of this section is to acknowledge the importance of continuing current monitoring programs and to identify gaps and areas for improvement. Significant improvements will clearly come from coordination at multiple levels in both planning and implementation. As such, some of the following actions aim to better link the many different natural resource and AIS monitoring programs conducted by diverse agencies and academic institutions to improve AIS detection. Actions also seek to better integrate Geographic Information System (GIS) mapping into AIS management, and to make state databases more compatible with, and responsive to, AIS management needs. Actions under Objective 3 should be coordinated with research efforts under Objective 7 and with priority lists developed under 1A6.

STRATEGY 3A: *EARLY DETECTION*

Develop a standardized monitoring system focused on early detection for high priority AIS.

ACTIONS

3A1. Assess all current monitoring of the state's coastal, marine and inland waters for opportunities to incorporate early detection of AIS.

(CAAIST, RI, CeNCOOS, SCCOOS) Year 1

Discussion: High priority AIS for early detection may include zebra mussel, quagga mussel, Northern Pacific seastar, snakehead, *Caulerpa*, *Hydrilla*, *Salvinia*, golden mussel and others. A more complete and up-to-date list for use in any assessment will be developed under Action 1A6.

3A2. Assess how current monitoring under the state's Marine Invasive Species Program could assist with early detection.

(SLC, DFG, RI) Ongoing

3A3. Develop a statewide integrated approach to early detection based on the assessment in 3A1 and 3A2. The approach should address any gaps and link directly with the centralized reporting system and rapid response program described in 4A2 and Appendix A.

(CAAIST, AISWG) Year 1

3A4. Conduct outreach to entities regularly sampling coastal, marine and inland waters for other purposes so they can easily identify and report high priority AIS.

(CAAIST, UCCE, Sea Grant) Year 2-3

Discussion: Those already conducting field work or surveys – researchers, graduate students, resource managers, water quality monitors, law enforcement personnel and others – should be encouraged and trained to identify high priority AIS (as defined under 1A6). Special identification materials for high priority AIS should be developed and distributed to support the early detection effort.

3A5. Create and train a statewide citizen monitoring network to assist in the detection and monitoring of AIS distribution.

(CAAIST, UCCE, SH) Year 3

Discussion: Trained volunteers and knowledgeable water users already working near or in the water can provide relevant information on the occurrence of new species. To be effective, this network will need a direct link into an early warning system that incorporates follow-up. Some elements necessary to the development of an effective citizen-monitoring network may include: a structured training program; expansion of current monitoring and restoration programs to better engage community groups; outreach to existing watershed councils, diver associations, flood control districts, reclamation districts and other monitoring efforts; distribution of key species pictures and descriptions (as defined under 1A6); and the creation of a website to allow volunteers and water users to report their AIS sightings (see 4A2).

3A6. Create a program to engage professional divers in the early detection network.

(CAAIST, AISWG, NGOs) Year 1

Discussion: Involve and educate professional divers – who are frequently in the water and under boats cleaning hulls – in AIS detection and management, among them the California Professional Divers Association. Link with 3A5 and with appropriate educational and outreach activities in Objective 6 (such as 6A9 and 6A13).

3A7. Regularly review the efficacy of the state’s AIS early detection monitoring systems and pursue any necessary improvements, in conjunction with 3B7.

(AISWG) Ongoing

Discussion: State AIS staff should review the type, intensity, frequency and distribution of monitoring activities on a regular basis to assess continued relevance and effectiveness. Such a review should occur at a minimum on a biennial basis.

STRATEGY 3B: LONG-TERM MONITORING

Improve and standardize the long term monitoring program for AIS.

3B1. Assess current long-term AIS monitoring efforts for the state’s coastal, marine and inland waters; identify gaps, and recommend improvements for a more integrated approach.

(AISWG, CeNCOOS, SCCOOS, DFG/OSPR) Year 2-3

Discussion: Within the current agency management framework, monitoring occurs, and will continue to occur, on two parallel tracks: DFA monitors specific target species in order to undertake early detection or eradication; DFG/OSPR monitors populations over time, and notes new populations or changes in species abundance. Both types of monitoring are critical to sound management and provide building blocks for a more integrated approach.

3B2. Coordinate with ocean observing groups.

(AISWG, CeNCOOS, SCCOOS) Ongoing

Discussion: Monitoring of invasives in the marine and coastal areas of California should be coordinated with the regional ocean observing systems (SCCOOS-Southern California Coastal Ocean Observing System and CeNCOOS-Central and Northern California Coastal Ocean Observing System).

3B3. Identify and monitor locations with a high invasion rate.

(AISWG, DFG/OSPR, RI) Ongoing

Discussion: High risk locations may include ports, ballast water release sites, popular recreational lakes and marinas near state borders, as well as areas with high density AIS populations.

3B4. Identify and monitor the population growth and dispersal of established AIS.

(AISWG, DFG/OSPR, RI) Ongoing

Discussion: Species-specific monitoring is needed for those species identified as high risk or high priority (see 1A6). Examples of established species that may require monitoring appear in Table 3 and Chapter 8.

3B5. Obtain funding to incorporate DFG's historical stream surveys and report findings into a central database.

(DFG) Year 1

Discussion: These historical surveys document areas where rare or native fish occur, and where incipient populations of AIS could cause extirpation of local fish populations. Funding has been obtained for new surveys of some streams in southern California in 2007.

3B6. Include maps of existing AIS in California's coastal and inland waters in the DFG Biogeographic Information and Observation System (BIOS).

(DFG, DFA) Year 2-5

Discussion: Mapping is an important step in determining the spatial distribution of AIS, and could help with the completion of other early detection and monitoring tasks. BIOS is available to the public and contains user-friendly, Internet-based maps.

3B7. Regularly review the efficacy of the state's AIS long-term detection and monitoring systems, and pursue any necessary improvements, in conjunction with 3A7.

(AISWG) Year 2-5

Discussion: Such a review such should occur at a minimum on a biennial basis.

OBJECTIVE 4: RAPID RESPONSE & ERADICATION

Establish and manage systems for rapid response and eradication.

Once AIS are established, complete eradication is often infeasible. Eradication or containment of pioneering populations is generally much more feasible, making rapid response a key AIS management strategy. Rapid response is facilitated by formal advance agreements between likely participants that address roles, responsibilities and procedures. As such, it requires a pre-planned collaborative effort on the part of government agencies, academic institutions and private interest groups.

STRATEGY 4A: RAPID RESPONSE

Implement a coordinated system for rapid response efforts to contain newly detected AIS.

ACTIONS

4A1. Develop and implement a statewide rapid response plan.

(DFG, AISWG) Year 1

Discussion: The Rapid Response Plan for AIS in California appears in Appendix A. This DRAFT plan was written in accordance with the federal guidelines for rapid response systems (USEPA 2005) and includes concepts presented in DFA's Model Rapid Response Plan for Aquatic Nuisance Species (see bibliography in Appendix A for references). It includes a proposed rapid response procedure that is based on formal interagency agreements. It also includes a planning section that discusses coordination among interested parties, issues that must be addressed to finalize the plan, funding and the need to develop interim rapid response protocols prior to plan completion.

4A2. Evaluate how existing systems for reporting AIS sightings or other natural resource problems (e.g. poaching, pollution discharge, birds infected with West Nile Virus) can either be used directly or as a blueprint for an AIS reporting system in California and coordinate systems as in 3A3.

(CAAIST, AISWG) Year 1

Discussion: Based on the results of this evaluation, utilize an existing system or develop a new system for the public to report AIS sightings. This reporting system needs to feed into the first steps of the rapid response procedure (Appendix A) which requires obtaining a definite identification of the species, determining whether it is a detrimental invasive species and notifying the appropriate authorities. Currently there are a number of options for submitting reports of possible aquatic invasive

species sightings, but focusing outreach efforts on one website/hotline destination may prove more efficient in the future. Current general reporting options include: 1) sending an e-mail to invasives@dfg.ca.gov; 2) submitting a form to the federal Nonindigenous Aquatic Species Program – <http://nas.er.usgs.gov> (click on Alert System); 3) calling their hotline – 1-877-STOP-ANS. The federal system passes information on to DFG and USFWS.

4A3. Develop species- and/or location-specific rapid response plans.

(AISWG) Ongoing

Discussion: A generic plan, described in Task 4A1, is necessary because it is not possible to write a plan for every species or location that may require rapid response to an AIS infestation. Species or location specific rapid response plans can include information that makes them more efficient to implement than a generic plan. The state needs to prioritize which species (using the list developed in 1A6) and locations warrant specific rapid response plans and develop these plans. Models already developed, such as the Non-Native Invasive Pest Intervention Team model (Anderson 2005) may be of value in creating such plans.

4A4. Explore the establishment and administration of permanent funding to implement rapid response plans, in conjunction with 1C4.

(AE, NGOs, SH) Year 2

Discussion: Washington, Massachusetts and other states have established emergency funds reserved for the containment/eradication of pioneering AIS infestations. California lacks emergency funding for immediate species identification and control actions. Without such funding, rapid response may not occur. The Ocean Protection Council's Strategic Plan identifies establishment of such a fund for coastal AIS as a high priority.

STRATEGY 4B: ERADICATION

Eradicate targeted populations of AIS.

4B1. Review and evaluate the effectiveness of eradication programs.

(AISWG) Year 2

Discussion: Eradication programs often compete for limited resources, and sometimes result in conflicts and trade offs among different public mandates. Regular evaluation and discussion among state agencies and the AISWG, with major conflicts brought to the attention of agency executives, will help streamline state eradication efforts. Findings and recommendations from research on the economic benefits and efficacy of

various management and prevention approaches developed under Actions 7B1-2 and 7C1-2 and 7C4 would be incorporated in the review.

4B2. Continue and complete effective current eradication efforts, in coordination with 4B1 and conduct follow-up monitoring to ensure eradication.

(AISWG) Ongoing

Discussion: As of fall 2006, recent or ongoing eradication programs within the state of California included, but were not limited to, *Hydrilla*, giant salvinia, smooth cordgrass, *Arundo*, alligatorweed, Japanese eelgrass and Northern pike. More information on some of these eradication efforts and species appears in Chapters 2, 4 and 8.

4B3. Standardize and apply sets of criteria that can be used to identify priority species for eradication under rapid response scenarios or more long-term efforts.

(CAAIST, RI, Science Advisory Panel) Year 1-2

Discussion: It would be helpful establish criteria to answer questions such as: Is it feasible and appropriate to attempt to eradicate a particular AIS infestation? Is it worthwhile to attempt a statewide eradication effort for a given species? These criteria would provide tools for DFA and DFG to reconcile their current screening strategies for AIS importation, help streamline decision making during the rapid response process and categorize AIS species into different management classes for planning purposes.

4B4. Develop and implement a method to identify priority sites of AIS invasion concern, in order to better prepare for rapid response and eradication.

(AISWG, Science Advisory Panel) Year 2

4B5. Identify ecologically sensitive waters as targets of additional precautionary protocols.

(AISWG, Science Advisory Panel) Year 2 and Ongoing

Discussion: To the extent possible, existing designations (e.g. National Estuarine Research Reserves, National Marine Sanctuaries, Marine Reserves, Critical Coastal Areas, etc.) should be used to compile locations and maps of ecologically sensitive waters. This action should also be coordinated with BIOS mapping efforts under 3B6.

OBJECTIVE 5: LONG-TERM CONTROL & MANAGEMENT

Control the spread of AIS and minimize their impacts on native habitats and species.

Long-term control and management activities should be focused on populations of established species where there is a clear and significant impact on economically important species, native species, human health, infrastructure, recreation and navigation, and where the control of specific populations is both technically and economically feasible. In many cases, past control efforts occurred as the result of a local management priority such as a weed clogging a favorite fishing spot, swimming hole or creek habitat, and the control measures undertaken by local groups and entities, sometimes with state support. State control programs tend to focus on larger scale impacts (water hyacinth in Delta waterways, for example), or AIS that threaten sensitive species, protected areas or water conveyance systems. As such, some control programs are coordinated among state, regional and local agencies, and some are not. The actions in this objective seek to prioritize control efforts; coordinate state control efforts with local and federal efforts; interface with appropriate researchers; provide technical assistance to local watershed groups, irrigation districts and others undertaking AIS management; and address AIS concerns in habitat restoration planning, landscape construction and maintenance projects.

STRATEGY 5A: CONTROL

Control known AIS populations where economically and technically feasible.

ACTIONS

5A1. Develop a method or criteria to prioritize control actions based on both the threat level and the anticipated efficacy of control actions.

(CAAIST, FA, RI) Year 2

Discussion: Criteria developed under 4B3 may be of some help in this endeavor.

5A2. Prioritize control efforts for all organisms, including new organisms of concern.

(CAAIST, FA, RI) Year 2

Discussion: With limited resources, prioritization of control efforts is a necessary part of addressing AIS issues throughout California. Statewide staff must coordinate priorities with local and regional staff and other agencies. A decision tree should be developed for determining whether to implement a control program, what types of control actions to use and how to accomplish the necessary permitting. Species could be placed in the

species management categories mentioned in Table 3, in coordination with lists developed under 1A6.

5A3. Continue ongoing control programs, following program review and in coordination with 5A1, 5A2 & 5A4.

(DFA, DFG, SCC, FA, RI) Ongoing

Discussion: Agencies can request that one of the AIS technical panels review an ongoing program and provide advice on what future actions should be. In addition, panels and agencies should take into consideration any findings from the Action 5A1 and 5A2 prioritization, the high-priority species lists developed under 1A6 and any findings and recommendations from research on efficacy of various management approaches developed under Objective 7.

5A4. Develop new species- and site-specific control plans as necessary for projects that are implemented by state agencies based on 5A1-3 above and on lessons learned from relevant projects inside and outside California. Coordinate with AISWG regarding plans being developed for entities other than state agencies.

(CAAIST, FA, RI) Year 2

5A5. Provide technical assistance to watershed councils, irrigation districts and other local boards for development of AIS management plans.

(AISWG, UCCE, CACASA, RCD) Year 3-5

STRATEGY 5B: *LIMIT DISPERSAL TO NEW AREAS*

Limit the dispersal of established AIS to new water bodies or to new areas within inland water bodies.

5B1. Establish boat washing stations and disposal facilities at infested water bodies.

(DFG, DBW, DFA, SH) Year 1

5B2. Install warning and information signs in infested areas at local kiosks, boat ramps and on floating buoys to limit the spread of existing AIS by boats, personal watercraft, movement of live fish and bait buckets.

(DBW, DFG, DPR, SH) Year 1

5B3. Use volunteer monitors to conduct AIS inspections at heavily used boat access areas.

(DFG, DBW, NGOs, SH, FA) Year 1

5B4. Develop criteria and a plan for enforcing the temporary or long-term closure of specific areas infested with high priority AIS, as defined in 1A6.

(DFA, DFG, DBW, SH) Year 2

STRATEGY 5C: PROTECT NATIVES

Protect areas of special ecological significance, and state and federally listed rare, threatened and endangered species, from AIS invasions.

5C1. Coordinate among appropriate state, federal and local government agencies, existing relevant coalitions such as the Weed Management Areas and private land management organizations, to prioritize ecologically sensitive areas most at risk due to AIS impacts.

(AISWG) Years 2-5

5C2. Coordinate the entities discussed in 5C1 to meet protection and restoration objectives with respect to AIS.

(AISWG) Years 3-5

5C3. Develop GIS-based maps that show coincidence of AIS and critical ecosystems.

(DFG, DFA, RI, DFG/OSPR) Years 3-5

Discussion: Mapping should be in coordination with other mapping actions under 3B6 and 4B5. These GIS layers will assist in setting priorities for eradication and control projects.

5C4. Establish and disseminate clear guidelines for action when AIS eradication or control efforts will take place in areas of special ecological significance.

(AISWG) Year 2

5C5. Adopt guidelines on best management practices for timber, crop production and livestock activities around water in order to prevent invasions.

(AISWG) Year 2

5C6. Assess any existing guidelines, and where necessary develop new guidelines, for preventing AIS spread through projects involving riparian, wetland and shallow water habitat restoration and/or shoreline landscaping.

(CAAIST) Year 1

Discussion: Newly cleared and created habitats can easily and immediately be colonized by opportunistic invasives. Measures are often necessary to prevent such invasions. Some work to gather existing guidelines for invasive plant species has been conducted by USFWS' Non-Native Invasive Species Program on behalf of the California Interagency Noxious and Invasive Plant Committee (L. McLaughlin, Personal Communication).

OBJECTIVE 6: EDUCATION & OUTREACH

Develop a comprehensive education and outreach program to ensure awareness of AIS threats and management priorities throughout California.

Most people do not recognize the threat that aquatic invasive species pose and how their own actions may lead to new infestations. The strategies and actions listed below are some of the elements that should be included in a comprehensive AIS education and outreach program. For many of these strategies and associated tasks, similar efforts are being undertaken in other states and on an international level. California should link with these existing efforts and use tools and methods proven effective elsewhere. Many outreach efforts and materials are developed outside of state or federal agencies, particularly by University of California and Sea Grant extension programs. Agencies should utilize the expertise and products available as much as possible. These programs should, in turn, seek agency input in product development. In addition to the many general outreach actions described below, several targeted outreach actions are listed under other objectives in this plan (2C6, 2D2-3, 2D5-6, 2D9, 2D12, 2G2-3, 2G5-6, 2H2, 3A4-6, 5B2, 5C1 and 5C5-6).

STRATEGY 6A: OUTREACH

Increase education of, and outreach to, those who may be potential sources for AIS introductions.

ACTIONS

6A1. Inventory existing education and outreach efforts in order to prioritize future strategies and develop a statewide AIS communication strategy.

(CAAIST, UCCE, Sea Grant) Year 2

Discussion: A dedicated effort is needed to inventory diverse existing education and outreach programs so that gaps and overlaps can be addressed and priorities for new programs identified. This effort should be closely coordinated with activities under Objective 2: Prevention.

6A2. Partner with ongoing outreach campaigns.

(CAAIST, UCCE, Sea Grant) Year 1

Discussion: National campaigns now underway include *Habitattitude* (pet industry and pet owner outreach) and *Stop Aquatic Hitchhikers* (boating and recreational outreach). Other state and NGO programs have established AIS outreach efforts and campaigns within California or in specific regions. Future partners for state education efforts may include industry groups, UCCE, Sea Grant and NGO programs. See Appendix D.

6A3. Develop a DFG Communications Plan.

(DFG) Year 2

Discussion: Currently, DFG staff develops brochures, posters, articles and press releases in an ad hoc manner. A communications plan will provide stakeholders and the general public with ongoing coordinated exposure to AIS issues.

6A4. Develop and distribute printed material (posters, brochures and articles) for specific industry sectors and user groups.

(AISWG, UCCE, Sea Grant) Year 1-5

Discussion: Target audiences may include the owners and employees of pet and aquarium stores, nurseries; wholesalers and shippers dealing in aquarium organisms; operators of water-based businesses (such as boat charter operators, marinas, angling guides, fishing tournament organizers, harbor masters, dive shops, seaplane operators, and dredging contractors).

6A5. Develop permanent interpretive displays at appropriate marinas, boat ramps and state fishing access sites.

(AISWG, SH) Year 2-5

Discussion: Educational signage should also be developed for important stream/river crossings on major recreational trails. Non-aquatic outdoor sports that involve aquatic crossings (equestrian trails, hiking and bicycle trails, 4-wheel drive dirt roads) can be targeted through information posted at trailheads and other high use areas.

6A6. Work directly with promoters of industry trade shows to deliver the AIS message.

(DFG, DFA, DBW, SLC, Sea Grant, RI, SH) Ongoing

Discussion: Some initial work done by DFG, DFA, DBW, SLC, Sea Grant, UCCE, and other organizations, can contribute to a comprehensive outreach program.

6A7. Present and distribute AIS information at various conferences, tournaments, fairs and other public gatherings.

(AISWG, Sea Grant, SH) Ongoing

Discussion: The ongoing efforts should reach as many venues as possible and avoid duplication.

6A8. Continue to include information on AIS in state hunting, fishing and boating regulations and licenses.

(DFG, DBW) Ongoing

6A9. Publish information about AIS in fishing and recreational newspapers, magazines, and newsletters.

(DFG, DBW, UCCE, Sea Grant, NGOs) Year 2-5

6A10. Develop AIS identification cards to be distributed to all appropriate audiences.

(AISWG, SH, Sea Grant) Ongoing

6A11. Encourage industries to offer noninvasive alternatives to AIS whenever possible and to educate their consumers about the availability of such alternatives.

(AISWG, SH) Year 3-5

Discussion: To aid with this effort, develop “California-friendly” or “green species” lists for specific user groups and industries.

6A12. Partner with diverse stakeholders and interest groups to multiply education efforts and distribute some of the materials developed in 6A4-6A10.

(AISWG, SH) Ongoing

Discussion: Work can be done, for example, with aquarium, water garden and other target industries to educate consumers, retailers and wholesalers of the importance of preventing the release of unwanted organisms into aquatic systems.

6A13. Educate waterfront and shoreline property owners, including those on lakes, rivers and streams, about AIS.

(DBW, SCC, NGOs, SH) Year 3-5

6A14. Develop and offer AIS management classes for professional organizations.

(AISWG, UCCE, SH) Year 4

Discussion: Training programs are needed for professionals such as pest control applicators, diving instructors, water/irrigation engineers and habitat restoration planners.

- 6A15. Continue state education measures concerning ballast water.**
(SLC, Sea Grant) Ongoing

STRATEGY 6B: POLICYMAKERS

Engage policymakers and legislative staff in AIS policy and outreach efforts.

- 6B1. Provide decision makers and legislators with educational briefings on AIS threats and economic impacts, site visits showcasing impacts and controls and regular updates on AIS management progress.**

(CAAIST, FA, RI, NGOs, SH) Years 1-3

- 6B2. Periodically update the Fish and Game Commission, SLC, OPC, SCC and CCC on invasive species activities.**

(DFG, CAAIST) Years 1-5

STRATEGY 6C: RESOURCE MANAGERS & RESEARCHERS

Increase AIS awareness and support for management within the scientific community and natural resource agency staff.

- 6C1. Increase awareness of AIS among scientific and natural resource management interests.**

(RI, CAAIST, FA, NGOs, SH) Ongoing

Discussion: This effort should promote greater awareness and information-sharing among those working in the field and in resource management projects that may be impacted by AIS. Possible avenues for this networking include: supporting symposia, workshops and conferences (highlighting new findings and activities discussed at local, national and international conferences); developing a centralized AIS communication forum for California (such as a species-specific list serve); and engaging managers and scientists in identifying, monitoring and reporting AIS as described in 3A4. Classes in AIS management (such as those offered by UCCE and Sea Grant) should be offered through public agency training programs, and held in locations resource managers can easily attend, or be offered on-line or in video.

- 6C2. Work with institutions and agencies conducting scientific research to ensure awareness of proper AIS containment and disposal methods, as well as legal restrictions.**

(DFA, DFG, RI) Year 2

Discussion: Such an effort may be coordinated with the interests listed under 3A4.

6C3. Develop an AIS regulatory handbook.

(CAAIST, FA) Year 3

Discussion: The handbook should explain laws, regulations and permitting processes aimed at people that plan or practice various AIS control measures.

6C4. Share and disseminate information on current mechanical, chemical, biological and physical control methods.

(AISWG, SH) Ongoing

6C5. Disseminate guidelines developed in 5C4-6 and promote the use of native plants and/or non-invasive species in restoration, shoreline landscaping, and for timber, agricultural, or livestock activities around waterways.

(CAAIST, UCCE, Sea Grant) Year 2

Discussion: California-friendly species lists developed under 6A11 can be used.

6C6. Encourage the training of more taxonomists.

(AISWG, NGOs, SH, RI) Year 3

Discussion: A lack of professionally trained taxonomists is becoming a bottleneck in early detection efforts. Universities and colleges have significantly cut taxonomist positions and classes in recent years. AISWG and stakeholder groups, with a vested interest in protection from AIS, should address this problem and seek funding for training.

STRATEGY 6D: SCHOOLS

Increase AIS awareness within the educational system.

6D1. Train speakers to give guest presentations on AIS issues at schools, and develop resource packets for them to use when visiting classrooms, in coordination with 6E5.

(AISWG, NGOs, SH) Year 2-5

6D2. Assess existing K-12 environmental education curricula for opportunities to integrate AIS information, and develop new curricula as necessary.

(UCCE, Sea Grant, DOE) Year 3-5

Discussion: AIS related curricula should be integrated into in-service training and continuing education programs for teachers. California may be able to build on existing curricula, and other school and educational materials, developed through Sea Grant programs in other states.

6D3. Further integrate AIS issues into service and education projects that involve students as part of a science class, science club or for community service credit offered at some schools.

(UCCE, Sea Grant, DOE) Year 3-5

6D4. Educate teachers about proper disposal methods for organisms used in the classroom and at science fairs to prevent release or transfer of AIS.

(UCCE, Sea Grant, DOE) Year 2

Discussion: ANSTF protocols for science fairs can be adapted to in-classroom disposals and other education activities.

STRATEGY 6E: GENERAL PUBLIC

Raise awareness, concern and achieve buy-in on AIS issues by all California residents and visitors.

6E1. Develop a press kit and work with the media to ensure the accuracy of any information published.

(DFA, DFG) Year 1

6E2. Increase local television, radio and newspaper media coverage of California's AIS threats and management priorities using the press kit described in 6E1 and other outreach techniques.

(CAAIST, UCCE, Sea Grant, NGOs, RI) Year1

6E3. Identify key state publications and websites to which AIS information can be added.

(CAAIST, UCCE, Sea Grant, NGOs, RI) Ongoing

Discussion: Ensure website links are established so that public information on AIS is easy to find and gets wide exposure. Coordinate with efforts under 1A9.

6E4. Develop multi-cultural educational materials on AIS that can engage California's diverse population.

(UCCE, Sea Grant, AISWG) Year 2-5

6E5. Develop a variety of presentations, including AIS traveling trunks and portable presentation boards, for use in both public and private venues, and train presenters.

(UCCE, Sea Grant, AISWG) Year 1

Discussion: Venues might include state parks, schools, libraries, natural history museums, aquariums, coastal access points and other recreational facilities.

OBJECTIVE 7: RESEARCH

Increase research on the baseline biology of AIS, the ecological and economic impacts of invasions, and options for control to improve management.

Increased knowledge of the biology of invasive species and associated control methods will improve AIS management. The state would benefit from the development of a comprehensive research agenda that sets priorities and guides researchers towards important topics. Such important topics include: quantifying and clarifying the effects of non-native species on native plants and animals and their habitats; examining economic effects of AIS; pinpointing any human health and safety concerns resulting from infestations; and exploring improved methods of restoring invaded habitats to their native condition, during and after the effective management of AIS. Partnerships with universities, research institutes, consulting firms and others conducting such research are necessary so that agencies can develop their management programs with scientific input. In addition, given the plethora of organizations involved in AIS issues in California, it is important that any available research funds are allocated competitively, based on a research group's specialized ability. Actions under Objective 7 should be coordinated with monitoring efforts under Objective 3.

STRATEGY 7A: BASELINE BIOLOGY

Increase our knowledge about AIS in order to develop effective prevention, control and management programs.

Discussion: Management must be based on solid scientific information on AIS population dynamics, reproductive biology and ecological conditions fostering growth. Many of these factors are not yet fully understood for both the AIS that are already in California and the AIS that are at high risk of being introduced in the foreseeable future.

ACTIONS

7A1. Host workshops to develop AIS research priorities and identify research gaps.

(RI, AISWG) Ongoing

Discussion: In 2005, two research priority workshops were held, one that addressed freshwater invasive plants and another that looked at invasive seaweed research needs.

7A2. Baseline biological studies on AIS and biological invasions should continue in coordination with 7A1 and 7C4.

(RI, AISWG) Ongoing

7A3. Develop a strategy to communicate and support research needs.

(AISWG, RI) Year 3

Discussion: Research needs could be communicated to the scientific community and institutions that support research in several ways: through networking among existing or new interagency committees, through a new research center that deals specifically with AIS or, through an existing center with an AIS component or emphasis.

STRATEGY 7B: ECONOMICS

Increase knowledge of economic impacts of AIS.

7B1. Perform economic impact studies on the effects of AIS on California, including costs and benefits of vector prevention.

(CAAIST, RI) Year 1

Discussion: A small number of studies around the world have begun to document the economic impacts of AIS but California-specific studies are needed. In many cases, economic impacts will be the driving force for change in personal and business actions, management and policy. Prevention is often more cost-effective than control when addressing AIS concerns. Economic analysis can help determine priorities for use of limited funds. Results of these studies should be communicated to those responsible for 4B1-2, and 5A1-3, and 6A1.

7B2. Conduct an economic assessment of different AIS management techniques, in support of Strategy 7C.

(RI, AISWG) Year 2

STRATEGY 7C: MANAGEMENT OPTIONS

Research current and potential management alternatives and determine their efficacy in controlling invasions and their effects on native species.

7C1. Evaluate and research current AIS management methods to improve their efficacy, safety and efficiency.

(AISWG, RI) Ongoing

Discussion: This should include a review of public health and environmental risks associated with various management options so that decision makers can take those constraints into account and be better prepared to answer inquiries about any risks. Results of these studies should be communicated to those responsible for Actions 4B1-2, and 5A1-3, and 6A1.

7C2. Investigate the efficacy of invasion prevention techniques.

(AISWG, RI) Year 2

Discussion: Different prevention techniques need to be investigated in terms of their efficacy in achieving the goals of this plan. For example, antifouling techniques available for larger ships are often inappropriate for smaller recreational boats and boats that travel different routes. Anti-fouling techniques need to be examined, compared and tested, as one method is unlikely to work in all instances. Results of these studies should be communicated to those responsible for developing prevention programs under Objective 2.

7C3. Consider the establishment of a testing and evaluation center for shipboard ballast water treatment technology.

(SLC) Year 1 and Ongoing

Discussion: The existing state program does not have the expertise, equipment, facilities or financial resources necessary for the testing and certification of treatment technologies for discharged ballast water. A new center would substantially improve the implementation of performance standards and the ongoing evaluation of technologies once approved. USCG and Naval Research Labs have recently established a testing and evaluation center in Key West, Florida; however, this single facility will only be able to consider three or four systems annually, once testing and verification protocols are established. Discussions between SLC staff and USCG have identified the need for additional testing and evaluation centers. Complementary California and Key West facilities could subject technologies to an array of environmental conditions that may be more reflective of the range of conditions vessels encounter during the course of international trade. The budget to establish such a facility, including capital start-up cost, personnel, operating expenses and equipment is estimated at approximately \$10 million over three years.

7C4. Identify and communicate opportunities for interagency funding of research necessary for improved management.

(AISWG) Year 3

Discussion: Consider developing a grant program administered by managers that pools money on an annual basis to do directed research studies.

OBJECTIVE 8: LAWS & REGULATIONS

Ensure state laws and regulations promote the prevention and management of AIS introductions.

Currently, California has numerous laws, regulations and policies that pertain to the introduction, distribution, importation, transportation, possession, propagation, planting, sale and release of non-native plants and animals. These authorities are spread over several agencies. This objective aims to review regulations for gaps and overlaps, and explore the need for new AIS laws and regulations. This section will likely be expanded in the next version of the plan to include specific legislative and regulatory actions, as well as new policy directions.

STRATEGY 8A: LAWS & REGULATIONS

Review the laws and regulations governing AIS in California for gaps and overlaps, compare them to other state and federal AIS laws, and recommend changes to improve our ability to protect California's waters from the introduction and spread of AIS.

ACTIONS

8A1. Establish a regulatory review committee.

(CAAIST, FA, RI, SH) Year 2

Discussion: This committee, to be comprised of representatives from agencies and non-governmental organizations, among others, will emphasize working in a coordinated fashion with existing state, federal and international programs. The committee will invite input from all groups affected by any proposed vector control measures and undertake step 8A2.

8A2. Identify the potential for improved regulatory coordination among state agencies.

(CAAIST) Ongoing

Discussion: The regulatory review committee will also coordinate this effort with tasks under Objective 1.

8A3. Pursue the authority to establish an interagency California AIS rapid response program, as detailed in Strategy 4A.

(AE, SH) Year 1

8A4. Explore the need for new legislation to address gaps in the state's authority to manage AIS and to strengthen California's AIS-related statutes.

(CAAIST, AISWG) Ongoing

Discussion: Legislation may be needed to address the results of the vector assessments and resulting management recommendations, developed under Objective 2.

8A5. Perform an interagency review to assess the current system for regulating plant and animal importations and the necessity of further restrictions.

(DFA, DFG, FA, AISWG) Year 1 and Ongoing

8A6. Explore the need for new or modified regulations to address gaps in the state's authority to manage AIS and to strengthen California's AIS-related statutes, taking into account any findings of Action 8A6.

(CAAIST, AISWG) Ongoing

8A7. Based on findings from Action 8A7, develop new regulations and pursue adoption.

(AE, DFA, DFG) Ongoing

7. PRIORITIES, IMPLEMENTATION & PLAN EVALUATION

Priorities

During the development of this plan, the state agencies with primary AIS responsibilities discussed their priorities for AIS management. They considered the more than 80 actions identified (out of 163 total) that were identified as high priorities by various attendees at the three 2006 public meetings (see Appendix E). The priorities of agencies and public meeting attendees overlapped.

In December 2006, representatives of these agencies met to determine which actions should be implemented during state fiscal years 2007-2008 and 2008-2009 (i.e. July 2007 through June 2009) and which entities should have primary responsibility for each of the actions. The results of that meeting are shown in the CAISMP Implementation Matrix (Table 5). At that meeting it was also decided to develop a separate table showing the amount of funds expended on actions during fiscal years 2005-2006 and 2006-2007. This information is shown in Table 6. Both tables are included at the end of this chapter. DFG's effort to collect expenditure information for ongoing projects met with limited success, and therefore, Table 6 is not complete. It is, however, a start at tracking this information in a comprehensive manner. A more thorough table will be developed in future years to assist with assessment and planning.

In more general terms, the highest priorities of this plan are as follows:

1. Formalize the creation of two major new coordinating entities, one entirely for state agencies and one for a broader range of AIS interests (Action 1A2 and 1A3).
2. Formalize a process for the team of state AIS managers to share information with, and get input from agency executives (Action 1A1).
3. Secure funding for state AIS staff (Action 1C3).
4. Conduct a statewide assessment of the risk from four specific AIS vectors: commercial fishing, recreational boating, live bait, and live imported seafood (Actions 2B7, 2C1, 2D1, and 2D4).
5. Fund and launch early detection and rapid response actions, including efforts to coordinate various AIS monitoring programs and expand monitoring of freshwater systems (Strategies 3A and 4A, and Appendix A).

If these core actions can be accomplished, it will provide a basis for pursuing the larger list of AIS management priorities in the future.

Plan Evaluation

To evaluate the effectiveness of the plan, formal evaluation will be conducted on a regular basis. Systematic monitoring and evaluation of the progress made toward implementation of actions and their effectiveness will be undertaken by the agencies designated as leads on the implementation table. Updates will be compiled by DFG on an annual basis.

In addition to an evaluation of efforts and implementation, the objectives, strategies and actions will also come under regular review, as this plan is intended to adapt to changing circumstances. It is envisioned that this evaluation will be conducted by a Plan Implementation Panel under the direction of the CAAIST. Evaluations will be conducted following years one, two and five; and on an “as needed” basis after that. Before updating the plan and Implementation Matrix, performance based criteria will be established to determine if the agencies and entities included are appropriate.

Table 5
California Aquatic Invasive Species Management Plan
IMPLEMENTATION TABLE
(see Chapter 6 for complete descriptions of actions)

Explanation of Terms

- 1) Implementing Entity: Since this is a state plan, these are state agencies, entities within state agencies, or groups that include state agencies that fund and have primary accountability and authority for an action being carried out.
- 2) Cooperating Organizations: Entities whose participation is needed or may be needed to conduct an action.
- 3) Non-governmental Organizations (NGOs): Non-profit organizations directly involved in AIS research or control activities.
- 4) Stakeholders: Relevant recreation, industry, local government, landowner representatives and special interest groups.
- 5) Plan Implementation and Science Advisory Panels: Panels created per Action 1A5 to help the work of the CAAIST and AISWG.

Acronyms

AISWG	Aquatic Invasive Species Working Group (see Action 1A2)
BOE	Board of Equalization
CAAIST	California Agencies Aquatic Invasive Species Team (see Action 1A3)
CACASA	California Agricultural Commissioners and Sealers Association
CAISMP	California Aquatic Invasive Species Management Plan
CALFED	CALFED Bay-Delta Program
CeNCOOS	Central and Northern California Ocean Observing System
DBW	California Department of Boating and Waterways
DFA	California Department of Food and Agriculture
DFG	California Department of Fish and Game
/OSPR	/Office of Spill Prevention and Response
DOE	California Department of Education
DPR	California Department of Parks and Recreation
DWR	California Department of Water Resources
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCCOOS	Southern California Coastal Ocean Observing System
Sea Grant	California Sea Grant College Program
SLC	California State Lands Commission
SWRCB	State Water Resources Control Board
UCCE	University of California Cooperative Extension
WCB	Wildlife Conservation Board

Other Abbreviations

AE	Agency Executives (Upper management of state agencies and departments)
SH	Stakeholders
FA	Federal Agencies
FY	State fiscal year (July 1 through June 30)
RI	Research Institutions (e.g. Public and private universities, government research organizations, etc)

Implementation Year



Starts Year 1 (FY 2007/2008)

Ongoing (started during or before FY 2006/2007)

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 1. COORDINATION AND COLLABORATION								
Improve coordination and collaboration among the people, agencies and activities involved with AIS.								
INTERNAL STATE COORDINATION								
1A1	Develop an executive level consultation process.		AE	CAAIST, RI, NGOs, SH				
1A2	Formalize the California Agencies AIS Team (CAAIST).		AE					
1A3	Establish, fund and staff an Aquatic Invasive Species Working Group (AISWG).		AE	CAAIST, RI, NGOs, SH				
1A4	Evaluate the need for an invasive species center.		AE	NGOs, RI, SH, CAAIST				
1A5	Form and fund technical advisory panels.		CAAIST, AISWG					
1A6	Draft and update a list of AIS at high risk for introduction.		CAAIST	FA, RI, Sea Grant, UCCE, NGOs, SH				
1A7	Identify lead state agency for particular AIS, water bodies and invasion vectors.		AE	CAAIST				
1A8	Identify agency personnel required for AIS management.		AE	CAAIST				
1A9	Improve state websites related to AIS.		CAAIST					
1A10	Assess effectiveness of and gaps in state AIS programs.		AISWG	Plan Imp. Panel				
1A11	Coordinate AIS management with SWRCB & RWQCBs.		CAAIST	SWRCB, RWQCBs				
1A12	Develop and update AIS expert list.		CAAIST	Science Advisory Panel				
1A13	Develop boilerplate AIS language for official agency review.		CAAIST					

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 1. COORDINATION AND COLLABORATION (continued)								
LOCAL, NATIONAL AND INTERNATIONAL COORDINATION								
1B1	Identify AIS reps in government agencies and NGOs.		CAAIST	RI, FA, NGOs, SH				
1B2	Identify conflicts and overlaps among government and NGO AIS programs.		CAAIST	RI, FA, NGOs, SH				
1B3	Invite community groups for AIS planning and education.		AISWG					
1B4	Expand participation in local AIS efforts and task forces.		AISWG	SH				
1B5	Expand participation in regional, national and international AIS task forces.		AE, CAAIST, RI					
1B6	Partner with Mexico, Canada, Pacific Coast and Colorado River states.		AE, RI	AISWG				
1B7	Participate in national and international conferences.		AE, CAAIST, RI					
FUNDING								
1C1	Identify and apply for state and national grant funding.		CAAIST, RI, NGOs					
1C2	Establish stable, long-term funding to help implement this plan.		AE	CAAIST				
1C3	Provide state funding for AIS positions.		AE	CAAIST				
1C4	Provide state funding for rapid response actions.		AE					
1C5	Hire a funding development specialist.		AE	CAAIST				
1C6	Provide new funding mechanisms.		AISWG					

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 2. PREVENTION								
Minimize the introduction and spread of AIS into and throughout California waters.								
REGIONAL VECTOR ASSESSMENT								
2A1	Rank AIS vector importance in different regions of California.		RI	DFG				
COMMERCIAL VESSELS & MARITIME ACTIVITIES								
2B1	Quantify ballast water and hull fouling vectors and assess invasion risk.		SLC	RI	2,013*	2,593*		
2B2	Continue and improve state ballast water inspection and enforcement program.		SLC					
2B3	Implement discharge standards for treated ballast water.		SLC					
2B4	Identify and address gaps in the Marine Invasive Species Act.		AISWG	SLC, DFG				
2B5	Develop a commercial vessel fouling outreach and management program.		SLC	Sea Grant				
2B6	Investigate how moving maritime structures can contribute to AIS dispersal.		DFG, SLC	RI, FA				
2B7	Quantify and assess the role of commercial fishing vessels as AIS vectors.		DFG	RI, NGOs, SH, FA		100		100
2B8	Develop a commercial fishing outreach and management program.		DFG	AISWG, FA				
*SLC contracts with BOE to collect the Fee from qualifying voyages. The numbers above do NOT include BOE's budget.								
RECREATION								
2C1	Quantify and assess recreational boating as an AIS vector.		DBW, DFG	RI, SH		150		150
2C2	Develop a recreational boating outreach and management program.		DBW	UCCE, Sea Grant				
2C3	Develop a watercraft inspection program for high priority boat launch sites.		DBW, DFG, DPR	SH				

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 2. PREVENTION (continued)								
2C4	Quantify and assess recreational fishing as an AIS vector.		DFG, DBW	RI, SH				
2C5	Develop a recreational fishing outreach and management program.		DFG	UCCE, Sea Grant				
2C6	Develop guidelines for: disposal of invasive species, cleaning of gear and equipment, disposal of bait.		DFG, DBW	Sea Grant				
BAIT, LIVE SEAFOOD, AQUACULTURE & AQUARIUM								
2D1	Quantify and assess bait as an AIS vector.		DFG	RI		125		125
2D2	Work with the bait industry to develop prevention strategies.		DFG	UCCE, SH				
2D3	Develop a bait outreach and management program.		DFG	UCCE, SH				
2D4	Quantify and assess imported live seafood as an AIS vector		DFG, DFA			125		125
2D5	Work with live seafood industry to develop preventative strategies.		DFG, DFA	UCCE, Sea Grant				
2D6	Develop an imported live seafood outreach and management program.		DFG, DFA	UCCE, Sea Grant				
2D7	Assess risks posed by water handling systems.		SWRCB, DFG	RI, SH				
2D8	Educate aquaculture industry on containment systems.		DFG	SH, UCCE				
2D9	Develop an aquaculture outreach and management program.		DFG	UCCE				
2D10	Quantify and assess how aquarium and aquascaping trades contribute to AIS introductions.		DFG, DFA	RI		125		125
2D11	Work with aquarium, water gardens and other industries on accessible disposal.		DFG, DFA	UCCE, FA		20		20

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 2. PREVENTION (continued)								
2D12	Implement an aquarium and aquascaping outreach and management program.		DFG, DFA	UCCE, FA				
FISHERIES ENHANCEMENT								
2E1	Quantify and assess fisheries enhancement as an AIS vector.		DFG	RI		50		50
2E2	Review DFG practice of intentional introduction of non-native species for recreational purposes.		DFG	RI				
2E3	Reduce unauthorized stocking of non-natives species.		DFG					
2E4	Weigh benefits of mosquitofish introduction.		DFG	RI				
RESEARCH, MANAGEMENT & EDUCATION								
2F1	Quantify and assess research, resource management and educational activities as AIS vectors.		AISWG			125		125
2F2	Establish protocols to minimize spread of AIS by these activities.		DFG, AISWG	RI				
2F3	Evaluate regulations and protocols for in-water research.		DFG	SWRCB, RI				
2F4	Quantify and assess live aquatic species shipments for research as an AIS vector.		DFG	RI				
CONSTRUCTION & RESTORATION								
2G1	Quantify and assess construction activities as an AIS vector.		DFG	RI				
2G2	Work with industry to develop equipment decontamination guidelines.		DFG, SLC, DPR, FA	RI				
2G3	Develop a construction outreach and management program.		DFG, SLC, DPR, FA	UCCE				
2G4	Quantify and assess restoration activities as an AIS vector.		AISWG	RI				

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 2. PREVENTION (continued)								
2G5	Encourage the use of native species.		DFG, SCC	AISWG				
2G6	Develop a restoration outreach program.		AISWG	UCCE				
WATER DELIVERY & DIVERSION SYSTEM								
2H1	Quantify and assess the water delivery and diversion system as an AIS vector.		DWR					
2H2	Develop an outreach and management program for the system.		DWR	UCCE, Sea Grant				
ENFORCEMENT & INSPECTION								
2I1	Increase staffing and hours at DFA Border Protection Stations.		DFA	SH				
2I2	Develop guidelines for border inspections.		DFA, DFG			1		
2I3	Increase DFG enforcement of current regulations on prohibited and restricted species.		DFG	SH				
2I4	Ensure adequate staffing and cargo inspection guidelines for port and airport enforcement.		FA	AISWG, SLC				
2I5	Continue disease sampling for shipments and stocks of live aquatic species.		DFG					
2I6	Identify mail order, online vendors selling CA prohibited and restricted species.		AISWG	RI				
OBJECTIVE 3. EARLY DETECTION & MONITORING								
Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.								
EARLY DETECTION								
3A1	Assess current monitoring of state waters for early detection opportunities.		CAAIST	RI, CeNCOOS, SCCOOS		100		100

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 3. EARLY DETECTION & MONITORING (continued)								
3A2	Assess how the state's Marine Invasive Species Program monitoring can aid early detection.		SLC	DFG, RI				
3A3	Develop a statewide approach to early detection.		CAAIST	AISWG		100		100
3A4	Outreach to those regularly sampling state waters.		CAAIST	UCCE, Sea Grant				
3A5	Create and train a statewide citizen monitoring network.		CAAIST	UCCE, SH				
3A6	Engage professional divers in the early detection network.		CAAIST	AISWG, NGOs		100		100
3A7	Review efficacy of the state's AIS early detection systems.		AISWG					
LONG-TERM MONITORING								
3B1	Assess long-term AIS monitoring of state waters.		AISWG	CeNCOOS, SCCOOS, DFG/OSPR				
3B2	Coordinate with ocean observing groups.		AISWG	CeNCOOS, SCCOOS				
3B3	Monitor locations with a high invasion rate.		AISWG	DFG/OSPR, RI				
3B4	Monitor the population growth and dispersal of established AIS.		AISWG	DFG/OSPR, RI				
3B5	Fund the incorporation of DFG's historical stream surveys and report findings into a central database.		DFG					
3B6	Include maps of existing AIS in California waters in DFG BIOS system.		DFG	DFA				
3B7	Review the efficacy of long-term monitoring systems.		AISWG					

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 4. RAPID RESPONSE & ERADICATION								
Establish systems for rapid response and eradication.								
RAPID RESPONSE								
4A1	Develop and implement a statewide rapid response plan.		DFG	AISWG				100
4A2	Evaluate and coordinate existing systems for reporting AIS sightings.		CAAIST	AISWG				10
4A3	Develop species- and/or location-specific rapid response plans.		AISWG					
4A4	Explore permanent funding to implement rapid response.		AE	NGOs, SH				
ERADICATION								
4B1	Review effectiveness of eradication programs.		AISWG					
4B2	Continue and complete current eradication efforts.		AISWG					
4B3	Standardize criteria for identifying priority species for eradication.		CAAIST	RI, Science Advisory Panel				
4B4	Develop a method to prioritize sites of AIS invasion concern.		AISWG	Science Advisory Panel				
4B5	Identify ecologically sensitive waters requiring additional precautions.		AISWG	Science Advisory Panel				
OBJECTIVE 5. LONG-TERM CONTROL & MANAGEMENT								
Control the spread of invasives and minimize their impacts on native habitats and listed species.								
CONTROL								
5A1	Develop a method or criteria to prioritize control actions.		CAAIST, FA	RI				
5A2	Prioritize control efforts for existing and new organisms of concern.		CAAIST, FA	RI				

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 5. LONG-TERM CONTROL & MANAGEMENT (continued)								
5A3	Continue ongoing control programs.		DFA, DFG, SCC, FA	RI				
5A4	Develop species- and site-specific control plans.		CAAIST, FA	RI				
5A5	Provide technical assistance to watershed councils, irrigation districts and other groups.		AISWG	UCCE, CACASA, RCD				
LIMIT DISPERSAL TO NEW AREAS								
5B1	Establish boat washing stations and disposal facilities at infested waters.		DFG, DBW, DFA	SH				
5B2	Install AIS warning and information signs in infested areas.		DBW, DFG, DPR	SH				
5B3	Use volunteer monitors to conduct AIS inspections.		DFG, DBW	NGOs, SH, FA				
5B4	Develop criteria for enforcing closure of infested areas.		DFA, DFG, DBW	SH				
PROTECT NATIVES								
5C1	Prioritize ecologically sensitive areas at risk of AIS impacts.		AISWG					
5C2	Coordinate entities to meet AIS protection and restoration objectives.		AISWG					
5C3	Develop GIS maps showing coincidence of AIS and critical ecosystems.		DFG, DFA	DFG/OSPR, RI				
5C4	Establish guidelines for when AIS eradication or control will occur in sensitive areas.		AISWG					
5C5	Adopt guidelines on best practices for timber and agricultural activities.		AISWG					
5C6	Assess guidelines for preventing AIS spread in habitat restoration and shoreline landscaping projects.		CAAIST			10		10

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 6. EDUCATION & OUTREACH								
Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.								
OUTREACH								
6A1	Inventory education and outreach efforts and develop a state AIS communication strategy.		CAAIST	UCCE, Sea Grant				
6A2	Partner with ongoing outreach campaigns.		CAAIST	UCCE, Sea Grant				
6A3	Develop a DFG Communications Plan.		DFG					
6A4	Develop posters, brochures and articles for industry sectors and user groups.		AISWG	UCCE, Sea Grant				
6A5	Develop permanent interpretive displays at marinas, boat ramps and fishing sites.		AISWG	SH				
6A6	Work directly with industry trade shows to deliver the AIS message.		DFG, DFA, DBW, SLC	Sea Grant, RI, SH				
6A7	Present AIS information at public gatherings.		AISWG	Sea Grant, SH				
6A8	Include AIS information in state hunting, fishing and boating regulations and licenses.		DFG, DBW					
6A9	Include AIS information in local fishing and recreational publications.		DFG, DBW, UCCE, Sea Grant, NGOs					
6A10	Develop and distribute AIS identification cards.		AISWG	SH, Sea Grant				
6A11	Encourage industries to offer noninvasive alternatives to AIS.		AISWG	SH				
6A12	Partner with stakeholders and interest groups to broaden education efforts.		AISWG	SH				
6A13	Educate waterfront and shoreline property owners about AIS.		DBW, SCC	NGOs, SH				

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 6. EDUCATION & OUTREACH (continued)								
6A14	Develop and offer AIS management classes for professional organizations.		AISWG	UCCE, SH				
6A15	Continue state education measures concerning ballast water.		SLC	Sea Grant				
POLICYMAKERS								
6B1	Brief decision makers and legislators on AIS management progress.		CAAIST, FA	RI, NGOs, SH				
6B2	Brief the Fish and Game Commission, SLC, OPC, SCC and CCC.		DFG	CAAIST				
RESOURCE MANAGERS & RESEARCHERS								
6C1	Increase AIS awareness among scientific and natural resource managers.		RI	CAAIST, FA, NGOs, SH				
6C2	Educate researchers on AIS containment, disposal methods and legal restrictions.		DFA, DFG	RI				
6C3	Develop an AIS regulatory handbook.		CAAIST, FA					
6C4	Share information on current mechanical, chemical, biological and physical control methods.		AISWG	SH				
6C5	Disseminate guidelines to promote use of native plants.		CAAIST	UCCE, Sea Grant				
6C6	Encourage the training of more taxonomists.		AISWG	NGOs, SH, RI				
SCHOOLS								
6D1	Train speakers to give guest presentations at schools.		AISWG	NGOs, SH				
6D2	Assess existing K-12 environmental education curricula.		UCCE, Sea Grant	DOE				

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 6. EDUCATION & OUTREACH (continued)								
6D3	Integrate AIS issues into service and education projects.		UCCE, Sea Grant	DOE				
6D4	Inform teachers about proper disposal methods for organisms.		UCCE, Sea Grant	DOE				
GENERAL PUBLIC								
6E1	Develop press kits.		DFA, DFG			100		100
6E2	Increase local TV, radio and newspaper media coverage.		CAAIST	UCCE, Sea Grant, NGOs, RI				
6E3	Identify state publications and websites to add AIS information.		CAAIST	UCCE, Sea Grant, NGOs, RI				
6E4	Develop multicultural educational materials.		UCCE, Sea Grant	AISWG				
6E5	Develop AIS traveling trunks and portable presentation boards.		UCCE, Sea Grant	AISWG				
OBJECTIVE 7. RESEARCH								
Increase research on the baseline biology of AIS, the ecological and economic impacts of invasions, and control options to improve management.								
BASELINE BIOLOGY								
7A1	Host workshops to develop AIS research priorities and identify gaps.		RI	AISWG				
7A2	Assess, continue and complete current studies.		RI	AISWG				
7A3	Develop a strategy to communicate and support research needs.		AISWG	RI				
ECONOMICS								
7B1	Perform economic impact studies on AIS effects.		CAAIST	RI		200		200

Table 5. CAISMP Implementation Table

Tasks		Priority *	Implementing Entity	Cooperating Organizations	Year 1 Planned Efforts (FY07-08)		Year 2 Planned Efforts (FY08-09)	
Number	Title/Summary				Dedicated	Requested	Dedicated	Requested
					\$1,000	\$1,000	\$1,000	\$1,000
OBJECTIVE 7. RESEARCH (continued)								
7B2	Assess and compare costs of different management techniques.		RI	AISWG				
MANAGEMENT OPTIONS								
7C1	Evaluate efficacy of AIS management methods.		AISWG	RI				
7C2	Investigate the efficacy of invasion prevention techniques.		AISWG	RI				
7C3	Consider test center to evaluate ballast water treatment technologies.		SLC					
7C4	Identify opportunities for interagency funding of AIS management research.		AISWG					
OBJECTIVE 8. LAWS & REGULATIONS								
Ensure State laws and regulations promote the prevention and control of AIS.								
LAWS & REGULATIONS								
8A1	Establish a regulatory review committee.		CAAIST, FA	RI, SH				
8A2	Identify the potential for improved regulatory coordination.		CAAIST					
8A3	Pursue the authority to establish an interagency rapid response program.		AE	SH				
8A4	Explore the need for additional state authority for AIS management.		CAAIST	AISWG				
8A5	Review current system for regulating plant and animal importations.		DFA, DFG, FA	AISWG				
8A6	Explore how new or modified regulations can bridge authority gaps.		CAAIST	AISWG				
8A7	Develop and pursue the adoption of new regulations.		AE	DFA, DFG				

Table 6 – Funds Spent on Ongoing AIS Programs and Activities

Name of Program or Activity	Implementing Entity ¹	CAISMP Action Number(s)	FY 05/06 ²	FY 06/07
Aquatic and Riparian Invasive Species Control on DFG Lands (One Time Funding)	DFG	5A2		\$720,000
Aquatic and Riparian Invasive Species Control on DFG Lands (Regular Funding)	DFG	5A2	\$160,000	\$160,000
Wetlands Invasive Plant Control	WCB	5A2		\$3,610,000
Riparian Invasive Plant Control	WCB	5A2		\$1,000,000
Santa Clara River Invasive Species Control (Santa Clara River Trustee Council Grants)	DFG	5A2		\$507,700
Santa Clara River Invasive Species Research (Santa Clara River Trustee Council Grants)	DFG	7C1		\$100,000
Santa Clara River - Education for Restoration Workers	DFG	2G2, 2G3		\$24,734
Santa Clara River Invasive Species Monitoring	DFG	3B4		\$200,285
Santa Clara River - Public Outreach and Education (est. portion for Invasive Species)	DFG	6E5,6A4, 6A7		\$25,000
Shellfish Health Laboratory	DFG	2D1	\$10,000	\$10,000
Shellfish Health Laboratory	DFG	2D4	\$10,000	\$10,000
Shellfish Health Laboratory	DFG	2D7	\$70,000	\$70,000
Shellfish Health Laboratory	DFG	2D8	\$10,000	\$10,000
Shellfish Health Laboratory	DFG	2D10	\$20,000	\$20,000
Shellfish Health Laboratory	DFG	2F2	\$10,000	\$10,000
Marine Invasive Species Program – Invasive Species Monitoring	DFG/OSPR	3B3, 7C2	\$1,080,000	\$1,080,000
Marine Invasive Species Program – Commercial Vessel Vectors	SLC	2B1	\$1,531,000	\$2,013,000
Quagga Mussel Response – Unified Command participation, planning and logistics, dive and surface surveys, border inspection stations, public outreach	DFG, DFA	4A3, 2I1 & many others		\$1,048,119
Quagga Mussel Response – Unified Command participation, eradication planning, dive inspections	DWR	4A3, 5A4,2H1		\$36,320

¹ See “Explanation of Terms” and “Acronyms” above Table 5.

² This table shows funds that were allocated in the 05/06 and 06/07 fiscal years. There were additional AIS projects being worked on in 05/06 and 06/07 that were not included in the table because they were funded in previous years.

Table 6 – Funds Spent on Ongoing AIS Programs and Activities

Name of Program or Activity	Implementing Entity ¹	CAISMP Action Number(s)	FY 05/06 ²	FY 06/07
Quagga Mussel Response – Training surface survey units	DWR	4A3		\$3,624
Quagga Mussel Response – Outreach to boaters	DBW	4A3		\$400,000
Aquatic Weed Control (water hyacinth and <i>Egeria densa</i>)	DBW	5A3	\$7,000,000	\$7,000,000
Hydrilla Eradication Program	DFA	3B4, 4B2,5A3	\$2,100,000	\$2,100,000
Coordination and Collaboration Activities	Sea Grant	1A4, 1C1, 1C2, 1C3	\$9,000	\$9,000
Commercial Vessels and Maritime Activities	Sea Grant	2B1, 2B2, 2B3, 2B6	\$137,250	\$137,250
Reduce AIS introductions related to recreational activities	Sea Grant	2C1, 2C4, 2C6	\$9,000	\$9,000
Reduce AIS introductions related to the live seafood industry	Sea Grant	2D5, 2D6	\$4,500	\$4,500
Early detection program development	Sea Grant	3A4, 3A6	\$11,250	\$11,250
Identify and monitor locations with high AIS invasion rates	Sea Grant	3B3	\$50,000	\$50,000
Work with volunteers to conduct AIS inspections at heavily used boat access areas	Sea Grant	5B3	\$4,500	\$4,500
Education and outreach to groups that may be a source of AIS introductions	Sea Grant	6A1, 6A2, 6A4, 6A5, 6A6, 6A7, 6A10, A12, 6A13	\$29,250	\$29,250
Increase awareness of AIS among, and share information on control methods with, scientific and natural resource management interests	Sea Grant	6C1, 6C4	\$4,500	\$4,500
Increase awareness of AIS in the educational system	Sea Grant	6D2, 6D4	\$4,500	\$4,500
Increase awareness and knowledge of AIS by the general public	Sea Grant	6E2, 6E3, 6E4, 6E5	\$9,000	\$9,000
Baseline biological studies on AIS	Sea Grant	7A2	\$60,000	\$60,000
Economic assessment of different AIS management techniques	Sea Grant	7B2	\$9,000	\$9,000

¹ See “Explanation of Terms” and “Acronyms” above Table 5.

² This table shows funds that were allocated in the 05/06 and 06/07 fiscal years. There were additional AIS projects being worked on in 05/06 and 06/07 that were not included in the table because they were funded in previous years.

Table 6 – Funds Spent on Ongoing AIS Programs and Activities

Name of Program or Activity	Implementing Entity ¹	CAISMP Action Number(s)	FY 05/06 ²	FY 06/07
Northern Pike Containment System at Lake Davis	CALFED	5A3	\$2,000,000	
Lake Davis Pike Eradication Project: Planning Feasibility Phase	CALFED	4B2		\$5,800,000
Lake Davis Pike Eradication Project: Implementation Phase	CALFED	4B2		\$11,700,000
Invasive Spartina Monitoring	CALFED	3B4,5A3		\$1,234,396
Total of Reported Activities			\$14,342,750	\$39,234,928

¹ See "Explanation of Terms" and "Acronyms" above Table 5.

² This table shows funds that were allocated in the 05/06 and 06/07 fiscal years. There were additional AIS projects being worked on in 05/06 and 06/07 that were not included in the table because they were funded in previous years.

8. CASE STUDIES IN ERADICATION & CONTROL

See also the explanation of species names in the introductory matter.

1. RAPID RESPONSE IN SAN DIEGO: CAULERPA

Invasion: *Caulerpa taxifolia* is a marine alga native to the warm waters of the Red, Indo-Pacific and Caribbean seas. The bright-green plant, which has feathery, fern-like fronds extending upward from a main stem, is fast-growing and easy to cultivate. *C. taxifolia* gained popularity as an aquarium plant in the 1970s. In the early 1980s, a strain of *C. taxifolia* that had adapted to temperate waters escaped from Germany's Stuttgart Aquarium into the northern Mediterranean. By 2001, the temperate strain of *C. taxifolia* carpeted more than 30,000 acres of coastal waters from Spain to Italy, moved into the Croatian Adriatic, and from there, spread to Northern Africa. As the plant spread, it excluded native plants and animals.

Nearly twenty years after its introduction into the Mediterranean Ocean, *C. taxifolia* was observed in the Americas. In July 2000, biologists conducting an eelgrass restoration project in Carlsbad, California, near San Diego, found monoculture patches of *C. taxifolia* covering approximately 1,100 square meters of a coastal estuary known as Agua Hedionda Lagoon. The resulting press coverage brought attention to a previously known second infestation of scattered individual plants over seven acres of Huntington Harbour near Los Angeles. Genetic tests confirmed that both areas had been invaded by clones of the aquarium strain, suggesting aquarists had dumped the contents of their saltwater tanks into California waters.

Concern: *C. taxifolia* is one of the world's most notorious marine invasives. Though tropical in origin, the clone cultivated in home aquaria has adapted to waters as cool as 50 degrees F. The aquarium strain can grow on rock, sand and mud, and increase in size by an inch per day, developing in monoculture patches that are both taller and more vigorous than its wild ancestor, which is genetically distinct from the aquarium strain and is not known to be invasive. Sexual reproduction has not been documented, but *C. taxifolia* reproduces easily, regenerating from small fragments broken off from the main plant. *C. taxifolia* is not particularly vulnerable to predation. Chemicals in its tissues make it unpalatable to most animals. In the laboratory, *C. taxifolia* has survived a wide array of kill techniques, including high doses of herbicides and algicides as well as light exclusion for more than one month.

Response: The plant's notoriety helped galvanize an immediate response to the California infestations. Plant samples taken from Agua Hedionda Lagoon were identified literally overnight as *C. taxifolia*. A task force consisting of representatives from more than ten state, federal and local agencies plus local stakeholders and experts met within days to determine how to manage the outbreaks. Given the speed with which *C. taxifolia* had invaded the

Mediterranean and the ecological havoc that ensued, the task force approved a plan calling for an immediate eradication response. Regulatory agencies agreed in advance to green-light permits for eradication work to begin within two weeks.

Both infestations occurred in bodies of water with restricted ocean access. This enabled kill procedures to take place in areas sheltered from ocean waves, and made surveys for regrowth safer and easier to conduct. In Agua Hedionda, divers surveyed the lagoon and mapped patches of the alga. The patches were covered by tarpaulins and the edges secured by sandbags and rebar. Solid chlorine pucks were placed beneath the tarps to make up a five percent bleach solution. Before the tarpaulins were lifted, sediment cores were grown out in the laboratory to determine whether any viable *C. taxifolia* remnants remained. Meanwhile, teams of divers continuously resurveyed the 200-acre lagoon to ensure no other plants had been missed. A similar tarp, bleach, and survey protocol was followed at Huntington Harbour. The last specimens of *C. taxifolia* were found outside the tarpaulins at both sites in fall of 2002. The alga was officially declared eradicated in July 2006. All told, the eradication effort cost \$7.7 million, including planning, field work, monitoring and reports.

Lessons: Several factors contributed to the success of *C. taxifolia* eradication in southern California. Rapid identification, an expedited process and cooperation among stakeholders, plus adequate funding and follow-up, all contributed to eradication. Biologists were aware of *C. taxifolia*'s invasion of the Mediterranean and rapidly identified the problem. Concern over a similar outbreak in California spurred the prompt formation of an invasion task force. Stakeholders were identified within days and agreed to participate in response plan discussions. The specter of the alga's escape prompted task force members to aim for eradication despite the fact that some native species, such as eelgrass and estuary invertebrates, would be harmed. Team members divided tasks, some turning their full attention to eradication while others concentrated on permitting applications and approval. Regulatory agencies agreed to cooperate with the eradication plans and expedite permitting. Financing was adequate to maintain a sustained response. Intensive monitoring surveys were conducted for least three years to guard against any regrowth.

Background Studies:

Merkel & Associates, Inc. 2006. *Final report on eradication of the invasive seaweed Caulerpa taxifolia from Agua Hedionda Lagoon and Huntington Harbour, California*. Prepared for the Steering Committee of the Southern California Caulerpa Action Team.

2. ERADICATION EFFORT IN THE SAN FRANCISCO BAY ESTUARY: SMOOTH CORDGRASS

Invasion: Intentionally introduced to the San Francisco Bay Estuary in the 1970s to stabilize shorelines, smooth cordgrass spread rapidly, hybridized with Pacific cordgrass and today threatens thousands of acres of tidal marshes and restoration projects around the Bay. In 2000, surveyors tallied 470 acres of hybrid smooth cordgrass, while the original introduced parent had become quite rare. By 2003, the hybrids covered 2000 acres. The smooth cordgrass was not confined to certain areas; the invader was widely dispersed through 69,000 acres of tidal marsh and mudflats and had invaded every marsh restoration project in the Bay.

Concern: The hybridization between smooth and Pacific cordgrass resulted in a high degree of genetic variation, which allowed individual plants to survive in different parts of the marsh and to exploit open niches. Some hybrids grow well in higher marsh elevations while others flourish on open mudflats. Other adaptive qualities of the smooth cordgrass hybrids include the ability to produce up to 23 times more seed than the native, to grow taller and/or faster, and to tolerate higher or lower salinity. The hybrid cordgrass tends to grow in dense stands, turning diverse marshes into monocultural meadows, crowding out the meandering tidal channels used by native salt marsh species, and reducing fish habitat. This invasion sequence can also transform open mudflats into uniform expanses of cordgrass, destroying foraging habitat for shorebirds. Flood control channels are also threatened, as the cordgrass can significantly impede flow with increased siltation rates and biomass accumulation, threatening adjacent residential and commercial areas with flooding.

Response: In 2000, SCC began to organize a multi-agency, region-wide control effort in the San Francisco Estuary called the Invasive Spartina Project (ISP). With substantial funding from CALFED Bay Delta Program (CALFED), ISP surveyed and mapped the invasive cordgrass, evaluated a wide range of potential treatment strategies and methods, prepared environmental review documents under CEQA and NEPA, developed extensive partnerships with regional marsh owners and managers, obtained necessary permits (e.g., ESA Section 7 and CWA Section 402/NPDES), and prepared site-specific treatment plans for over 130 known infested marshes. ISP also coordinated funding from CALFED through SCC to the land owner/manager partners. In 2004, ISP partners initiated treatment efforts, which consisted of spraying selected infested marshes with glyphosate (Aquamaster(r), the aquatic version of Roundup(r)), and using light mechanical removal methods.

ISP faced a number of constraints as it attempted to respond to the fast-moving invasion of hybridized smooth cordgrass. Mechanical removal methods, such as mowing, sometimes aggravated the problem. Spraying was slow, difficult work. It had to be limited to days with no rain, low wind and periods of low tides, so as to minimize drift issues and keep the herbicide from washing off

of the surface of the plants. Targeted plants had to be entirely coated with the glyphosate herbicide to achieve maximum efficacy, which in most cases proved to be around 50% at best. Another problem was that glyphosate tends to become deactivated when it binds with sediment; since these bay waters contain a great deal of suspended sediment which is deposited on the cordgrass twice daily, much of the applied herbicide was rendered inactive before it even entered plant tissue.

To add to the difficulty, herbicide application had to take place in the late summer before the plants set seed and go dormant, but also had to be scheduled so as not to interfere with the breeding season of a federally endangered species, California clapper rail (February through August). Mowing and other mechanical removal methods could not be used in marshes frequented by the clapper rail.

In November 2004, ISP and USEPA hosted the Third International Conference on Invasive *Spartina*, where ISP shared its experiences with *Spartina* experts from around the world. At this meeting, ISP requested guidance regarding the feasibility and approach to controlling the hybrid cordgrass invasion. Conference participants were impressed by the level and complexity of the invasion problem and advised that control could potentially be achieved if the ISP proceeded immediately with an aggressive regional control program.

Before such a program could get underway, surveys for California clapper rails in the infested marshes had to be performed, as well as an analysis of the potential impacts of treating each site where the rail was present. ISP partnered with local bird, park and fish and wildlife groups to conduct coordinated annual Bay-wide clapper rail surveys. Their results directly informed treatment approaches.

In 2005, ISP targeted 132 infested areas, with a goal of treating 70-80 percent of the infestation in that year. ISP began using a new herbicide, imazapyr (Habitat(r)), which had been registered for use on August 30, 2005 in California and was known to be highly effective in eradicating invasive cordgrass in Willapa Bay, Washington. Imazapyr has several advantages over glyphosate. It does not require a 6-12 hour post-application period without tidal inundation, it is less toxic to aquatic organisms than glyphosate, and it can be used more sparingly and with greater success. One drawback is that it can damage non-target plants if it is over-sprayed, though preliminary observations of treated sites show normal seasonal regrowth of native marsh plants such as pickleweed.

In 2005, imazapyr was applied to 1,010 acres of invasive cordgrass, sprayed from amphibious tracked vehicles, helicopters, airboats, backpacks and trucks. Because the new herbicide requires less spray volume than glyphosate, application time was reduced by as much as one-third, and 2006 monitoring showed that it killed from 40-90% of the treated plants. Also, the 2005 results showed that helicopter application provided the best efficacy (up to 90% kill) and

lowest cost (\$250-\$350 per acre). In 2006, ISP partners treated more than 1,700 acres (including retreatment of the previous years sites), with 60% of that by helicopter. Based on the 2005 results and the demonstrated coordination and aggressive action of ISP partners in 2006, ISP envisions that, given continued adequate funding, non-native cordgrass could be effectively eradicated from the San Francisco Estuary within the next several years.

ISP and affected resource agencies are also starting to develop an "exit strategy" for ISP, whereby long-term monitoring and treatment responsibilities will be turned over to a network of informed land managers around the S.F. Bay Estuary.

Lessons: Years of frustrated attempts by individual landowners to manage invasive cordgrass on their properties demonstrated the need for a coordinated regional approach. Landowners could not control reinfestation from adjacent properties and had nearly given up by the time SCC initiated efforts through ISP. At the outset of ISP in 2000, non-native cordgrass infestation in the Bay was roughly one-third the area mapped in 2005. In the five years it took to develop the necessary budgeting, permitting and scientific framework to comprehensively tackle the problem, the infestation grew significantly. Because of substantial and reliable support from SCC, CALFED, the Bay Area environmental community and regional land managers, the ISP was able to adapt to the expanding scope of the problem, despite setbacks along the way.

One of the most difficult aspects of controlling an invasive species in a region that is highly urbanized and carefully monitored for its unique environmental values is coming up with a sufficiently rapid response. Environmental regulation around sensitive tidal marshlands had been instituted in response to urban growth, or in some cases, was designed to reflect specific issues: endangered species protection, or water use. By contrast, the cordgrass invasion in the Bay encompassed multiple jurisdictions, habitat types, developmental zones, political mindsets, animal and plant species and levels of enthusiasm. Currently there is no overarching mechanism to cut through the permitting process for an effort that is, in essence, aimed at controlling the rapid spread of a biological pollutant, and enhancing and maintaining the health of the environment. The experience of ISP shows that having a coordinated regional effort is critical for overcoming budgetary and regulatory obstacles. When that kind of alignment is absent, worthy projects of lesser scale would likely be unsuccessful.

Background Studies:

Daehler, CC and DR Strong. 1997. "Hybridization between introduced smooth cordgrass (*Spartina alterniflora*; *Poaceae*) and native California cordgrass (*S. foliosa*) in San Francisco Bay". *American Journal of Botany* 84(5): 607-611.

Daehler, CC, CK Antilla, DR Ayres, DR Strong and JP Baily. 1999. "Evolution of a new ecotype of *Spartina alterniflora* in San Francisco Bay." *American Journal of Botany* 86, 543-544.

Leson & Associates. 2005. "Use of imazapyr herbicide to control invasive cordgrass (*Spartina* spp.) in the San Francisco Estuary: Water quality, biological resources, and human health and safety." Prepared for the San Francisco Estuary Invasive *Spartina* Project/State Coastal Conservancy, Oakland, California. May 4, 2005.

Patten, K. 2002. "Smooth cordgrass (*Spartina alterniflora*) control with imazapyr". *Weed Technology* 16, pp. 826-832, 2002.

Patten, K. 2003." Persistence and non-target impact of imazapyr associated with smooth cordgrass control in an estuary". *Journal of Aquatic Plant Management* 41, pp. 1-6.

San Francisco Estuary Invasive *Spartina* Project. 2004-2006 Studies covering site specifics, tidal marsh carrying capacity for clapper rails, rail distribution, field operations and an aquatic pesticide application plan, as well as EIRs and endangered species consultations, among other topics. Go to www.spartina.org/project_documents/.

3. CONFOUNDING COMPLICATIONS IN THE DELTA: BRAZILIAN ELODEA

Invasion: Brazilian elodea, commonly referred to as *Egeria*, is a fast-growing shallow-water submerged aquatic plant that now infests approximately 12,000 acres of the 50,000 surface acres of the San Joaquin/Sacramento River Delta (Delta). This species is a native of Brazil and Argentina, has also become widespread in New Zealand, Australia, Japan and Chile. In the U.S., it has invaded lakes and ponds along the western coast from Washington to California, through the South, and as far north as New Hampshire and Vermont in the Northeast. The plant, which has individual strands that resemble a long, furry brush, was identified in the Delta approximately 40 years ago. *Egeria*'s introduction is believed to have resulted from someone cleaning an aquarium and discarding the plant into the Delta.

The first recorded complaints by boaters in the Delta about *Egeria* mats impeding navigation are from 1988. The initial infestation appeared limited to a relatively small area. In 1999 aerial surveys indicated *Egeria* covered approximately 4,000 surface acres, or about 8% of the Delta. Six years later, in 2005, *Egeria* coverage had tripled to 12,000 acres, or about 24 percent of the Delta. *Egeria* is currently estimated to be spreading at a rate of about 1,000 acres per year. Some of the most heavily infested areas of the Delta are Rhode Island, where almost the entire 66 acres of the island are covered, and Franks Tract State Recreation Area, where the invader covers approximately 700 of the 900 acres. Thousands of acres of the Delta remain at risk; much of the ecosystem consists of freshwater areas less than 10 feet deep, the habitat in which *Egeria* thrives.

Concern: *Egeria* grows in subsurface mats that can be several feet thick. *Egeria* is a visible and immediate problem for boaters but an *Egeria* infestation also has a host of broader impacts. *Egeria* can obstruct waterways -- forcing boaters to stop frequently to clear propellers -- or in more extreme cases, prevent passage of large and small vessels. The San Joaquin County Sheriff's Office has reported that underwater vegetation may have contributed to a fatal boating accident. The plant can also impede migration of anadromous and pelagic fish. *Egeria* changes the architecture of shallow water ecosystems, forming walls between deepwater and inter-tidal habitat. Impenetrable mats of *Egeria* can force fish such as salmon and Delta smelt into more open waterways, where food resources may be scarce and where fish are more vulnerable to predators. The mats of *Egeria* can also impede water flows, crowd out native plants, entrap sediments, alter the food web by impeding light access, and clog agricultural and municipal water intakes.

Response: Legislative delays, treatment complexity and conflicts between herbicide application and native species protection have all been ongoing problems in the effort to eradicate *Egeria*. The initial response to the *Egeria* invasion was not rapid. Complaints of waterway obstruction by *Egeria* went on for nine years before state legislation authorizing DBW to address the invasion

passed in 1997. Two additional years passed before the legislature authorized funding to study *Egeria*. During this period, *Egeria* continued to expand in the Delta. A plant that had once been a localized nuisance soon became the most widespread aquatic weed in the Delta.

Once it was authorized to deal with the problem, DBW explored many different treatment and control options. These included a variety of herbicide types as well as mechanical harvesting. Department officials discovered that the harvesting of *Egeria* causes fragments to escape and freely float to new areas where they can take hold and sprout new growth elsewhere. Mechanical harvesting's unintended consequences made it a tool only to be used in an emergency.

Herbicides based on chelated copper have proven the most effective at destroying *Egeria*. Chelation helps prevent copper from entering the food web, and causing preferential binding to sediments; however, concerns over adding more heavy metals to the Delta forced DBW to turn to another herbicide, fluridone.

Fluridone treatment had its share of problems too. The herbicide is most effective against *Egeria* during the growth cycle of the plant. The peak growth period for *Egeria* is in early spring; however, spring in the Delta coincides with the spawning and migration of several protected species, including chinook salmon (out migration), steelhead trout (in-migration, spawning and out-migration), delta smelt (spawning) and candidate species green sturgeon (spawning).

Federal agencies, including NOAA's National Marine Fisheries Service (NOAA Fisheries Service) and USFWS have requested numerous toxicity tests to ascertain whether fluridone is harmful to these species. Research thus far has confirmed that the concentration of fluridone used to treat *Egeria* does not harm these species. For example, Chinook salmon fingerlings showed no toxic effects at or below concentration levels used by DBW. However, continued concern over the health of migrating and spawning species has led to limitations in fluridone treatment timing.

During the 2001 treatment season, DBW applied the herbicide during the summer months of July through September instead of during the optimum time frame of April through June as recommended by the manufacturer and other scientific studies. While the herbicide did prevent proliferation of some of the *Egeria*, it failed to substantially reduce the total acreage covered.

Monitoring during applications has been extensive. The fluridone treatments at each site are monitored using immunoassays analyzed to ensure applications are occurring at an efficacious rate and are within all published (agricultural and municipal) limits. The immunoassays are collected within the

treatment area, receiving waters and at all agricultural and municipal water intakes on a bi-weekly basis. DBW also takes water samples and monitors water quality of the treatment area to comply with its NPDES General Permit.

In 2005, NOAA Fisheries agreed for the first time to permit *Egeria* treatment to begin in spring in a few select sites. The new treatment schedule proved extremely effective. At one site, the treatment appears to have eliminated populations of *Egeria*, suggesting fluridone may only need to be applied in the future every second or third year to maintain control of the plant.

Treatment success has been measured using two relatively new methods. The plant grows in dense mats just below the surface of the water, where it is difficult to determine whether treatments have had an effect. DBW uses hydroacoustic measurements to determine biomass/volume of the plants prior to and after treatments have occurred. In addition, a new technique known as hyperspectral analysis now permits more refined estimates of *Egeria* coverage in the Delta. Each type of plant species, including *Egeria*, produces a unique spectrum of infrared reflectance. Aerial images of the Delta are taken before and after treatment using digital broad spectrum photographs. The light wavelengths captured in these images are then analyzed to determine a percentage of *Egeria* in a given waterway. Some analysis has been completed on watermilfoil, pepperweed, and purple loosestrife, as well. DFA, DFG, and DBW have all used hyperspectral analysis to measure the extent of coverage for these plants and other species since 2002.

In 2005, DBW treated 14 sites comprising 648 acres. The relatively small area reflects treatment crew limitations and other restrictions placed on the program. Additional funding for application crews and continued easing of restrictions on start dates could enhance DBW *Egeria* Control Program.

Lessons: First, delays in early identification, authorization and funding permitted *Egeria* to expand from a local waterway nuisance to an invasion widespread throughout the Delta. Second, new analytical tools have allowed scientists to gather basic data about the plant's growth characteristics and response to herbicide application. The information should help managers fine-tune future treatment methods. Third, toxicity testing is critical to prevent damaging resident wildlife populations and municipal water supplies and should be balanced against the need to control an invader known to be detrimental.

Background Studies:

Residues of Fluridone in Chinook Salmon Smolts from the Sacramento-San Joaquin Delta, California, 2005 conducted for DBW by the California Department of Fish and Game.

Fluridone (4AS) Dissipation During Typical Applications of Sonar (4AS), December 2004, Lars W.J. Anderson, Ph.D, conducted for DBW by the USDA-ARS Exotic and Invasive Weed Research, Davis, CA.

Residues of Fluridone and Diquat Dibromide in Sediment from the Sacramento-San Joaquin Delta, California, 2002-2005 - conducted for DBW by the California Department of Fish and Game.

Monitoring Aquatic Herbicide Treatment Efficacy on Egeria densa, Sacramento-San Joaquin Delta, California 2004-2006, conducted for DBW by ReMetix LLC.

4. STRATEGY FOR TAHOE BASIN: EURASIAN WATERMILFOIL

Invasion: Eurasian watermilfoil was first found to occur on the south shore of Lake Tahoe in 1975. By 1980, it became well established in the Tahoe Keys, a large marina complex on the south shore built out of a marshland. From 1994 to 1997 USDA/ARS confirmed the presence of Eurasian watermilfoil outside the Keys and found it to be spreading rapidly elsewhere in the lake. In 1997, it was reported that out of 200 acres of Eurasian watermilfoil in Lake Tahoe, 170 acres were in the Tahoe Keys. Aerial and boat surveys since 1995 indicate the plant continues to spread to new locations in the near shore zone and has established in several marinas and natural areas including Emerald Bay, which is leased to the California Department of Parks and Recreation (PARKS) as an underwater park. In addition to Eurasian watermilfoil, an equally aggressive aquatic weed, curly pondweed has recently been detected in Lake Tahoe.

Concern: Eurasian watermilfoil and other invasive aquatic weeds grow prolifically and aggressively invade native aquatic plant communities. Native aquatic plant communities provide many ecological benefits such as food and habitat for waterfowl, fish and other aquatic organisms. They also help maintain water quality by absorbing nutrients, providing oxygen and reducing shoreline erosion; however, when Eurasian watermilfoil is introduced, it dominates fresh water ecosystems quickly by way of buds and surface runners when fragmented by boat propellers. It also tolerates a wide range of environmental conditions, including low light levels, high or low nutrient waters, and freezing water temperatures. Eurasian watermilfoil also creates its own habitat by trapping sediment and initiating a favorable environment for further establishment. For these reasons, Eurasian watermilfoil can out-compete and eliminate native aquatic plants.

Aquatic weeds in Lake Tahoe impact several of Tahoe Regional Planning Agency (TRPA) thresholds including water quality, fish habitat, vegetation and recreation. Impacts pushing the limits of these thresholds include accelerated nutrient cycling, contributing to algae growth and decreased water clarity; lost or impaired fisheries habitat, including feed and cover; threats to native aquatic vegetation; and restrictions to boating, water skiing, fishing, and swimming due to dense matting (Eurasian watermilfoil has been linked to drowning deaths in other areas of the U.S.).

Response: In 2002, the Lahontan RWQCB began providing fact sheets to interested parties and agencies to promote awareness of Eurasian watermilfoil in Lake Tahoe, share information about options for controlling the growth and proliferation of this weed, and present the regulatory requirements applicable to weed management activities. Because Lake Tahoe is a bi-state water of the U.S. that has been federally adopted as an Outstanding National Resource Water, Lahontan RWQCB has taken the position that chemical treatment to control invasive aquatic weeds is not justified at this time and other non-chemical means of control should be explored. Currently, the only efforts to control

Eurasian watermilfoil have been mechanical harvesting in the Tahoe Keys to clear areas for boat traffic. This method, however, is likely one of the contributing factors to the increased spread watermilfoil in Lake Tahoe.

In 2005, SLC funded and implemented a pilot project in Emerald Bay to examine control methods outside of the Tahoe Keys. The methods included diver-assisted hand and suction removal in the infested portions of Emerald Bay. The initial effort had limited success because the work was conducted too early in the season (late May). Many plants were not observed and emerged later in the season following the removal efforts. Follow-up surveys in the fall, however, found that areas where plants were removed previously were free of Eurasian watermilfoil. Removal activities in Emerald Bay will continue in 2006 and will be expanded to include an infestation in one of the smaller south shore marinas.

The Tahoe Resource Conservation District (TRCD) is currently applying for an approximate \$500,000 multi-year grant (2007-2010) to survey and remove invasive aquatic weeds throughout Lake Tahoe using the methodology of the pilot project.

Lessons: The initiative of one agency to fund and implement efforts to remove an invasive weed in a sensitive environment like Lake Tahoe through a pilot removal project has encouraged other key agencies (e.g. TRPA and TRCD) to increase their role in the management of invasive aquatic weeds in Lake Tahoe. This has expanded participation and increased cooperation within the existing Lake Tahoe Basin Weed Coordinating Group and led to the formation of an Aquatic Weed Subcommittee.

Background Studies:

Lahontan RWQCB. 2002. Fact Sheet: *Control of the invasive aquatic weed Eurasian Watermilfoil in Lake Tahoe*. South Lake Tahoe, California.

University of Nevada Cooperative Extension. 2002. Fact Sheet: *Eurasian watermilfoil*. FS-02-09. Reno, NV.

Walter, K. 2000. *Ecosystem effects of the invasion of Eurasian watermilfoil (Myriophyllum spicatum) of Lake Tahoe, CA-NV*. M.S. Thesis in Ecology, University of California, Davis.

For more information and contacts on some of these case studies, see Appendices B-D.

OTHER AIS SPECIES OF CONCERN

The following is a representative, rather than comprehensive, list of AIS species not previously mentioned in this report. Some are already here in California and widespread, some are fairly limited in their distribution and some are yet to arrive. The list is merely meant to convey some of the variety of challenges that must be addressed by state management programs. Full scientific names appear in the "Species Names" section of the introductory pages of this plan.

African clawed frog: Shipped around the globe for use in human pregnancy testing during the 1940s and 1950s, populations of African clawed frogs have been introduced into parts of Europe, North America, and South America. Although its impacts to native fauna have undergone little scrutiny, this voracious and prolific frog has shown a remarkable capacity to colonize a broad range of aquatic habitats. In southern California, it occupies more than a 300-mile long range through seven counties. In 2003, the African clawed frog was found in a pond at Golden Gate Park in San Francisco.

Asian swamp eel: The swamp eel is a fish found in brackish and fresh waters from South America, Africa, and India east to Australia. U.S. populations have been found in Hawaii, Florida and Georgia. It is a voracious predator that poses a threat to native frogs, fish, and aquatic insects. The Asian swamp eel has the ability to live out of water for a considerable length of time, allowing it to move from one body of water to another. The Asian swamp eel was most likely introduced through the Asian food market and/or as an aquarium pet later released. There are no known populations in California.

Bullfrog: The North American bullfrog was introduced to California in the early 1900s. A voracious predator, the bullfrog feeds on snakes, worms, insects, crustaceans and other frogs and tadpoles. The female can lay as many as 20,000 eggs in a single breeding season. The bullfrog may be having impacts on native frogs, such as the red-legged frog and has also been implicated as a leptospirosis vector and may pose a threat to human health.

Channeled apple snail: In the United States, this South American apple snail has invaded the southern states of Florida, North Carolina, Texas and central Ohio. There have been reports of at least two populations in California. The apple snail is a common aquarium snail also cultured for sale to restaurants, making its spread through these pathways likely. It has a voracious appetite and will eat most types of vegetation. In Hawaii, the apple snail is considered to be problematic in some natural and agricultural wetlands, most notably in the taro fields which play an important role in Hawaiian culture. The snail's potential as a rice pest as well as a pest of natural wetland ecosystems has spurred the USDA to list them as a high priority threat should they spread or be introduced more widely.

Golden Mussel: A freshwater mussel native to the rivers and streams of China and southeast Asia, the golden mussel was first found in the Americas in 1991, at the mouth of Argentina's Rio de la Plata. It has subsequently spread up the river basin into Uruguay, Paraguay and Brazil. The first colonies are thought to have arrived as larvae in the ballast water of shipping vessels. Like its relative the zebra mussel, the golden mussel readily colonizes hard surfaces including logs and silt, colonies of other bivalves, walls, and piers. Because it settles on floating vegetation, fouls boat hulls and fishing equipment, and can survive for more than 120 hours out of water, it is easily transported to new waterways. Though primarily aquatic, the golden mussel also tolerates slightly brackish waters. It has been found in aggregations of more than 80,000 mussels per square meter. At such high densities, these filter feeders can deplete local waters of plankton and starve or suffocate native filter feeders. Golden mussel infestations can also clog or foul and cooling pipes, intake screens and other aquatic machinery.

Green sunfish: The green sunfish was mistakenly introduced to California from the Midwest in the late 1800s to early 1900s. Green sunfish spawn in shallow waters and have enormous reproductive potential. They compete with native fishes by feeding on insects and small fish and are adaptable to varying lake conditions and climates.

New Zealand mudsnail: Native to freshwater lakes and streams of New Zealand, this snail has spread to six Western states, reaching California's Owens River in the Eastern Sierra in 1999. Since then, it has spread up and down the Owens River as well as into seven other sites scattered throughout Northern California and to multiple sites in southern California. The snail's tight-fitting operculum permits it to survive out of water in damp conditions for several weeks. It likely hitchhiked into California within waders or other equipment used in infested streams. The New Zealand mudsnail has a prodigious reproductive capacity, competes with native mollusks for resources, and offers virtually no nutritional value to aquatic predators. Population levels in California's Putah Creek have been estimated excess of 100,000 snails per square meter. To date, limited research has documented decreases in native macroinvertebrate populations in several rivers where the mudsnail has invaded.

Northern Pacific seastar: Native to the coasts of northern China, Korea, Russia and Japan, this five-armed seastar has spread to many other countries. Its arrival has been linked to ballast water discharges. It is a voracious predator, attacking fleshy organisms such as shellfish. Able to detect food from a distance, it digs shallow pits into the seabed to extract prey. The northern Pacific seastar was the focus of extensive eradication efforts by the Australian government in the mid-1990s and remains on their watch list because of the threat it poses to shellfish production.

Saltcedar (Tamarisk): Saltcedar is native to southeastern Europe and much of central Asia and was introduced to the United States as a landscape ornamental and soil stabilizer. In California, it occurs in the southern Klamath Ranges, Central Valley, eastern Sierra Nevada, Tehachapi Mountains, western Transverse Ranges, South Coast deserts to over 6,000 ft in elevation (DiTomaso and Healy 2003), and the southeastern corner of the state. It is now the dominant plant in the riparian forests of the lower Colorado River. Saltcedar is able to colonize small stream channels where it traps sediments and alters the hydrology. True to its name, the tree concentrates salts in its leaves, and when the leaves drop, local soil salinities may increase. Saltcedar's ability to colonize degraded river systems has allowed it to grow in places where cottonwood and other native riparian vegetation may not. Yet its presence also offers cover, shade and nesting habitat to the endangered southwestern willow flycatcher and other native animal species.

Salvinia: Native to tropical South America, Salvinia Complex consists of four closely-related, free-floating aquatic fern species that can be difficult to distinguish from one another. Giant salvinia is considered one of the world's worst aquatic pests: in favorable environments, plants may double in volume within a week. Giant salvinia forms extensive mats that can completely cover water surfaces, shadowing out native plants, reducing available dissolved oxygen, and creating large amounts of decaying plant material. It can also clog water intakes, interfering with irrigation, drainage and electric power generation. Its arrival in the U.S. has been linked to commercial nurseries and pet stores, where it is sold for ornamental ponds and aquariums. Giant salvinia tends to spread locally because the plants adhere to boats, wheels, and recreational gear entering infested waters. It reproduces so rapidly that infestations quickly become impossible to eradicate. Giant salvinia mats may grow up to three feet thick, hindering the effectiveness of chemical controls. In California, giant salvinia populations have naturalized in the Colorado River drainage and have invaded some canals in the Sonoran Desert and San Luis Obispo County (DiTomaso and Healy 2003). It has also been detected in two ponds in San Diego County.

Northern snakehead: The northern snakehead is a fish native to China that was most likely imported from Asia to the United States as a food fish. It is also sold in the aquarium trade. It can be found in a variety of habitats, and can breathe air with a bladder that works like a primitive lung. The northern snakehead is a voracious predator with no natural enemies. It disrupts native aquatic ecosystems and transmits diseases and parasites, including several species that can infect humans. Its impact on local economies dependent on fishing and other related resources is significant. All 28 species of snakehead are on the federal list of injurious wildlife species, and their importation and transportation across state lines is illegal. See also federal risk assessment at http://fisc.er.usgs.gov/Snakehead_circ_1251/html/risk_assessment_process.html.

Waterlettuce: Waterlettuce is a floating aquatic plant native to South America and is considered to be one of the worst weeds in subtropical and tropical regions of the world. Under optimal environmental conditions, waterlettuce can double its population size in less than three weeks. Seed production makes this plant resilient to adverse environmental conditions such as drought. Waterlettuce populations often form large, impenetrable floating mats, limiting boat traffic, recreation, flood control and wildlife use. It is a popular species for pond landscaping and is frequently sold through nursery mail order catalogs and on the Internet. In California, it has only been reported from the eastern Sonoran Desert (Colorado River drainage), but its range is expected to expand (DiTomaso and Healy 2003).

Paleyellow Iris (Yellowflag Iris): A hearty perennial that grows from tuberous rhizomes, yellowflag iris can grow to 5 feet tall. It is a European native that has adapted well to conditions throughout the U.S., where it can now be found in at least 40 states. It typically grows in wetlands, along river and stream banks, in irrigation ditches and on the margins of lakes and ponds. It was first found in California in the 1970s. It now occurs in the San Francisco Bay region, southern San Joaquin Valley, Central Coast, and South Coast (DiTomaso and Healy 2003). When consumed in large quantities, paleyellow iris can be toxic to livestock. A resinous substance from the leaves and rhizomes can irritate the skin of those removing the rhizomes by hand. Pulling the rhizomes can cause extensive damage to the substrate, inviting the establishment of other unwanted plants. Control techniques such as burning are not recommended because the rhizomes re-sprout. Cutting followed by herbicide applications may be the best method to control this plant.

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