

Woods Hole Sea Grant in the 21st Century



**Issues,
Opportunities,
and Action for Massachusetts
2014 – 2017**





Woods Hole Sea Grant in the 21st Century: Issues, Opportunities, and Action for Massachusetts, 2014-2017, is the Woods Hole Sea Grant Program's plan to address local, regional, and national issues and opportunities over the next several years. The plan identifies marine-related issues of importance, institutional resources, and potential partnerships in the Commonwealth of Massachusetts and the Northeast region of the United States.

Massachusetts is one of only two states that have a Sea Grant College Program and a Sea Grant Institutional Program. The Sea Grant College Program in Massachusetts is located at the Massachusetts Institute of Technology (MIT), while the Sea Grant Institution Program is located at the Woods Hole Oceanographic Institution (WHOI). The two programs coordinate solicitation of research proposals throughout Massachusetts, serve in an advisory capacity to each other's research review panels and outreach guidance committees, and collaborate wherever possible in extension and outreach activities.

In order to continue a successful history of developing collaborative, interdisciplinary research programs for this strategic plan, Woods Hole Sea Grant in collaboration with MIT Sea Grant conducted a joint survey soliciting input on issues of concern from coastal scientists, managers, regulators, and business and environmental group representatives throughout the Commonwealth of Massachusetts and partner organizations throughout Northeast U.S. In utilizing these data to aid development of this plan, consideration was given to scientific merit, degree of community concern, relevance to the National Sea Grant College Program goals, opportunity for inter-agency collaboration, and degree of public benefit. Issues and opportunities were also assessed on the basis of their relevance to other partner agency goals and strategic plans.

Woods Hole Sea Grant in the 21st Century: Issues, Opportunities, and Action, for Massachusetts, 2014-2017, addresses the collective concerns of the Massachusetts marine community at all levels. It highlights important marine issues and research needs, suggests investigative approaches, and proposes research-based outreach programs. Perhaps most importantly, this plan serves as a catalyst for creative thinking and identifying new opportunities.

A handwritten signature in black ink that reads "Judith C. McDowell". The signature is written in a cursive style.

Director, Woods Hole Sea Grant

Sea Grant in the Commonwealth of Massachusetts

The Commonwealth of Massachusetts is one of the smallest states in the U.S. with only 7,800 square miles of total area, yet it is also the third most densely populated state, with a population of over 6.5 million people (*U.S. Census Bureau, 2010*; quickfacts.census.gov/qfd/states/25000.html). In particular, the coastal communities of Cape Cod, the islands of Martha's Vineyard and Nantucket, and the South Coast have seen dramatic growth when compared to the rest of the state: populations in these coastal communities represent one-third of the total population.

The Commonwealth's 1,980 miles of coastline include extensive wetlands, tidal flats, and salt marshes, totaling 12 percent of the landmass. The Massachusetts coast is one of the most valuable natural and economic resources of the Commonwealth, providing jobs, transportation, and recreation to residents and visitors. There are 27 distinct watersheds within Massachusetts and critical issues related to the protection of these watersheds include wise planning of both land and aquatic resources.

Despite its small geographic size, the Commonwealth of Massachusetts has many diverse communities—cities, colonial villages, historic mill towns, and rustic farmlands. The economic base of these communities is equally diverse. Massachusetts continues to show strong economic growth in the 21st century. The Corporation for Enterprise Development's *State Asset Development Report Cards* for 2007, the most recent year for which data were compiled for a state status report (http://cfed.org/knowledge_center/research/DRC/) show Massachusetts as a leader in economic performance, business vitality, development capacity, and education, building on the area's strengths: knowledge-based economy, highly educated work force, high quality of life in communities, increased global trade, and industry clusters that share resources. There were weaknesses identified, however, in infrastructure and natural resource management.


The communities in Massachusetts are divided into different regions with unique characteristics. **Central and Western Massachusetts** have replaced many traditional manufacturing operations with new industries, such as biotechnology and fiber optics development. The **Northeastern region** of the state has seen a transition from textile mills along the banks of the Merrimack River being replaced by high-technology electronics companies.

Metro Boston is a center of educational institutions, financial service companies, medical centers, and advanced technology centers. **Southeastern Massachusetts**, including Cape Cod, the islands of Martha's Vineyard and Nantucket, and the South Coast, is the center of marine science related industries, including marine instrumentation, fishing, aquaculture, and tourism.

The Massachusetts marine economy is strong and diverse as evidenced by the data presented on different sectors of the Massachusetts economy in Table 1. Jobs are distributed in various sectors including the commercial seafood industries, marine transportation, tourism, recreation, marine science and technology, aquaculture, mining of sand and gravel, and coastal construction and real estate. In spite of a strong economy within the Commonwealth of Massachusetts, there are concerns that need to be addressed to endure future growth and prosperity, especially in Southeastern Massachusetts, Cape Cod, and the Islands. These issues include education and job training, expanded infrastructure for emerging and expanding industries, and balanced and sustained growth.



Table 1. Annual Value of Some Marine-Related and Other Sectors of the Massachusetts Economy ^a

Sector	Estimated Dollar Value
Marine Fishing ^b 	~ \$2.3 billion
Recreational	> \$1 billion
Commercial Landings (2011)	\$473.7 million
Commercial Fishing Salary and Support	~ \$800 million
Tourism (2010) ^c	\$24.7 billion
Cape Cod and the Islands	\$2.0 billion
Agriculture (2010) ^d	\$489.6 million
Cranberries	\$140.0 million
Forest Products (2010) ^e	\$580 to \$845 million
Sand and Gravel Mining (2008) ^f	\$109 million
Aquaculture ^g	\$15 million
Marine Transportation ^h	\$529 million
Coastal Construction and Real Estate ^h	\$2.8 billion
Marines Science and Technology ^h	\$3.3 billion
Marine Instrumentation Sales	\$1.5 billion
M S & T Payroll and Services	\$1.3 billion
Recreational Boating	\$241 million

Sources: **a** Figures represent most current data available; they do not reflect associated economic multipliers; **b** Gettner & Steinback (2008) The economic contribution of marine angler expenditures in the U.S., 2006, NOAA Technical Memorandum NMFS-F/SPO-94; National Marine Fisheries Service, Annual Commercial Landings Statistics (2011); **c** Massachusetts Office of Travel and Tourism (2010); **d** Massachusetts Department of Agricultural Resources (2010); **e** UMASS Extension; **f** The Mineral Industry of Massachusetts (2008), this includes both land-based and marine sources; offshore mining represents ~1% of the total; **g** Reitsma et al. (2012), Massachusetts Outlook on Aquaculture; **h** Barrow et al. (2005) Sailing into a Strong Future; **i** MA DMF and MOPP (2009).

In 2003, Massachusetts undertook an extensive review of ocean industries and use conflicts within its coastal waters. The Ocean Management Task Force made its recommendations in the 2004 report, *Waves of Change, the Massachusetts Ocean Management Task Force* (www.mass.gov/czm/momi/finalrpts.htm). Many of the challenges identified in the Commonwealth of Massachusetts mirror those facing coastal regions throughout the U.S.—discussed extensively in the Pew Oceans Commission report *America’s Living Oceans: Charting a Course for Sea Change*, and the U.S. Commission on Ocean Policy report *An Ocean Blueprint for the 21st Century*. In 2009 the Commonwealth of Massachusetts became the first state in the nation to pass a comprehensive Ocean Management Plan.

Development of Woods Hole Sea Grant Strategic Plan, 2014-2017

The National Sea Grant Program has undertaken the development of a national strategic plan that focuses on “Sustaining our nation’s ocean, coastal, and Great Lakes resources through university-based research, communications, education, extension and legal programs” (NOAA National Sea Grant College Program 2014-2017 Strategic Plan, 2012). Achieving this goal requires: (1) acquisition of science-based information on how ecosystems function and how human activities affect habitats and living resources; (2) education of citizenry to inform them of the complexities of coastal environments and the interactions between human use and coastal ecosystem health; (3) development of decision-making processes that include the best scientific and technical information, the engagement of citizen stakeholders, and involve mechanisms to evaluate trade-offs between human and environmental needs; and (4) incorporation of the social sciences into ecosystem-based management decisions.

With these goals in mind the National Sea Grant College Program has identified four focus areas for the 2014-2017 Strategic Plan:

- ◆ Health Coastal Ecosystems (HCE)
- ◆ Sustainable Fisheries and Aquaculture (SFA)
- ◆ Resilient Communities and Economies (RCE)
- ◆ Environmental Literacy and Workforce Development (ELWD)

These focus areas evolved from previous strategic plans and highlight the most critical needs in along the coastline of the United States. These areas also build on strategic goals of NOAA and the unique strengths and capabilities of the Sea Grant network.

Development of the Woods Hole Sea Grant Strategic Plan, 2014-2017, builds on the national plan, but also focuses on issues that are of greatest importance to the Commonwealth of Massachusetts. In developing this plan, consideration was given to scientific merit, degree of community concern, relevance to the National Sea Grant College Program goals, opportunity for inter-agency collaboration, and degree of public benefit. Issues and opportunities were also assessed on the basis of their relevance to other agency goals and strategic plans.

To guide the development of strategic plans for both Woods Hole Sea Grant and MIT Sea Grant, the two programs issued a joint survey soliciting input on issues of concern from coastal scientists, managers, regulators, and business and environmental group representatives throughout the Commonwealth of Massachusetts, in addition to partner organizations throughout Northeast U.S. The plan developed by Woods Hole Sea Grant was also informed by stakeholder input from the communities that Woods Hole Sea Grant serves in Southeastern Massachusetts, and from needs assessments conducted for the NOAA sponsored Coastal Training Program (CTP) at Waquoit Bay National Estuarine Research Reserve (WBNERR). The CTP is a partnership between WBNERR, the Massachusetts Office of Coastal Zone Management, and Woods Hole Sea Grant.

The survey issued by Woods Hole Sea Grant and MIT Sea Grant was sent to our respective list serves SEMCO and NEMCO, posted on our respective program websites and on the Massachusetts Office of Coastal Zone Management monthly calendar and website. Survey questions are listed in Table 2.

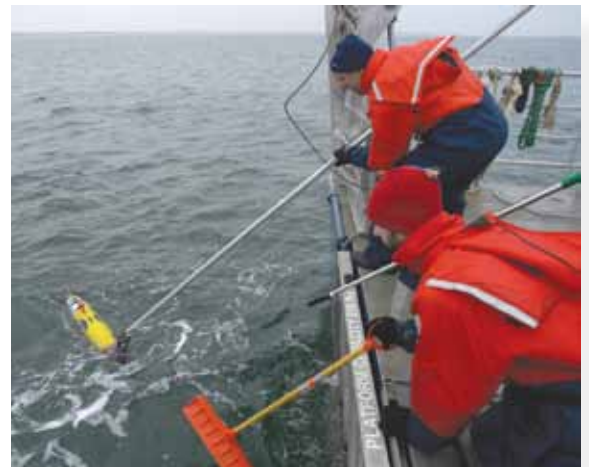
Table 2. Survey Questions

1.	Which coastal region in Massachusetts interests you the most?
2.	What are your primary interests (with respect to areas of concern)?
3.	With respect to coastal hazards, what are your major concerns?
4.	How do use information related to coastal hazards?
5.	With respect to sustainable seafood, what are your primary concerns?
6.	With respect to marine related socio-economic issues, what issues do you feel are most pressing?
7.	With respect to marine biology and biogeography, what issues are most important to you?
8.	With respect to water quality, what are your major concerns?
9.	With respect to STEM-related marine education, what would be most beneficial to you?
10.	With regard to your use of data in support of your programs, what type of data do you use the most?
11.	How do you access information on coastal issues that are important to you?
12.	With respect to environmental literacy, what would be most beneficial to you?

In response to Question 1, all areas of the Massachusetts coastline were of interest to survey respondents, but Cape Cod and the Islands received the highest number of responses (51.0%). In response to Question 2, the top three responses were preserve coastal resources, provide environmental stewardship, and make wise use of coastal resources. The top concerns with respect to coastal hazards (Question 3) were shoreline erosion, coastal flooding, and storm damage. Survey respondents use information on coastal hazards (Question 4) for monitoring, management, and information dissemination.

With respect to safe and sustainable seafood (Question 5), major concerns of respondents were protection and management of fishery resources, contaminants in fishery resources and aquaculture. Marine-related socio-economic concerns (Question 6) focused on U.S. fisheries and aquaculture viability, alternative energy sources, and human dimensions of management decisions. In response to Question 7, the top three responses were loss of species and habitat, biodiversity, and invasive species, followed by harmful algal blooms. With respect to water quality (Question 8), major concerns were river runoff and land-based human activities, climate oriented changes in biophysical processes, and ocean acidification. With respect to needs in STEM curricula (Question 9), biology curricula, biogeophysical processes curricula, and engineering curricula were the primary needs. Data needs (Question 10) include water quality data, biological data and physical data. Questions 11 and 12 inform our outreach and public education efforts. Survey respondents indicated that websites, workshops, specific newsletters, and newspapers were the media vehicles they accessed for information on coastal issues (Question 11). With respect to environmental literacy (Question 12), the top three choices among respondents were websites, workshops, and public events/presentations.

The needs assessments for the CTP revealed a similar suite of issues as those identified from the survey described above. Storm intensity and flooding, shoreline change and erosion, water quality, watershed protection, harmful algal blooms, aquaculture and fisheries management were among the top issues identified as areas of concern.



Program Focus Areas and Goals

Healthy Coastal Ecosystems

Issues related to healthy coastal ecosystems on the coast of Massachusetts and in Northeastern U.S. are similar to those issues experienced in other areas of the U.S. coastline. Decline in water quality, loss of habitat, invasive species, and increasing pressure on coastal resources are just some of the items of concern. A significant portion of the research portfolio of the Woods Hole Sea Grant program during the past few years has been focused on gaining a better understanding of nutrient enrichment in coastal watersheds, characterization of habitats for resource species and threats to those habitats, and ocean acidification.

Extension and outreach activities that complement the *Healthy Coastal Ecosystems* focus area are (1) collaborative workshops with the Massachusetts Office of Coastal Zone Management and the Waquoit Bay National Estuarine Research Reserve on waste water management and coastal water quality issues through the Coastal Training Program; (2) teacher workshops on topics such as the effects of ocean acidification on coastal ecosystems; and (3) establishing a water quality monitoring system using remotely accessed YSI devices. New techniques and approaches will be added to this portfolio as reciprocal relationships between resource users/managers and scientists, social scientists and engineers identify new problems, develop or facilitate solutions to existing problems, and transfer technical information that can be used in management decisions. Specific goals, outcomes and targets for **Healthy Coastal Ecosystem** are listed in Table 3.

Table 3. Healthy Coastal Ecosystems Focus Area: National Goals and Program Plan Goals, Outcomes and Targets

National Plan Goals	Program Plan Goals	Program Plan Outcomes	Program Plan Targets
Ecosystem services are improved by enhanced health, diversity, and abundance of resource species.	Understanding processes controlling biodiversity and habitat integrity will lead to a reduction in degraded habitats in Southeastern Massachusetts.	Scientific understanding of ecosystem processes will be improved and applied to management decisions related to habitat use and restoration.	<p>Support research to understand species responses to changes in environmental conditions.</p> <p>Support research to understand the effects of nutrient enrichment and chemical contaminants on coastal embayments.</p> <p>Support social science research to understand management implications of changes in environmental conditions.</p> <p>Support extension activities to translate scientific information for decision makers.</p>
Ecosystem-based approaches are used to manage resources.	A stronger scientific foundation for ecosystem-based approaches to management is developed and implemented.	Communities are engaged and informed regarding the scientific needs for ecosystem-based management.	<p>Extension and outreach staff will assist communities in developing management approaches that ensure protection of habitats and maintenance of biodiversity.</p> <p>Support research in the social and natural sciences to improve ecosystem-based management approaches.</p>
Ecosystems and their habitats are protected, enhanced or restored.	A stronger scientific foundation for habitat preservation and restoration is developed and implemented.	Sea Grant staff activities will result in measurable improvements in habitat quality across Southeastern Massachusetts.	<p>Support research on restoration techniques for habitats impacted by changes in water quality or sediment dynamics.</p> <p>Support demonstration projects on the application of restoration techniques.</p> <p>Inform communities on the utility of restoration programs.</p>

To evaluate our progress and success within this focus area, we will align our activities with the following National Performance Measures and State Performance Measures:

- ◆ **National Performance Measure:** Number of Sea Grant supported tools, technologies and information services that are used by NOAA partners/customers to improve ecosystem-based management.
State Performance Measure: Coastal and marine issue based forecast capabilities will be developed and used for management decisions on Cape Cod, the islands, and Southeastern Massachusetts.
- ◆ **National Performance Measure:** Number of coastal communities who have protected or restored ecosystems as a result of Sea Grant's activities.
State Performance Measure: The number of tools, technologies, and information services that are used by managers (NOAA and/or its partners and customers) will increase to improve ecosystem-based decisions.

State Performance Measure: Number of locations where water conditions are monitored and data provided to the public.

State Performance Measure: Number of sites individually tracked for marine debris with at least 75 data points, using enhanced GIS capabilities.
- ◆ **Cross Cutting Performance Measure:** Satisfaction of citizens who participate in Sea Grant engagement programs.
- ◆ **Cross Cutting Measure:** Economic (market and non-market) benefits derived from Sea Grant activities.

Sustainable Fisheries and Aquaculture

Woods Hole Sea Grant has identified the revitalization of our nation's fisheries and sustainable aquaculture as priority areas that fit within the capacity of the academic and research environment within the region served by our program. It is our belief that these two priority areas are very closely linked technologically and culturally within New England and thus we are approaching these areas as a unified and coordinated effort. The program elements include: (1) development of technology and programs to promote stock enhancement of natural fish and shellfish resources, including mechanisms to evaluate the efficacy of enhancement programs and the overall effectiveness of such programs; (2) investigation of larval recruitment processes for fish and shellfish and development of means to understand the relationship between recruitment and physical and chemical characteristics of the environment; (3) investigation of disease processes in marine organisms with an emphasis on prophylactics and management of diseased stocks to minimize economic losses to the natural fisheries and aquaculture industries; and (4) promotion of business and industrial development through expanding efforts in coastal management and through understanding of the economics of marine related businesses.



Extension and outreach efforts that support the *Sustainable Fisheries and Aquaculture* focus area include: (1) providing technical information to local natural resource managers and harvesters to manage the fisheries resources for continued sustainable production; (2) assisting the regional aquaculture industry as a growing contributor to the local economy and to the national and global production of farmed marine products in an environmentally sustained manner; (3) conducting teacher workshops and a training course on aquaculture; and (4) distributing extension bulletins and other information on seafood production. New techniques and approaches will be added to this portfolio as new harvesting and resource management techniques are explored and developed. Specific goals, outcomes and targets for **Sustainable Fisheries and Aquaculture** are listed in Table 4.

Table 4. Sustainable Fisheries and Aquaculture Focus Area: National Goals and Program Plan Goals, Outcomes and Targets

National Plan Goals	Program Plan Goals	Program Plan Outcomes	Program Plan Targets
A safe, secure, and sustainable supply of seafood will be available to meet public demand.	Wild caught fish and shellfish and aquaculture products are healthy and sustainable.	<p>Scientific foundations for sustaining fisheries and aquaculture are improved.</p> <p>Safety and sustainability of fisheries and aquaculture industries are improved.</p> <p>Research and synthesis informs ecosystem-based fisheries management.</p>	<p>Support research to understand the effects of environmental factors on recreationally and commercially harvested species.</p> <p>Research and extension personnel will contribute technical information required to help local natural resource managers and harvesters manage the fisheries resources in their communities for continued sustainable production.</p> <p>Extension staff will assist the regional aquaculture industry to continue to succeed as a growing contributor to the local economy and to the national and global production of farmed marine products in an environmentally sustainable manner.</p>
Informed consumers will understand the health benefits of seafood consumption and evaluate the safety and sustainability of the seafood they buy.	Seafood industries use safe seafood practices.	<p>Communities are engaged and informed regarding the scientific needs for ecosystem-based management.</p> <p>Communities are informed regarding issues related to seafood safety.</p>	<p>Support natural science and social science research that promotes healthy, diversified natural ecosystems and their long-term sustainable management through science-based decisions.</p> <p>Woods Hole Sea Grant will work with state and local authorities to ensure that issues related to seafood safety are well characterized and documented for the public.</p>

To evaluate our progress and success within this focus area, we will align our activities with the following National Performance Measures and State Performance Measures:

- ◆ **National Performance Measure:** Number of responsible production and harvesting techniques and practices implemented by the fishing and aquaculture industries.

State Performance Measure: Shellfish aquaculture opportunities on Cape Cod and southeastern Massachusetts will continue to expand and support a viable local industry with highly sought after local products.

State Performance Measure: Local shellfish products are highly sought after market choices. Continued efforts will be directed toward restoration and enhancement of wild shellfish stocks and aquaculture products and increasing marketing opportunities for local products.
- ◆ **Cross Cutting Performance Measure:** Satisfaction of citizens who participate in Sea Grant engagement programs.
- ◆ **Cross Cutting Measure:** Economic (market and non-market) benefits derived from Sea Grant activities.

Resilient Communities and Economies

Coastal communities in the U.S. provide a wide range of economic, social, and recreational opportunities. Over one third of the population of Massachusetts lives along the coastline, and as evidenced by the data presented in Table 1, the marine related economy in Massachusetts is quite strong. At the same time, coastal ponds, embayments, open coasts, and coastal resources may be impacted by society’s commercial, recreational and residential activities. Threats to coastal communities include sea-level rise and climate change, shoreline erosion, conflicts between the protection of waterfront property and the preservation of the beneficial functions of coastal landforms and resources, conflicts between private ownership of the coast and public access, and recreational demands on the coast through boating, fishing, shellfishing, and the use of beaches for swimming and sunbathing. Emerging interests in coastal wind farms present new opportunities to gather information on scientific, social and economic concerns of wind farm siting and development. Woods Hole Sea Grant’s portfolio in this theme includes both research and extension activities that directly interface with the management community charged with making regulatory decisions. Program elements include characterization of coastal processes, assessing sound in coastal waters before installation of coastal wind turbines, and developing new approaches for managing marine spatial planning and ocean zoning.



Extension and outreach efforts that support the *Resilient Communities and Economies* focus area are (1) assisting coastal resource managers, property owners, and the general public in making informed, effective decisions that contribute to maintaining the beneficial functions of coastal landform systems through an understanding coastal processes and hazard mitigation research; (2) producing extension bulletins and other information on sea level rise, coastal erosion, hurricanes and other storms; (3) conducting teacher workshops on beach and dune dynamics, coastal processes, and sound in the sea with a consideration of potential effects of coastal wind farms; and (4) co-sponsoring workshops and conducting needs assessments in collaboration with the Massachusetts Office of Coastal Zone Management and the Waquoit Bay National Estuarine Research Reserve on issues relevant to sustainable coastal development. New techniques, topics, and approaches will be added to this portfolio as information needs are identified. Specific goals, outcomes and targets for **Resilient Communities and Economies** are listed in Table 5.

Table 5. Resilient Communities and Economies Focus Area: National Goals and Program Plan Goals, Outcomes and Targets

National Plan Goals	Program Plan Goals	Program Plan Outcomes	Program Plan Targets
Development of vibrant and resilient coastal communities.	Local communities are supplied with information needed to support decisions related to economic resiliency.	Communities are informed and understand issues important to community resilience.	Support research on and develop technologies and strategies for sustainable communities. Support social science research to understand multiple use conflicts in coastal communities. Support extension activities to translate scientific information for decision makers.
Improvements in coastal water resources sustain human health and ecosystem services.	Communities are informed and engaged on issues related to water quality and water resource management.	Community understanding of sustainable water quality and water resource management issues is improved.	Sea Grant supported research scientists will conduct studies on nutrient management in coastal embayments and disseminate their results at workshops for local decision makers to ensure that the latest scientific information is brought to bear in the management of water resources.

Table 5 continued.

National Plan Goals	Program Plan Goals	Program Plan Outcomes	Program Plan Targets
Resilient coastal communities adapt to the impacts of hazards and climate change.	Communities are informed and engaged on issues related to coastal hazards and the impacts of climate change.	Scientific understanding of climate change and hazards is improved and translated for decision-makers and the public.	Sea Grant extension staff will facilitate research and conduct workshops on climate adaptation and through these efforts contribute to regional efforts on disseminating information on climate change.
Communities use comprehensive planning to make informed strategic decisions.	Comprehensive planning efforts help communities make informed strategic decisions.	Coastal management and community planning are informed by research, development of management tools, workshops, and other activities.	Through workshops and one-on-one consultations, Sea Grant extension staff will assist coastal resource managers, property owners, and the general public in making informed, effective decisions that will contribute to community resiliency. Sea Grant extension staff will conduct studies on coastal processes and hazard mitigation and apply this information to both local management decisions and recommendations for state-wide adoption of hazard mitigation policies.

To evaluate our progress and success within this focus area, we will align our activities with the following National Performance Measures and State Performance Measures:

- ◆ **National Performance Measure:** Number of communities who have adopted adopted/implemented sustainable, economic, and environmental development practices and policies (e.g., land use planning, working waterfronts, energy efficiency, climate change planning, smart growth measures, green infrastructure) as a result of Sea Grant activities.
 State Performance Measure: Coastal communities and industries have healthy economies that include working waterfronts, an abundance of recreation and tourism opportunities, and coastal access for all citizens.
- ◆ **National Performance Measure:** Number of communities who adopt/implement hazard resiliency practices to prepare for and respond to/minimize coastal hazardous events.
 State Performance Measure: Through workshops, technical reports, and other media vehicles, communities have access to the best available information to make decisions on hazard planning and response.
- ◆ **Cross Cutting Performance Measure:** Satisfaction of citizens who participate in Sea Grant engagement programs.
- ◆ **Cross Cutting Measure:** Economic (market and non-market) benefits derived from Sea Grant activities.

Environmental Literacy and Workforce Development

In 2005 the National Research Council published a report entitled, *Rising Above the Gathering Storm*, that focuses on the need to build a competent workforce that is literate in science, technology, engineering and mathematics in order to meet the global challenges of the 21st century. This need is directed at not only the next generation of scientists and engineers, but also those who will develop new approaches to managing resources, and the general public who will make decisions. Within this focus area Sea Grant has assumed the responsibility to improve the environmental literacy of the general public, to inform teachers and informal educators of new advances in science and technology, to inform decision makers of advances in science that informs policy, and to assist in the training of undergraduate, graduate, postdoctoral, and law students. Each of these diverse audiences requires a different approach in providing technical information that will enhance opportunities for learning. Specific goals, outcomes and targets for **Environmental Literacy and Workforce Development** are listed in Table 6.

Table 6. Environmental Literacy and Workforce Development Focus Area: National Goals and Program Plan Goals, Outcomes and Targets

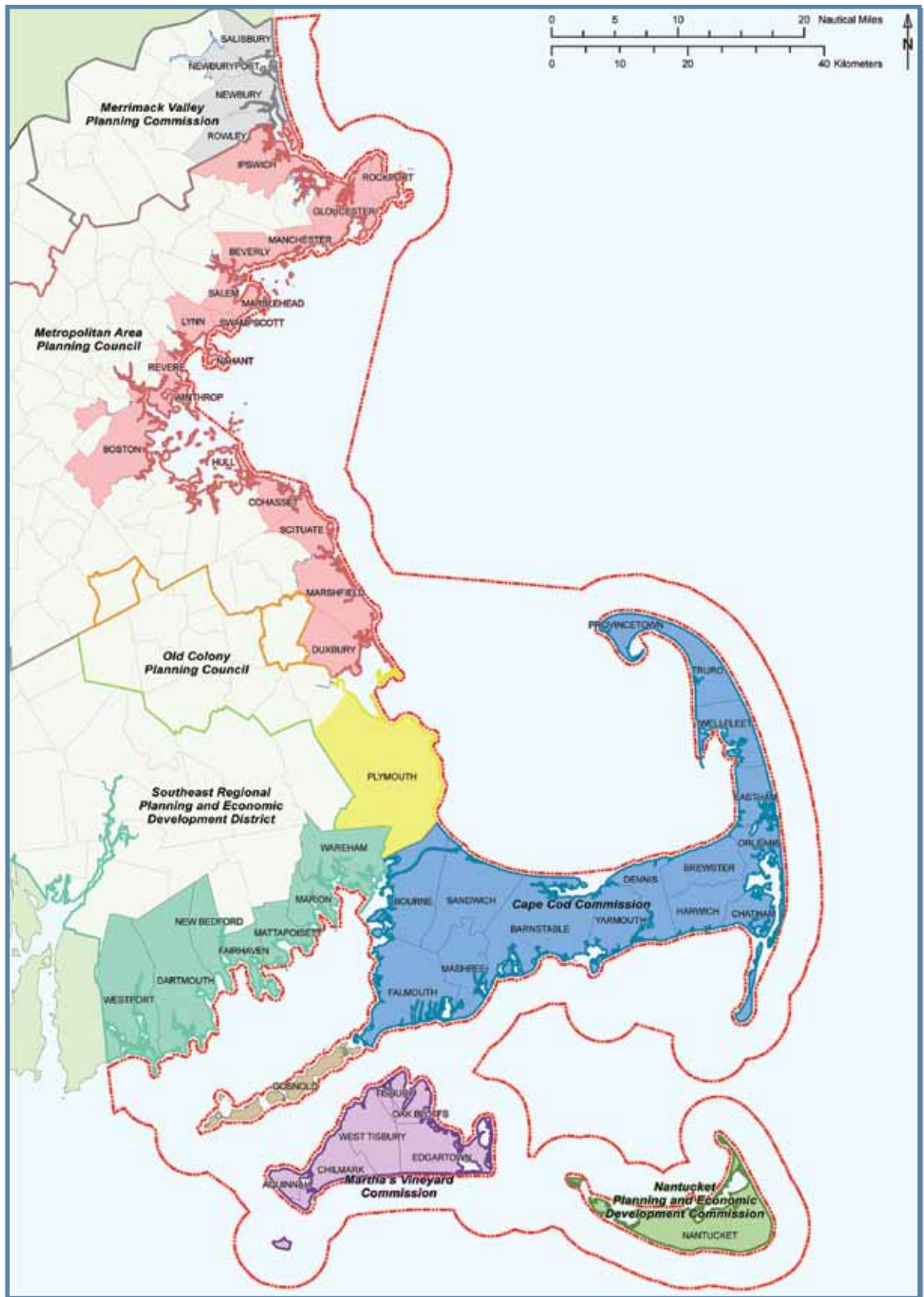
National Plan Goals	Program Plan Goals	Program Plan Outcomes	Program Plan Targets
An environmentally literate public will be supported and informed by a continuum of lifelong formal and informal engagement opportunities.	The public will be educated about watershed, coastal and marine issues.	Knowledge and stewardship capacity in the public is enhanced.	Coastal decision makers will utilize Sea Grant research results and other outreach products and participate in training opportunities to increase their ability to implement environmentally sound policies. Educators in southeastern Massachusetts will use ocean science examples, including those derived from Sea Grant supported research, to convey basic scientific concepts to students at all educational levels. Students within Massachusetts will have access to ocean sciences research and information to develop an appreciation for the oceans and an awareness of marine science related career opportunities.
Future workforce will reflect the diversity of Sea Grant programs, skilled in science, technology, engineering, mathematics, and other disciplines critical to local, regional, and national needs.	A stronger scientific foundation for ecosystem-based approaches to management is developed and implemented.	Communities are engaged and informed regarding the scientific needs for ecosystem-based management.	Researchers from the ocean science community will have access to and participate in scientific, educational and outreach opportunities. Support for undergraduate, graduate and postdoctoral students will be provided through research awards to their universities or research institutions.

To evaluate our progress and success within this focus area, we will align our activities with the following National Performance Measures and State Performance Measures:

- ◆ **National Performance Measure:** Number of curricula adopted by formal and informal educators.
State Performance Measure: Educators will have access to information that will enable them to use ocean science examples, including Sea Grant funded research, to convey science concepts to their students.

State Performance Measure: Organize teacher training workshops or mini-courses to provide content accessibility for teachers.
- ◆ **Cross Cutting Performance Measure:** Number of Sea Grant supported undergraduate, graduate and law degrees.
- ◆ **Cross Cutting Performance Measure:** Number of Sea Grant supported graduates who become employed in a career related to their degree.
- ◆ **Cross Cutting Measure:** Number of peer-reviewed publications and citations from Sea Grant activities.





- Massachusetts ocean management planning area boundary
- Regional planning agencies:
- █ Cape Cod Commission (CCC)
 - █ Martha's Vineyard Commission (MVC)
 - █ Merrimack Valley Planning Commission (MVPC)
 - █ Metropolitan Area Planning Council (MAPC)
 - █ Nantucket Planning and Economic Development Commission (NPEDC)
 - █ Old Colony Planning Council (OCCPC)
 - █ Southeast Regional Planning and Economic Development District (SRPEDD)
 - █ Belongs to both MAPC & OCCPC

Data sources: Massachusetts Office of Coastal Zone Management, Massachusetts Office of Geographic and Environmental Information (MassGIS).



Map coordinate system: North American Datum of 1983 (NAD83), Massachusetts State Plane Coordinate System, Mainland Zone (FIPS zone 2001), meters.



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