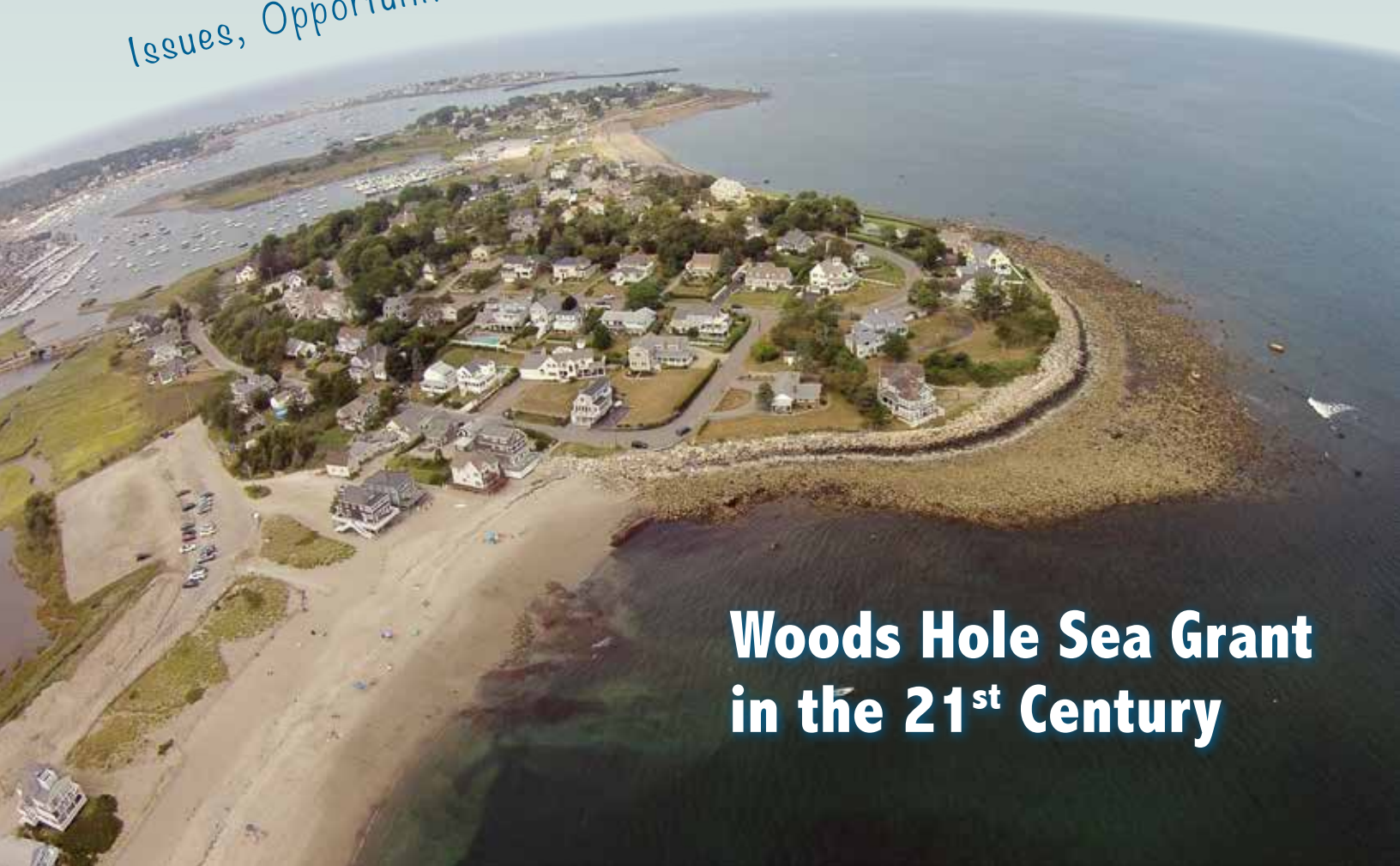
Woods Hole Sea Grant

Issues, Opportunities, & Action for Massachusetts 2018-2021



Woods Hole Sea Grant in the 21st Century

Letter from the Director

Here in Massachusetts we are indelibly connected to the sea, with seventy-five percent of our citizens living within coastally situated counties. As such, our wellbeing and economy are increasingly reliant upon a healthy ocean and a resilient coastline.

Woods Hole Sea Grant in the 21st Century: Issues, Opportunities, and Action for Massachusetts, 2018-2021, 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.

While the Woods Hole Sea Grant Program supports the entire state in concert with our partner Sea Grant Program at the Massachusetts Institute of Technology, much of our impact will be felt in Southeastern Massachusetts, Cape Cod, and the Islands. For example, our researcher's work on Healthy Coastal Ecosystems will support the tourism economy through a better understanding of what drives coastal water quality. Jobs will be created and sustained through shellfish aquaculture training, disease monitoring, and habitat assessment. Storm hazard identification and floodplain management will foster a resilient coastline. Educating our teachers through topical workshops and supporting graduate and undergraduate student research projects will help train the next generation of marine scientists.

Sea Grant, which was established by Congress in 1966, "engages citizens, communities, scientists, organizations and governments to sustain and enhance the vitality, value and wise use of the nation's coastal resources". This strategic plan follows the guiding principles set forth by Congress over 50 years ago while addressing 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.

Matthew A. Charette

Director, Woods Hole Sea Grant

The Commonwealth of Massachusetts is one of the smallest states in the U.S. with only 7,800 square miles of total area, yet is also the third most densely populated state, with a population of over 6.8 million people (http://www.census.gov/quickfacts/table/PST045215/25,00). Coastal communities in Massachusetts have seen dramatic growth when compared to the rest of the state. The population in the coastal communities of Southeastern Massachusetts (Barnstable, Bristol, Dukes, Nantucket, and Plymouth counties) represents 19% of the total population, and Boston and the North Shore (Essex, Middlesex, Norfolk, and Sussex) represent another 56%. The Commonwealth's 1,980 miles of coastline include extensive wetlands, tidal flats, and salt marshes, totaling 12 % of the landmass. Thus, 75% of the population places pressure on coastal watersheds and ecosystems.

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, recognized as a national leader in economic performance, business vitality, development capacity, and education. Some of the strengths in Massachusetts include a knowledge-based economy, highly educated work force, high quality of life in communities, increased global trade, and industry clusters that share resources.

The Massachusetts marine economy is represented by many diverse sectors and an estimated annual value in 2015 of ~$35 billion: commercial and recreational fishing, tourism, cranberry culture, aquaculture, sand and gravel mining, marine technology, marine shipping, coastal construction and real estate, and recreational boating. In spite of a strong economy within the Commonwealth of Massachusetts, there are concerns that need to be addressed to ensure future growth and prosperity. These issues include education and job training, expanded infrastructure for emerging and expanding industries, and balanced and sustained growth.

Two Sea Grant programs – Massachusetts Institute of Technology Sea Grant and Woods Hole Sea Grant – serve Massachusetts. Woods Hole Sea Grant primarily serves Southeastern Massachusetts, including Cape Cod, the islands of Martha's Vineyard and Nantucket, and the South Coast. This region is the center of marine science related industries, including marine instrumentation, fishing, aquaculture, and coastal tourism. A major initiative for Cape Cod and the Islands is fostering a Blue Economy, an initiative that catalyzes the Cape region's coastal marine and aquatic-based economy to invigorate resilient communities (http://www.bluecapecod.org/). The Blue Economy portfolio includes a diverse array of projects, ranging from sustainable tourism to advanced marine technology. The Cape Cod Chamber of Commerce is defining sustainable goals for this initiative to ensure the economic and environmental vitality of the region. Woods Hole Sea Grant plays a critical role in developing the assets and policies of the Blue Economy that ensure sustainable and resilient communities, not only for Southeastern Massachusetts but the entire state.

Many of the challenges identified in the Commonwealth of Massachusetts for sustainable and resilient communities 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 and amended this plan in 2015, *2015 Massachusetts Ocean Management Plan*. The amended plan focuses on the advances made in both management and science priorities since 2009 and sets the stage for regional priorities and programs. In 2016 the Northeast Region Ocean Council (NROC) drafted the first regional ocean plan, *Northeast Ocean Plan*, with major program objectives directed at improved understanding of critical coastal habitats and resources, tribal cultural resources, socioeconomic conflicts in coastal regions, coastal community vulnerability, climate change impacts to coastal habitats and communities, and ecosystem-based management. The Northeast Regional Planning Board approved the plan in December 2016.

Development of Woods Hole Sea Grant Strategic Plan, 2018-2021

The National Sea Grant Program has initiated the development of a national strategic plan that "envisions thriving coastal ecosystems and communities that are supported by an engaged public and informed decision-makers" (*National Sea Grant College Program Strategic Plan: Charting the Course for the Future, 2018-2021*). Sea Grant's mission is to enhance the practical use and conservation of coastal, marine and Great Lakes resources in order to create a sustainable economy and environment. Woods Hole Sea Grant shares this vision for our coasts and supports directing efforts and resources toward sustaining "our natural resources in ways that capture the economic, environmental and cultural benefits they offer, while preserving their quality and abundance for future generations."

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 2018-2021 Strategic Plan: Healthy Coastal Ecosystems (HCE), Sustainable Fisheries and Aquaculture (SFA), Resilient Communities and Economies (RCE), and Environmental Literacy and Workforce Development (ELWD). These focus areas evolved from previous strategic plans and highlight the most critical needs in coastal regions of the United States. These areas also build on strategic goals of NOAA and the unique strengths and capabilities of the Sea Grant network.

The mission of Woods Hole Sea Grant is to develop comprehensive understanding and application to coastal issues at local, regional, national, and international scales. To fulfill this mission Woods Hole Sea Grant seeks input and advice from state and federal agencies, resource stakeholders, and the public, and recruits talent and expertise from public and private academic institutions throughout the Commonwealth of Massachusetts. Our outreach efforts are conducted in a cooperative partnership between the Woods Hole Oceanographic Institution and Cape Cod Cooperative Extension.

Development of the 2018–2021 Woods Hole Sea Grant Strategic Plan builds on the national plan, but also focuses on issues that are of greatest importance to the Commonwealth of Massachusetts and the Northeast region. 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 regional partnerships, and the 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. Partner organizations throughout Northeastern U.S. were also solicited for input. 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 discussions raised at the annual Cape Coastal Conferences, attended by most regional partner agencies. The survey issued by Woods Hole Sea Grant and MIT Sea Grant was sent to our respective list serves SEMCO (Southeastern Massachusetts Coastal Organizations) and NEMCO (Northeastern Massachusetts Coastal Organizations), 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 1.

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 (37.7%). In response to **Question 2,** the top three responses were to preserve and restore coastal resources, promote environmental stewardship, and coastal resilience. 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 sustainable fisheries and aquaculture (**Question 5**), major concerns of respondents were protection and management of fishery/shellfish resources and aquaculture. Marine-related socio-economic concerns (**Question 6**) focused on U.S. fisheries and aquaculture viability, human dimensions of impacts to coastal communities and resources, working waterfronts, and management decisions. In response to **Question 7**, the top three responses were loss of species and habitat, biodiversity, and invasive species. With respect to water quality (**Question 8**), major concerns were septic discharge, runoff

Table 1. Survey Questions

1. Which coastal region in Massachusetts interests you the most?
2. What are your primary interests?
3. With respect to coastal hazards, what are your major concerns?
4. How do you use information on coastal hazards?
5. With respect to sustainable fisheries and aquaculture, what are your major concerns?
6. With respect to marine-related socioeconomic 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. Which focus areas do you frequently require data to support your programs?
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?

and land-based human activities, climate-oriented changes in biophysical processes, and ocean-based human activities. With respect to needs in STEM curricula (**Question 9**), workshops for teachers and informal educators, biology-related curricula, and biophysical processes and engineering curricula were the primary needs. Data needs (**Question 10**) include fisheries and shellfish resource data, water quality data, and biological data.

Questions 11 and 12 inform our outreach and public education efforts. Survey respondents indicated that websites, workshops, peer-reviewed journals, and newsletters 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 workshops, reports distributed on websites, and informal public events/presentations.

Program Focus Areas and Goals

The Woods Hole Sea Grant Program is based at the Woods Hole Oceanographic Institution (WHOI) and supports research, education, outreach, and extension projects that encourage environmental stewardship, long-term economic development, and responsible use of the nation's coastal and ocean resources. Woods Hole Sea Grant's affiliation with WHOI began in 1971 with support for several individual research projects. In 1973, WHOI was designated a Coherent Sea Grant Program and, in 1985, was elevated to its current status as an Institutional Sea Grant Program.

The Woods Hole Sea Grant Program channels the expertise of world-renowned ocean scientists and engineers toward meeting the research and information needs of users of the marine environment. Public and private institutions throughout the Commonwealth of Massachusetts, and collaborators outside of Massachusetts, participate in the Woods Hole Sea Grant Program. The program adheres to the core values inherent within the National Sea Grant College Program – visionary, collaborative, dedicated to sustainability, and accountable. Inherent in the National Sea Grant College Program and individual state programs is the integrity of being an honest broker of information, distributing information to all relevant stakeholders. Woods Hole Sea Grant embraces the core principles through the following examples:

- **Visionary** – Woods Hole Sea Grant supports innovative solutions to address coastal monitoring, resilience planning, and protection of valuable coastal resources.
- **Collaborative** – Woods Hole Sea Grant seeks partnerships that leverage our strengths, especially within Southeastern Massachusetts, and in collaboration with MIT Sea Grant and other Sea Grant programs in the Northeast, the entire Northeast Region. Support for the Northeast Sea Grant Con-

sortium regional projects, the **Northeast Ocean Plan**, and the annual **Cape Coastal Conference** reflect the cooperation of many organizations and partnerships toward common goals.

- **Dedicated to Sustainability** – Woods Hole Sea Grant works with communities to promote sustainable use of natural resources and to promote the blue economy that supports sustainable tourism and other services that coastal ecosystems provide to the Nation.
- **Accountable** – Woods Hole Sea Grant conducts all activities with integrity and transparency in the support of research, extension, education and communication.

In addition to the core values, cultivating partnerships and enhancing diversity and inclusion in all program activities need to be addressed in implementing the 2018–2021 Strategic Plan. Woods Hole Sea Grant will integrate expertise and capabilities of partners from international, federal, regional, tribal, and state organizations in addition to academic and nongovernmental organizations; and will seek and welcome diverse perspectives and viewpoints to enhance cultural understanding, preserve heritage and traditions, and enable the network to pursue its vision and mission effectively and efficiently.

The Woods Hole Sea Grant Program reports directly to the Deputy Director and Vice President for Research of WHOI, Dr. Laurence P. Madin. Woods Hole Sea Grant has a small staff, but works collaboratively with other staff at both the Woods Hole Oceanographic Institution and the Cape Cod Cooperative Extension Service. Through a memorandum of understanding between Woods Hole Oceanographic Institution and Cape Cod Cooperative Extension, the two organizations manage and administer outreach and extension programs. In addition, WHOI's Communications Department assists in publication preparation, teacher workshop facilitation, and other outreach activities. Thus, through effective partnerships at WHOI and CCCE, Woods Hole Sea Grant's small staff leverages the expertise and talent available throughout the parent organizations and extends opportunities throughout the Commonwealth of Massachusetts. Woods Hole Sea Grant's advisory board, the Marine Outreach Guidance Group (MOGG), provides oversight of program plans and strategic planning. MOGG's membership includes representation from academia, industry, the public, media, and government agencies. Through these efforts the Woods Hole Sea Grant Program strives to maintain organizational excellence, engage partners throughout the Northeast region to support program goals, and ensure diversity and inclusion by reaching out to diverse groups throughout the region.

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 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 support the healthy coastal ecosystems focus area include: (1) collaborative workshops on wastewater management and water quality issues; (2) sponsorship of the annual Cape Coastal Conference where innovative local strategies on nutrient management are discussed; (3) teacher workshops on the effects of ocean acidification on coastal ecosystems, primary productivity, ocean circulation, and derelict fishing gear and marine debris; (4) participation in the Northeast Coastal Acidification Network workshops on stakeholder engagement on ocean acidification; (5) establishing a water quality monitoring system using remotely accessed YSI instruments; (6) conducting a boat-wrap recycling program; (7) shellfish enhancement of nitrogen removal

in coastal ponds; (8) establishment and management of a network for river herring managers; and (9) oral histories of those involved in the river herring resource and the shellfish industry on Cape Cod (posted on NOAA's Voices from the Fisheries, http://www.st.nmfs.noaa.gov/voicesfromthefisheries/.

New techniques and approaches are 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 the **Healthy Coastal Ecosystems** focus area are listed in Table 2.

Table 2. Healthy Coastal Ecosystems Focus Area

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
Habitat, ecosystems, and the services they provide are protected, enhanced, or restored.	Develop and share decision-support tools, technologies and approaches to protect and restore ecosystems.	Scientific understanding and technological solutions inform and improve conservation and the management of natural resources. Ecosystem science and conservation priorities developed through stakeholder participation are addressed. Greater awareness and understanding of ecosystem functions and services they provide improves stewardship efforts. Ecosystem priorities are developed with stakeholder participation.	Support research to understand habitat responses to changes in environmental conditions and processes leading to restoration. Support social science research to develop decision-support tools for managing ecosystems and restoring habitats. Support extension activities to translate scientific information for decision makers. Through workshops and conferences stakeholder engagement will identify priorities for research and management.
	Sustain the habitat, the biodiversity, and the abundance of coastal ecosystems, fish, wildlife, and plants.	Declining biodiversity, habitats, and ecosystem functions and services are restored and sustained. Improved collaborative planning and decision making leads to enhanced stewardship. Collaborations with partners and stakeholders support planning, research and technological solutions to address resource management needs. Citizen science initiatives are engaged and contribute to improving our knowledge with respect to coastal communities and ecosystems. Communities have access to sound science, data, tools, and the training to be effective in planning and decision-making processes.	Support research and extension activities to enhance species and habitat restoration. Support programs that inform local communities on restoration efforts.

Table 2 continued.

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
Land, water, and living resources are managed by applying sound science, tools, and services to sustain ecosystems.	Support a sound science and management-driven framework that integrates observations, monitoring, research, and modeling to provide a scientific basis for informed decision-making.	Collaborations with partners and stakeholders support planning, research and technological solutions to address resource management needs. Citizen science initiatives are engaged and contribute to improving our knowledge with respect to coastal communities and ecosystems. Communities have access to sound science, data, tools, and the training to be effective in planning and decision-making processes.	Extension and outreach staff will assist communities in developing management approaches that ensure protection of resources and support communities and economies. Support research in the social and natural sciences to improve ecosystem based management tools and assessment. Through training workshops and conferences provide communities with case studies and management tools to support resiliency for coastal ecosystems.
	Identify and promote case studies and strategies to enhance resilient ecosystems and watersheds in the context of changing conditions.	Resource managers understand the risks, the options, tradeoffs, and impacts of their decisions. Communities have access to information and understand projected changes within coastal ecosystems and how changes will impact coastal ecosystems. Communities can access case studies, training and tools to improve their ability to plan, prepare and adapt to future ecosystem conditions.	Extension and outreach staff works with communities to provide training and examples of applications of management tools for decisions on habitat protection and restoration.

Performance Metrics:

- Number of resource managers who use ecosystem-based approaches in the management of land, water, and living resources as a result of Sea Grant activities

This measure counts the number of managers who use ecosystem based approaches in the management of land, water, and living resources in ocean, coastal and Great Lakes areas as a result of Sea Grant activities, and assesses Sea Grant's role in informing decisions by delivering scientifically rigorous and integrated approaches to managing ocean, coastal and Great Lakes ecosystems to resource managers.

- Number of acres of coastal habitat protected, enhanced, or restored as a result of Sea Grant activities

This metric tracks the number of acres involved in successful ecosystem restoration projects, and highlights the area (in acres) of ocean, coastal, and Great Lakes habitat relieved of environmental stressors or returned to a more natural state through Sea Grant projects.

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. 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, and investigating alternative species to augment and diversify current aquaculture crops.

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) conducting a municipal shellfish propagation/natural resource enhancement program for all 15 towns within Barnstable County; (3) 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; (4) establishing a shellfish disease monitoring network in the region; (5) restoring oysters, bay scallops, and eel grass habitat; (6) conducting site visits and technical assistance to shellfish farms experiencing growing and harvesting problems; (7) working with local resource managers to enhance shellfish resources; (8) publication of results quantifying nitrogen in shellfish from local habitats; (9) continued monitoring of Vibrio in shellfish and using that information to reduce risks for human health; (10) providing predator/pest identification and advice on their control; (11) examining alternative species for culture and harvest; (10) producing and disseminating brochures on safe and sustainable seafood practices; (11) supporting long-term habitat assessments to address variability in shellfish growth and survival; (12) supporting a shellfish research farm network to provide high quality, relevant data to local shellfish farmers, providing multiple platforms for demonstration and outreach in different communities, and increasing communication among shellfish farmers; (13) conducting teacher workshops and a training course on aquaculture; (14)

distributing extension bulletins and other information on seafood production; (15) contributing to a study on the economic value of the Massachusetts shellfish industry (UMASS-Dartmouth, 2015); (16) participating in a working group assessing the effects of climate change on the shellfish industry, supported by the NOAA Climate Program Office, Coastal and Oceans Climate Applications (COCA) Program; and (17) participating in the 21st International Symposium on Society and Resource Management, Understanding and Adapting to Change.

New techniques and approaches are 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 3.

Table 3. Sustainable Fisheries and Aquaculture Focus Area

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
Fisheries, aquaculture, and marine and freshwater resources provide food, jobs, and economic and cultural values.	Develop a trained workforce and enhance technology transfer in domestic aquaculture.	Increased understanding and technological solutions aid aquaculture management and production. Partnerships that enable the aquaculture industry to adapt and acquire innovative technologies expand.	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.
	Promote and support harvest and processing techniques that lead to safe, sustainable and high quality food and economic and ecosystem benefits.	Coastal resource industries employ technologies and reinforce strategies to ensure safe and sustainable seafood and products. Consumers understand the health benefits of seafood and purchase safe and sustainable products. Coastal resource industries employ strategies that balance economic, community and conservation goals.	Extension staff will assist the regional aquaculture industry continue to succeed as a growing contributor to the local economy and to the national and global production of farmed marine products. Distribute informational brochures at markets and restaurants on the health benefits of safe seafood.
Natural resources are sustained to support fishing communities and industries, including commercial, recreational, and subsistence fisheries, and aquaculture.	Ensure sound science, services, and tools are available and accessible for fishing and aquaculture communities.	Commercial and recreational fishermen and aquaculturists are knowledgeable about efficient, sustainable, and responsible tools, techniques, and uses of coastal and freshwater resources. Innovative solutions that increase understanding of climate impacts on fisheries and aquaculture are available and accessible to resource managers and fishing and aquaculture communities. Resource managers and fishing and aquaculture communities have access to science and tools to increase their capability to adapt to future resource management needs.	Extension and outreach staff will work with state and local authorities to ensure that issues related to seafood safety are well characterized and documented for the public.

Program Metrics:

- Number of fishermen, seafood processing or aquaculture industry personnel who modify their practices using knowledge gained in fisheries sustainability and seafood safety as a result of Sea Grant activities

This measure tracks Sea Grant's success in having stakeholders adopt responsible fishery practices, and tracks Sea Grant's success in assisting industry personnel with the adoption of responsible harvesting and processing techniques that improve social, economic, and ecological sustainability.

Resilient Communities and Economies

Coastal communities in the U.S. provide a wide range of economic, social, and recreational opportunities. Seventy-five percent of the population of Massachusetts lives in coastal counties and the marine related economy in Massachusetts is quite strong. At the same time, coastal ponds, embayments, open coasts, and coastal resources are impacted by society's commercial, recreational and residential activities. Threats to coastal communities include climate change driven sea-level rise, shoreline erosion, conflicts between the protection of waterfront upland 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, assisting with coastal floodplain management, 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 include: (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 of coastal processes, floodplain management, and hazard mitigation research; (2) producing extension bulletins and other information on sea level rise, coastal erosion, flooding, hurricanes and other storms; (3) conducting teacher workshops on beach and dune dynamics and coastal processes; and (4) co-sponsoring workshops and conducting needs assessments on issues relevant to storm hazards in coastal communities; (5) identification of risks and impacts associated with the Northeastern U.S. region's coastal natural hazards with agency partners such as the U.S. Geological Survey (Marine Geology Branch, Woods Hole, MA), Cape Cod Commission, Massachusetts Emergency Management Agency, Federal Emergency Management Agency and coastal communities throughout the Commonwealth of Massachusetts; (6) a coastal climate adaptation project designed to provide regional and local predictions of future coastal storm activity and sea-level rise to user groups within the region and to promote wise utilization and conservation of resources; (7) creation of a Community Rating System User Group that provides continuing education credits for Certified Floodplain Managers and assists town staff to stay up-to-date on floodplain regulations; (8) publication of the, now in its 2nd edition, *Massachusetts Homeowner's Handbook to Prepare for Coastal Hazards*; (9) production of a brochure on *Questions and Answers on Purchasing Real Estate in Coastal Massachusetts*; (10) incorporation of an extension bulletin, *Dealing with Coastal Erosion: The Spectrum of Erosion Control Methods*; and (11) collaboration with

the Northeast Regional Ocean Council (NROC) on issues related to coastal economies and coastal resilience.

New techniques, topics, and approaches are added to this portfolio as information needs are identified. Specific goals, outcomes and targets for Resilient Communities and Economies are listed in Table 4.

Table 4. Resilient Communities and Economic Focus Area

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
Coastal communities use their knowledge of changing conditions and risks to become resilient to extreme events, economic disruptions, and other threats to community well-being.	Use innovative tools to increase the public's awareness of changing conditions and the potential impacts their communities and economies may encounter.	Members of the community, including the underserved, are aware of and understand changing conditions and hazards and the implications to their communities, and are prepared to respond, and adapt.	Support research and extension activities that develop technologies and strategies promoting resilient communities to natural hazards.
		Existing and innovative training programs improve community leaders' understanding of changing conditions in their communities and implement adaptive strategies.	Provide training to communities on adaptive strategies to promote resilience.
	Utilize comprehensive planning and adaptive management strategies to enhance community resilience and adapt to hazards and changing environmental and socioeconomic conditions.	Communities have access to information needed to understand the factors impacting ecosystems and participate in adaptive management planning.	Extension and outreach staff disseminates information and conduct training workshops on community resilience and adaptive strategies.
		Communities employ adaptive management strategies and apply tools to engage diverse members of the community to improve resilience and community sustainability.	Coastal communities adopt policies and/or regulations to improve their resilience, including improved understanding of floodplain management regulations to increase rates of enforcement.
	Increase the resilience of coastal communities through diversification, growth, and strengthening of coastal economic sectors.	Members of the community, including the underserved, have access to information needed to understand how coastal economic activities and trends will impact environmental and community well-being.	
		Communities have access to tools, services, and technologies to adapt and grow resilient economies.	Assist communities in efforts to join the Community Rating System.
		Leaders in coastal economic sectors understand how they can become more resilient through diversification and through conservation of ecosystem services.	

Table 4 continued.

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
Water resources are sustained and protected to meet existing and emerging needs of the communities, economies, and ecosystems that depend on them.	Inform community members about how actions impact water quality and availability. Collaborate with stakeholders to develop and share best management practices (BMPs) and measures to protect and manage water resources	Community members understand watershed functions and the services they provide that support communities and economies. Community members understand how actions will impact water quality and quantity and are able to make informed decisions. Communities have access to sound science, data, tools, and services to understand and anticipate changes in water quality and quantity. Communities have diverse, sustainable economies and industries that support the existing and emerging water resource needs. Communities have access to science, tools, and technologies to protect and sustain water resources and make informed decisions.	Through cooperative partnerships promote the wise management and protection of water resources.

Program Metrics:

- Number of communities that adopt/ implement sustainable economic and environmental development practices and policies as a result of Sea Grant activities

This measure tracks communities that have made strides in sustainable development with Sea Grant aid, moving beyond analysis and planning and into implementation, and improving the balance of natural resource use and conservation.

- Number of communities that adopt/ implement hazard resiliency practices to prepare for and respond to minimize coastal hazardous events

This metric tracks Sea Grant's contribution to communities that develop comprehensive emergency preparedness and response plans to increase their resiliency and enable them to respond effectively. Sea Grant contributes to this by building a sound knowledge base to improve forecasting capabilities, by identifying development and best management practices that reduce the vulnerability of people, buildings and businesses to coastal hazards, and by advancing ways communities can manage and recover from these events when they occur. This measure indicates increased capacity of communities to assess vulnerability, minimize potential impacts to ecological and human systems, and improve ability to respond to hazards and adapt to a changing climate by learning from past events and adopting risk reduction measures. Improving community resilience is a continuous effort that requires ongoing local attention and action.

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. In *NOAA's Education Strategic Plan 2015–2035*, the agency emphasized the important role of science education in supporting, promoting, and coordinating formal and informal educational activities at all levels to enhance public awareness and understanding of ocean, coastal, and Great Lakes resources.

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.

Stakeholder engagement through educational programs includes: (1) the long-running workshop series that attract teachers throughout Northeastern U.S.; (2) participation in the NSF-funded informal education project "Global Viewports" that brought New Bedford science teachers to both the Ocean Explorium and WHOI, introducing teachers with students from underrepresented populations to these two resources for ocean science; (3) a workshop taking Cape Cod teachers to several beaches to view coastal erosion and processes including sea level rise on Cape Cod, and providing teachers with not only a field experience, but also web-based resources and classroom activities; (4) an 8-week course; Fundamentals of Shellfish Farming, for a diverse stakeholder audience interested in gaining an in-depth understanding of shellfish aquaculture, covering topics from shellfish biology to site selection, husbandry, safety, and permitting; course graduates have included shellfish growers, Massachusetts fisheries biologists and regulators, local municipal resource managers, and persons seeking information to initiate their own aquaculture business; (5) a 2-day workshop, Volunteer Shellfish Community Action Program, to educate and train volunteers interested in helping municipal shellfish wardens raise shellfish for the community; (6) a Community Rating System workshop, sponsored by Massachusetts' Congressman William Keating; (7) organizing both the Cape Coastal Conference and the Martha's Vineyard Coastal Conference, bringing scientists and decision makers together; (8) organizing the Cape Cod Conservation Commission network and providing training opportunities for new conservation agents; (9) Massachusetts Congressional roundtable discussions on coastal issues; and (10) numerous youth groups, K-12 classes and community organizations participating in marine debris data collection and educational efforts via regional beach cleanups.

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 5.

Table 5. Environmental Literacy and Workforce Development Focus Area

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
An environmentally literate public that is informed by lifelong formal and informal opportunities that reflect the range of diversity of our communities.	Enable the public to engage in community planning processes with respect to adaptive management to changing conditions by providing the best available information. Increase effective environmental literacy instruction for K-12 students by formal and informal educators. Increase effective environmental literacy communication to stakeholders, including how ecosystem change affects economic, social, and cultural values, as well as implications for conservation and management.	Communities are knowledgeable and equipped with the best available science and technology in order to contribute to adaptive management planning processes and stewardship. Teachers and students are better informed in science, technology, engineering, and mathematics fields and can employ their knowledge to support sustainable practices within their communities. Stakeholders develop a sense of awareness, understanding and stewardship in order to sustain watershed, coastal, and marine ecosystems and resources. Communities implement sustainable strategies when managing natural resources and make decisions based on information acquired through informal science education.	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 will have access to ocean sciences research and information, via the WHSG and WHOI websites and Marine careers.net, to develop an appreciation for the oceans and an awareness of marine science related career opportunities. Researchers from the ocean science community will have access to and participate in scientific, educational and outreach opportunities.

Table 5 continued.

National Plan Goals	National Plan Action	Desired Outcomes	Program Plan Targets
A diverse and skilled workforce is engaged and enabled to address critical local, regional, and national needs.	Grow awareness among the nation's diverse population of career paths that support the needs of the nation's coastal communities. Increase opportunities for undergraduate and graduate students to gain knowledge and experience in the science and management of watershed, coastal, and marine resources. Prepare a responsive and diverse workforce to advance and benefit from sectors that support the needs of the nation's coastal communities and ecosystems (e.g. industry, research, government, etc.), and to adapt and thrive in changing conditions.	All members of a community are enabled to explore and pursue the variety of occupations that are essential to sustain the nation's coastal communities and ecosystems. College level courses and internships provide increased literacy, experience, and preparedness in areas of watershed, coastal, and marine ecosystems for all students particularly those from underrepresented groups. Undergraduate and graduate students, particularly those from underrepresented groups, are supported and have access to formal and experiential learning, training, and research experiences. Employment in all sectors of the U.S. coastal resource enterprise expands and diversifies. The existing and future workforce is able to adapt and thrive in changing environmental, social, and economic conditions.	Support for undergraduate, graduate and postdoctoral students will be provided through research awards to their universities or research institutions. Staff participates in career events for high school and college students and disseminates information on training opportunities and career choices.

Program Metrics:

- Number of Sea Grant products that are used to advance environmental literacy and workforce development

This metric tracks the number of Sea Grants products that are used by stakeholders or program staff to advance environmental literacy and workforce development, and indicates Sea Grant efforts to develop and implement Sea Grant educational, extension, and communications products that are used by stakeholders or program staff to advance environmental literacy and workforce development.

- Number of people engaged in Sea Grant-supported informal education programs

This metric counts the number of people who engage in Sea Grant informal education programs, and provides an estimate of individuals that actively participate in Sea Grant supported informal education programs, thus advancing environmental literacy.

- Number of Sea Grant-supported graduates who become employed in a job related to their degree within two years of graduation

This metric counts the number of Sea Grant-supported graduate students who become employed in a job related to their degree within two years of graduation, and indicates the societal benefit of Sea Grant education for students who find jobs relating to their degree after graduating.

Cross-Cutting Measures:

- Number of Sea Grant tools, technologies and information services that are used by our partners/customers to improve ecosystem-based management

This measure tracks success in translating research findings into useful tools, technologies and information services that improve the use and management of coastal, ocean, and Great Lakes ecosystems, and communicates the number of Sea Grant products that address the management of land, water and living resources in coastal areas resulting from Sea Grant activities.

- Economic and societal impacts derived from Sea Grant activities (market and non-market; jobs and businesses created or sustained)

Society benefits from Sea Grant-supported technical assistance and innovation that lead to new businesses/jobs and sustaining existing businesses/jobs. This measure also tracks dollars that communities or businesses save due to Sea Grant assistance (i.e., providing information to help businesses make better decisions and avoid mistakes), and tracks economic benefits from the development of new ocean, coastal and Great Lakes resources and technology.

Sea Grant supports research and provides the information and training that informs business decisions, and in some cases firms create or sustain jobs as a result. Moreover, Sea Grant activities can have positive effects on restoring, maintaining or improving environmental goods and ecosystem services, broadly defined as natural capital. Even if not valued by the market, these goods and services have economic value to humans.

Cross Cutting Output Metrics

- Number and origination of core funding pre-and full proposals

This metric is used to demonstrate the scale and diversity of Sea Grant's research enterprise as programs report the number of pre-proposals, full proposals, and funded proposals for omnibus core funding and the number of participating institutions.

- Number of marinas certified as "Clean Marina" by the Clean Marina Program as a result of Sea Grant activities

The Clean Marinas Program is an ongoing endeavor, by a marina industry alliance, determined to provide environmentally clean facilities and protect the states' coastal and inland waters from pollution through compliance of best management practices. This metric tracks Sea Grant efforts to provide clean facilities to the boating community and protect waterways from pollution through Clean Marina certifications or re-certifications awarded as a result of Sea Grant activities.

- Number of individuals certified in Hazard Analysis Critical Control Point (HACCP) due to Sea Grant efforts

Sea Grant Programs provide HACCP training and this metric demonstrates Sea Grant's effort to train professionals to identify and prevent hazards that could cause foodborne illnesses through the number of HACCP certifications awarded as a result of Sea Grant activities.

- Number of peer-reviewed publications produced by Sea Grant

This metrics tracks the number of publications produced by Sea Grant. The end product of scientific and engineering

research is information, and Sea Grant research results are not realized until they are available to users in the marine community. To further the use and development of marine and coastal resources, NOAA encourages wide dissemination of the results of Sea Grant research and other activities. A major part of that dissemination occurs in the form of publications and other communications documents and products aimed at Sea Grant's various audiences; all refereed documents are submitted to the National Sea Grant Library (http://nsgl.gso.uri.edu/about/pdfs/pubdefinitions.pdf).

- Number of individuals and full-time equivalents (FTEs) supported by Sea Grant

This metric reports the number of individuals and FTEs devoted to Sea Grant during the reporting period, providing information regarding the personnel composition of each program.

- Number of postsecondary students and degrees financially-supported by Sea Grant in higher education programs (undergraduate, graduate)

This metric assesses the number of undergraduate/graduate students and degrees supported by Sea Grant through financial or other means.

- Number of P-12 students reached through Sea Grant-trained educators or directly through Sea Grant education programs

The estimated number of pre-school through 12th grade (P-12) students who attend a Sea Grant sponsored workshop or training (i.e., by an educator/extension agent), as well as the number of students reached by teachers who have utilized information from a Sea Grant workshop/training.

- Number of P-12 educators who participated in Sea Grant education programs

This metric indicates the number of pre-school through 12th (P-12) educators who attend a Sea Grant-sponsored workshop or training (i.e., by an educator/extension agent) and can then enhance the environmental literacy of students for years to come.

- Number of volunteer hours

The estimated number of hours that citizens volunteer without payment for their time and services to help a state Sea Grant program accomplish the goals and objectives of its four-year plan (e.g., co-sponsored events/trainings).

- Number of Sea Grant-sponsored/organized events

This metric reports the number of events in which Sea Grant support was integral (e.g., planning/ financial/ personnel contributions), and indicates the scale of Sea Grant outreach as it provides the number of meetings, workshops, festivals, conferences, etc., in which Sea Grant played an integral role.

- Number of attendees at Sea Grant-sponsored/organized events

This metric reports the estimated number of attendees at the events counted in the preceding metric (i.e., events in which Sea Grant support was integral via its planning/ financial/ personnel contributions), and demonstrates the scale of Sea Grant outreach.

- Number of public or professional presentations

This metric reports the estimated number of presentations given by Sea Grant staff and investigators presenting Sea Grant-funded research.

- Number of attendees at public or professional presentations

This metric reports the estimated number of attendees at the presentations counted in the previous metric (i.e., a presentation given by Sea Grant staff member and investigators presenting Sea Grant-funded research).

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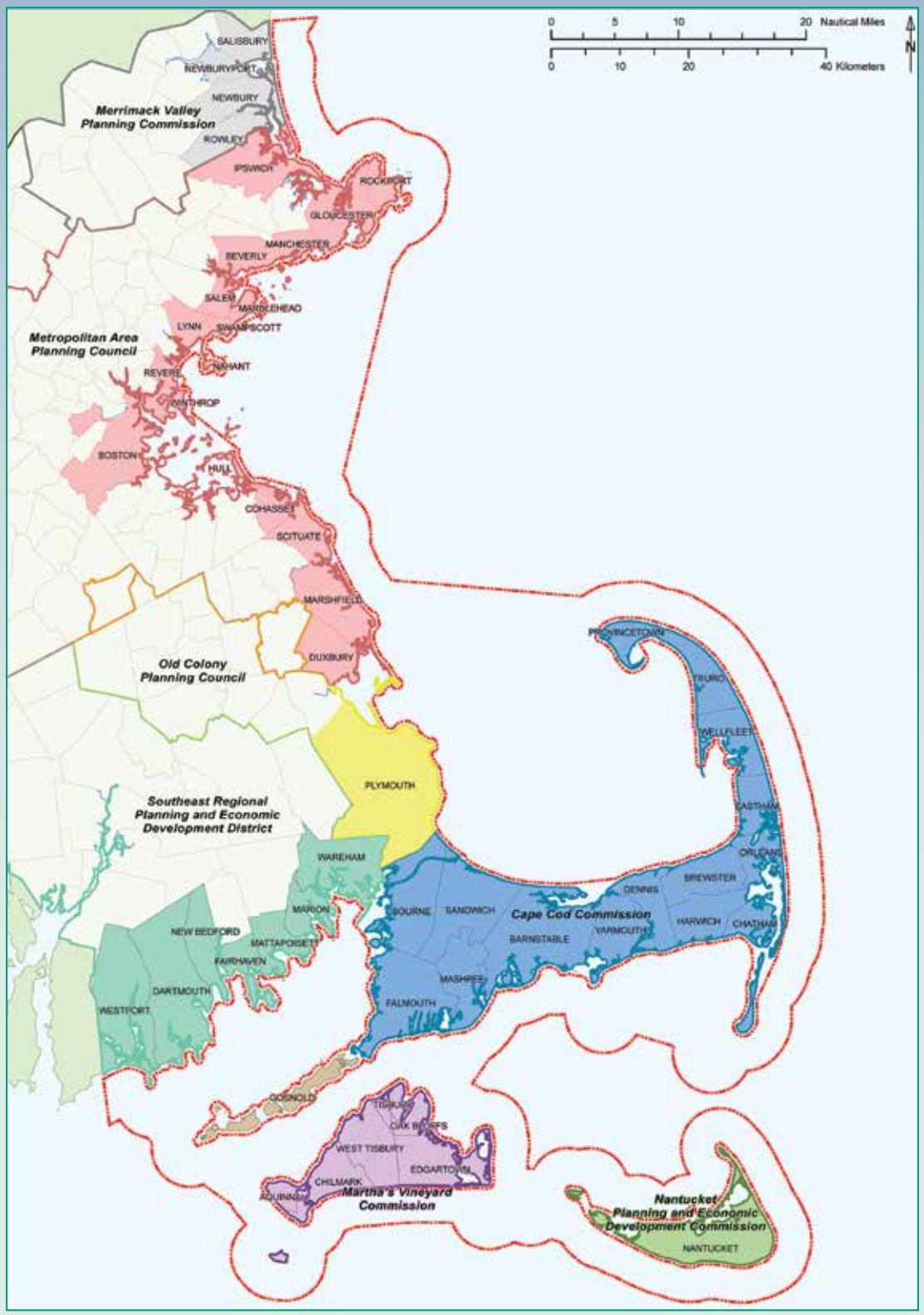

Massachusetts ocean management planning area boundary[1]

Regional planning agencies[2]

- 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 (OCPC)
- Southeast Regional Planning and Economic Development District (SRPEDD)
- Belongs to both MAPC & OCPC

Data sources: [1]Massachusetts Office of Coastal Zone Management, [2]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.