

MASSACHUSETTS AQUATIC INVASIVE SPECIES MANAGEMENT PLAN

MASSACHUSETTS AQUATIC INVASIVE SPECIES WORKING GROUP

Prepared by: The Massachusetts Office of Coastal Zone Management
DECEMBER 2002



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Acknowledgements

This plan was created by the Massachusetts Aquatic Invasive Species Working Group, a member group of the Massachusetts Secretary of Environmental Affairs' Council on Invasive Species established to develop and implement strategies to combat the growing problem of invasive species in the Commonwealth. The Aquatic Invasive Species Working Group included 18 representatives of 14 state and federal agencies and academic institutions. The Working Group was co-chaired by Susan Snow-Cotter (Massachusetts Office of Coastal Zone Management), Jim Straub (Massachusetts Department of Environmental Management), and Jan Smith (Massachusetts Bays National Estuary Program). Jay Baker (Massachusetts Office of Coastal Zone Management) was the primary author. Judy Pederson (Massachusetts Institute of Technology Sea Grant Program) provided considerable technical and moral support. Graduate students Cory Riley and Shannon Weigle also contributed to various components of Plan development.

The Working Group was also assisted by the efforts of the Federal Aquatic Nuisance Species Task Force, and, in particular, the contribution of Sandra Keppner (US Fish and Wildlife Service).

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Executive Summary

The intentional and accidental introduction of nonindigenous species into the Commonwealth of Massachusetts is not a new phenomenon. In fact, we can assume that the human-assisted movement of species, both plant and animal, has occurred since humans first inhabited this region. It was not until recent decades that the globalization of our economy and with it, the rapid movement of both people and goods, indirectly resulted in a corresponding rise in rates of species introductions. Many of these species introductions have been seemingly harmless while others have been extremely problematic and/or expensive. The introduction of invasive species is thought to be second only to habitat loss in contributing to declining biodiversity throughout the United States. While Massachusetts has been fortunate thus far to have averted the big name aquatic invaders like zebra mussels and the Chinese mitten crab, many other lesser known species have moved into the state and now call it home.

Problematic marine invaders that have become established in Massachusetts include the European green crab, Asian shore crab, lace bryozoan, codium, and various species of sea squirts and shellfish pathogens. Marine species of concern (due to their proximity to Massachusetts and/or aggressive tendencies) include the veined rapa whelk, nori, Chinese mitten crab, the Pacific oyster, and caulerpa. On the freshwater front, aquatic macrophytes such as water chestnut and Eurasian water milfoil have become established and are aggressively spreading in lakes and ponds. In addition, common reed and purple loosestrife are rapidly clogging waterways and outcompeting native species. Although the zebra mussel has yet to be documented in Massachusetts, it is found in the Connecticut side of the Housatonic watershed, very close to the Massachusetts border. The Asian clam and other species of aquatic macrophytes such as hydrilla and giant salvinia are causing problems in nearby states and have a reasonable chance of making it to Massachusetts if conditions are favorable.

Generally speaking, responses to the spread of aquatic invasive species have been slow and poorly coordinated. The introduction and subsequent spread of freshwater macrophytes has probably received the most attention from natural resource managers due to the impacts of these invasions on boating, fishing, and other recreational uses. On a lake by lake basis, landowner groups, with support from the state, have tried to control further species spread with limited success. On the marine side, the European green crab has caused the most tangible impacts and thus is best known. Attempts to eradicate and/or control this voracious shellfish predator have proven ineffective. Outside of fishery and aquaculture circles, the general public is not aware of the impact that invasive species have on our marine ecosystem and local economy. State and federal agencies have limited jurisdiction and/or mandate to address aquatic species issues and small or non-existent budgets to deal with the wide range of species impacts that face local waterways.

The Massachusetts Aquatic Invasive Species Management Plan (The AIS Plan) is the first comprehensive effort to assess the impacts and threats of aquatic invasive species in Massachusetts. In response to the identified impacts and threats, the AIS Plan lays out a series of management strategies intended to curb the spread of invasive species.

The AIS Plan outlines an ambitious five-year plan for aquatic invasive species management in Massachusetts with the goal of *implementing a coordinated approach to minimizing the ecological and socio-economic impacts of aquatic invasive species in the marine and freshwater environments of Massachusetts*. The plan is constructed around eight general objectives: 1) coordinate AIS management efforts; 2) prevent new introductions of AIS to Massachusetts waters; 3) monitor the introduction of new invaders and the spread of established organisms; 4) detect and eradicate pioneering invasive species posing high or unknown risk to Massachusetts aquatic ecosystems before they become established; 5) control the spread and distribution of AIS in infested water bodies and reduce the risk of dispersal to uninfested waters; 6) educate the public, resource managers, and industry representatives regarding their role in preventing the introduction and transport of AIS; 7) continue to research and identify new measures for the prevention and control of AIS, and evaluate the effectiveness of existing management measures; and 8) identify needs for additional legislation relating to the control of AIS. Each objective is supported by strategic actions and 99 specific tasks with lead agencies and budget identified (Table A). Plan priorities include staff to serve as the agency leads for plan implementation, continuation of current research on the relative risks of various transport vectors, coordination with industry to minimize invasions, development of a regional web page and database on AIS distribution, and various educational initiatives.

The AIS Plan follows guidance provided by the federal Aquatic Nuisance Species Task Force, which is co-chaired, by the National Oceanic and Atmospheric Administration and the US Fish and Wildlife Service. Once the plan is approved, the Task Force provides limited funds to support plan implementation. The AIS Plan was developed by the Massachusetts Aquatic Invasive Species Working Group, which includes 18 representatives of 14 state and federal agencies, as well as private and public entities. The Working Group met for approximately 14 months to develop the AIS Plan. This same group will lead plan implementation.

The threat of invasive species appears overwhelming and some believe that such species expansion is inevitable. Due to this sense of powerlessness, many resource managers and agencies have been reluctant to take on the issue, despite pressure from affected user groups. In Massachusetts, we believe that by working together and maximizing limited resources we can stem the flow of species across our borders by educating the public and affected industries on the threat and impacts of these species. It is important to acknowledge that most of the pathways that species use to move from place to place – ballast water, boat fouling, private and public aquaria, aquaculture, seafood industry, etc.—are largely unregulated in terms of preventing species invasions. However, by creatively raising awareness of these pathways and by changing behaviors of different users and industries, the likelihood of introductions can be significantly reduced. This Plan provides a blueprint for Massachusetts to make headway in protecting our natural systems and economy from the potentially devastating effects of aquatic invasive species.

Table A: Implementation Table and Budget Summary for the Massachusetts Aquatic Invasive Species Management Plan.

Strategic Action	Tasks/Actions Task Description	year	Planned Efforts (\$000/FTEs)								Future Needs \$(000)/yr
			FY '02				FY '03				
			dedicated		seeking		dedicated		seeking		
		\$ (000)	FTE	\$ (000)	FTE	\$ (000)	FTE	\$ (000)	FTE		
1A	Coordinate Massachusetts AIS Management Activities	1, ongoing	84	1.4	75	1.25	84	1.4	75	1.25	75
1B	Coordinate With Other States and Nations	1, ongoing	37	0.25			25	0.25			
1C	Coordinate with Federal Agencies on AIS Management	ongoing	3				3				
2A	Assess the Risks of Priority AIS	1,2	330				60				
2B	Coordinate with Industries in Managing AIS	1, 2, ongoing	10								
2C	Educate Industry Representatives	2									
2D	Improve AIS Data Management	1	31	0.2							
2E	Prevent Introductions Via Commercial Shipping	1, 2	29		5				10		
2F	Prevent Introductions Via Recreational Boating	1, 2, ongoing	18		47	0.2			45	0.2	2
2G	Prevent Introductions Via the Seafood Industry	1			10						
2H	Prevent Introductions Via the Aquaculture Industry	1, ongoing	7	0.1	40	0.5			40	0.5	40
2I	Prevent Introductions Via the Bait Industry	1	7	0.1	5						
2J	Prevent Introductions Via Aquatic Plant Dealers	1, 2, ongoing	30	0.5			30	0.5			
2K	Prevent Introductions Via Research Facilities	1 to 5									
2L	Prevent Introductions Via Aquatic Organism Suppliers	1 to 5, ongoing			5						
3A	Monitor for AIS in Massachusetts Coastal Waters	1 to 5	50						10		
3B	Monitor for AIS in Massachusetts Freshwater Systems	1, 2, ongoing	150	3	50	0.5	150	3	140	1.5	95
3C	Assist in the Development of Improved Monitoring Technologies	2									
4A	Monitor Massachusetts Waters for New Invasions as Outlined in Objective 3										
4B	Identify Resources for Eradicating New Introductions	1,2,ongoing	60	1	85		72	1.2	75		75
4C	Develop an Early Response Protocol	1 to 5, ongoing			45	0.5			45	0.5	22.5
4D	Evaluate the Risk of Introductions of Priority Species	2							30		
5A	Implement Early Response Protocols Outlined in Objective 4										
5B	Support Development of AIS Control Technologies	1, ongoing			2				2		2
5C	Identify Priority AIS for Management	1									
5D	Disseminate Information on Existing Controls for Priority Species	1, 2	465				440				
5E	Expand Funding for AIS Management	2	250				250				
5F	Monitor the Effectiveness of AIS Control Efforts	2, ongoing	6	0.1	24	0.2	6	0.1	24	0.2	10
5G	Control Established Aquatic Macrophytes	ongoing			65				65		30
6A	Distribute Regional AIS Educational Materials	1, 2, ongoing	5				5				
6B	Distribute Materials Targeted at Priority AIS	1, ongoing	16								
6C	Distribute Materials Targeted at AIS Transport Vectors	1 to 5, ongoing	35		20				20		10
7A	Identify Research Priorities	1, 2, ongoing							20		20
8A	Evaluate Authority to Restrict AIS Imports	2, ongoing			10						
8B	Make Recommendations Regarding Legislative Needs	2, ongoing									
Totals			1,623	7	488	3	1,125	6	601	4	382

Total Match (FY02-FY03)	\$2,748, 000
Total Sought (FY02-FY03)	\$1,089, 000

I. Introduction

The introduction and spread of **aquatic invasive species** (AIS) in the marine and freshwater environments of Massachusetts pose a serious threat to the ecology of **native** systems, and can effect the economic stability of the Commonwealth. These **nonindigenous** species have the potential to establish and spread rapidly, due to a lack of physical and biological constraints in the habitats to which they have been introduced. The range of impacts these organisms can have on aquatic systems is extensive, including the loss of habitat and community diversity, the localized or complete extinction of rare and endangered species, the spread of human **pathogens**, and the choking of waterways, water intakes, and wetland systems.

The proliferation of aquatic invaders has come at great cost to Massachusetts. While no comprehensive study of economic impacts has been conducted, Massachusetts has expended significant funds for the management of aquatic invaders, and has incurred the indirect costs associated with the impacts of these species. State agencies spent over half a million dollars in 2001 on the control of nonindigenous aquatic plants through cost share assistance and direct control efforts on state lands. This figure does not include extensive control efforts undertaken by municipalities and private landowners, lost revenue due to decreased recreational boating, fishing, and swimming opportunities, or documented decreases in property values due to infestations of neighboring lakes and ponds by aquatic macrophytes (Hsu, 2000). A Cornell University study (Pimentel, 1999) estimates a loss of \$44 million per year to New England and the Canadian Maritime Provinces due to predation on commercially valuable shellfish by the introduced European green crab (*Carcinus maenas*). During the drafting of this plan the aquatic invasive plant hydrilla (*Hydrilla verticillata*) was identified for the first time in Massachusetts in a Cape Cod pond. This notorious invader can spread rapidly within and between lakes and ponds, quickly altering the balance of aquatic systems. In addition to established invaders, nonindigenous species known to have had disastrous effects on the ecosystems and economies of other states, such as the zebra mussel (*Dreissena polymorpha*), are rapidly encroaching upon the borders of Massachusetts and its **watersheds** (Figure 1).

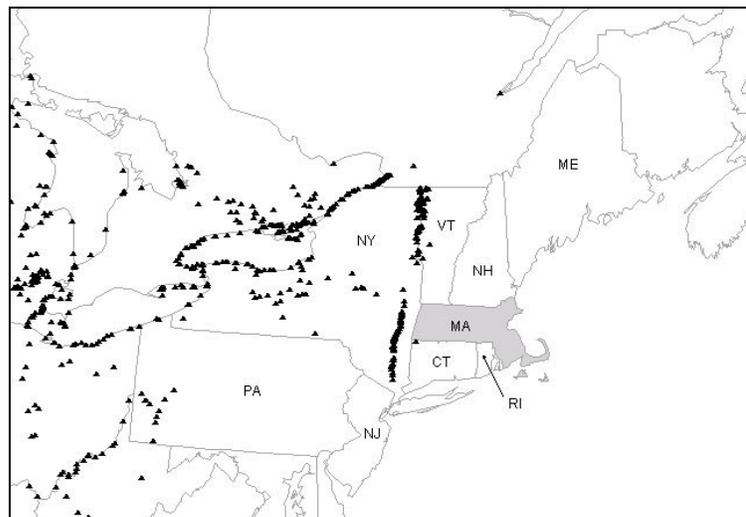


Figure 1: November 2000 zebra mussel distribution in the Northeastern US (USGS, 2002)

Recognizing the importance of the invasive species issue, the Massachusetts Executive Office of Environmental Affairs (EOEA) established the Council on Invasive Species (the Council) in 1999. The Council is charged with coordinating invasive species management activities within the Commonwealth, and facilitating forward movement on new initiatives to prevent and control biological invasions in the state. This Massachusetts Aquatic Invasive Species Management Plan represents the efforts of the Aquatic Invasive Species Working Group, a subcommittee of the Council, to address the overarching goal of *implementing a coordinated approach to minimizing the ecological and socio-economic impacts of aquatic invasive species in the marine and freshwater environments of Massachusetts*. More specific goals addressed through the development and implementation of this management plan are as follows:

- 1) Educate the public about threats from aquatic invaders and measures that can be taken to prevent their further introduction and spread.
- 2) Reduce the potential for the introduction of AIS into Massachusetts waters through preventative measures.
- 3) Control the spread of established AIS to uncolonized waters of Massachusetts.
- 4) Minimize harmful ecological, socioeconomic, and public health and safety impacts from aquatic invaders that have been introduced to Massachusetts waters.

Massachusetts has further recognized the limited success worldwide in the eradication of established **populations** of aquatic invaders, as well as the potentially detrimental impacts to native populations resulting from some invasive species control efforts. As a result, management objectives and actions outlined in the plan are heavily weighted towards the prevention of new introductions and the education of interest groups and the general public regarding their role in minimizing the spread and transport of these species.

Scope of the Aquatic Invasive Species Management Plan

Section 1204 of the Aquatic Nuisance Prevention and Control Act of 1990 (amended as the National Invasive Species Act of 1996) specifically calls for states to develop comprehensive Nonindigenous Aquatic Nuisance Species Management Plans. 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 (ANS Task Force, also established by the 1990 Act). In developing this plan, the Massachusetts Aquatic Invasive Species Working Group has closely followed the *Guidance for State and Interstate Aquatic Nuisance Species Management Plans* developed by the ANS Task Force (2000).

Management actions outlined in this document are targeted at both marine and freshwater AIS. For the purposes of this plan, **aquatic invasive species** are defined as *nonindigenous or cryptogenic species that threaten the diversity or abundance of native species or the ecological stability and/or uses of infested waters* (adapted from the Aquatic Nuisance Prevention and Control Act of 1990). The term **aquatic** refers to open waters of marine and freshwater environments as well as coastal and freshwater wetlands. (Note: In many cases, legislation relevant to invasive species management uses alternate terminology for invasive species such as **nuisance** or **exotic**. When referencing programs established by various

legislative efforts in this document, the terminology used in each act or regulation has been retained. The Glossary in Section VII provides definitions for bolded terms.)

While the authority and programs outlined in this plan are generally limited to the political boundaries of Massachusetts, it is recognized throughout that there is a need for interstate and international cooperation to prevent the introduction and spread of AIS. In particular, this plan describes efforts to coordinate with Northeastern US states, as well as bordering Canadian provinces, through the recently formed Northeast Regional Panel of the Federal ANS Task Force.

Process and Participation

Massachusetts established the Aquatic Invasive Species Working Group (the AIS Working Group) in the fall of 2000 to coordinate and enhance efforts for the prevention and management of AIS through the development of this management plan. The Working Group is made up of 18 representatives from 14 state and federal agencies, academic institutions, and a consulting group (Appendix A) and has worked to coordinate existing management efforts, identify priority invasive species to target for prevention and control, and develop specific management objectives and actions.

Many Working Group members serve on additional committees involved in invasive species management initiatives in Massachusetts and the region, including the Massachusetts Lakes and Ponds Watershed Action Strategy, the Silvio O. Conte National Wildlife Refuge Invasive Plant Control Initiative, and the Northeast Regional Panel of the ANS Task Force (each described below). Integration of these committees into the AIS Working Group has ensured that management measures outlined in this plan represent a fully coordinated approach.

Public comment during the development of this document has been an important component of the planning process. AIS Working Group members led public scoping meetings in Metropolitan Boston, the North Shore, South Shore, Cape Cod and Islands, Central, and Western regions of Massachusetts. Participants represented a range of organizations and interests and included conservation commissioners, harbormasters, watershed associations, municipal representatives, industry representatives, and others. Scoping meetings were successful in offering the Working Group a local perspective on AIS issues, and wherever possible, comments received at these meetings have been incorporated into the Management Objectives and Actions of Section IV. A summary of questions, comments, and responses given at each public scoping meeting is included in Appendix B. A draft version of the AIS Plan was also posted on the Massachusetts Office of Coastal Zone Management (CZM) web, and notice of a public comment period was published in the *Environmental Monitor* (Executive Office of Environmental Affairs, 2002) soliciting feedback on the draft Plan from all interested parties. The AIS Working Group will continue to incorporate suggestions received through outreach efforts into future revisions of this Plan.

Relationship to Existing Management Efforts

Currently, multiple initiatives in Massachusetts and the Northeastern United States are working to address AIS issues in the state and region. Several of these initiatives have been developed concurrently with this Massachusetts AIS Management Plan, underscoring the

heightened awareness of AIS problems and concerns in the region over the past year. Members of the Massachusetts AIS Working Group are part of each of the initiatives described below. These existing and developing management efforts have been beneficial to the development of this plan by identifying needs within the region, state, and in local watersheds, many of which have been addressed by the AIS Working Group in this document.

Northeast Regional Panel of the Federal Aquatic Nuisance Species Task Force

Section 1203 of the National Aquatic Nuisance Prevention and Control Act of 1990 directs the federal ANS Task Force to encourage the development and use of regional panels to:

- 1) Identify priorities for each region with respect to aquatic nuisance species.
- 2) Make recommendations to the Task Force regarding education, monitoring (including inspection), prevention, and control of nuisance species.
- 3) Coordinate, whenever possible, other aquatic nuisance species program activities in each region.
- 4) Develop an emergency response strategy for federal, state, and local entities for stemming new invasions of aquatic nuisance species in the region.
- 5) Provide advice to public and private individuals and entities concerning methods of preventing and controlling aquatic nuisance species infestations.
- 6) Submit an annual report to the Task Force describing activities within the region related to aquatic nuisance species prevention, research, and control.

Once formally recognized by the federal ANS Task Force, each regional panel becomes eligible for limited funding for implementation.

Until recently, regional panels existed only for the Great Lakes Region, the Western United States and the Gulf of Mexico. Recognizing the need for interstate and international cooperation on AIS issues in the Northeast, CZM and the AIS Working Group have taken the lead in forming a Northeast Regional Aquatic Nuisance Species Panel (the Northeast Panel). The Northeast Panel will include state, federal and regional government representatives, as well as non-government organizations from the states of New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine, and the Canadian provinces of Nova Scotia, New Brunswick, and Quebec. The Northeast Panel was recognized by the federal ANS Task Force in July of 2001, and development of the first annual work plan is underway.

The Massachusetts Council on Invasive Species

The Council on Invasive Species was established in 1999 by EOEa to serve as a coordinating mechanism for the various invasive species management activities undertaken by Massachusetts state agencies. The Council addresses both terrestrial and AIS management issues and is comprised of four member groups, including:

- The Massachusetts Invasive Plant Group.

- The Invertebrate Invasives and Biocontrols Group.
- The Wildlife and Plant Diseases Group.
- The AIS Working Group.

All member groups of the Council will meet periodically to update stakeholders on invasive species management activities and coordinate any overlapping management initiatives.

The Massachusetts Invasive Plant Group (MIPG)

A broad based coalition of state and federal governmental agencies, MIPG formed under the leadership of the Silvio O. Conte Refuge (below) in order to:

- 1) Share invasive plant information among members.
- 2) Educate the public and other interest groups about invasive plants and their control.
- 3) Promote native alternatives to those nonindigenous species still being used for various purposes in Massachusetts.
- 4) Promote research in the field of invasive plant management.

MIPG has drafted a standard definition and set of biologically based criteria upon which to objectively evaluate plants suspected to be invasive in the state. Existing data about these species are being gathered to identify those that are currently invasive in Massachusetts and those that have the potential to become problematic. Once the status is known, an action plan will be developed and educational efforts will begin. MIPG will serve as an important advisory committee for state agencies working to develop control strategies and identify invasive plant priorities.

The Massachusetts Invertebrate Invasives and Biocontrols Group

The Invertebrate Invasives and Biocontrols Group is made up of representatives of each of the EOE agencies, including the Department of Environmental Management (DEM), Department of Fisheries, Wildlife, and Environmental Law Enforcement (DFWELE), Department of Environmental Protection (DEP), Metropolitan District Commission (MDC), Department of Food and Agriculture (DFA), and CZM. This group has most recently focused on the Hemlock Woolly Adelgid (*Adelges tsugae*), which is documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves. The Invertebrate Invasives and Biocontrols Group has overseen the pilot introduction of the Japanese Lady Beetle (*Harmonia axyridis*) to control the adelgid. The group also evaluated the safety of releasing leaf-eating *Galerucella* beetles to control purple loosestrife in several Massachusetts wetlands. Next tasks include developing a Biocontrols Release Protocol that protects against secondary impacts from invertebrates intentionally introduced to control invasive species, and an Invertebrate Prevention Protocol for preventing the natural spread or accidental introduction of invasive invertebrates such as the Asian Longhorn Beetle (*Anoplophora glabripennis*) and zebra mussel.

The Massachusetts Wildlife and Plant Diseases Group

The Wildlife and Plant Diseases Group is made up of a small group of veterinarians and biologists conducting research and monitoring of wildlife and plant diseases that are presently infecting flora and fauna in the state or pose the threat of introduction or natural spread to Massachusetts. Representatives from Tufts University and the Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program lead this small network of specialists undertaking research and monitoring of wildlife and plant diseases. The parasite *pfisteria* that is affecting fish in Maryland, and the West Nile virus, a new danger to people in Massachusetts that is also showing impacts to the state's avian species, are among the afflictions being studied and monitored by the group.

The Silvio O. Conte National Fish and Wildlife Refuge Invasive Plant Control Initiative

The Silvio O. Conte National Fish and Wildlife Refuge has developed an Invasive Plant Control Initiative in response to the threat to natural diversity posed by invasive plant species. This initiative examines the problem of freshwater invasive plants from a regional perspective and identifies tasks that will enhance the capability within the region to address identified issues.

In cooperation with a number of partners, the Refuge obtained a grant from the National Fish and Wildlife Foundation to develop a strategic plan discussing the state of the issue, outlining future actions for the Connecticut River Watershed and Long Island Sound, and recommending funding for high priority invasive plant control projects in 1998. The Connecticut River Watershed/Long Island Sound Invasive Plant Control Initiative Strategic Plan was completed and distributed in March of 1999. This plan identifies problem plants in the watershed, gives a detailed description of the efforts of agencies and organizations working to mitigate the problem, and makes recommendations for additional management activities.

As part of the initiative, a partnership of federal, state, municipal, business and non-profit groups formed to control water chestnut (*Trapa natans*), a new invader to the watershed. Components of the strategy include mechanical harvesting of the source population and organizing volunteers to monitor water bodies for satellite populations within the watershed, hand-pulling them when found.

The AIS Working Group has incorporated actions in the Massachusetts AIS Plan that address needs identified in the Connecticut River Watershed/Long Island Sound Strategic Plan including the development of priority species lists, education of specific stakeholders regarding the invasive plants problem, and coordination of resources within and across New England States. The AIS Working Group will continue to work with proponents of the Invasive Plant Control Initiative to ensure that management efforts in the Connecticut River Watershed are coordinated with state and regional initiatives.

The New England Invasive Plant Group (NIPGro)

In keeping with its aquatic invasive plant management priorities, the Silvio O. Conte Refuge has taken the lead in the establishment and administration of both MIPG (above) and the New England Invasive Plant Group (NIPGro). NIPGro is a networking link among the organizations and agencies involved with terrestrial and freshwater aquatic invasive plant issues in the region. Priorities of the group include:

- 1) Minimizing new introductions to the region by instituting an early warning and response system.
- 2) Using the NIPGro network to exchange information, share educational materials, identify research needs, and establish links with researchers.
- 3) Developing standardized criteria for creating priority species lists.
- 4) Coordinating control efforts.

Funding was recently granted by the US Department of Agriculture to support the development of an Invasive Plant Atlas of New England, which will be the foundation of an early warning and response system for the region. The University of Connecticut will be overseeing the Atlas work, assisted by the New England Wild Flower Society. The grant will also provide the salary for the NIPGro coordinator from 2002-2005. Massachusetts and the Northeast Regional Panel will work closely with NIPGro on various AIS management issues, and, in particular, on the sharing and organization of invasive species distribution information.

The Massachusetts Lakes and Ponds Watershed Action Strategy

In the fall of 2000, the Massachusetts Secretary of Environmental Affairs assembled a Blue Ribbon Committee on Lakes and Ponds (the Committee) to develop a Lakes and Ponds Watershed Action Strategy for the Commonwealth. The Committee worked to develop a plan for the improvement of lake and pond protection efforts, and identified priority management objectives, including the support of local lake and pond stewardship, the protection of biodiversity and habitat, and the establishment of an invasive species response team.

Currently, the Committee is working to implement the action plan through development of demonstration projects, coordination with watershed groups and municipalities, and enhancement of existing program areas such as the DEM Lakes and Ponds Program. The AIS Working Group has worked closely with the Blue Ribbon Committee to ensure that these efforts are coordinated, and that needs identified in the Lakes and Ponds Watershed Action Strategy have been integrated into the Management Objectives and Actions section of this plan. Consequently, recommended activities and implementation efforts developed by the Committee comprise a significant portion of freshwater management efforts outlined in Section IV of this plan.

The Guide to Lake and Pond Management in Massachusetts

DEM and DEP are joint proponents of a General Environmental Impact Report (GEIR) on eutrophication and control of aquatic vegetation in the lakes and ponds of Massachusetts. Upon finalization of this report, DEM and DEP will issue a "Guide to

Lake and Pond Management in Massachusetts.” This guide will provide the non-technical reader with the key information in the GEIR along with information that will help citizens and town conservation commissions more clearly understand options for lake management, including control techniques for both native and nonindigenous aquatic weeds. The guide will provide the basis for more informed and consistent decisions by municipalities on lake and pond management projects through training programs for conservation commissioners. Additionally the guide will lay the foundation for many of the lakes and ponds education and training initiatives outlined in Section IV.

II. Existing Authorities and Programs

Relevant programs that currently address the AIS problem at the federal, regional, and state level are described briefly in the following paragraphs with emphasis on those that have been active in Massachusetts and are necessary to facilitate the implementation of this plan. Where possible, the AIS Working Group has developed the management actions outlined in Section IV based on expansion of the capabilities of these existing programs, particularly at the state and regional level.

Federal Authorities

At the federal level, no single agency has authority over the management of AIS. Rather, multiple agencies have developed invasive species programs, largely in reaction to severe AIS issues. Effective invasive species management in the United States will require federal agencies to expand existing efforts to deter nonindigenous species introductions through the oversight of international and interstate trade and commerce and associated transport **vectors** such as commercial shipping and the trade of organisms via mail order and the Internet (Section III).

The federal government first responded to the invasive species issue in reaction to the devastating economic and ecological impacts of the zebra mussel introduction to the Great Lakes. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA, PL 101-646), amended and broadened in scope as the National Invasive Species Act of 1996, calls for the development of state aquatic nuisance species management plans and outlines the following objectives (Section 1002):

- 1) To prevent further unintentional introductions of nonindigenous aquatic species.
- 2) To coordinate federally funded research, control efforts and information dissemination.
- 3) To develop and carry out environmentally sound control methods to prevent, monitor, and control unintentional introductions.
- 4) To understand and minimize ecological damage.
- 5) To establish a program of research and technology development to assist state governments.

Section 1201 of NANPCA establishes the federal interagency ANS Task Force. The ANS Task Force is charged with coordinating federal aquatic nuisance species management efforts with the efforts of the private sector and other North American interests. The ANS Task Force is responsible for initiating research programs, planning initiatives, and policy direction for the prevention, detection and monitoring, and control of aquatic nuisance species, and operates through regional panels as well as issue-specific working groups that address particularly problematic invaders.

An additional element of NANPCA is the establishment of ballast management regulations. Under Section 1101 of the Act, the US Secretary of Transportation is charged with developing mandatory **ballast water** guidelines for the Great Lakes (and later for the upper Hudson River). This task was delegated to and completed by the US Coast Guard, the lead federal

agency for ballast water management issues. Amendments to NANPCA in 1996 directed the Secretary to extend ballast water management regulations to the remainder of US waters. Developed and implemented by the Coast Guard in July of 1999, the Voluntary National Guidelines apply to waters outside of the Great Lakes Ecosystem. This voluntary program consists of a suite of ballast water management (BWM) guidelines, and includes a requirement that all vessels entering US waters from outside the Exclusive Economic Zone file a BWM report. A third Coast Guard related element of the 1996 amendments was the publication of voluntary guidelines aimed at controlling the spread of AIS through recreational activities (i.e., boating, fishing, SCUBA diving, etc.) The Coast Guard worked with the ANS Task Force to complete these guidelines in December of 2000.

Federal programs dealing with nonindigenous species that existed prior to the passage of NANPCA are largely related to interstate and international transport of known pest plants and animals and the protection of valuable horticultural, aquacultural, or endangered species. These laws include:

- **The Lacey Act of 1900 (and amendments):** The Lacey Act establishes a permitting process administered by the US Fish and Wildlife Service regulating the importation and transport of vertebrates, mollusks, and crustacea that are "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States." The Secretary of the Interior maintains the Injurious Species List.
- **The Federal Seed Act of 1939 (and amendments):** This act prohibits the importation of seeds of unknown type and origin by ensuring the purity and proper labeling of seed imports.
- **The Endangered Species Act of 1973 (and amendments):** The Endangered Species Act can be used to authorize the eradication or control of AIS in the case that a listed species is threatened by the invader's presence or spread.
- **The Plant Protection Act of 2000 (amending the Noxious Weed Act of 1974).** The Plant Protection Act gives the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) the authority to prohibit the import and interstate transport of species included on the Noxious Weed List developed by the USDA. In cooperation with state agricultural departments, APHIS annually designates priority agricultural pest species for annual intensive monitoring efforts.

The most recent invasive species initiative developed at the federal level came in February of 1999 with Executive Order 13112. This order establishes the National Invasive Species Council, a federal interagency organization charged with the biennial development of a National Invasive Species Management Plan.

Federal Programs and Activities

In addition to the regulations outlined in the above legislation, several government agencies have recognized the severity of the invasive species problem, and have adopted the management and control of invasive species as priority programs areas.

The US Fish and Wildlife Service (USFWS)

The USFWS has traditionally been the lead in dealing with invasive species at the federal level and is co-chair of the federal ANS Task Force. Thus, the USFWS provides technical assistance to states in developing invasive species control plans. The USFWS has been active in AIS management activities in Massachusetts through the Silvio O. Conte National Wildlife Refuge Invasive Plant Control Initiative and control efforts at other refuges within Massachusetts. In addition to these activities, the USFWS administers grants that can be used for invasive species management through the Wildlife Restoration Program (Appendix C).

The US Geological Survey (USGS)

The USGS has acknowledged its role in nonindigenous species management in a White Paper on Invasive Species, in which the goal of developing new strategies for the prevention, early detection, and prompt eradication of new invaders is identified. The USGS further identifies information management and documentation of invasions as a priority for the agency. In keeping with this objective, the USGS has developed and maintains an extensive, spatially referenced database of nonindigenous species, which is accessible via the Internet (<http://nas.er.usgs.gov/>).

The US Department of Agriculture (USDA)

Through the APHIS Cooperative Agricultural Pest Survey (CAPS), the USDA works with state agricultural agencies to monitor for agricultural pests and noxious weeds. Individual state monitoring programs are directed by a state survey committee, which is made up of representatives from state agencies and scientific institutions. Each year, the state survey committee reviews an APHIS recommended list of potential pests for survey (the Noxious Weed List), and chooses one or more for annual surveillance efforts. Target species may include weeds, plant diseases, insects, and other invertebrates. APHIS also cooperates with the US Customs Service to limit the import of specified plant pests and their hosts into the country.

Massachusetts Institute of Technology (MIT) Sea Grant College Program

The National Sea Grant College Program was established in 1966 to foster research, outreach, and education for the promotion of sustainable development of coastal regions. The Program has played an active role in research on invasive species issues in the United States through projects such as the National Aquatic Nuisance Species Clearinghouse, the Zebra Mussel Training Initiative, and a competitive grant program for invasive species research and outreach projects.

MIT Sea Grant has been at the forefront of marine invasive species research and management in Massachusetts. MIT Sea Grant sponsored the First International Conference on Marine Bioinvasions in 1999. In the summer of 2000, MIT Sea Grant worked with Massachusetts state agencies and organizations to conduct a Rapid Assessment Survey of Invasive Species on floating docks and piers along the Massachusetts and Rhode Island Coast. The survey documented the presence and distribution of 24 nonindigenous and 49 cryptogenic species, developing some of the baseline information necessary to designate invasive species

management priorities in New England marine systems. This program also heightened awareness of AIS threats to Massachusetts and generated momentum towards the development of this plan.

State Authorities and Programs

To date, Massachusetts AIS management activities have been dominated by the management of aquatic invasive plant species in lakes and ponds. Otherwise, AIS management efforts in Massachusetts have included programs to protect native shellfish resources and manage agricultural pests (largely in terrestrial environments). Recently, the need to expand existing programs in freshwater systems and develop marine program areas has been recognized. Through the coordinating efforts and action strategies outlined in this document, and through the coordinating efforts of the Massachusetts Council on Invasive Species and member groups, existing program areas will be expanded to more comprehensively address AIS priorities in Massachusetts. The following is an overview of the current roles of Massachusetts agencies and organizations involved in invasive species management.

Department of Environmental Management (DEM) Lakes and Ponds Program

DEM is the primary land management and natural resource planning agency, as well as the largest landholder in Massachusetts. Under MGL c.21 §37, DEM is required to establish an aquatic nuisance control program that must:

- 1) Receive and respond to aquatic invader complaints.
- 2) Work with municipalities, local interest organizations, and agencies of the state to develop long-range programs regarding aquatic nuisance controls.
- 3) Work with federal, state and local governments to obtain funding for aquatic nuisance control programs.
- 4) Administer an aquatic nuisance species grants program.

The aquatic nuisance species control program is geared towards freshwater species and is administered by the DEM Lakes and Ponds Program. The program manages a variety of lake improvement projects as well as providing technical assistance, education, and outreach to Massachusetts lake and pond managers. While the aquatic nuisance control program has never been directly funded, DEM has dedicated resources to the above tasks through the Lakes and Ponds Program and, more recently, through the Lakes and Ponds Watershed Action Strategy (though full compliance with the Act is not possible without additional funding). DEM also administers the Lakes and Ponds Grant Awards Program, which provides funds for the control of incipient aquatic invasive plant infestations (Appendix C).

Department of Environmental Protection (DEP)

DEP has three main program areas relevant to the management of AIS:

- 1) **Monitoring and Assessment of Surface Waters:** DEP, through its Division of Watershed Management, Watershed Planning Program, has had an active lake monitoring and assessment program for 27 years (MGL c.21 §27(8)). These activities have included the identification of aquatic **macrophytes**, both native and nonindigenous. Monitoring and

assessment work conducted by the Watershed Planning Program leads to the development of assessment reports that identify impaired waters, including lakes impaired by non-native macrophytes, and recommend activities to remedy the impairments.

- 2) Administration of the Herbicide License Program: The Watershed Planning Program approves aquatic herbicide application projects for native or non-native plants on individual water bodies through its Licenses to Apply Chemicals for the Control of Nuisance Aquatic Vegetation (Herbicide Licenses; MGL c.111 §5E). At present, DEP has limited staff time dedicated to the Herbicide Licensing Program and is seeking additional resources to provide for more thorough review of licenses and monitoring of effectiveness.
- 3) Administration of the Wetlands Protection Act: The DEP Wetland and Waterways Program administers and enforces the Massachusetts Wetlands Protection Act (MGL c.131 §40). Under this act, any activity that occurs within the 100-foot wetland buffer, including the removal or control of vegetation or other organisms, must be permitted by DEP and town conservation commissions (also set up by the act). Conservation commissions may also govern practices and activities within the 100-foot jurisdictional boundary through the passage of local ordinances.

Department of Food and Agriculture (DFA)

DFA is responsible for the monitoring and regulation of plant imports to Massachusetts. DFA works closely with the USDA to limit introductions of (largely agricultural) plant pests through the following program areas (MGL 128:16-31):

- 1) The DFA Pesticide Bureau administers all state and federal regulations related to the use of pesticides, including those used in aquatic environments. DFA must approve and register all pesticides before they can be licensed by DEP for application in Massachusetts.
- 2) DFA funds and is involved with Research and Demonstration programs at the University of Massachusetts concerning Integrated Pest Management. While most of these research initiatives are based in agriculture, there is potential for these efforts to consider aquatic environments. Further, DFA administers the Gro-Enviro Technology Grant Program, which may be used to fund projects related to the control of AIS (Appendix C).
- 3) The Bureau of Plant Industries, in cooperation with USDA's APHIS, approves permits to allow nonindigenous organisms into the state. DFA maintains the state Noxious Weeds List, which identifies species prohibited for import and sale in Massachusetts. State surveys are run through CAPS (see federal programs: USDA) in cooperation with the University of Massachusetts. MGL c.128 §20A prohibits the deliberate sale or movement of water chestnut (*Trapa natans*) plants or propagules.
- 4) DFA conducts annual inspections of all nurseries and water garden suppliers, which include screening for prohibited non-indigenous plants, plant pests, and noxious weed species.

DFA has general responsibility for pet shop licensing and oversight (with the exception of “fish only” pet shops) and promotion and marketing of the **aquaculture** industry and its products. DFA provides technical assistance for the aquaculture industry (permit development, operations, etc.) and administers the Massachusetts Aquaculture Grants Program.

Division of Marine Fisheries (DMF)

Under MGL chapter 130 (various sections), DMF is given the authority to regulate the sources of shellfish for aquaculture. The goal of this legislation and the resulting permitting program is to protect native shellfish resources from possible introductions of non-endemic diseases, parasites, predators, and to protect the genetic integrity of local shellfish resources. A permit is required to “...plant, transplant, or introduce for the purposes of transplanting seed or adult oysters, into any waters or into any shellfish areas within the Commonwealth.” DMF has established guidelines for acceptable shellfish seed sources, and is able to regulate the transport of any species designated as a threat to these resources (322 CMR).

Massachusetts Office of Coastal Zone Management (CZM)

CZM has 27 federally approved coastal policies that guide the implementation of its program. These policies, relating to water quality, habitat, protected areas, coastal hazards, port and harbor infrastructure, public access, energy, ocean resources and growth management, are all backed by the legal authority of sister state agencies. By virtue of having a federally approved coastal plan, CZM has "federal consistency" jurisdiction over projects located in the state coastal zone that are either direct federal actions, receive federal funds, or require federal permits. Federal consistency review gives CZM the authority to ensure that all projects under its jurisdiction are consistent with state CZM policies. Although CZM policies do not directly address AIS, Ocean Resources Policy #1 states among its guidelines for aquaculture siting, "Utilize technologies and species which are compatible with local conditions and do not threaten the biological diversity of our marine waters." CZM does not have independent authority to regulate any aspect of the AIS problem.

CZM has identified AIS as a priority for action, both in its recent five-year Section 309 Assessment and Strategy and in its recent grant application to the National Oceanic and Atmospheric Administration (NOAA). CZM was a co-sponsor of the 2000 Rapid Assessment Survey of Invasive Species in coastal Massachusetts and has led efforts to develop the AIS Management Plan. In addition, CZM initiated the formation of the Northeast Regional Panel of the ANS Task Force.

Massachusetts Bays National Estuary Program (MBP)

MBP has identified habitat protection, which includes addressing invasive species issues, as an important action item in its Comprehensive Conservation and Management Plan (CCMP). Recent revisions to the CCMP have elevated the management of invasive species to a top priority action item. MBP has worked cooperatively with other state agencies to conduct the 2000 Rapid Assessment Survey of Invasive Species in coastal waters and has provided financial support for the development of the AIS Management Plan.

Division of Fisheries and Wildlife (DFW)

DFW is charged by law to conserve, maintain, and protect the natural and aesthetic qualities of the environment for the benefit and enjoyment of the people (MGL chapters 21, 131, and 131A). Authority is shared with the USFWS for migratory birds, anadromous fish (in fresh water), and federally threatened and endangered species. DFW regulations, which are designed, in part, to help prevent the establishment of nonindigenous vertebrate species, relate to the following issues:

Vertebrate Importation: DFW has enacted regulations that prohibit the importation of fish, amphibians, reptiles, birds, and mammals into the Commonwealth without an importation permit (321 CMR 2.15 (6)).

Fish Liberation: Release of live fish or spawn requires both a Liberation Permit and a Health Certificate (321 CMR 2.15(5)) that ensures that fish have been tested for certain pathogens, both of which are issued by the Department of Fish, Wildlife, and Environmental Law Enforcement (parent agency of DFW and DMF).

Fish Transport: Transport of any live fish (except legal baitfish) without a permit is prohibited and monitored by the DFW (321 CMR 2.15(6)).

Bait Fish Sale and Harvest: DFW designates fish species that can be harvested for both personal and commercial uses (321 CMR 4.01) as well as those that are allowed for import and areas eligible for baitfish harvest. Species that may be imported for commercial sale include eight species commonly found in Massachusetts waters.

Aquaculture: DFW issues licenses for the propagation and culture of fish species. Aquaculture operations are divided into classes based on the types of fish cultured and sold. The type of license is dependent largely on the native range of the species held at each facility (321 CMR 4.09(4)).

Aquarium Fish Sale: DFW exempts all aquarium fish (defined as those species that cannot survive year-round in a wild environment above 30 degrees north latitude) except several species whose introduction is of particular concern in Massachusetts 321 CMR 9.01(3). These fish species have been included in the priority species section of this plan (Section III).

DFW also addresses adverse impacts from the establishment of invasive species through administration and enforcement of the Massachusetts Endangered Species Act (MGL c.131A; 321 CMR 10.00) and by providing comments to conservation commissions under the Wetlands Protection Act (MGL c.131 §40; CMR 10.00).

Finally, DFW has several non-regulatory program areas relating to invasive species management. These efforts include: 1) identifying the problem species in natural ecosystems through biological surveys; 2) educating the public through publications about invasive species; 3) maintaining the Natural Heritage & Endangered Species

Program’s Biological Conservation Database, which identifies habitats threatened by invasive species; and 4) actively removing invasive species through ongoing land management activities and the Habitat Restoration Program.

Massachusetts Port Authority (Massport)

Massport is an independent, public authority that manages, promotes and develops Massachusetts airports, the Port of Boston, and portions of the regional transportation infrastructure. The Maritime Department operates and leases major shipping terminals and related port facilities in Boston Harbor, and plays a role in supporting and promoting the Port of Boston as a whole. While Massport has no program areas directly related to invasive species management, the Maritime Department participates in various interagency working groups to address port-related environmental issues, including ballast water management, and engages in regular outreach and education efforts with the shipping community in relation to these issues.

International Agreements

While international organizations have limited authority in the United States and countries worldwide, organizations such as the International Maritime Organization (below) have taken a lead role in developing policies and guidelines relating to international trade and commerce. Clearly, invasive species management is an international issue, and limiting uncontrolled global transport of AIS will require some reliance on these agencies to shape and implement management strategies.

The International Maritime Organization (IMO)

The IMO was established in 1948 to address safety and pollution mitigation measures for the international shipping industry. The United States plays a leadership role on the Marine Environment Protection Committee (MEPC), which is comprised of all 161 Member States, 37 Intergovernmental Organizations, and 61 Non-Governmental Organizations. The MEPC is empowered to consider any matter within the scope of the IMO concerned with prevention and control of pollution from ships, including ballast water management and the transport of AIS. IMO Assembly Resolution A.868(2) was adopted in 1993 and establishes international guidelines for the control of ballast water, which have served as a model for ballast water management in many countries.

The Gulf of Maine Council on the Marine Environment (GOMC)

GOMC was created in 1989 by the governors and premiers of the jurisdictions that border the Gulf of Maine. The Council’s mission is “to maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations...” Through GOMC, Massachusetts, New Hampshire, Maine, New Brunswick, Nova Scotia, six federal environmental agencies, and five non-government representatives work together to protect their shared resources. GOMC develops action plans that are largely implemented by the member agencies.

While GOMC has no regulatory authority, it is the only binational environmental organization in this region that regularly works together on common problems and, as a result, is in a key position to facilitate interstate and international coordination on AIS issues in the region. As such, GOMC has been selected to serve as the host agency for the Northeast Regional Panel of the Federal ANS Task Force. GOMC will provide administrative and logistical support, and will play an important role in raising public awareness and preparing the Gulf of Maine region to address AIS issues.

Legislative Efforts

Massachusetts Senate Bill no. 1071 (introduced by Senator Susan Fargo) outlines an Act that would expand DEM's current aquatic invasive control efforts to include:

- 1) One full time program coordinator.
- 2) A comprehensive aquatic exotic species monitoring program.
- 3) Development of a comprehensive aquatic nuisance species database.
- 4) A public education program.
- 5) An additional grant program funding public and non-public exotic, aquatic plant control projects, as well as research by academic institutions into new control technologies.
- 6) Maintenance of a comprehensive list of aquatic invasive plants.
- 7) Prohibition of the transport of listed species to be enforced by the Massachusetts Environmental Police.

Many of the items addressed through the bill have been identified as needs in the AIS Management Plan, and its passage would greatly benefit implementation of major components by providing funding and authority for freshwater AIS management efforts. The AIS Working Group will carefully monitor the progress of this bill and make appropriate amendments to this plan based on the outcome (see also Section IV; Objective 8: Legislation).

III. Problems and Concerns

The problem of aquatic invasions poses unique challenges to managers of aquatic systems as well as those developing policy affecting aquatic environments. Unlike other sources of pollution, established populations of aquatic invaders are self-sustaining. As a result, resources must be devoted to both prevention of new introductions and to the control of existing populations of invaders. The introduction of only a few organisms or, in the case of aquatic plants and **algae**, a fraction of an organism, can result in the infestation of a water body, watershed, or an entire **biogeographic region**. These introductions can occur through any number of transport vectors, further complicating preventative measures. The following section highlights some of the major impacts of past introductions, identifies priority pathways by which these species may have been imported, and identifies established and threatening species of greatest concern to the Commonwealth. The discussion and identification of the major problems and concerns outlined below have served as the foundation for the development of detailed Management Objectives and Actions outlined in Section IV.

Aquatic Invasive Species Impacts

Massachusetts currently faces a variety of impacts from aquatic invaders in both fresh and coastal waters, which can have significant and lasting impacts on the Massachusetts economy. Current impacts from AIS generally include:

- Reduced diversity of native plants and animals.
- Impairment of recreational uses such as swimming, boating, and fishing.
- Degradation of water quality.
- Degradation of wildlife habitat.
- Increased threats to public health and safety.
- Diminished property values.
- Declines in fin and shellfish populations.
- Loss of coastal infrastructure due to habits of **fouling** and boring organisms.
- Local and complete extinction of rare and endangered species.

In addition to AIS impacts already experienced in Massachusetts, the effects of encroaching species must also be considered when developing management priorities. For example, Massachusetts has yet to be significantly impacted by fouling invertebrates such as the zebra mussel or Asian clam (*Corbicula fluminea*) in freshwater systems. However, if introduced, these species could have dramatic impacts on water intakes, power generation, and wastewater treatment facilities.

Management Priorities

Targeted strategies will be necessary to prevent new introductions and the spread of established AIS populations. The Massachusetts AIS Working Group has developed a list of transport vectors that have the greatest potential to result in furthering the AIS problem, as well as a list of priority species for management. While the list of priority

transport vectors has become somewhat standardized nationwide, the pathways of introduction are described below in the context of Massachusetts activities. Identified species include both established invaders and those not yet documented in Massachusetts but which have had significant impacts elsewhere. Priority transport vectors and species have been designated based on the most current research in the region (Appendix D) and will be updated as new information becomes available.

In addition to the transport and priority species described below, the AIS Working Group has identified the protection of endangered, threatened, or otherwise rare aquatic species or aquatic ecosystems from encroachment by invasive organisms as a priority for management in Massachusetts. These concerns must be addressed through the designation of priority species and habitats, and on-site management of aquatic invaders.

Transport Vectors

To date, the shipping industry has dominated the field of AIS research in the United States. Although Massachusetts recognizes the threat from ballast water discharge, ports in the Commonwealth may receive relatively little ballast water as compared to other major ports in the US due to local trade patterns (Smith et al., 1999). Massachusetts has recognized the need to evaluate a variety of transport vectors to explain the prevalence of invaders in the region. A coalition of scientists from MIT Sea Grant, Williams College, Northeastern University, and Smith College are working to assess the risk of introduction through a variety of potential pathways including **seafood** companies, aquaculture facilities, bait shops, pet stores, public aquaria, marine research facilities, and wetland restoration efforts (The New England Transport Vector Study, Smith et al., 1999). The research team has developed a database of companies and organizations involved in the transport and trade of both native and nonindigenous organisms and distributed a survey to industry representatives to determine the type, quantity, and frequency of nonindigenous species imports and exports. The survey also inquired about the industry specific handling techniques that could result in AIS introductions. Once completed, the AIS Working Group will reevaluate the relative regional importance of the transport vectors described below and make the appropriate adaptations to the actions identified for each.

Commercial Shipping

Commercial shipping is often considered the most important means of unintentional introductions of AIS to coastal and estuarine waters of the United States and worldwide (Thresher, 2000). The steady rise of global commerce, increased shipping activities, and shorter transport times suggest that the threat of introductions through this pathway is likely increasing. The AIS Working Group has identified ballast water discharge and hull fouling as high priorities for management in this plan.

Ballast Water: Shipping vessels commonly fill and release ballast tanks with seawater from harbors as a means of stabilizing loads. Research clearly indicates that live marine organisms ranging from plankton to adult fish are regularly transported and released via this pathway (Cohen and Carlton, 1995). US Coast Guard regulations recommending

ballast water exchange at sea are currently voluntary. However, low compliance with these guidelines will likely result in a transition to the installation of mandatory ballast water management guidelines nation-wide.

A recent Coast Guard/Massport study of ballast water management practices in Massachusetts suggests that ballast water discharge does occur in Massachusetts, but is likely minimal in comparison to other large US ports (Burke, 2001). However, this study is based on limited ballast water management reporting, and should be revisited as more records become available.

Concern over new AIS introductions to Massachusetts through ballast water discharge, limited knowledge of current ballast water practices, and questions regarding the effectiveness of ballast water exchange point to the following needs:

- Further assessment of the compliance with voluntary US Coast Guard ballast water exchange guidelines among vessels using Massachusetts ports.
- Evaluation of additional needs for mandatory ballast water guidelines.
- Development and evaluation of additional ballast water treatment technologies, both on-board, and dockside.
- Risk assessments of threats posed by different shipping facilities in Massachusetts.
- Increased awareness of the AIS issue to the shipping community.

Hull fouling: Hull fouling may rival ballast water discharge as the leading historical cause of harmful AIS introductions (Thresher, 2000). Organisms with sedentary life history stages can attach themselves to the hulls of commercial vessels or become entangled in submerged ship components. These organisms can survive for extended periods on vessels of any size and be introduced through dislodging, disentanglement, or by spawning in the ports to which they are transported.

Increased awareness by the commercial shipping industry of the threats posed by transported fouling organisms will be necessary to limit introductions through this pathway. In addition, research into environmentally safe and effective antifouling methods will be necessary as traditional tributyltin (TBT) antifouling agents are gradually phased out in many countries worldwide.

Recreational Boating

Lakes, ponds, and coastal waters of Massachusetts provide recreational opportunities for a large population of boaters. The transportation of boats and their trailers between water bodies presents a risk of introduction through hull fouling, entanglement, and water discharge from bilge pumps and bait buckets (Helquist, 2001; Thresher, 2000). The use of recreational boats for fishing poses the additional risk of the release of imported bait species or species that serve as hosts for nonindigenous organisms.

Currently, Massachusetts DEM and DFWELE Public Access Boards educate boaters regarding AIS transport via this pathway through signage posted at many boat ramps

across the state. Extension of this program to include clear labeling of AIS infested waters would further reduce the risk of the transport of established invaders and has been identified as a management objective in the AIS Management Plan. Additional needs include providing public facilities for cleaning of vegetative materials attached to boats and boat trailers.

Bait Industry/Recreational Fishing

The shipment of live organisms into the state for use as bait may serve as pathways of introduction through their release (fish or invertebrates). Packing materials are often comprised of plant or algal matter and could harbor additional organisms. DFW regulates the culture, import, harvest and sale of fish species sold as bait. However the sources of invertebrate imports to Massachusetts for recreational fishing purposes are largely unknown. Massachusetts has limited authority to control the import of invertebrates. The AIS Working Group will evaluate the regulatory needs for minimizing the threats from introduction via this pathway. In addition, DMF and CZM will take the lead in developing and distributing guidance materials for the proper disposal of unused bait and packing materials.

Seafood Import and Sale

The import, sale, and distribution of live and fresh seafood is a historically important component of the Massachusetts economy. Processing and sale of live fin and shellfish constitute a risk of AIS introduction through intentional or unintentional release of live organisms, **parasites**, and pathogens. Specific seafood related pathways of introduction include:

Shellfish waste disposal: Shells and other unwanted materials discarded following shellfish processing (shucking) might harbor shellfish pathogens or live **epiphytes**. 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 of shellfish in flow-through systems subjects the surrounding surface waters to pathogens and other organisms that may be contained in discharged waters. Packing and transport of shellfish in algal or plant material also poses the risk of introductions through the dispersal of packing materials.

Creation of new fisheries: Several introductions of aquatic invaders, such as the Chinese mitten crab (*Eriocheir sinensis*), may have resulted from the intentional release of species that constitute commercially valuable fisheries in other countries (Whitlatch et al., 1995). Seafood suppliers and commercial and recreational fishers, unaware of detrimental impacts resulting from their introduction, may be tempted to release these species into local aquatic systems to establish a self-sustaining population that can be harvested for consumption, pointing to the need for additional educational efforts specific to this pathway.

Aquaculture

Like the seafood industry, aquaculture is an important sector of the Massachusetts economy and will likely see significant growth due to increasing constraints to wild fish harvests in the United States and worldwide (CZM, 1995). While intensive culture of both finfish and shellfish reduces environmental impacts resulting from the harvest of wild stocks, concerns related to water quality impairment, growth and distribution of pathogens, escape of nonindigenous species, and genetic dilution indicate the need for careful planning for this industry. The following are examples of mechanisms for nonindigenous species introductions through intensive aquaculture operations.

Shellfish seed import: Shellfish seed are commonly grown in hatcheries and imported to Massachusetts for use in shellfish culture operations. While DMF carefully 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 out of state. Enhanced culture of local seed stocks in Massachusetts, and an enhanced capacity to identify and manage shellfish diseases will be necessary to minimize the loss of shellfish due to these threats.

Use of cultch: Several shellfish species cultured in Massachusetts seek clean, hard surfaces on which to settle and attach. Placement of shellfish waste (shells and associated materials, or **cultch**) in grow-out areas attracts settling juveniles of desirable species such as the eastern oyster (*Crassostrea virginica*). Concern has been raised over the source and proper disinfections of cultch material and the potential transport of shellfish pathogens or other associated nonindigenous species.

Finfish culture: Growth and maintenance of finfish in open systems such as raceways, flow-through tanks, and net pens expose surrounding aquatic systems to pathogens associated with cultured fish populations. DFW carefully regulates this industry, requiring that species cultured in watersheds where they are not native are isolated from natural systems. The DFW maintains and periodically updates a list of species that can be cultured in Massachusetts under specified conditions.

Genetic dilution: Cultured fin and shellfish often represent imported or altered genetic stocks that are selected for maximum growth or some other desirable trait (i.e., shell shape and color) in the selected culture setting (CZM, 1995). Cultured stocks are usually at a disadvantage in competing with wild populations. However, interbreeding may dilute the wild genetic pool, making offspring more poorly adapted to life in natural systems. While there are currently few marine finfish operations in Massachusetts, such operations are common in other parts of the Gulf of Maine and could make their way to the Massachusetts Coast. Shellfish growing operations are abundant in the Commonwealth, particularly on Cape Cod.

Massachusetts has addressed many of these concerns through existing legislation (see State Authorities and Programs: DFW and DMF). As a result, the AIS Management Plan does not focus heavily on the aquaculture industry. However, several tasks related to the

prevention of introductions through the shellfish and aquaculture industries have been identified Section IV.

Aquarium/Water Garden Trade

Nonindigenous marine and freshwater organisms can be introduced accidentally or purposefully after being imported for use in aquaria and water gardens (Carlton, 2001; Crow & Hellquist, 2000). DFW prohibits the sale of most freshwater fish that can overwinter in the wild in temperate climates. However, freshwater macrophytes available through these industries are often native to temperate regions, and are selected due to 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.

Currently, Massachusetts's authority to monitor and regulate sales of invasive plants and invertebrates through the aquarium and water garden trades is unclear or non-existent. While DFA has authority over pet stores, inspections focus on animal health and safety. The AIS Working Group will form a subcommittee to develop a strategy for managing the import of dangerous aquarium and water garden plants and animals as well as develop and distribute best management practices for the disposal of unwanted aquarium organisms.

Research and Supply

Marine and freshwater species can be ordered from research and education supply companies around the world through catalogue or Internet web sites. While these organisms are generally supplied for research purposes, multiple companies supply species for use in home aquaria. Few organism suppliers, including marine labs and research facilities, require documentation of use and handling practices prior to shipping. Massachusetts has limited capacity to monitor and regulate the import of these species, particularly those that are obtained through mail order or via the Internet. Control of introductions via this pathway is likely a federal responsibility, though states can play a role by ensuring that providers carefully monitor their shipments and provide recommendations for care and handling.

Once organisms are delivered, improper handling techniques may result in the release of nonindigenous imports. Both lab and field routines present the opportunity for accidental or purposeful release through wastewater discharge, disposal of unwanted organisms, poorly contained studies, etc. At least one invasion has been documented in Massachusetts via this pathway (Whitlatch et al., 1995).

The Marine Biological Laboratory, Woods Hole, is currently developing guidelines for both distribution and handling of nonindigenous organisms. Through the implementation of this plan, Massachusetts and the Northeast Regional Panel will undertake steps to ensure that such management practices are considered for implementation by research facilities and laboratories maintaining and distributing live aquatic organisms in the region.

Priority Species (Or Species Groups)

The species described below were designated as high priorities by the AIS Working Group based on the following priority species designation criteria.

- 1) Severity of the problem posed to Massachusetts by the introduced species.
- 2) Existing capabilities for management (species for which management options are currently available are given higher priority).
- 3) Associated costs and benefits of management.

Species were selected based on a review of the most current lists of nonindigenous aquatic species in Massachusetts (Appendix E). Further prioritization was based on evaluation by subcommittees of the Working Group and completion of priority species information templates (table 1).

Table 1: Priority Species Information Template

1) Taxonomic name (or major taxa for groups)
2) Common name
3) Place and time of introduction (if already here)
4) Transport vectors (initial and subsequent)
5) Geographic range
6) Life history (if known) or provide reference
7) Ecological impacts (if known), existing and potential
8) Economic impacts (if known), existing and potential
9) Current research
10) Research needs
11) Current (Massachusetts) management actions
12) Potential/desired management actions

The AIS Working Group will formalize information found in priority species templates and will make this information available once templates have been peer reviewed. The AIS Working Group will update the list of priority species annually based on new information generated through implementation of this plan.

Established Freshwater Species

The following species are established in Massachusetts freshwater systems and are considered highest priorities for management.

Aquatic Macrophytes: To date, invasive freshwater plants have received the greatest amount of attention in Massachusetts among aquatic invaders due to their dramatic and widespread impacts on lakes and ponds throughout the Commonwealth. Many of these species are able to propagate through both seed dispersal and fragmentation, resulting in rapid colonization through a variety of natural and human vectors (Crow and Hellquist, 2000). These species often form dense mats at the water's surface, significantly altering the original community structure, blocking shipping lanes, restricting swimming and

fishing, and generally rendering the waterway unusable. Priority aquatic invasive plants established in Massachusetts include:

- Water chestnut (*Trapa natans*).
- Hydrilla (*Hydrilla verticillata*).
- Curly leaf pond weed (*Potamogeton crispus*).
- Fanwort (*Cabomba caroliniana*).
- Lesser naiad (*Najas minor*).
- Waterweed (*Egeria densa*).
- Yellow floating-heart (*Nymphoides peltata*).
- Eurasian water milfoil (*Myriophyllum spicatum*).
- Variable milfoil (*Myriophyllum heterophyllum*).

Existing control efforts in Massachusetts are conducted largely through local initiatives, many of which receive support from the DEM Lakes and Ponds Program. Improved detection and rapid response to new invasions and additional public education are priority actions for management of aquatic invasive plant species.

Common Reed (*Phragmites australis*): Invading both fresh and saline marshes, *Phragmites* forms dense monocultures, displacing native vegetation and reducing habitat value of many wetland systems (Crow and Helquist, 2000). Often responding to modified drainage, *Phragmites* can impede access to water bodies and completely clog channels and drainage ditches. Removal is by mechanical harvesting, application of herbicides, or restoration of natural **hydrology**, and is difficult and costly. There has been debate over whether *Phragmites australis* is a native species that has aggressively responded to human disturbance or an imported variety better suited to rapid growth in North American wetland environments (Ohio Sea Grant, 2000). Recent research (2002) suggests that an aggressive strain of *Phragmites* has been introduced to North America (Saltonstall, 2002).

Purple Loosestrife (*Lythrum salicaria*): This now prolific wetland species was introduced as early as 1824 in New England and Canada, likely escaping from flower gardens (Crow and Hellquist, 2000). This plant, which is still sold in Massachusetts retail nurseries, is dispersed through seed and rhizomes, and forms dense mats excluding all other plant species in many types of freshwater and brackish wetlands (Hellquist, 2001). While its presence reduces the ecological value of wetland systems, purple loosestrife serves as an important pollen source for bees and commercial beekeeping operations. Currently, management efforts are focused on experimental biological control and are led by the Massachusetts Wetland Restoration Program (MWRP) and the Association of Massachusetts Wetland Scientists statewide. Effective control of this species will require continued monitoring and research into biocontrol effectiveness and elimination of sales through nurseries in the Northeast.

Threatening Freshwater Species

The species listed below have not yet been documented in Massachusetts, but are considered as viable threats to freshwater systems in the Northeastern United States.

Zebra Mussel (*Dreissena polymorpha*): Introduction of the zebra mussel into the Great Lakes and the resulting impacts such as fouling, alteration of community structure, and competition with rare species led to an increased awareness of the AIS problem at the national level, and the passage of the National Invasive Species Prevention and Control Act. Since its introduction in 1988, the zebra mussel has spread throughout many of the major drainage basins of the Midwest and Northeast, including the Mississippi River down to the Gulf of Mexico (USGS, 2002). The zebra mussel has yet to be documented in Massachusetts, but has recently been found in Connecticut in the Housatonic watershed, which lies on the Massachusetts/Connecticut border.

Clearly, keeping the zebra mussel out of Massachusetts is a high priority. Increased efforts towards monitoring for this species, and development of a rapid response strategy will be essential to minimize its impacts on the aquatic environments of the Commonwealth.

Asian Clam (*Corbicula fluminea*): The Asian clam was first reported in the United States in Washington's Columbia River in the 1930s. It was likely introduced intentionally for harvest and consumption purposes (Counts, 1986). Since then it has spread across the country and has been documented in the Connecticut River just a few miles south of the Massachusetts border (Smith, 2001; pers. comm.). The most prominent economic impacts of the Asian clam introduction in the United States have been related to biofouling of power plant water intakes and other municipal and industrial water intake and supply systems (Isom et al. 1986, Williams and McMahon 1986). Ecological impacts result from competition with native species for space and other limited resources. The Asian clam has been blamed for the decline and local extinctions of several native freshwater mussel species (Williams, 1997).

Aquatic Macrophytes: Several species of aquatic plants are causing major economic and environmental damage in Southern and Mid-Atlantic states. These plants include:

- Parrot feather (*Myriophyllum aquaticum*).
- European frog-bit (*Hydrocharis morus-ranae*).
- Giant salvinia (*Salvinia molesta*).

Recent trends in their distributions show that these plants are moving northward towards Massachusetts and may be able to survive New England winters (Crow and Helquist, 2000, Langland, 1996).

Freshwater Fish: DFW has identified several fish species as posing significant threats to the natural resources of the Commonwealth. The following fish species cannot be kept without a permit from DFW (321 CMR 9.01(3)):

- The grass carp (*Ctenopharyngodon idella*) is an herbivorous fish that is native to China. In the 1960s, the US began to culture the grass carp for biological control of rooted aquatic vegetation. Since then, the fish has escaped from containment facilities to invade the surrounding aquatic habitats. The grass carp is now found

in all 48 contiguous states of the US. Though the grass carp has successfully decreased populations of certain aquatic invasive macrophytes, it is not selective in its feeding and is capable of destroying all of the plant life where it has been introduced, including native species. In Massachusetts, some believe that it may also have been intentionally introduced to some ponds as a food source (Hartel et al., 1996). Introduction of the grass carp may also be responsible for the presence of nonindigenous parasites in waters of the US, such as the Asian tapeworm (Ganzhorn et al., 1992). Despite these concerns and the banning of the grass carp in numerous states, these fish are still being raised and introduced as biological controls of aquatic macrophytes.

- The popularity of the various piranha species (*Pygocentrus* spp. and *Serrasalmus* spp.) as aquarium fish has resulted in their introduction to many US states including Massachusetts (USGS, 2002). Though these fish are not likely to survive winters in the Northeast, these species are renowned as voracious predators that can quickly impact local populations of fish and invertebrates (Moe, 1964). Sale and possession of this species is still legal in several Northeastern states, and it is readily available via the Internet trade.
- The rudd (*Scardinius erythrophthalmus*) was originally imported from Europe in the late 1800s to be used as a baitfish. The species has since been found in freshwater and estuarine habitats in at least 20 states, including most of the Northeastern United States. Reproducing populations of rudd have been found in the lower Charles River in Boston. Dispersal appears to be through interstate traffic from the bait and aquaculture industries rather than new European imports. The impact of the rudd is largely unknown, but it is able to hybridize with the native golden shiner. The rudd will likely compete for invertebrate food sources with native fish species (Burkhead and Williams, 1991).
- The walking catfish (*Clarias batrachus*) first escaped from a Florida aquarium fish farm in the mid-1960s. It has since invaded the entire southern region of Florida and has also been found in Connecticut, California, Georgia, Massachusetts, and Nevada. An extremely opportunistic species that will feed on any available food source, the walking catfish has the potential to cause serious damage to native species (USGS, 2002). The walking catfish is also readily available through Internet web sites as an aquarium fish.

Established Ocean and Coastal Species

The following species are found in the marine and estuarine environments of Massachusetts. Though most are well established, reductions in the populations of organisms, like the green crab and shellfish pathogens, could result in measurable economic benefits, and a shift towards historical biological communities in Massachusetts.

European Green Crab (*Carcinus maenas*): The European green crab was probably introduced to New England via ballast water in the mid-1800s. Now the most prolific

crab in Massachusetts coastal waters, the green crab is a voracious predator of aquatic macroinvertebrates, and has been blamed by some for the collapse of the New England soft-shelled clam industry (Pimentel et al., 1999). Eradication of this now naturalized species is not possible. However, reductions in the overall population size may allow populations of displaced native species to recover. Continued research on commercial uses and biological controls will be necessary to impact this population.

Asian Shore Crab (*Hemigrapsus sanguineus*): The Asian shore crab was first documented in North America along the coast of southern New Jersey in 1988 (Williams and McDermott, 1990). Likely introduced via ballast water, this crab has expanded its range southward to North Carolina and north to northern Maine at the Canadian border. Little is known about the role this species could play in changing coastal ecosystem structure. However, in rocky intertidal areas dominated by boulder and cobble substrates, this species has been found in densities of 80 to 100 individuals/m² (L.D. Smith, as quoted by Blake, 2001) suggesting that it may be having dramatic impacts on the intertidal community. Continued research on the life history and impacts of this species will be important to determine appropriate next steps in its management.

Lace Bryozoan (*Membranipora membranacea*): Initially settling on kelp where it forms flat colonies, this species is a calcareous bryozoan whose growth weakens the alga and causes it to break. The lace bryozoan has contributed to the declines of kelp beds in the Gulf of Maine since the early 1990s, facilitating colonization by another invader, *Codium fragile* ssp. *tomentosoides*. The introduction of these organisms has caused declines in available habitat for important finfish such as juvenile cod, the green sea urchin (*Strongylocentrotus droebochiensis*), and numerous invertebrate species (Scheibling, 2001).

An introduced opisthobranch or other predatory snails may graze this species. More research into specific predators, effects of local predators on the population, and better documentation of ecological effects are necessary to understand the impacts and management of this organism (Harris and Mathieson, 2000; Chavanich and Harris, 2000; Harris and Tyrell, 2001).

Codium (*Codium fragile* ssp. *tomentosoides*): The green algae *Codium fragile* was first documented in the Gulf of Maine in 1964 at Boothbay Harbor, Maine (Harris and Mathieson, 1999; Boerner 1972; Coffin and Stickney 1966). *Codium* can now be found in rocky intertidal and subtidal habitats from the Gulf of St. Lawrence in Canada to North Carolina. Where found, *Codium* can radically change community composition, structure, and function (Harris and Mathieson, 1999). It has been blamed for lower abundances of limpets, chitons, and brittle stars in Nova Scotia (Scheibling, 2001). This algae has also devastated kelp beds off the coasts of Nova Scotia and Maine, and disrupted cyclical synergistic interactions between kelp and several sea urchin species (Scheibling, 2001). These disruptions are expected to have major impacts on subtidal systems, but they are not yet well documented or understood (Harris and Mathieson, 1999). Impacts may also include change in water flow and sedimentation rate, lower water and light qualities, altered food webs, and lowered productivity. Ecologically and economically important

species such as finfish, sea urchins, and lobsters may be affected, as they utilize kelp for food, habitats, and nurseries (Scheibling, 2001).

Ascidians: Also called tunicates or sea squirts, ascidians are encrusting organisms that are able to rapidly colonize marine substrates as solitary organisms or in colonies. Potential impacts of these organisms include competition with native species for suitable substrate, direct impacts to organisms on which they settle and attach, and fouling of vessels and coastal infrastructure (pipes, traps, etc.). To date, six nonindigenous species of tunicates have been documented in New England waters: *Styela clava*, *Styela canopus*, *Diplosoma listerianum*, *Asciella aspersa*, *Botryllus schlosseri*, and *Botrylloides violaceus*.

Ecological impacts of these organisms remain largely unknown, though concern has been raised by their ability to rapidly spread over vast geographic areas. *Styela* and *Botrylloides* were documented to have spread from Connecticut to Maine in fewer than 10 years (Whitlatch and Osman, 2000). Research into means of transport and control technologies will be necessary to manage impacts from these organisms.

Shellfish Pathogens: Shellfish pathogens have periodically decimated shellfish stocks throughout the United States, particularly in the Chesapeake Bay region. Shellfish pathogens of concern in the Northeast include both cryptogenic species and species thought to have been recently introduced to Massachusetts coastal waters. Difficulty in identifying these species makes tracking their distribution difficult. Range expansion of these organisms is generally attributed to the planting of contaminated shellfish seed and the warming of near shore ocean temperatures. The following are several examples of important shellfish pathogens in Massachusetts:

- MSX (*Haplosporidian nelsoni*) first appeared in Wellfleet Harbor, Massachusetts, in 1967 when it was revealed as the cause of a large eastern oyster (*Crassostrea virginica*) mortality on a private oyster grant (Hickey, 2001, pers. comm.). It is believed that MSX was introduced into Wellfleet through an oyster transplant from an infected area in Virginia. Detection of the disease prompted DMF to prohibit any oyster transplants in the Commonwealth without state approval. Permits for oyster transplants are now issued only after disease testing of oyster stocks and a review of the disease history of the source. This process prevented spread for 15 years until misreading of tissue slides allowed introduction into Cotuit Bay. MSX is now known to exist in other locations in Massachusetts. Attempts to develop disease resistant oyster stocks have yet to be successful. Control of oyster movement and sources of oyster stocks and careful pathological monitoring are the best available methods of managing this pathogen.
- SSO (*Haplosporidian costalis*) was considered a disease of concern in Massachusetts in the 1970s but was later declared endemic in the Northeast and a non-factor in causing appreciable mortalities of oysters in cooler regions (Hickey, 2001, pers. comm.). Recently, it has been looked at again as a possible

nonindigenous pathogen of concern and may be responsible for significant oyster losses.

- **Dermocystidium (*Perkinsus marinus*):** Another eastern oyster pathogen, Dermocystidium, or Dermo, was first documented in the Gulf of Mexico in the late-1940s after it caused a large-scale oyster die-off (Mackin, 1966). Later, Dermo was blamed for massive oyster kills in the Chesapeake Bay. Since 1990 it has been documented from Delaware Bay to Southern Maine (Ford, 1996). As with MSX and SSO, eradication of this pathogen is likely impossible. Minimizing contamination will require careful screening of oyster seed and monitoring of existing oyster growing areas.
- **QPX (Quahog Parasite Unknown)** was first documented in Massachusetts 1992 but is suspected to be a significant cause of quahog (*Mercenaria mercenaria*) mortality prior to 1990. Currently, its range extends from New Brunswick, Canada, where it was first documented in 1960, to New Jersey and Virginia where it has been found within the last five years (Ragone et al., 1997). A third major infestation occurred in the spring of 2001 in several Cape Cod embayments (Fraser, 2001). As with oyster diseases, management of this invader will require careful monitoring of the sources of shellfish seed as well as adult quahogs in grow-out areas across the state.

Threatening Ocean and Coastal Species

The following marine and estuarine species have been documented in the United States, but not yet in New England. Several of these species listed below have had dramatic ecological and economic impacts outside of their respective native ranges.

Veined Rapa Whelk (*Rapana venosa*): Native to the Sea of Japan, the veined rapa whelk was introduced to the Black Sea in the 1940s from where it spread to the Mediterranean Sea and subsequently the Chesapeake Bay, where it was discovered in 1998 (Harding and Mann, 1999). This species feeds on reef forming and **epibenthic** bivalves and has caused major damage to the shellfish industry in the Black Sea. There is serious concern about the impact this species could have on similar Atlantic Coast fisheries as well as native **benthic** community structures. Currently, the potential range of this organism is unknown, and additional research into its ability to tolerate cold-water conditions will be necessary to determine the need for additional preventative measures in Massachusetts.

Nori (*Porphyra yezoensis*): Red algae of the genus *Porphyra* are the most widely consumed seaweed in the world (Ohio Sea Grant, 2000), and several species of *Porphyra* are commonly found along the Massachusetts coast. An effort to grow a nonindigenous species of the algae, *Porphyra yezoensis*, for commercial purposes is underway in the coastal waters of southern Maine. Current research is largely focused on developing a variety that is better adapted to the waters of the Gulf of Maine but will not sexually reproduce nor out-compete native species in vegetative growth. There is concern in the

region over the potential escape and proliferation of this and other cultivated algal species.

Chinese Mitten Crab (*Eriocheir sinensis*): The Chinese mitten crab has undergone explosive growth along the California coast since its discovery in San Francisco Bay in 1992. A highly valued food item throughout China, it is unclear if this species was intentionally introduced, or was released in ballast water originating in the Yellow Sea or Europe (Wynn et al., 2000). Threats from this species include clogging of fish collection devices, fish-ways and hydropower intakes; damage to levees and other coastal structures that result from its burrowing habits; and alteration of the native community structure through predation (Washington Sea Grant, 2001). The dramatic ability of this species to grow in great numbers as shown in central California indicates the need to prevent the introduction of this species to New England waters and to develop a response protocol in the event that it is discovered here.

Pacific Oyster: (*Crassostrea gigas*): The Pacific oyster was intentionally introduced to the United States from Japan for commercial culture in the early 1900s. Though this species is able to survive in cold Pacific waters, it spawns at about 18 degrees Celsius and thus only sporadically in wild populations along the Pacific Coast of the United States (Pacific States Marine Fisheries Commission, 2001). This species would likely survive and reproduce in the warmer waters of the South Coast of Massachusetts (Buzzards Bay) and Cape Cod where water temperatures often exceed 20 degrees during summer months (Estrella and Glenn, 1999). The Pacific oyster may out-compete the eastern oyster (*Crassostrea virginica*) for space, dilute the local genetic stock through interbreeding, and potentially introduce a variety of shellfish pathogens native to the Pacific (Hickey, 1979). There is current concern over the intentional introduction of this species by shellfish growers or unintentional discard by a member of the general public. Additional measures for prevention include education targeted at the aquaculture industry regarding threats to native oyster species.

Caulerpa (*Caulerpa taxifolia*): Dubbed “the killer algae,” this aquatic plant with a feather-like appearance has caused tremendous ecological damage in the regions where it has invaded. This alga is associated with the aquatic pet industry and public aquariums. In the late 1980s, a hybrid strain of *Caulerpa taxifolia* invaded the Mediterranean coast, believed to have been accidentally released by a public aquarium (Meinesz, 1999). The invasive hybrid strain was recently discovered along the California coast. Although primarily a warm-water species, this hybrid can thrive in temperatures as low as 5 degrees Celsius (Makowka, 2000). *Caulerpa taxifolia* has been banned for importation into the United States yet it is still sold in many areas and is available through the Internet trade.

IV. Management Objectives and Actions

The following objectives and actions outline a five-year plan for AIS management in Massachusetts in order to achieve the following overarching Goal.

By 2007, fully implement a coordinated approach to minimizing the ecological and socio-economic impacts of aquatic invasive species in the marine and freshwater environments of Massachusetts.

Objectives and actions were developed to address priority species and transport vector management concerns, and to expand the general capabilities of Massachusetts agencies and organizations to address AIS issues.

Resources currently dedicated to each objective have been identified within task descriptions along with estimates of additional resource requirements for the completion of each task. Massachusetts does not expect to receive all of the necessary funds to fully implement this plan from the federal ANS Task Force. The AIS Working Group has begun to seek additional resources through avenues such as state and federal grants and will use the following objectives and actions to direct future state and federal appropriations. Acronyms used to denote state and federal agencies and other entities are shown in Table 2.

Table 2: Acronyms for agencies and organizations referenced in Management Objectives and Actions (below).

CZM	Massachusetts Office of Coastal Zone Management
DEM	Massachusetts Department of Environmental Management
DEP	Massachusetts Department of Environmental Protection
DFA	Massachusetts Department of Food and Agriculture
DFW	Massachusetts Division of Fish and Wildlife
DFWELE	Division of Fish Wildlife and Environmental Law Enforcement
DFWELE	Division of Fish and Wildlife
EOEA	Massachusetts Executive Office of Environmental Affairs
EPA	US Environmental Protection Agency
GOMC	Gulf of Maine Council
LPI	Massachusetts Lakes and Ponds Initiative
MBP	Massachusetts Bay National Estuary Program
MIPG	Massachusetts Invasive Plant Group
NEAMGLL	Northeast Association of Marine and Great Lakes Labs
NEP	National Estuary Program
NIPGro	New England Invasive Plant Group
NOAA	National Oceanic and Atmospheric Administration
USGS	US Geological Survey
WRP	Massachusetts Wetlands Restoration Program

The approximate year of implementation for each task has been identified following each task description. A detailed annual work plan will be developed following the submission of this plan and prior to each subsequent year of implementation. Work plans will be developed based on foreseeable resources available for implementation during each year and incorporate additional management needs as they are recognized.

Objective I: Coordination:

Strategic Action 1A: Coordinate Massachusetts AIS Management Activities

Issue addressed: Current AIS management efforts in Massachusetts have not been fully coordinated across agencies. Dedicated staff will be necessary for effective implementation of AIS control strategies.

Task 1A1: (DEM/CZM/MBP) DEM will support two full time positions to coordinate and implement actions identified in the Lakes and Ponds Watershed Action Strategy (Lakes and Ponds Program Coordinators). A portion of their time will be devoted to AIS Management Activities in addition to existing DEM staff time dedicated to AIS management actions (totaling approximately 0.75 FTE). EOE A has dedicated \$45,000 for the support of these staff. DEM is seeking an additional \$30,000 to support 0.5 full time equivalent employees (FTE) dedicated specifically to implementation of actions identified in this plan in freshwater systems. CZM has dedicated funding to support 0.25 FTE and is seeking resources for an additional 0.75 FTE to coordinate coastal AIS management activities (CZM Coastal AIS Coordinator). The MBP has dedicated 0.4 FTE to working on coastal AIS issues (MBP Coastal AIS Coordinator). Staff from these three agencies will be responsible for the overall implementation of this plan. YEAR ONE

Task 1A2: (CZM/DEM/MBP) The Lakes and Ponds Program Coordinators and the Coastal AIS Coordinators will organize four meetings of the AIS Working Group annually. ONGOING

Task 1A3: (AIS Working Group/Council on Invasive Species) The AIS Working Group will meet annually with other member groups of the Massachusetts Council on Invasive Species (the Massachusetts Invasive Plant Group, the Invertebrate Invasives and Biocontrols Group, and the Wildlife and Plant Diseases Group) to identify priority species and sites for management and to coordinate overall invasive species control efforts. YEAR ONE/ONGOING

Strategic Action 1B: Coordinate With Other States and Nations to Prevent Interstate and International Transport of AIS

Issue addressed: AIS management is a regional issue and not confined by political boundaries. Formal mechanisms for interstate and international coordination will be necessary to limit new introductions and the spread of established populations.

Task 1B1: (CZM/MIT Sea Grant/GOMC/DEM/MBP) CZM will continue to coordinate with state and federal agencies and industry representatives in the region to implement a Northeast Regional ANS Panel. CZM will co-chair and staff the Panel and has dedicated 0.25 FTE to this task through 2003. YEAR ONE

Task 1B2: (CZM/DEM/MBP) The Lakes and Ponds Program and Coastal AIS Coordinators will participate in national and international AIS workshops and conferences. ONGOING

Task 1B3: (AIS Working Group/DEM/MIT Sea Grant/NIPGro) AIS Working Group members will coordinate with other New England states to share educational resources related to aquatic invasive plant management. Specific coordinating efforts include biennial information sharing conferences sponsored by the NIPGro, an ongoing exchange of educational materials between DEM and the New Hampshire Department of Environmental Services, and distribution of the Sea Grant Aquatic Nuisance Species Report (Ohio Sea Grant, 2000) and Proceedings of the First National Marine Bioinvasions Conference (Pederson, 2000). To date, MIT Sea Grant has expended \$60,000 for printing and distributions costs. YEAR ONE/ONGOING

Task 1B4: (MBP) MBP, in conjunction with six other National Estuary Programs, (NEPs) has received \$12,000 from the US EPA to sponsor a Northeast Regional Marine Bioinvasions Workshop. The focus of the two-day workshop, to be held in the fall of 2002, will be the monitoring and management of marine invaders. YEAR ONE

Strategic Action 1C: Coordinate with Federal Agencies to Develop Regional Priorities and Sound Management Activities at the Federal Level

Issue addressed: AIS management strategies at the federal level should be fully coordinated with state and regional management efforts and guided by regional priorities.

Task 1C1: (CZM) The CZM Coastal AIS Coordinator and additional AIS Working Group members will participate in meetings of the federal ANS Task Force. CZM has dedicated \$3,000/year for travel expenses. ONGOING

Objective 2: Prevention

Strategic Action 2A: Assess the Risks and Types of Introduction Through Priority Transport Vectors

Issue addressed: Currently, little is known regarding the specific role transport vectors play in AIS introduction and spread in Massachusetts and the region. Careful study of species introduction through these vectors, followed by efforts to communicate with related industry representatives, will be a critical first step in reducing AIS transport.

Task 2A1: (Smith/Williams/MIT Sea Grant/Northeastern) The team of researchers from Smith College, Williams College, MIT Sea Grant, and Northeastern University will make

the results of Massachusetts Components of the New England Transport Vector Study identified in Section III early in 2002. Results will include lists of species imported to and exported from Massachusetts as well as handling practices that pose a risk of introductions through:

- The seafood industry.
- Trade of species for bait (fish and invertebrates).
- The aquarium trade.
- Marine research.
- Aquatic organism suppliers.

The research team has dedicated \$270,000 (including funds through a grant from the National Sea Grant Office and nonfederal match) to the completion of this task as well as Task 2A2 (below). YEAR ONE

Task 2A2: (Smith/Williams/MIT Sea Grant/Northeastern) The research team identified in Task 2A1 will make the results of the Transport Vector Study for all New England states available in late 2002. YEAR ONE

Task 2A3: (Smith/Williams/MIT Sea Grant) The research team identified in task 2A1 will expand this study to include additional transport vectors. The research team has acquired \$120,000 from the National Sea Grant Office for the completion of this project, which will include workshops similar to those described in tasks 2B1 and 2B2 (below). YEAR TWO

Task 2A4: (AIS Working Group) A freshwater subcommittee of the AIS Working Group will assess the need to expand the above study to transport vectors relating to freshwater systems in Massachusetts. YEAR ONE

Strategy Action 2B: Coordinate With Industry Representatives to Minimize Introductions of Invaders Through Priority Transport Vectors

Issue addressed: Effective management of AIS will further require that industries that may serve as transport vectors be involved in AIS prevention efforts.

Task 2B1: (Smith/Williams/MIT Sea Grant, MBP) Researchers from the New England Transport Vector Study will work with MBP to convene focus groups made up of representatives from industries identified as potential pathways for introduction (Section III) as well as the commercial shipping industry to identify priority preventative strategies and educational needs. The research team has allocated \$10,000 to support staff time and workshop costs. YEAR ONE

Task 2B2: (MBP/AIS Working Group) The Massachusetts Bays Program will work with a subcommittee of the AIS Working Group to establish ongoing working groups made up of industry representatives to carry out strategies identified in task 2B1. YEAR TWO/ONGOING

Strategic Action 2C: Educate Industry Representatives Regarding Possible Means of Introductions Through Development and Dissemination of Targeted Outreach Materials

Issue addressed: Representatives of industries that pose the risk of AIS transport may be unaware of the problems associated with AIS introductions and existing options for management.

Task 2CI: (AIS Working Group) The AIS Working Group will identify educational needs through the above focus and working groups and develop educational strategies for representatives of priority industries (see also Objective 6: Education). YEAR TWO

Strategic Action 2D: Improve Data Management as It Relates to AIS Distributions in Massachusetts Watersheds and in the Northeast Region

Issue addressed: AIS distribution information is currently housed in multiple databases and formats, making comprehensive assessments of introduction and the spread of established populations difficult or impossible.

Task 2D1: (CZM/Northeast Regional Panel) CZM will work with the Northeast Regional Panel to develop a Marine Invader Database and Web Page (CZM, 2001) using the Massachusetts and Rhode Island Rapid Assessment Survey data as the foundation. CZM has dedicated 0.2 FTE to the completion of this task. An additional \$19,000 has been obtained through the National Sea Grant Office to support two students for data mining and database population efforts. YEAR ONE

Task 2D2: (DFW/DEP/DEM) The DFW will coordinate with the DEM and DEP to develop a framework for a comprehensive freshwater invasive species database for Massachusetts. The database will include information developed through ongoing monitoring efforts led by these agencies and will incorporate data generated through enhanced monitoring of aquatic systems known to contain rare species or represent diverse and pristine habitats. DFW, DEP, and DEM will develop a strategy and identify budgetary needs for integrating existing data management efforts. YEAR ONE

Strategic Action 2E: Reduce the Threat of Introductions Via Commercial Shipping (Ballast Water and Hull Fouling)

Issue addressed: AIS introductions via commercial shipping continue to be a major concern worldwide. The role this industry plays in Massachusetts is currently unclear, and development of measures at the state level to prevent the import and export of aquatic invaders through this pathway will require improved communication with the commercial shipping industry.

Task 2EI: (MIT Sea Grant/Massport) MIT Sea Grant and Massport will develop a regional database of ballast water discharged to major ports in the region using the

National Ballast Survey, a Massport survey of shipping agents and transporters examining the ballast water release practices in Massachusetts, and additional data sets. MIT Sea Grant has committed \$11,000 to the completion of this task and is seeking an additional \$5,000 to support a research assistant. YEARS ONE AND TWO

Task 2E2: (MIT Sea Grant/Massport) MIT Sea Grant and Massport will convene a regional (Canadian Maritime Provinces and Northeastern United States) steering committee to develop long- and short-term goals for preventing or minimizing nonindigenous species imports and exports via ballast water discharge. The Workshop will include an overview of new Ballast Water Reporting Requirements as well as a discussion of appropriate reporting procedures. MIT Sea Grant has committed \$25,000 to support an initial symposium and follow-up meetings. YEAR ONE

Task 2E3: (Massport) Massport will work with the USCG to assemble ballast water reporting information at Massport operated facilities. Massport will further assist and advise the coast Guard in the development of sampling programs to evaluate ballast water management compliance rates in Massachusetts. ONGOING

Task 2E4: (MIT Sea Grant/Massport) MIT Sea Grant and Massport will develop a strategic plan for providing ballast water management practice information to key shipping industry decision-makers in Northeastern states and provinces (see also Task 2B1). YEAR TWO

Task 2E5: (CZM/MBP/MIT Sea Grant): CZM, MBP, and MIT Sea Grant will reevaluate ballast water management practices in Massachusetts and make additional recommendations for management and/or regulations based on the findings. Massachusetts is seeking \$10,000 to support a research assistant. YEAR TWO

Strategic Action 2F: Prevent New Introductions of AIS Via Recreational Boating and Fishing

Issue addressed: Continued and enhanced education and outreach efforts will be necessary to control the spread of fouling organisms and aquatic weeds to uninfested water bodies via recreational boating and fishing. Massachusetts must evaluate its capacity to facilitate the cleaning of boats and their trailers at infested water bodies, and require the removal of plant and algal species from recreational vehicles.

Task 2F1: (DEM) DEM will update and distribute signage relating to boat and trailer AIS transport to all ponds with boat ramps in the Commonwealth. DEM has dedicated \$13,500 to the completion of this task through the Lakes and Ponds Initiative. YEARS ONE AND TWO

Task 2F2: (DEM) DEM will continue to distribute AIS educational materials to lake and pond associations. DEM has expended \$8,200 for the printing of educational materials and is seeking an additional \$12,000 for re-printing. ONGOING

Task 2F3: (DEM/DEP/DFWELE) DEM, DEP, and DFWELE will develop a pamphlet detailing the potential transport of AIS with boats and their trailers for distribution with boater registration forms and/or commercial fishing licenses. Massachusetts is seeking \$10,000 to support development, printing, and distribution costs. YEAR TWO

Task 2F4: (DEM/CZM/MBP) The DEM Lakes and Ponds Program and CZM and MBP Coastal AIS Coordinators will assemble AIS educational materials for distribution to local Public Access Boards. YEAR TWO

Task 2F5: (DEM) Through the Lakes and Ponds Watershed Action Strategy, DEM has dedicated \$4,500 to study the feasibility of installing a public boat wash station at a Massachusetts boat ramp. DEM anticipates a cost of \$40,000 for installation of the station and is seeking an additional \$2,000/year to support general maintenance costs. CZM, DEM, and DEP will gage the utility of installing additional boat-wash stations based on the results of this pilot effort. YEAR TWO

Task 2F6: (DEP/DFW) DEP will work with DFW to evaluate Massachusetts's capacity to develop an AIS inspection program for recreational boats. Massachusetts is seeking funding to support 0.2 FTE for two years to scope and develop a boat inspection program in Massachusetts, and a feasibility study of program implementation. YEAR TWO

Strategic Action 2G: Prevent New Introductions of AIS Through the Seafood Industry and the Freshwater Fish Market

Issue addressed: Little is currently known regarding the type and quantity of live fish and shellfish imports to Massachusetts, warranting further research into seafood industry practices as well as the distribution of AIS educational materials to industry representatives.

Task 2G1: (Smith/Williams/MIT Sea Grant/CZM/MBP/DMF) CZM will contract with a student to update and expand the preliminary list of seafood species imports and exports generated by the New England Transport Vector Study through field surveys. CZM is seeking \$5,000 to support a student for one semester. YEAR ONE

Task 2G2: (CZM/DMF/MIT Sea Grant) CZM, DMF, and MIT Sea Grant will develop guidance and educational materials on the use of live packing materials for seafood transport based on the proceedings of the seafood industry focus group described in Task 2B1. CZM and MIT Sea Grant are seeking \$5,000 to support a student researcher and the development and distribution of educational materials. YEAR ONE

Strategic Action 2H: Prevent the Introduction and Spread of Pathogens Through the Aquaculture Industry

Issue addressed: DMF does not currently have the in-house capacity to identify shellfish pathogens once an outbreak occurs. Recruitment of a shellfish pathologist as well as

development of measures to reduce the risk of pathogen introductions are necessary to limit the impacts of potentially devastating outbreaks.

Task 2H1: (DMF) DMF is seeking \$40,000 to fund a half time (0.5 FTE) shellfish pathologist to assist in monitoring for and identifying shellfish diseases. YEAR ONE/ONGOING

Task 2H2: (CZM/DMF) CZM is working with DMF and Cape Cod towns to identify economically viable uses for shellfish waste as well as proper disinfection practices prior to use as cultch. CZM has dedicated 0.1 FTE/year to this task over two years. ONGOING

Task 2H3: (AIS Working Group) The AIS Working Group will evaluate current nonindigenous game fish stocking practices in Massachusetts and develop recommendations for changes in these practices, if necessary. YEARS THREE-FIVE

Strategic Action 2I: Prevent Introductions of AIS to Freshwater and Marine Systems Via the Bait Industry

Issue addressed: The import of baitfish and invertebrate species along with their packing materials may pose a significant threat of AIS introductions to Massachusetts. There is currently little guidance on what species should be imported as bait or as packing materials.

Task 2I1: (DFW/DMF) DFW and DMF will develop guidance for the disposal of unused bait species for distribution with commercially sold bait or for printing directly on bait packing materials. DMF has dedicated 0.1 FTE to this task and is seeking \$5,000 for printing and distribution costs. YEAR ONE

Strategic Action 2J: Prevent New Introductions of AIS Through the Aquarium Trade, Nurseries and Water Garden Suppliers, and Other Wetland Vegetation Growers

Issue addressed: Species distributed for use in aquaria and water gardens are often selected due to their ability to survive and grow with minimal care under a range of environmental conditions. Intentional or unintentional release of these organisms is common, and several harmful introductions have been documented through these pathways worldwide.

Task 2J1: (AIS Working Group) The AIS Working Group will establish a subcommittee to develop a strategic plan and guidelines for limiting the introduction of potentially invasive species through the aquarium and water garden trade. Issues addressed by this committee will include:

- 1) Import and sale of potentially invasive invertebrate species.

- 2) Import and sale of potentially invasive plant species and organisms that may be transported with these species.
- 3) Proper labeling of plant and animal species sold by pet stores and water garden suppliers.
- 4) Inspections of pet stores and water garden suppliers for priority AIS.
- 5) Best management practices for the disposal of diseased or unwanted organisms and wastewater.

YEAR ONE

Task 2J2: (DFA) DFA will continue field inspections for species listed on the Massachusetts Noxious Weed List. DFA has dedicated 3 FTE to field inspections, which include Noxious Weed List monitoring efforts (approximately 0.5 FTE year). ONGOING

Task 2J3: (DFA) DFA will evaluate its authority to include additional marine and freshwater species on the state Noxious Weed List. YEAR ONE

Task 2J4: (DFA/AIS Working Group/MIPG) Pending the results of task 2J3, DFA will annually update the state Noxious Weed List (or a new list of aquatic invasive plant species) to include in DFA inspections in consultation with the Massachusetts Invasive Plant Group and the AIS Working Group. YEAR TWO ONGOING

Task 2J5: (DFWELE/DFW) DFWELE and its DFW will review their authority to publish lists of invasive species in nonagricultural or minimally managed areas. YEAR ONE

Strategic Action 2K: Prevent new introductions of AIS by Marine Research Facilities and Public Aquaria.

Issue addressed: Marine research facilities often hold nonindigenous organisms for experimental and display purposes. Maintenance of these live species often requires the exchange of water with the natural environment, providing the opportunity for the release of these species, which often have microscopic life history stages. Furthermore, experimentation with live nonindigenous organisms may be conducted in the natural environment, requiring careful controls to prevent their release or escape.

Task 2K1: (CZM/MPB/DMF/NEAMGLL) CZM, MBP, and DMF will cooperate with the Northeast Association of Marine and Great Lakes Labs (NEAMGLL) to develop a notification/reporting system for the import of live marine organisms for research purposes. YEAR TWO

Task 2K2: (AIS Working Group) The AIS Working Group will work with the New England Aquarium to develop best management practices for treatment of wastewater and release of unwanted organisms from public aquaria and marine research facilities. YEAR ONE

Task 2K3: (AIS Working Group) Massachusetts agencies will work to enter into a Memorandum of Understanding (MOU) with marine research and aquaculture facilities in the Commonwealth ensuring incorporation of best management practices developed by the Marine Biological Laboratory and the AIS Working Group for the handling and distribution of nonindigenous organisms. YEARS THREE-FIVE.

Strategic Action 2L: Prevent New Introductions of AIS to Marine and Freshwater Systems Through Aquatic Organism Supply Companies (Including Internet Sales)

Issue addressed: Sale of live organisms via mail order and the Internet is common practice. These organizations, often affiliated with marine research facilities, are able to ship organisms across the country, often with few or no restrictions on the recipient's purposes or handling practices.

Task 2L1: (CZM) CZM will contract with a student researcher to identify organizations supplying live marine and freshwater organisms to Massachusetts. Massachusetts is seeking \$5,000 to support this student for one semester. YEAR ONE

Task 2L2: (AIS Working Group) A subcommittee of the AIS Working Group will make recommendations to the federal ANS Task Force on limiting introductions to Massachusetts through the Internet trade. YEAR TWO

Task 2L3: (AIS Working Group) A subcommittee of the AIS Working Group will work to identify industry representatives and coordinate on the development of shipping and disposal guidelines. YEARS THREE-FIVE

Objective 3: Monitoring

Strategic Action 3A: Monitor the Introduction and Spread of AIS in Massachusetts Coastal Waters

Issue addressed: The distribution of AIS in Massachusetts marine systems is poorly understood. Continued designation of priorities for management (both species and pathways) will require ongoing AIS monitoring efforts.

Task 3A1: (MIT Sea Grant/MPB/CZM) MIT Sea Grant, CZM, and MBP will work to identify funds to conduct rapid assessments surveys of ports and harbors every five years at an estimated cost of \$30,000 per assessment. YEARS THREE-FIVE

Task 3A2: (MBP/MIT Sea Grant/CZM/) In cooperation with other Northeastern National Estuary Programs, MBP has received \$50,000 from EPA to conduct a rapid assessment survey of invasive species in intertidal benthic habitats in the northeast United States. The survey is planned for the summer of 2003. YEARS ONE AND TWO

Task 3A3: (MBP/CZM) MBP Regional staff will work with the Coastal AIS Coordinators to develop a volunteer monitoring program. Massachusetts is seeking \$10,000 to support development, printing, and training workshop costs. YEAR TWO

Task 3A4: (AIS Working Group): Representatives from the AIS Working Group will develop an AIS monitoring strategy for coastal Massachusetts which will include evaluation of resource needs for establishing sentinel stations for detecting new invasions in Boston Harbor and the Connecticut River. YEAR TWO

Strategic Action 3B: Monitor the Introduction and Spread of AIS in Massachusetts Freshwater Systems

Issue addressed: Effective management of aquatic macrophytes and other freshwater invaders will require the expansion of monitoring efforts that have been limited by lack of staff time and monetary resources.

Task 3B1: (DEP/DEM) DEP and DEM will continue lakes and ponds assessments and aquatic vegetation inventories in support of water quality assessments and the Total Maximum Daily Load (TMDL) Program. DEP has dedicated \$150,000 and 3 FTEs/year over the next two years to support these programs, representing an increase over traditional funding levels by \$100,000/year and 2 FTEs. DEP is seeking an additional 0.5 FTE and \$50,000/year to expand the annual coverage of this monitoring program and its effectiveness in documenting the distribution of nonindigenous organisms. ONGOING

Task 3B2: (DEM) Through the Massachusetts Lakes and Ponds Watershed Action Strategy, DEM will develop a volunteer “Weed Watcher” program to monitor for AIS invasions. DEM staff acquired through the Lakes and Ponds Watershed Action Strategy will carry out this task. YEAR ONE

Task 3B3: (DEP) DEP is seeking 1 FTE to manage its (currently informal) database of aquatic macrophytes in Massachusetts Lakes and Ponds. This staff person will be responsible for the development of a database structure and format in year two, ongoing database population, and web publishing. Once developed, database management will require the equivalent of 0.5 FTE/year. YEAR TWO/ONGOING

Task 3B4: (DFW): DFW will continue to inventory and monitor sites where nonindigenous aquatic species are impacting native flora and fauna, especially where they co-exist with state listed rare species. ONGOING

Strategic Action 3C: Assist in the Development of Improved Technology for Monitoring the Spread of Nonindigenous Aquatic Macrophytes

Issues addressed: The widespread distribution of nonindigenous aquatic macrophytes and the limited personnel time available for monitoring efforts constitute the need for improved monitoring technology that facilitates large scale monitoring efforts.

Task 3CI: (USGS/DEP/DEM) Through a grant from the DEM, the USGS has evaluated the use of remote sensing technology for monitoring and assessment of the distribution of aquatic plants. DEM and DEP will evaluate the results of this effort to determine the feasibility of an ongoing remote sensing based lake and pond monitoring effort. YEAR TWO

Objective 4: Early Detection/Eradication

Strategic Action 4A: Monitor the Marine and Freshwater Environments to detect the Introduction of Nonindigenous Species to Waters of the Commonwealth or the Spread of Established Aquatic Invaders to Previously Uninfested Waters as Outlined in Objective 3

Strategic Action 4B: Identify Funding and Personnel Resources for the Eradication of New Introductions to Previously Uninfested Waters

Issues addressed: Once established, invasive species may be impossible to completely eradicate. Removal of any introduced species will require a coordinated protocol for immediate response and eradication of the species of concern.

Task 4B1: (DEM/DEP/EOEA/DFW) Through the Massachusetts Lakes and Ponds Watershed Action Strategy, Massachusetts will assemble an Emergency Response Team to monitor for and eradicate pioneer infestations in lakes and ponds. DEM has dedicated 1.0 FTE to the development of a monitoring and response protocol in five freshwater pilot sites across the state. Massachusetts is seeking \$75,000/year for the acquisition of necessary plant control supplies and equipment and the support of additional staff time to manage the Emergency Response Team. YEAR ONE

Task 4B2: (DEM/DEP/EOEA/DFW) The Emergency Response Team will coordinate with the volunteer groups involved in the Weed Watcher Program to track the distribution of freshwater invaders and identify early infestations for control. YEAR ONE

Task 4B3: (DFW/DEM/DEP): The Emergency Response Team will coordinate with the DFW's Natural Heritage and Endangered Species Program to identify potential conflicts with rare plants or animals at the site of the proposed actions. YEAR ONE

Task 4B4: (DMF/CZM): The Coastal AIS Coordinators will work with DMF to develop an AIS training program for DMF field staff. Training will include identification of nonindigenous marine species and reporting protocols. Massachusetts is seeking \$10,000 to support staff time, workshop costs, and development of training materials to complete this task. YEAR ONE

Task 4B5: (CZM/MIT Sea Grant/MBP/DMF) The Coastal AIS Coordinators and a subcommittee of the AIS Working Group will evaluate the need for and develop a coastal Emergency Response Team based on the model developed by the Lakes and Ponds Initiative. CZM will dedicate 0.2 FTE to this task. YEAR TWO

Strategic Action 4C: Develop a Response Protocol for the Eradication of Newly Established AIS

Issue addressed: See the issue addressed by strategic action 4B

Task 4C1: (AIS Working Group) The AIS Working Group will identify agencies responsibilities for eradicating or controlling specific types of introductions (i.e., aquatic plants, fouling organisms, marine species, freshwater species). YEAR TWO

Task 4C2: (AIS Working Group) The AIS Working Group will develop and implement an appropriate response protocol for the eradication of newly detected priority invaders. This protocol will include specification of appropriate biological, chemical, and physical controls where necessary, and will address priority species or species groups identified in Section IV including, but not limited to:

- Freshwater bivalves.
- Aquatic macrophytes.
- Marine and estuarine decapods.
- Marine and estuarine algae.
- Marine and estuarine mollusks.

YEAR ONE

Task 4C3: (AIS Working Group/DFA) Based on the response protocols identified in Task 4C2, the AIS Working Group will work with DFA to generate a list of pesticides currently not registered for use that may be necessary for the control of pioneering AIS. YEAR TWO/ONGOING

Task 4C4: (AIS Working Group) Massachusetts will work to enter into a Memorandum of Understanding with state and federal agencies and environmental nongovernment organizations that recognizes and facilitates implementation of early response protocols. YEARS THREE-FIVE

Task 4C5: (DEP/DFA) DEP and DFA will develop a facilitated permitting process and/or emergency herbicide application provisions through the Herbicide Licensing Program. The revised process will contain careful guidelines to determine appropriate control technologies to be applied to pioneering AIS populations that consider both the effect on targeted invaders and secondary impacts. DFA is also considering regulations that will guide the aquatic application of all pesticides. DFA will involve the AIS Working Group in discussion regarding the development of these regulations. Massachusetts is seeking 0.5 FTE for two years to restructure the permitting process and 0.25 FTE in subsequent years for technical assistance for applicants undertaking the permitting process. YEAR TWO

Strategic Action 4D: Evaluate the Risk of Introductions of Priority Species Not Yet Established in Massachusetts

Issue addressed: Massachusetts faces the risk of introduction from a number of species that have proven to be damaging in other regions (see Section III: Problems and Concerns). Development of a methodology for evaluating the risk of introduction of these species will be necessary to identify and implement species-specific preventative measures.

Task 4DI: (AIS Working Group) A subcommittee of the AIS Working Group will develop a strategy for evaluating the risk of the introduction and spread of priority species or major taxa through a pilot evaluation including one freshwater and one marine invader. Massachusetts is seeking \$30,000 (\$15,000 per species) to contract with a student researcher to conduct these assessments. Current candidates include the veined rapa whelk and the Chinese mitten crab. YEAR TWO

Objective 5: Control

Strategic Action 5A: Implement Early Response Protocols Outlined in Objective 4 for Newly Detected Infestations of AIS

Strategic Action 5B: Support Development of Improved Control Technologies for Established Populations of AIS

Issue addressed: Control of established populations of AIS continues to be costly and labor intensive in most if not all cases. Limiting the spread of priority AIS will require continued development of cost-effective and far-reaching control technologies.

Task 5BI: (AIS Working Group) The AIS Working Group will work with the Invertebrate Invasives and Biocontrols Group of the Invasive Species Council on developing a strategy to encourage research and development of biological controls for AIS in the state and region. Research priorities will include further evaluation of potential non-target impacts from the release of biological control measures (see also Objective 6, Education). ONGOING

Task 5B2: (WRP) WRP will continue to propagate and release biocontrols to reduce populations of purple loosestrife across the Commonwealth. WRP has dedicated \$7,000 for the completion of this task and is seeking an additional \$2,000/year for the purchase of biocontrol (beetle) rearing equipment. YEAR ONE/ONGOING

Strategic Action 5C: Identify Priority Marine and Freshwater Invasive Species for Management Actions

Issue addressed: Allocation of limited resources for AIS management will require the ongoing designation of priority species. As this plan is implemented and monitoring

efforts enhanced, improved knowledge of AIS distribution and impacts must be used to continually update management priorities.

Task 5C1: (AIS Working Group) The AIS Working Group will develop protocols for additions and deletions to the priority AIS lists and appoint a subcommittee of biologists with expertise in aquatic organisms to make recommendations for list changes. The subcommittee will include representatives from the Massachusetts Invasive Plant Group, the Massachusetts Invertebrate Invasives and Biocontrols Group, and the Massachusetts Wildlife and Plant Diseases Group. YEAR ONE

Task 5C2: (AIS Working Group) The AIS Working Group will work with the Natural Heritage Program, academics and non-profit environmental organizations to develop protocols for developing a priority list of sites for management action each year in order to control marine and freshwater AIS. Control of invasive species on sites where they co-exist with federal or state endangered and threatened species will constitute high priorities for action. YEAR ONE

Strategic Action 5D: Identify and Disseminate Information on Existing Control Mechanisms for Priority Species

Issue addressed: Organizations involved in invasive species management in Massachusetts may not be aware of the full range of options available for the control of established populations. Effective control of AIS with limited resources will require that the range of mechanical, chemical, biological, and other control techniques are available to managers of aquatic systems.

Task 5D1: (DEP/DEM) DEM and DEP will compile information detailing available control techniques and technologies for the management of freshwater priority invaders in the "Guide to Lake and Pond Management in Massachusetts." DEP and DEM have dedicated \$50,000 for the completion of this task. YEAR ONE

Task 5D2: (DEM/EOEA) Through the Lakes and Ponds Initiative, DEM is currently implementing demonstration projects involving, in part, the control of freshwater invaders. Massachusetts expects to contribute up to \$440,000/year over the next three years to support the implementation of these restoration efforts. YEAR ONE

Task 5D3: (DEM/EOEA) Through the Lakes and Ponds Initiative, DEM will train municipalities and watershed groups in the use of techniques for the control of invasive species. Lakes and Ponds Initiative Staff will carry out this task. YEAR TWO

Task 5D4: (DEM) DEM will include guidance on the reintroduction of native species as a component of lake and pond restoration efforts in the GEIR on eutrophication and control of aquatic vegetation. YEAR ONE/ONGOING

Strategic Action 5E: Expand Funding for Local Invasive Species Management and Related Projects

Issue addressed: Municipalities and local organizations often take the lead in AIS management efforts, particularly in freshwater environments. There is currently limited funding available from state and federal agencies to support these control initiatives.

Task 5E1: (DEM/EOEA) The EOEA and DEM will make up to \$250,000/year available to municipalities and local managers for lake and ponds restoration measures through the Lakes and Ponds Grant Program (Appendix C). YEAR TWO

Strategic Action 5F: Monitor and Document the Effectiveness of AIS Control Efforts

Issue addressed: The effectiveness of AIS control efforts often goes unmonitored following implementation. Refinement of existing techniques and development of new management measures will require that the effectiveness of various control technologies are carefully documented and reported to appropriate user groups.

Task 5F1: (DEP) DEP will develop and include a monitoring requirement with permits for herbicide applications to aquatic invasive plants granted through the Herbicide Licensing Program. Massachusetts is seeking \$ 20,000 over two years to support staff time for the development of this program component and \$5,000/year in subsequent years for ongoing implementation. YEAR TWO

Task 5F2: (DEM/EOEA) DEM will monitor the effectiveness of AIS control efforts through Lakes and Ponds Initiative demonstration projects (identified as a need in the Lakes and Ponds General Environmental Impact Report). Massachusetts is seeking \$5,000/year to develop a monitoring program for demonstration projects and oversee the monitoring effort. YEAR TWO

Task 5F3: (DEM) DEM will include a monitoring requirement with grants distributed for AIS control under their Lakes and Ponds Grants Program. DEM has dedicated 0.1 FTE to the development of a monitoring requirement, associated protocols, and reporting mechanisms. YEAR TWO

Task 5F4: (WRP): WRP will continue to monitor the effectiveness of their purple loosestrife biocontrol efforts. WRP is seeking \$18,000 over the next two years to purchase two Global Positioning Systems for mapping of loosestrife populations. ONGOING

Strategic Action 5G: Continue to Implement Efforts to Control Established Populations of Invasive Aquatic Macrophytes

Issue addressed: Established nonindigenous aquatic macrophytes continue to degrade Massachusetts freshwater systems. Control of these populations will be necessary to minimize ongoing ecological and economic impacts.

Task 5G1: (Silvio O. Conte National Fish and Wildlife Refuge) The Connecticut River Watershed Invasive Plant Control Initiative's water chestnut partnership has been controlling water chestnut infestations for three years. Mechanical harvesting cost \$80,000 in 1999 and \$51,000 in 2000. An additional \$5,000 was spent in 2000 on the support of staff involved in additional harvesting efforts and in support of a volunteer monitoring effort. Approximately \$44,000 was spent in 2001 on mechanical harvesting in Long Pond Cove. Resources have not been secured beyond the 2002 field season. To thoroughly clean the cove using mechanical and manual means, expected needs are \$65,000 for 2003 and 2004, with decreasing but ongoing needs in subsequent years (approximately \$30,000/year). ONGOING

Objective 6: Education

Strategic Action 6A: Develop and Distribute Educational Materials Related to Regional Invasive Species Issues

Issue addressed: Continued education of the general public and resource managers regarding threats from AIS and as preventative measure will be necessary to limit the introduction and spread of aquatic invaders to Massachusetts.

Task 6A1: (MIT Sea Grant) MIT Sea Grant will continue to maintain and update the bioinvader web page (<http://massbay.mit.edu/pg?/ExoticSpecies/MIT>). MIT Sea Grant has dedicated \$5,000/year to support a web manager. ONGOING

Task 6A2: (NE Regional Panel) The Northeast Regional Panel will develop a web page that gives background information on the panel and its activities, identifies priority invasive species concerns in the region, and communicates information housed in the Marine Invasive Species Database identified in Task 2D1. Resources obtained through the national Sea Grant Office will be used to support staff time necessary to complete this task. YEAR TWO

Task 6A3: (EOEA/Lakes and Ponds Initiative) EOEA will continue to develop and maintain the Lakes and Ponds Strategy web page (<http://www.state.ma.us/envir/water/index.htm>) communicating the mission and activities of the Lakes and Ponds Watershed Action Strategy. Staff acquired through the Lakes and Ponds Initiative will complete this task. YEAR ONE/ONGOING

Task 6A4: (AIS Working Group/CZM/DEM) The AIS Working Group will develop a slide presentation that outlines the AIS problem and potential management approaches. YEAR ONE

Strategic Action 6B: Develop and Distribute Materials Targeted at Designated Priority AIS

Issues addressed: Assistance from the general public will be necessary to limit the spread of AIS and for effective monitoring of priority invaders.

Task 6B1: (MIT Sea Grant) MIT Sea Grant and the Massachusetts Audubon Society will distribute laminated "Hitchhiker I.D. Cards" depicting priority AIS to agency officials, coastal managers, and the public. MIT Sea Grant has dedicated \$25,000 for printing and distribution costs and will distribute the identification cards early in 2002. Information collected through this effort will be compiled in the Marine Invader Database (see Task 2D1). YEAR ONE

Task 6B2: (DEM) DEM will continue to distribute "A Guide to Selected Invasive Non-Native Aquatic Species in Massachusetts" (Helquist, DEM, 2002). To date, DEM has expended \$18,000 for printing and distribution costs. YEAR ONE

Task 6B3: (New England Aquarium/DEM) The New England Aquarium and the DEM will continue to distribute "A Guide to Aquatic Plants in Massachusetts" (New England Aquarium and DEM, 1996). ONGOING

Task 6B4: (EOEA) EOEA will contract with a consultant to design and fabricate a portable, interactive exhibit on the problems associated with AIS and how to prevent their introduction into lakes, ponds, rivers, and streams to be used in a variety of public settings. EOEA has dedicated \$3,500 to the development of the exhibit. YEAR ONE

Strategic Action 6C: Develop and Distribute Materials Targeted at AIS Transport Vectors

Issue addressed: The diffuse nature of the AIS problem and the wide variety of transport vectors will require that resource managers, industry representatives, and the general public are informed about potential pathways of introduction and spread.

Task 6C1: (CZM/DFA/DFW) CZM, DFA, and DFW will develop and distribute a poster (series) explaining the hazards of releasing aquarium plants and animals to Massachusetts waters. Massachusetts is seeking \$10,000 for development, printing, and distribution costs. YEAR ONE

Task 6C2: (CZM) The North Shore Office of CZM is currently developing a landscaping model promoting the use of native vegetation and management practices to improve water quality and water quantity. The project will include the development of educational materials and a targeted outreach strategy for encouraging the use of native species in water gardens. CZM has dedicated \$25,000 to the completion of this task. YEAR ONE

Task 6C3: (MIT Sea Grant/Massport) MIT Sea Grant and Massport will distribute ballast water management posters and brochures available from the California Sea Grant College Program along with other educational materials to representatives of the

commercial shipping industry. Massachusetts is seeking \$10,000 to support printing and distribution costs. YEAR TWO

Task 6C4: (DEM) The Department of Environmental Management will revise and distribute its “Stop the Spread of Invasive Species” poster at boat launches, bait and tackle shops, pet stores, and other locations. DEM has dedicated \$10,000 for printing and distribution costs. YEAR ONE

Task 6C5: (AIS Working Group/EOEA): The AIS Working Group will coordinate with EOEA and other organizations to sponsor an invasive species booth at state and regional gardening exhibitions including the annual Boston Flower Show. Massachusetts is seeking \$10,000/year to support travel expenses and printing and distribution costs. ONGOING

Task 6C6: (AIS Working Group) The AIS Working Group will develop a presentation relating regional AIS management issues to decision making bodies such as the Coastal Caucus of Legislators. YEARS THREE-FIVE

Objective 7: Research

Strategic Action 7A: Identify Research Priorities for Massachusetts and the Region

Issue addressed: As AIS populations change in size and new invaders are introduced to Massachusetts, priorities for management will change as will research needs. Effective AIS management will require that research priorities are reevaluated periodically, and that these priorities are recognized and addressed by scientists and managers in the region.

Task 7A1: (AIS Working Group/MIT Sea Grant) The AIS Working Group will sponsor a biennial symposium of area researchers for the development of regional AIS research priorities. A subcommittee of the AIS Working Group will develop a scope for the meeting, estimate resource needs, and identify potential funding sources for the research symposium. YEAR TWO

Task 7A2: (AIS Working Group) The AIS Working Group is seeking \$20,000/year to support a graduate fellowship for AIS research based on research priorities identified through Task 7A1. YEAR TWO

Task 7A3: (AIS Working Group) The AIS Working Group will develop a strategy to communicate AIS research needs to the scientific community and research supporters. YEAR ONE/ONGOING

Objective 8: Legislation

Strategic Action 8A: Evaluate Massachusetts's Authority to Restrict the Introduction of Specific Aquatic Species Designated as Threats to the Ecology and Economy of the Commonwealth

Issues addressed: Currently, Massachusetts's authority to prohibit the import of potentially harmful plant, algal, and invertebrate species is limited or unclear. In some cases, state agencies such as the DFA and DMF may wish to include new species as targets in existing inspection programs but do not have the clear authority to expand existing lists.

Task 8A1: (CZM) CZM will contract with a law student to evaluate Massachusetts's existing authority to prohibit the introduction and transport of AIS, particularly plant, algal, and invertebrate species designated as priorities by the AIS Working Group (see also Task 2J3). Massachusetts is seeking \$10,000 to contract with a law student for one semester. YEAR TWO

Task 8A2: (AIS Working Group) Based on the results of Task 8A1, the AIS Working Group will develop a regulatory strategy to limit the introduction of priority species. YEAR TWO/ONGOING

Strategic Action 8B: Make General Recommendations for Additional State and Federal Legislative Needs to Minimize Impacts from Invasive Species.

Issue addressed: As invasive species management evolves in Massachusetts, additional legislative needs may become apparent.

Task 8B1: (AIS Working Group) The AIS Working Group will biennially evaluate legislative and regulatory needs based on the results of implementation efforts outlined in the AIS Management Plan. YEAR TWO/ONGOING

V. Implementation Table

See insert.

VI. Program Monitoring and Evaluation

Following submission of this management plan to the Federal ANS Task Force, the AIS Working Group will generate the first annual work plan based on tasks identified in Section IV. Successes of the plan will be evaluated each year by the Working Group based both on progress in meeting the goals outlined on page 2 as well as successful implementation of identified tasks. Due to the difficulty in assigning quantitative measures of progress towards these goals, the AIS Working Group will evaluate plan implementation based primarily on the completion of specific tasks identified for each year (see Section V: Implementation Table). Results of the evaluation will be summarized in an annual report that will include:

- 1) A qualitative description of progress towards each of the four goals outlined in Section I.
- 2) A complete list of tasks identified in the previous year's work plan, budgetary needs identified for each, resources procured, and resources expended.
- 3) Designation of the implementation status (full, partial, or not implemented) of each task identified in the previous year's work plan and a brief justification of the designation.
- 4) A summary of resource requirements to achieve full implementation of tasks listed as partially or not implemented.

Evaluation of annual work plans will play a major role in directing activities for the following years, as well as restructuring tasks identified in the original plan. Work plans for upcoming years will be produced concurrently with each annual program evaluation document. Public meetings similar to those described in Section I will be held to solicit comments on the draft annual report and work plan prior to the distribution of a final document to relevant state and federal agencies, municipalities, academics, industry representatives, and the general public.

VII. Glossary

algae - organisms with no true roots, stems, or leaves that range in size from single celled organisms to large, plant-like organisms

aquaculture - the controlled cultivation and harvest of aquatic animals and plants

aquatic - relating to fresh or saltwater systems, including both open waters and wetlands

ballast water - any water that is placed in the hold of a ship for the purposes of maintaining stability

benthic - relating to the substrate (bottom) of a lake, pond, ocean, or other water bodies, which often provide habitat for a variety of organisms

biogeographic region - the area defining the geographic boundary of organisms, determined by a combination of climate, water temperature, or geologic boundaries

cryptogenic species - an organism of unknown origin; may be introduced or native

cultch - crushed shells deposited in a waterway to attract the spawn of reef building shellfish such as oysters

epibenthic - relating to organisms that exist exposed on the substrate (bottom) of a lake, pond, ocean, or other water bodies

epiphyte - an organism that grows on another plant or animal upon which it depends for mechanical support but not for nutrients

eradicate - to completely eliminate a population from a geographic area

exotic species - see nonindigenous species

fouling - entanglement, clogging, or obstruction by an undesired organism often resulting in diminished functioning of ships, intake pipes, and other submerged equipment or machinery

hydrology - the study or description of the behavior of atmospheric, surface, or groundwater

invasive species (invader) - nonindigenous or cryptogenic organisms that may threaten the diversity or abundance of native species or the ecological stability and/or uses of infested waters

macrophyte - a plant that is visible with the unaided eye; generally used to refer to floating or rooted aquatic plants

native - existing within a historical ecological range, usually within a balanced system of coevolved organisms

nonindigenous species - (non-native species) a species transported intentionally or accidentally from another region

nuisance species - (as defined by the federal ANS Task Force) animal and plant species that have been introduced into new ecosystems throughout the United States and the world and are having harmful impacts on the natural resources in these ecosystems and the human use of these resources

pathogen - any agent that causes disease in plants or animals; typically referring to microbes such as bacteria, viruses, or protozoan parasites

parasite - an organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host

population - all individuals of a single species within a defined habitat or geographic area such as a pond or watershed

propagules - any of various usually vegetative portions of a plant, such as a bud or other offshoot, that aid in dispersal of the species and from which a new individual may develop

seafood - any fish, shellfish, or other aquatic species harvested for the purposes of human consumption

vector - the physical means by which a species is transported from one area to another, usually referring to transport by humans

watershed - the geographic area that drains to a single water body or hydrographic unit such as a lake, stream reach, or estuary

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Appendices

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Appendix B: Public Scoping Meetings: Question/Comment Summaries

Northeast Regional Conservation Commission Network

- 1) Initial interest in the “Facilitated DEP Herbicide Licensing Process” (ref. Task 4C6).
 - a. Need to make small weed control projects (i.e., *Phragmites*) which private landowners wish to undertake easier to get underway.
 - b. Include readable guidance for the homeowner/citizens for recommended management strategies to deal with priority invaders.
 - c. Include conservation commissions in the discussion with DEP as the revised process is developed.
 - d. Include additional technical assistance during the herbicide licensing process. This could be in the form of permitting templates that are tailored to specific projects (defined by species to be controlled and the size of the project).
- 2) General concerns raised that the information generated through implementation of the plan should be used to make policy/legislation.
- 3) Integration with existing North Shore Programs.
 - a. CZM and the Conservation Commission Network are putting together a workshop for landscape architects geared towards use of plants for pollution prevention. There was a strong interest expressed in expanding this to include invasive species, and expanding the program to include nurseries.
 - b. Other ideas included developing educational materials that create demand for local species and using a model water garden.
- 4) Education: planning boards and conservation commissions need more general information on the invasive species issue i.e., documentation of major invasive species concerns and impacts.
- 5) Wetlands Protection Act: General Consensus that the Wetlands Protection Act could be used to promote/mandate the use of native species at new developments (within the jurisdiction of the Act). This is something we might think about incorporating in the Plan. We might better define what the role of conservation commissions might be.
- 6) Lakes and Ponds Initiative: Significant interest in the demonstration projects. Is DEM looking for ideas for projects, or are the sites already selected? How will the results of projects be translated to local decision makers?
- 7) Herbicide application: Need more information on the costs and benefits or risks of pesticide applications.

- 8) Other networks that might be tapped into for implementation/education:
 - a. Harbor masters.
 - b. Shellfish advisory boards (specifically Essex County).
- 9) Funding: Significant interest in the next Lakes and Ponds grant rounds for local control projects (when? how much? etc.).

Charles River Watershed Conservation Commission Network

- 1) Need additional information on the relationships between water withdrawals or other draw down, changes in temperature and water chemistry, and the growth of invasive species (suggested this may be a component of the DEP/DEM GEIR).
- 2) Along the same lines— what impacts do other lake and pond and wetland alterations (siltation, contaminant inputs) have on aquatic weeds? Will these be addressed in the GEIR and related publications?
- 3) Major concern expressed over the spread of wetland species and macrophytes from contractors. Include language on invasive species prevention in a pending DEP publication on wetland mitigation. Need to develop some BMPs for use of vehicles (construction) in areas of AIS infestation— maybe expand on the boat wash station idea.
- 4) Need expressed for guidance in controlling aquatic weeds and wetland invaders including:
 - a. Control techniques including mechanical harvesting and herbicide application.
 - b. Disposal of removed material.
 - c. Permitting requirements for small projects.
- 5) Selection of Lakes and Ponds for LPI demonstration projects
- 6) Outreach: Use local cable television networks.

Cape Cod Coastal Resources Commission

- 1) Initial questions were posed regarding definitions: Why did the AIS Working Group choose the term invasive? How is a species designated as invasive once it is designated as nonindigenous?

Discussion leaders explained that comprehensive lists of species were initially reviewed and working group subcommittees used the following criteria to designate priorities:

- a. Severity of the problem posed by the introduced species.
 - b. Potential impacts from managing the species (costs versus benefits).
 - c. Existing capabilities for management.
- 2) Questions posed regarding the scope of the plan. Why are water birds not included in the plan?

It was explained that in discussing the scope of the plan, it was determined that efforts to manage birds and mammals are already extensive in Massachusetts, and that control of these species would be handled through existing programs.

- 3) Interest expressed in the training of volunteer groups to do monitoring. Audience members explained that it is not always clear what should be done with data once they are collected.

Existing data management efforts such as the DEP aquatic macrophytes database and the Northeast Regional Panel database were explained in detail.

- 4) One audience member suggested that educational materials be distributed during boater safety course. In addition instructors (often members of the US Coast Guard) could be trained in invasive species issues and preventative measures, and that this information be integrated into boating safety course curricula.
- 5) One audience member suggested that a draft plan be placed in local libraries during the public review period.
- 6) It was suggested that the AIS Working Group increase communications with the Park Service, particularly with regards to management initiatives that have been undertaken at the Cape Cod National Seashore.

South Coastal Watershed Team Meeting

- 1) Concern was immediately expressed over the lack of management objectives and actions that deal with construction vehicles both transporting invasive organisms directly and creating disturbances or other pathways by which invasive species might spread (construction management actions have since been incorporated).
- 2) Additional concern was expressed over the transport of invasive species with fill material.
- 3) Representatives of the landscape architecture industry suggested that we distribute educational materials through the “New England Grows” show, to reach the majority of industry representatives.
- 4) An audience member asked if we address transport of AIS by waterfowl and if so how that might be done. The participant was informed that this had not been addressed in the plan due to necessary limitations in the scope of the plan.

- 5) An audience member warned that we exercise caution in promoting the economic benefits of harvesting invaders due to the interest that may be generated in protecting them.
- 6) The watershed team leader suggested that we protect against the genetic dilution of shellfish stocks resulting from the introduction of fast growing, genetically homogenous shellfish seed.
- 7) An audience member asked how groups would be contacted regarding Invasive Species Monitoring efforts through volunteers. The response was that volunteer monitoring groups will be solicited for their participation in the effort.

Additional interest was expressed in reviewing the plan. The audience was informed that the plan will be posted on the CZM web page following the next working group meeting Oct. 25.

Lakes and Ponds Association (LAPA) West

- 1) How will the state agencies get funds to the public to use on projects for controlling or preventing Invasive Species?
- 2) We are already working with DEM on invasive projects. Were these counted as part of the plan?
- 3) Will the Lakes and Ponds Watershed Action Strategy last more than three years?
- 4) Will implementation of the Aquatic Invasive Species Management Plan result in a staff person dedicated to AIS management issues in the regions?
- 5) Will the Aquatic Invasive Species Management Plan fund projects for Lake Associations?

SuAsCo Watershed Conservation Commission Network

- 1) How does the Aquatic Invasive Species Management Plan funnel \$\$ to the public?
- 2) How does the public get involved?
- 3) Will new laws be developed from this?
- 4) State agencies might consider reviewing laws from other states such as Maine.
- 5) Is there a public review process? Who is the lead for this initiative?

Appendix C: Grant Programs Applicable to Aquatic Invasive Species

Massachusetts

Lakes and Ponds Grant Program

Sponsor Agency: Department of Environmental Management
Contact: Steve Asen 617-626-1353
www.state.ma.us/dem/programs/lakepond/lakeapp.htm
Eligibility: Municipalities in conjunction with other groups (watershed groups, other non-profits, etc.)
Overview: Awards grants for the protection, preservation and enhancement of public lakes and ponds in the Commonwealth of Massachusetts.
Range of Funding: Maximum of \$10,000.00
Cost sharing: Yes, 50/50
Deadline: N/A

Rivers and Harbors Grant Program

Sponsor Agency: Department of Environmental Management
Contact: Leslie Lewis 781-740-1600 x.111
www.state.ma.us/dem/grants.htm
Eligibility: Towns and municipalities
Overview: Statewide program from the Office of Waterways for the design and implementation of solutions to address coastal and inland waterway problems.
Range of Funding: Maximum of \$300,000.00
Cost Sharing: Yes, 50/50 local match for all projects except dredging which requires 25% local match
Deadline: N/A

Division of Conservation Services Grant Programs

Sponsor Agency: Executive Office of Environmental Affairs
Contact: www.state.ma.us/dcs/dcsgrnt.htm
Eligibility: Massachusetts communities
Overview: To provide support for projects that prevent pollution, restore environmental Quality and protect natural resources.
Range of Funding: Maximum of \$500,000
Cost Sharing: Programs provide communities with 52%-70% reimbursement
Deadline: June 1

Agro-Environmental Technology Grant Program

Sponsor Agency: Massachusetts Department of Food and Agriculture
Contact: Craig Richov 508-792-7711 x14
142 Old Common Road
Lancaster, MA 01523
Eligibility: Public and private agencies and organizations, business and industry, educational institutions, and local Massachusetts government
Overview: Inviting proposals to fund demonstration projects, feasibility analyses and applied research designed to address agriculture related environmental concerns and development needs. At least one grant has been used recently for aquatic weed control.
Range of Funding: Maximum of \$50,000
Average grant last year: \$12,500
Cost Sharing: None
Deadlines: December 1 (2000)

National Programs

Partners for Fish and Wildlife Program

Sponsor Agency: United States Fish and Wildlife Service
Contact: Steve Hill 413-253-8614
<http://grants.fws.gov>
Eligibility: Private land owners
Overview: Offers technical and financial assistance for the voluntary restoration of wetlands and other fish and wildlife habitats on private land. Enhances reestablishment of native vegetation and ecological communities for benefit of fish and wildlife in concert with the needs and desires of private landowners.
Range of Funding: N/A
Cost Sharing: Yes, 50/50 local sharing
Deadline: N/A

Partnership for Wildlife

Sponsor Agency: United States Fish and Wildlife Service
Contact: Gary Reinitz
Gary_reinitz@fws.gov
Eligibility: State Agencies
Overview: To provide grants to state projects that benefit a variety of fish and wildlife species and/or encourage non-consumption fish and wildlife recreation opportunities.
Range of Funding: FY00 \$768,000 available
Cost Sharing: none
Deadline: N/A

Regional Geographic Initiative

Sponsor Agency: US Environmental Protection Agency
Contact: Deb Harsted 617-918-1085
www.epa.gov/regional/rgi.htm
Eligibility: Contact Deb Harsted
Overview: Provides up to four years of "seed money" for projects that address a high human health or ecosystem risk (such as those associated with aquatic invasive species) and have significant potential for risk reduction. These projects will focus on a place rather than a pollutant.
Range of Funding: N/A
Cost Sharing: none
Deadline: All stages of the process normally take place between October and January.

Wildlife Habitat Incentives Program

Sponsor Agency: US Department of Agriculture, Natural Resource Conservation Service.
Contact: Rick Devergilio
Rick.devergilio@ma.usda.gov
Eligibility: Owners, landlords, land operators or tenants
Overview: Provides financial incentives to develop habitat for fish and wildlife on private lands. The agreement generally lasts 10 years.
Range of Funding: Maximum of \$10,000.00 per contract
Cost Sharing: Yes, USDA pays up to 75%
Deadline: None, apply at local USDA Office

Watershed Protection and Flood Prevention

Sponsor Agency: US Department of Agriculture, Natural Resource Conservation Service
Contact: Carl Gustafson
Carl.Gustafson@ma.usda.gov
Eligibility: Any state agency, county, town, municipality, district, non-profit, tribe or group with authority under state law
Overview: Assistance for maintenance and operation of watershed works of improvement, including wildlife habitat improvements.
Range of Funding: Projects over \$5 million require congressional approval
Cost Sharing: Yes, varies
Deadline: Check with contact for deadline for 2001

North American Wetlands Conservation Grants

Sponsor Agency: US Fish and Wildlife Services
Contact: Regional: Andrew Milliken, andrew_milliken@fws.gov
National: Bettina Sparrowe, Bettina_sparrowe@fws.gov (Standard Grants)
Keith Morehouse, keith_morehouse@fws.gov (Small Grants)
Eligibility: Any individual or group
Overview: Provides assistance for long-term conservation efforts directed toward wetlands through habitat protection, restoration, or enhancement. The purpose of the grant is to encourage voluntary, public-private partnerships to conserve wetland ecosystems. Originally established to help support the North American Waterfowl Management Plan so many of the approved projects involved bird habitat preservation. Applicants working with invasive species may want to highlight the importance of native species in habitat restoration.
Range of Funding: Standard: up to one million
Small Grants: Up to \$50,000.00
Cost Sharing: 50/50 split, cost sharing
Deadline: Standard: March 23 and July 6, 2001
Small Grants: December 1, 2001

Coastal Wetlands Planning, Protection, and Restoration Act Program

Sponsor Agency: US Fish and Wildlife Services
Contact: Sue Essig 413-253-8611
sue_essig@fws@gov
300 Westgate Center Dr.
Hadley, MA 01035-9589
Eligibility: Coastal states including the lake region, Guam, US Virgin Islands, Puerto Rico, Commonwealth of the Northern Mariana Islands, the Trust Territories of the Pacific Islands, and America Samoa
Overview: Provides funds to assist in pursuing coastal wetland conservation projects. Funds can be used for acquisition of lands or waters and for restoration, enhancement or management of coastal wetland ecosystem. Programs will provide for long- term conservation of such lands and their hydrology, water quality and fish and wildlife.
Funding: FY00 \$11.8 million
Cost Sharing: Grant will provide between 50-75%
Deadline: June 8

Aquatic Resource Education

Sponsor Agency: United States Fish and Wildlife Service
Contact: Gary Reinitz

Eligibility: Gary_reinitz@fws.gov
State agencies
Overview: Through the Sport Fishing Restoration Act, states are reimbursed for aquatic resource education programs with budgets that do not exceed 15% of the total state sport fishing restoration funds.
Funding: The Sport Fishing Restoration funds come from taxes on fishing equipment and motor boat fuel taxes.
Cost Sharing: States must contribute any amount above the amount available through the Sport Fishing Restoration Funds.
Deadline: Ongoing

Wetlands Reserve Program

Sponsor Agency: US Dept. of Agriculture, Natural Resource Conservation Service
Contact: Rick Devergilio
Rick.devergilio@ma.usda.gov
Eligibility: State, private, association, any legal entity that has owned the land for at least one year.
Overview: This is a voluntary program to provide financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land. Landowners may sell a conservation easement or enter into a cost-share restoration agreement. Landowners voluntarily limit future use of the land, but retain private ownership. Landowners and the NRCS develop a plan for the restoration and maintenance of the wetland. This restoration may include the control and prevention of invasive species.
Funding: Based on acreage, not funding levels; FY00 150,000 acres
Cost Sharing: USDA will provide 75% unless owner opts for permanent easement, in which case the USDA purchases the land
Deadline: Continuous sign-up

Wetlands Program Development Grants

Sponsor Agency: US Environmental Protection Agency
Contact: Stafford Madison
Madison.Stafford@epa.gov
www.epa.gov/owow/watershed/academy/fund/wetlandsp.htm
Eligibility: States, tribes, local governments, intergovernmental organizations
Overview: Provides financial assistance to support development of new, or augmentation and enhancement of existing wetland programs. Projects must clearly demonstrate a direct link to an increase in the participant's ability to protect its wetland resources.
Funding: FY00 \$15 million
Cost Sharing: Grant will provide 75%
Deadline: Varies

Bring Back the Natives Grant Program

Sponsor Agency: National Fish and Wildlife Foundation
Contact: www.nfwf.org/programs.htm
Northeast Region contact: Eric Hammerling (202) 857-6166
hammerling@nfwf.org
Eligibility: Local governments, states, and local nonprofit organizations
Overview: Assists in restoring damaged or degraded riverine habitats and their native aquatic species through watershed restoration and improved land management.
Funding: FY00 \$4.5 million
Cost Sharing: No
Deadline: None, applications accepted through the year

Five Star Restoration Program

Sponsor Agency: US Environmental Protection Agency
Contact: US EPA Office of Wetlands, Oceans and Watersheds
202-260-8076
pai.john@epa.gov

Eligibility: Any public or private entity that engages in community based restoration
Overview: EPA provides funds to four intermediary organizations, the National Association of Counties, the National Fish and Wildlife Foundation, the Wildlife Habitat Council and the National Association of Service and Conservation Corps. These agencies then administer sub grants to support community-based wetland and riparian restoration projects that emphasize long term ecological, educational, and/or socio-economical benefits to a watershed. Projects must include multiple partners (volunteer groups, corporations, private landowners, government, nonprofits, etc.).

Funding: FY00 \$500,000.00
Sub grants average is \$10,000.00

Cost Sharing: No, information and technical support exchange necessary.

Deadline: January/ February

Watershed Assistance Grants

Sponsor Agency: US Environmental Protection Agency
Contact: Office of Wetlands, Oceans and Watersheds
Ariel Rios Bldg.
1200 Pennsylvania Ave., NW
Washington, DC 20460
202-260-4538
Cole.james@epa.gov

Eligibility: Nonprofits, tribes, local governments
Overview: Funds are provided to support organizational development and capacity building for watershed partnerships with diverse membership. The EPA establishes a relationship with one or more eligible entities to support watershed partnership, organizational development and long term effectiveness.

Funding: Maximum funds for one partnership: \$30,000.00

Cost Sharing: Match is encouraged but not required

Deadline: Varies

Community-Based Restoration Program

Sponsor Agency: National Oceanic and Atmospheric Administration
Contact: US Department of Commerce
National Oceanic and Atmospheric Administration
Office of Habitat Conservation, FHC3
1315 East-West Highway
Silver Spring, MD 20910
301-713-0174
chris.doley@noaa.gov

Eligibility: State, territorial, local, or tribal governments; regional governmental bodies; public or private agencies or organizations; universities and colleges; private and nonprofit organizations

Overview: Provides funds for small-scale, locally driven habitat restoration projects that foster natural resource stewardship within communities. Partnerships are sought at the national and local level to contribute funding, land, technical assistance, workforce support, or other in-kind services. The program emphasizes the use

of a grassroots, bottom-up approach to restoring fishery habitat across coastal America.

Funding: FY00 up to \$ 2 million
Cost Sharing: Grants are cooperative agreements, no set cost-sharing ratio
Deadline: As posted on the NOAA web site

Federal Aid in Wildlife Restoration

Sponsor Agency: US Fish and Wildlife Service
Contact: The Division of Federal Aid
Fw9_Federal_Aid@fws.gov
Eligibility: State agencies
Overview: Distributed to states to provide funding for the selection, restoration, information produced by these projects. "Teaming with Wildlife" is one of the Wildlife Restoration programs that may be applicable for invasive species work.
Funding: Funds are derived from an 11 percent federal tax on sport hunting guns, ammunition, and archery equipment and a 10 percent tax on handguns. The amount each state receives is determined by a formula considering the total area of the state and the number of licensed hunters in that state. The state covers the full cost of any approved project and then applies for reimbursement through Federal Aid.
Cost Sharing: State must provide 25%, Federal will support 75%
Deadline: Program dependant, email above address for details

Challenge Grants

Sponsor Agency: National Fish and Wildlife Foundation
Contact: Eric Hammerling
hammerling@nfwf.org
Eligibility: Federal, state, and local governments, educational institutions, nonprofit organizations
Overview: Awards funds for projects that promote species and habitat conservation that involve multiple community partners and have an evaluation component to project outcomes.
Funding: Most awards are between \$25,000-\$75,000 with some small grants and some over \$150,000
Cost Sharing: Non-federal dollars or goods and services of equal value must match each dollar awarded. Participants are encouraged to achieve at least a 2:1 ratio for each federal dollar.
Deadline: Revolving application process with Board of Directors decisions made October 31 and March 31

Pulling Together Initiative

Sponsor Agency: National Fish and Wildlife Foundation
Contact: Gary Kania 202-857-0166
kania@nfwf.org
Eligibility: Federal agencies, state and local governments, private landowners
Overview: Provides funds supporting partnerships in developing long-term weed management projects within the scope of integrated pest management strategy. The goals of the initiative are to (1) prevent, manage or eradicate invasive and noxious plants through a coordinate program of public/private partnerships; and (2) increase public awareness of the adverse impacts of invasive and noxious plants.
Funding: Contact Gary Kania
Cost Sharing: Yes, federal money must be matched by state, local or private funds
Deadline: Contact Gary Kania

Coastal Ocean Programs

Sponsor Agencies: Department of Commerce
Center for Sponsored Coastal Ocean Research/Coastal Ocean Program
(CSCOR/COP), National Ocean Service (NOS), National Oceanic and
Atmospheric Administration (NOAA)

Contact: Leslie McDonald 301-713-3338 ex. 137
CSCOR/COP Grants Administrator

Eligibility: All qualified non-federal and federal researchers. Participants must be affiliated
with a non-profit institution.

Overview: Provides predictive capability for managing coastal ecosystems through
sponsorship of research. COP supports research on issues critical to estuaries,
coastal waters, and Great Lakes and translates findings into accessible
information.

Funding: Average between \$5,000-500,000
FY00 \$8.5 million

Cost Sharing: No cost sharing requirements

Deadline: Check specific funding announcements

Research Grants

MIT Sea Grant Request for Proposals

Sponsor Agencies: MIT Sea Grant Program

Contact: Richard Morris 617-252-7042
rgmorris@mit.edu

Eligibility: Faculty and senior researchers at universities and colleges and senior researchers
at non-profit organizations

Overview: Solicitation for proposals that address the research needs identified by MIT Sea
Grant in the following four themes: 1) Coastal Management and Utilization
2) Coupled Ocean Observing and Modeling 3) Marine Biotechnology, and
4) Technical Development. This includes proposals for regional projects and the
Advisory Services and Educational Program.

Funding: Maximum annual funding per research project: \$75,000. Maximum annual
funding for education and outreach projects: \$25,000

Sharing: 50/50

Deadline: Preliminary Proposals: March 2001
Full Proposal: March 2002

Aquatic Nuisance Species Research and Outreach

Sponsor Agencies: National Sea Grant Program, National Oceanic and Atmospheric
Administration, Department of Commerce

Contact: Leon M. Cammen, Aquatic Nuisance Species Coordinator, National
Sea Grant College Program, NOAA
1315 East-West Highway
Silver Spring, MD 20910
Or contact local program director
MIT Sea Grant Director:
Chryssostomos Chryssostomosidis
chrys@deslab.mit.edu

Eligibility: Any individual, public or private corporation or partnership or other association or entities (including institutions of higher education, institutes, non-federal laboratories), or any State or political subdivision of the state or agency.

Overview: Provides support to projects to prevent and/or control nonindigenous species invasions in all US marine waters, the Great Lakes, and Lake Champlain. Projects will be selected through national competitions.

Funding: In FY 2001 and 2002, \$2,700,000 per year

Cost Sharing: 50/50

Deadline: November 15

Improved Methods for Ballast Water Treatment and Management and Prevention of Small Boat Transport of Invasive Species

Sponsor Agencies: National Sea Grant Program, National Oceanic and Atmospheric Administration, Department of Commerce and Fish and Wildlife Services, Department of the Interior

Contact: Dr. Leon Cammen 301-713-2435x136
leon.cammen@noaa.gov
www.nsgo.seagrant.org/research/nonindigenous/RFP00.html

Eligibility: Any person may apply. Applications from non-federal and eligible federal applicants will be competed against each other. Non-federal applicants will be funded through a project grant or cooperative agreements and federal agencies will be funded through an inter-agency transfer.

Overview: Provide support to projects to improve ballast water treatment and management in the Chesapeake Bay and Great Lakes in particular (Sea Grant) and in US coastal and Great Lakes waters in general (Service). Also to support projects to reduce the transport of invasive species by small boats.

Funding: FY2000 Sea Grant: \$700,000
Services: \$300,000
Sea Grant for small boats: \$40,000

Cost Sharing: Not specified in the grant

Deadline: Check web site for current deadline

Biology of Weedy and Invasive Plants

Sponsor Agency: NRI, Cooperative State Research, Education and Extension Service, Department of Agriculture

Contact: Program Director 202-401-6466
apark@reeusda.gov

Eligibility: Anyone

Overview: Provides support to research that leads to an improved understanding of the extent of genetic and phenotypic diversity within and between plant populations, species composition within a community, and or species competitiveness and invasiveness. The program also supports proposals aimed at understanding plant population dynamics and interactions between agricultural settings and lands of conservation. Support will also be given to development of new methods of controlling the spread weeds or invasive plants.

Funding: FY2001 \$300,000 over 3-4 years

Cost Sharing: Not specified in the grant

Deadline: November 15, 2000, check web site for current deadline

Appendix D: Summary of Research Activities

General

James T. Carlton

Williams College

jcarlton@williams.edu

Dr. Carlton has worked extensively on aquatic invasive species in New England and around the world. His publications and accomplishments cover a wide range of expertise, focusing on dispersal vectors, ecological and evolutionary impacts, community structure, and management and prevention issues relevant to aquatic invasive species. Currently, he is working with L. David Smith, Shannon Willard, and Judith Pederson on an investigation into the transport vectors of New England. He is the founding editor in Chief of the new international journal *Biological Invasions* and was Co-Chair of the Marine Biodiversity Committee of the National Academy of Sciences, which produced *Understanding Marine Biodiversity: A Research Agenda for the Nation* (1995).

Carlton is a member of the Steering Committee of the UN Global Invasive Species Program (GISP), and was Chair from 1991 to 2000 of the Working Group on Introductions and Transfers of Marine Organisms of the International Council for the Exploration of the Sea (ICES). He has testified five times on introduced species issues before Senate and House subcommittees, and was Principal Investigator of the "Shipping Study" mandated under 1990 federal law. In April 1999 Dr. Carlton was the first scientist to receive the US Government's interagency Recognition Award for Significant and Sustained Contributions to the Prevention and Control of Nonindigenous Species in America's Aquatic Ecosystem.

Representative Publications:

Carlton, J.T. and J.B. Geller. 1993. Ecological roulette: The global transport of nonindigenous marine organisms. *Science* 261:78-82

Carlton, J.T. 1996. Marine bioinvasions: the alteration of marine ecosystems by nonindigenous species. *Oceanography* 9:36-43

Carlton, J.T. 1996. Pattern, process, and prediction in marine invasion ecology. *Biological Conservation* 78:97-106

L. David Smith

Smith College

ldsmith@lynx.neu.edu

Dr. L. David Smith's research is actively examining two aspects of marine biological invasions in the Gulf of Maine. One research direction examines dispersal pathways of nonindigenous marine species. Nonindigenous species arrive by numerous pathways, yet

we know little about: (a) the identity, frequency or quantity of organisms being transported by a given pathway, (b) factors that make certain regions susceptible to invasion, or (c) the potential for invaders to continue to spread within a region. His research addresses these issues for both shipping (ballast water) and non-shipping (seafood, aquaculture, bait, and pet industries) pathways. A second research direction examines behavioral and morphological responses by introduced predators and native prey to each other. He is particularly interested in determining whether trophic interactions generate short or long-term arms races as induced defenses in prey are countered by improved foraging effectiveness in invading predators. His lab is currently testing for diet-induced changes in claw size and performance in an invading crab predator and induced changes in shell form in native snail prey over a latitudinal temperature gradient.

Representative Publications:

Smith, L.D., M.J. Wonham, L.D. McCann, G.M. Ruiz, A.H. Hines, and J.T. Carlton. 1999. Invasion pressure to a ballast-flooded estuary and an assessment of inoculant survival. *Biological Invasions* 1:67-87.

Trussell, G.C. and L.D. Smith. 2000. Induced defenses in response to an invading crab predator: An explanation of historical and geographical phenotypic change. *Proceedings of the National Academy of Sciences* 97:2123-2127.

Smith, L.D., M.J. Wonham, J.T. Carlton, and G.M. Ruiz. 2000. Fish and ships: relating dispersal frequency to success in biological invasions. *Marine Biology* 136: 1111-1121.

Judith Pederson

MIT Sea Grant
jpeterso@mit.edu

Dr. Judith Pederson is Manager of the Coastal Resource Center at MIT Sea Grant and has worked to improve the communications between scientists, managers, and commercial interests in marine issues. She organized the First National Conference on Marine Bioinvasions in 1999 and edited the proceedings. Dr. Pederson has established a web site dedicated to MIT Sea Grant work with invasive species and continues to seek funding opportunities to increase awareness and educational programs throughout the state. Judith Pederson is working with L. David Smith, Shannon Weigle and James Carlton on the transport vector study for New England marine invasive species. Finally, Dr. Pederson took the lead in implementing a Rapid Assessment Survey of invaders on floating dock and piers in coastal Massachusetts and Rhode Island in the summer of 2000.

Representative Publications:

Pederson, Judith, 1996. Exotic Species Workshop: Issues Relating to Aquaculture and Biodiversity. MIT Sea Grant College Program Publications: 96-15.

Pederson, Judith (ed). 1999. Marine Bioinvasions: Proceedings of the First National Conference January 24-27, 1999. MIT Sea Grant College Program.

Jan Pechenik

Tufts University

Jan.pechenik@tufts.edu

Dr. Jan Pechenik studies the stresses marine organisms experience in transport via ship ballast water. Food limitation for planktonic feeding larvae, delayed metamorphosis, and other stresses that could reduce the survival or competitive ability of some species after metamorphosis are studied to determine if they could help explain why some species are more successful invaders than others. The growth rates and post-settlement survivorship of gastropods, polychaete annelids, bryozoans and barnacles are studied in relation to food limitation and delayed metamorphosis to determine the relative competitiveness of different species that undergo transport via ship ballast water.

Representative Publications:

Pechenik, J. 2000. Larval Experience can influence invasion potential for benthos marine invertebrates. J. Pederson (ed.) Marine Bioinvasions: Proceedings of the first annual national conference. MIT Sea Grant, Cambridge, MA.

Pechenik, J. Metamorphosis is not a new beginning. *BioScience* 48 (11): 901-910. 1998.

Asian Shore Crab

Nancy O'Connor

University of Massachusetts-Dartmouth

noconnor@umassd.edu

Dr. Nancy O'Connor studies the ecology and history of the *Hemigrapsis sanguineus* in New England. Her work with the Asian shore crab ranges from the genetic to population level. Recently she has collaborated in using genetic patterns to determine the likelihood of multiple invasions on the eastern shore. Another project examined the population density and distribution along with feeding habits to assess the potential impact of *Hemigrapsis* on community structure in rocky intertidal communities. Currently her research is focused on the effect of *Hemigrapsis* on native crab species in New England.

Tara Cassanova

Cedar Island Marine Research Laboratory

biotara@aol.com

Tara Cassanova studies the ecological and population dynamics of the Asian shore crab, *Hemigrapsis sanguineus*. Abundance, distribution and feeding habits are analyzed to determine the niche overlap and possible competition with native species.

Representative Publications:

Casanova, T. 2000. The ecology of the Japanese shore crab and its niche relationship to the green crab along the coast of Connecticut, USA. J. Pederson (ed.) Marine Bioinvasions. Proceedings of the First National Conference. MIT Sea Grant, Cambridge, MA.

Paul Boudreau

Center for Marine Science and Technology: University of Massachusetts, Dartmouth
pboudreau@hotmail.com

Paul Boudreau has worked with Nancy O'Connor on the feeding preferences of *Hemigrapsis sanguineus* in southern Massachusetts. The prey selection of mollusks was investigated to gain insight into the crabs' potential to alter New England rocky intertidal ecosystems through predation. His work has found that the crab is omnivorous, feeding readily on mollusks and microalgae. However, *H. sanguineus* selectively removed small individuals from the experimental mollusk populations. *H. sanguineus* therefore has the potential to alter natural mollusk populations by affecting levels of prey recruitment into adult size classes. Paul Boudreau started work in the fall of 2001 on the role of anthropogenic disturbance on invasive species success in estuarine and coastal environments.

Representative Publications:

Boudreau, P. and N. O'Connor. 2000. Prey preferences of the recently introduced Western Pacific Crab, *Hemigrapsis sanguineus*, feeding on mollusks and macroalgae in southeastern Massachusetts. J. Pederson (ed.) Marine Bioinvasions. Proceedings of the First National Conference. MIT Sea Grant, Cambridge, MA.

Botryllid Ascidians

C. Sarah Cohen

Department of Organismic and Evolutionary Biology, Harvard
scohen@oeb.harvard.edu

Sarah Cohen works with fouling ascidians invasions. Her work is focused on determining the correct taxonomy of ascidians to aid in answering questions concerning their potential as threatening invasive species using genetic markers and molecular identification. Behavioral and life history variation between populations could be important to the distribution of these species as invaders. Her work deals with the identification and distribution of ascidians in general, with some studies on the identification of invading species.

Representative Publications:

Cohen, C.S. 2000. Botryllid Ascidians: Few Invaders or Many? J. Pederson (ed.) Marine Bioinvasions. Proceedings of the First National Conference. MIT Sea Grant, Cambridge, MA.

Cohen, S., Y. Saito, and I. Weissman. 1998. Evolution of allorecognition in botryllid ascidians inferred from a molecular phylogeny. *Evolution* 52(3): 746-756.

Cordylophora

Nadine Folino-Rorem

Biology Department, Wheaton College

Nadine.c.folino-rorem@weaton.edu

Dr. Nadine Folino-Rorem studies several aspects of the colonial hydroid *Cordylophora* spp. populations in brackish and freshwater habitats. The work done in her lab includes preliminary taxonomic classification and DNA analysis along with interbreeding experiments to clarify the potential discrepancy between the five documented species of *Cordylophora*. Mapping invasion patterns and affected areas in conjunction with laboratory experiments on the transfer of the organisms from fresh to brackish water and vice versa are used to help understand the adaptability of this hydroid in the invasion process. Experiments on growth and reproduction were conducted to determine how effective temperature and chlorine are in controlling the spread of *Cordylophora*. Currently Nadine Folino-Rorem is examining the fouling potential of this organism for power companies and irrigation systems, and the co-occurrence and interactions of *Cordylophora* with more familiar fouling pests such as zebra mussels and bryozoa.

Representative Publications:

Folino, N. 2000. The freshwater expansion and classification of the colonial Hydroid *Cordylophora*. J. Pederson (ed.). *Marine Bioinvasions: Proceedings of the First National Conference*. MIT Sea Grant 00-2. pp. 139-144.

Grateloupia

Martine Villalard-Bohnsack

Roger Williams University

mvillbohns@mediaone.net

Martine Villalard-Bohnsack focuses on two aspects of the *Grateloupia doryphora* invasion in Rhode Island waters. The first, in collaboration with Marilyn Harlin (University of Rhode Island) involves studies on the geographical spread of the species, morphological variations in relation to environmental factors, recruitment strategies, development and ecological impacts of the invasion. The second investigation's focus, conducted with Marcie Marston (Roger Williams University), explored the source of the Rhode Island *Grateloupia* and genetic variation within the species. The taxonomy of *G. doryphora* is also being examined in conjunction with Marc Verlaque (University of Marseille, France).

Representative Publications:

Villalard-Bohnsack, M. and M. Harlin. 1997. The appearance of *Grateloupia doryphora* on the northeast coast of North America. *Phycologia* 36(4): 324-328.

Villalard-Bohnsack, M and M. Marston. 2000. The Molecular Genetics to investigate the geographic origin and vector of invasive red algae. J. Pederson (ed.). *Marine Bioinvasions: Proceedings of the First National Conference*. MIT Sea Grant, Cambridge, MA.

Marcie Marston

Roger Williams University

mfm@alpha.rwu.edu

Marcie Marston is a molecular biologist and geneticist focused on the genetic diversity and origin of the Rhode Island invasive seaweed, *Grateloupia*. The specific objectives of her project are to analyze and then continue to monitor any changes in the genetic diversity of the *G. doryphora* population in the Narragansett Bay, to identify the geographical origin(s) of the parental stock of the Rhode Island population, and to examine the genetic relationships of *Grateloupia* species from locations around the world. DNA have been isolated from over 50 individuals representing all 14 locations and this genetic information is being used to construct phylogenetic trees to examine the relationships among individuals and to try to identify the geographic origin of the Rhode Island population. The data of Marcie Marston and her coworker suggests that there is an “invasive” genotype/species of *Grateloupia* that has been expanding in range and it appears as though the Rhode Island species originated from one of the European populations.

Representative Publications:

Marston, M.F. and M. Villalard-Bohnsack. Genetic variability and possible geographic origins of an invasive species, *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) in Rhode Island, USA. To be submitted to the *Journal of Phycology* (in prep)

Marston, M.F. and M. Villalard-Bohnsack. 2000. The use of molecular genetics to investigate the geographic origin of an invasive red algae. J. Pederson (ed.). *Marine Bioinvasions. Proceedings from the First National Conference*. MIT Sea Grant, Cambridge, MA.

Green Crab

William Walton

Wellfleet, MA Shellfish Program

Billy5@altavista.net

Dr. William Walton studies the effects of *Carcinus maenas* on shellfish and investigates possible solutions to the problems the green crab imposes upon the industry. Municipal managers consider the green crab a major predator limiting shellfish production and/or

enhancement efforts and William Walton has been attempting to scientifically document this through lab and field experiments. His current work also includes a study of the effectiveness of town efforts to trap green crabs, the exploration of new trapping methods, and population models that will guide targeted trapping programs to reduce their numbers. A pilot study has also been started at Beal's Island to explore the feasibility of harvesting soft-shell green crabs based on work in Italy on a sibling species, *C. aestuarri*.

Representative Publications:

Walton, W.C. 2001. Problems, predators and perception: Management of quahog (hard clam), *Mercenaria mercenaria*, stock enhancement programs in southern New England. *Journal of Shellfish Research*. 20(1):127-134.

Walton, WC 1997. Preliminary evaluation of the impact of *Carcinus maenas* upon the native Tasmanian clam (*Katelysia scalarina*) fishery. Proceedings of the First International Workshop on the Demography, Impacts and Management of Introduced Populations of the European Crab. Center for Research on Introduced Marine Pests Technical Report. 11:44-47.

Phragmites

Robert Buchsbaum

Massachusetts Audubon Society
rbuchsbaum@massaudubon.org

Dr. Robert Buchsbaum studies restoration and other management issues related to salt marshes. The replacement of native vegetation by the invasive common reed, *Phragmites australis*, is thought to reduce the wildlife value and ecological health of the area. Buchsbaum and his coworkers have examined differences between the types and numbers of birds found in *Phragmites*-dominated habitats with those in cattail and *Spartina* spp. He also has been examining changes in the vegetation and animal communities in salt marshes that have been subjected to increased tidal flushing as a management measure to reduce the cover of *Phragmites*. This work examines heights and spread rates, standard measures of the plant community, ground water salinities, fish, birds, and marsh surface invertebrates. Buchsbaum has also been exploring the effects of salinity stress on the spread and growth of *Phragmites*.

Representative Publications:

Burdick, D.M., Buchsbaum, R. and Holt, E. 2000. Tidal Manipulations and *Phragmites* invasion of Salt Marshes. Submitted to *Plant and Environment*. Presented at Symposium on Plants and Organisms in Stressed Wetland Environments, Quebec.

Buchsbaum, R., J. Catena, E. Hutchins, D. Burdick, A. Ridlon and E. Holt. 2000. Indicators of Salt Marsh Restoration. Proceedings of Conference on the use of biological

indicators to signal wetland health. Massachusetts Bays Program. November 2000, Boston, MA.

Buchsbaum, R. and E. Holt. 2000. Bird Use of *Phragmites* in Coastal Marshes of Northern Massachusetts. pp 232-240 in J. Pederson (ed.). Marine Bioinvasions, Proceedings of the First National Conference. MIT Sea Grant, Cambridge, MA.

Burdick, D.M., R. Buchsbaum, E. Holt. 2001. Variation in soil salinity associated with expansion of *Phragmites australis* in salt marshes. *Environmental and Experimental Botany*. 46:247-261.

Appendix E: Nonindigenous Aquatic Species Documented in New England

Marine Organisms (from Carlton, 1997)

<u>Taxon</u>	<u>Common Name</u>	<u>Comments</u>
PROTISTA		
<i>Haplosporidium nelsoni</i>	MSX (oyster disease)	Massachusetts (1967). Transported from mid-Atlantic coast with shellfish stocks?
<i>Perkinsus marinus</i>	Dermo oyster disease	Massachusetts? (1990) As above.
<i>Bonamia ostrea</i>	Bonamia oyster disease	Maine (1991). As above.
<i>Aureococcus anophagefferens</i>	Brown tide	Southern New England. Cryptogenic.
Diatomacea (diatoms)		
<i>Coscinodiscus wailesii</i>		Cryptogenic
Dinoflagellata (dinoflagellates)		
<i>Alexandrium minutum</i>		Cryptogenic
CHLOROPHYTA (Green Algae)		
<i>Codium fragile</i> spp. <i>tomentosoides</i>	Dead man's fingers	1957 Long Island; now Canada to North Carolina.
<i>Cladophora sericea</i>		Cryptogenic
RHODOPHYTA (Red Algae)		
<i>Antithamnion nipponicum</i>		1986 Long Island Sound (J. Foertch). Japanese.
<i>Porphyra yezoensis</i>	Nori	Under open sea mariculture in Maine.
<i>Furcellaria lumbricalis</i>		Nova Scotia (Europe).
<i>Lomentaria davellosa</i>		Connecticut to New Hampshire (European/Mediterranean).
<i>Lomeniana orcaeaensis</i>		Cryptogenic (Nova Scotia).
<i>Gymnogongrus</i> sp.		(Possibly <i>G. leptophyllus</i>) Cryptogenic
<i>Grateloupia doryphora</i>		1990s in Rhode Island (Pacific Ocean species). May spread north and south.
<i>Polysiphonia harveyi</i>		Filamentous.
PHAEOPHYTA (Brown Algae)		
<i>Fucus serratus</i> Fucus		European. 1972

<i>Mysotella myosotis</i>	European marsh snail	Also <i>Ovatella myosotis</i> . First record 1841, Massachusetts.
<i>Littorina littorea</i> <i>Littorina saxatilis</i>	European periwinkle	Periwinkle introgressions of eurogenes need to be checked for; a species native to Atlantic America but no doubt commonly transported from Europe for several centuries as well.
<i>Tritonia plebeia</i>	Sea slug	European; Massachusetts and New Hampshire.
<i>Tenellia adspersa</i> <i>Placida dendritica</i>	Sea slug Sacoglossan slug	Cryptogenic. First recorded in New England waters following the introduction of the green seaweed <i>Codium fragile tomentosoides</i> .
ANIMALIA		
Bivalvia		
<i>Rangia cuneata</i>	Atlantic rangia	Hudson River, introduced from mid-Atlantic or further south (1988).
<i>Dreissena polymorpha</i>	Zebra mussel	Freshwater and oligohaline populations in Hudson River and to be expected elsewhere in New England.
<i>Mytilopsis leucophaeata</i> <i>Ostrea edulis</i>	Dark false mussel European oyster	Introduced from mid-Atlantic or further south. Maine, New Hampshire, Rhode Island, Connecticut (the latter three states during and since the 1980s).
<i>Crassostrea gigas</i>	Pacific oyster	Releases over the years of the Pacific oyster have at this time not resulted in any known established populations.
<i>Venerupis philippinarum</i>	Manilla clam	Occasional specimens are taken "in the wild", but no established populations are yet known; Also <i>Tapes japonica</i> .
<i>Teredo bartschi</i>	Shipworm	Indo-Pacific species established in Long Island Sound.
<i>Teredo navalis</i>	Shipworm	Introduced from Europe in 18th or 17th centuries.
<i>Teredo furcifera</i>	Shipworm	Indo-Pacific species formerly established in Long Island Sound
CRUSTACEA		
Amphipoda (amphipods)		
<i>Corophium volutator</i> <i>Chelura terebrans</i>	Wood-boring amphipod	European. Bay of Fundy-Gulf of Maine. European?
Isopoda		
<i>Limnoria</i> sp./spp.	Gribbles	Status of non-native limnoriids requires review; <i>L. tripunctata</i> is likely present, at least south of Cape Cod.
Mysidacea (mysids, opossum shrimp)		
<i>Praunus flexuosus</i>		Europe. First found in 1960 in Massachusetts.

Cirripedia (barnacles)*Balanus amphitrite*

Indo-Pacific. Found in summers as far north as southern Cape Cod, is more likely the result of a lack of exploration. See Carlton, 1985

Balanus subalbidus

Introduced from mid-Atlantic. No records in New England since 1972, when specimens were found in the Charles River, but this

Brachyura (crabs)*Carcinus maenas*

European green crab

Known from Atlantic America since about 1820.

Hemigrapsus sanguineus

Japanese shore crab

First found in New Jersey in 1988, spreading to Long Island Sound by 1993. and now found north of Cape Cod (John McDermott, personal communication).

Insecta*Anisolabis maritime*

Maritime earwig

Europe

ECTOPROCTA (Bryozoa)**Cheilostomata***Bugula neritina*

Purple bugula

First found in 1993 in Millstone, CT (J. Foertch, pers. comm.).

Membranipora membranacea

Kelp bryozoan

From Europe or North Pacific. 1987. Cryptogenic.

*Aetea anguina***Ctenostomata***Bulbella abscondita*

Martha's Vineyard, MA (Europe).

Tangenella muelleri

Waquoit Bay, MA (Europe)

Tangenella appendiculata

Martha's Vineyard, MA. Cryptogenic.

ENTOPROCTA*Barentsia benedeni*

Massachusetts (Europe).

CHORDATA**Ascidiacea (sea squirts)***Botryllus schlosseri*

Star tunicate

Europe; present since early 19th century at least.

Botrylloides violaceus

Compound sea squirt

Published names include *A. diegensis* and *A. leachii* for this species in New England waters. First records are summer 1972 when it was released in Eel Pond, Woods Hole, MA. .

Diplosoma listerianum

Compound sea squirt

May be *Diplosoma listerianum* (also *D. macdonaldi audt.*) First records are mid-1980s in Massachusetts and Connecticut. L Harris first found it north of Cape Cod at the Isle of Shoals in 1992.

<i>Styela clava</i>	Stalked Sea Squirt.	Asia. First records about 1972 south of Cape Cod. Now known from Maine to New Jersey.
<i>Styela canopus</i>	Sea squirt	also <i>Styela partita</i> . An early introduction from the Pacific.
<i>Styela plicata</i>	Sea squirt	Records north of Chesapeake Bay need to be checked.
<i>Asciidiella aspersa</i>	European sea squirt.	First seen by R. Whittaker about 1985 in Massachusetts; abundant by late 1980s in Connecticut.
<i>Molgula manhattensis</i>	Sea squirt	Cryptogenic.
<i>Ciona intestinalis</i>	Sea Squirt	Cryptogenic.
Fish		
<i>Hypsoblennius ionthas</i>	Blenny	From mid-Atlantic; isolated record 1985 (Hudson River).
<i>Gobionellus hastatus</i>	Goby	From mid-Atlantic; isolated record 1993 (Hudson River).

PLANTAE

Salt marsh plant introductions List in preparation.

CAPE COD CANAL INTRODUCTIONS

A number of southern species are believed to have moved from the southern side of Cape Cod into Cape Cod and Massachusetts Bay via the Cape Cod Canal since 1914. A paper is in preparation.

Source: Carlton, J.T. 1997. Draft Marine Biological Invasions: An Annotated Check List. Unpublished data. Williams College-Mystic Seaport, Mystic, Connecticut. 4pp.

Freshwater Plants

Draft

Nonindigenous, Aquatic Vascular Plants in Massachusetts

Compiled by Paul Somers, Ph.D., State Botanist,
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Massachusetts Division of Fisheries & Wildlife
February 21, 2002

STRICTLY AQUATIC SPECIES (WITH FLOATING &/OR SUBMERSED LEAVES)

Scientific Name	Common Name
<i>Cabomba caroliniana</i> A. Gray	Fanwort
<i>Callitriche stagnalis</i> Scop.	Stream or pond water-starwort
<i>Egeria densa</i> Planchon	Brazilian waterweed
<i>Eichornia crassipes</i> (Mart.) Solms ⁰	Water-hyacinth
<i>Hydrilla verticillata</i> (L.f.) Royle	Hydrilla
<i>Myriophyllum heterophyllum</i> Michx.	Variable water-milfoil
<i>Myriophyllum spicatum</i> L.	Eurasian water-milfoil
<i>Najas guadalupensis</i> (Sprengel) Magnus	Guadalupe naiad
<i>Najas minor</i> All.	Lesser or brittle naiad
<i>Nymphaea odorata</i> ssp. <i>tuberosa</i> (Paine) Wiersema & Hellquist	Tuberous water-lily
<i>Nymphoides peltata</i> (Gmelin) Kuntze	Yellow floating heart
<i>Potamogeton crispus</i> L.	Curly pondweed
<i>Salvinia minima</i> Baker	Water-fern, water spangles
<i>Spirodela punctata</i> (Mey.) Thompson ¹	Dotted duckweed
<i>Trapa natans</i> L.	Water-chestnut
<i>Utricularia inflata</i> Walt. ²	Large floating bladderwort

SELECTED WETLAND SPECIES (I.E., THOSE OFTEN FOUND AS EMERGENTS OR GROWING IN SATURATED SOILS OF MARSHES, SWAMPS, STREAM BANKS)

Scientific Name	Common Name
<i>Agrostis gigantea</i> Roth	Redtop, black bentgrass
<i>Alopecurus carolinianus</i> Walter	Carolina foxtail
<i>Alopecurus geniculatus</i> L.	Marsh- or water-foxtail
<i>Amaranthus tuberculatus</i> (Moq.) Sauer	Water-hemp
<i>Amorpha fruticosa</i> L.	False indigo
<i>Arthraxon hispidus</i> (Thunb.) Makino	Arthraxon
<i>Bidens tripartita</i> L.	Leafy-bracted beggar-ticks
<i>Calamagrostis epigeios</i> (L.) Roth	Feathertop
<i>Cyperus amuricus</i> Maxim.	Golden flatsedge
<i>Cyperus flavescens</i> L.	Yellowish flatsedge
<i>Cyperus pseudovegatus</i> Steudel	Marsh or clay-flatsedge
<i>Diplachne fascicularis</i> (Lam.) Beauv.	Salt-meadow grass
<i>Diplachne uninervia</i> (C. Presl) Parodi	Mexican sprangletop
<i>Elytrigia pungens</i> (Pers.) Tutin	Seabeach or Saltmarsh wheatgrass
<i>Epilobium hirsutum</i> L.	Hairy willow-herb
<i>Glyceria maxima</i> (Hartman) Holmb.	Reed manna-grass, sweet reedgrass

<i>Hesperis matronalis</i> L.	Dame's rocket
<i>Iris pseudoacorus</i> L.	Yellow iris
<i>Iva annua</i> L.	Sump-weed
<i>Juncus brachycarpus</i> Engelm.	Small-headed rush
<i>Lepidium latifolium</i> L.	Broad-leaved pepperweed
<i>Lycopus europaeus</i> L.	European water-horehound
<i>Lysimachia nummularia</i> L.	Moneywort, Creeping Jenny
<i>Lysimachia vulgaris</i> L.	Garden-loosestrife
<i>Lythrum hyssopifolia</i> L.	Annual or hyssop loosestrife
<i>Lythrum salicaria</i> L.	Purple loosestrife
<i>Lythrum virgatum</i> L.	Wand-loosestrife
<i>Microstegium vimineum</i> (Trin.) A. Camus	Japanese stiltgrass
<i>Mollugo verticillata</i> L.	Carpetweed
<i>Myosotis scorpioides</i> L.	True forget-me-not
<i>Myosoton aquaticum</i> (L.) Moench	Giant chickweed
<i>Nelumbo lutea</i> Willd.	American lotus, Water-chinquapin
<i>Phalaris arundinacea</i> L. ³	Reed canary-grass
<i>Phalaris canariensis</i> L.	Canary-grass
<i>Phragmites australis</i> (Cav.) Trin. ex. Steudel ⁴	Phragmites, common reed
<i>Potentilla rivalis</i> Nutt.	Brook cinquefoil
<i>Rorippa amphibia</i> (L.) Baker	Water or amphibious watercress
<i>Rorippa microphylla</i> (Boenn.) Hyl.	Small-leaved water-cress
<i>Rorippa nasturtium-aquaticum</i> (L.) Hayek	Water-cress
<i>Rorippa palustris</i> (L.) Besser ssp. <i>palustris</i> (two other ssp. are native)	Marsh yellowcress
<i>Rumex aquaticus</i> L. var. <i>fenestratus</i> (Greene) Dorn	Window-dock
<i>Rumex saliciifolius</i> J.A. Weinm.	Willow-leaf dock
<i>Solanum dulcamara</i> L.	Bittersweet nightshade
<i>Stachys palustris</i> L. ssp. <i>palustris</i>	Marsh hedge-nettle
<i>Teucrium canadense</i> var. <i>occidentale</i> (A. Gray) McClintock & Epling	Hairy Germander
<i>Veronica beccabunga</i> L. var. <i>beccabunga</i>	Brooklime

⁰ Not fully documented as naturalized in Massachusetts, but a few reports of it being present and persisting in natural settings on Cape Cod and Nantucket have been made

¹ Not yet documented in MA by Sorrie and Somers (1999) or by MA NHESP, but cited in literature

² Possibly native, but all records are recent, suggesting it has been introduced into the state

³ May be a native species (Sorrie and Somers 1999) or a mix of native and introduced genotypes

⁴ Considered a native species in part, but inland and some coastal populations are probably alien (Sorrie and Somers 1999)