

# MIT SEA GRANT STRATEGIC PLAN 2014 – 2017

## Introduction

The MIT Sea Grant College Program strategic plan is inspired by our vision, focused on our goals and objectives and enhanced by the unique educational, scientific and technological resources of our home institution, local community, and state institutions and resources. Our mission is to conduct and support research and develop technology to enable scientific investigation into problems surrounding the health and human use of the sea. Our education and outreach efforts disseminate the results of our MIT Sea Grant-funded research, encourage the stewardship and the adoption of sustainable and useful technologies, support public policy and industry with information that is relevant, evidence-based and scientifically sound.

Efforts in research, education, and outreach are designed to address critical marine and coastal issues at the state, regional, national and global levels that have been identified by Massachusetts constituents and which are within the areas of focus for the National Sea Grant College Program. The goals of the focus areas shape priorities for our annual solicitation to fund new proposals, and they guide us in both the short- and long-term toward projects whose success can best serve our constituents.

## Vision

The Sea Grant College Program at MIT is positioned to bring the substantial intellectual abilities of the Massachusetts Institute of Technology and our institutional collaborators to bear on a number of ocean-related challenges. In meeting these challenges with extraordinary technical contributions and strong commitment to scientific research, we will expand our knowledge of the ocean, and also establish the collaborative infrastructure to support the initiatives and talent needed to address threats to our critical and fragile marine resources and the people who depend on them.

## Background

### The National Sea Grant College Program

Congress established the National Sea Grant College Program in 1966 to hasten the development, use and conservation of the nation's coastal waters and Great Lakes. The legislation called for a network of Sea Grant Colleges to conduct education, training, and research in all fields of marine study, and directed that grants and contracts would go to "suitable public and private institutions of higher education, institutes, laboratories, and public or private agencies which are engaged in, or concerned with, activities in the various fields related to the development of marine resources." [PL 89-688 Sec. 204(c)]

Administered through the National Oceanic and Atmospheric Administration, the National Sea Grant College Program supports scientific research in marine biology, coastal and ocean engineering, fisheries science, and marine-related social sciences and law toward informing long-term economic development and environmental stewardship. The Massachusetts Institute of Technology received its first funding from Sea Grant in 1968 and was designated as a Sea Grant College Program in 1976. Today, there are 33 Sea Grant programs in coastal and Great Lakes states and in Puerto Rico and Guam. To ensure that programs respond to local as well as national concerns, it is mandated that one-third of the program funds come from non-federal sources such as industry or state or local governments.

## The Region - Massachusetts and the Gulf of Maine

The Massachusetts coastline is diverse and productive extending from New Hampshire in the north to Mount Hope Bay in the south and encompassing Massachusetts and Cape Cod Bays, Buzzard Bay and portions of Mount Hope Bay. The geological history of Massachusetts is a legacy of sand and gravel deposits left by glaciers to rocky shores with exposed preglacial bedrock. The natural harbor of Boston and several other port cities was a destination for early settlers. The legacy of colonial settlements and various immigrant groups contributes to the diverse and rich cultural heritage that continues to make Massachusetts an attractive destination.

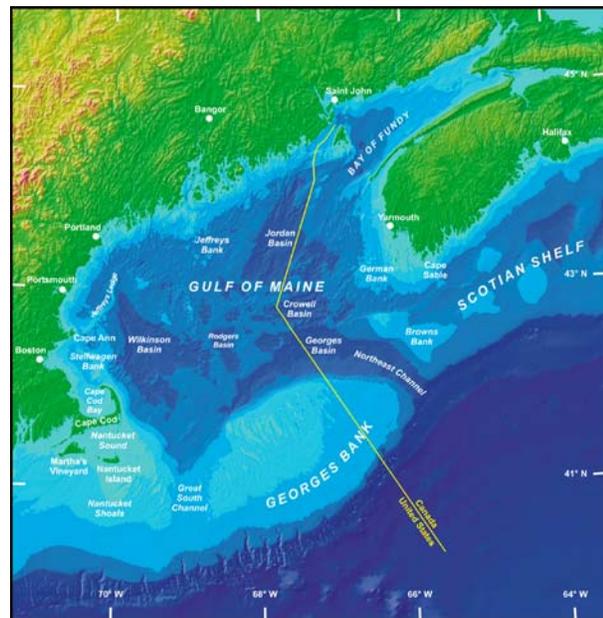


Figure 1. The Gulf of Maine exclusive economic zone is subject to international agreements. Image courtesy Gulf of Maine Council on the Marine Environment, <http://www.gulfofmaine.org/gommi/imagegallery.php>.

Massachusetts sits within a larger ecosystem, the Gulf of Maine, which is a semi-enclosed sea bounded by the coasts of Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia and seaward by mounts and banks. The southern portion of the Massachusetts coast including the outer portion of Cape Cod, Buzzards Bay, and Mount Hope Bay is part of the Mid-Atlantic region.

Two geological areas within the Gulf of Maine are notable for their productivity and diversity. Georges Bank is a relatively shallow water area that is one of the most accessible and productive fishing grounds in the world. The currents tend to accumulate plankton that serve as the basis of the food web supporting groundfish and scallop fisheries.

The second notable area in the Gulf of Maine, Stellwagen Bank is one of 14 designated National Marine Sanctuaries and is virtually within sight of Boston. Stellwagen Bank is a popular destination for whale-watching tourists in particular for it is home to many; cetacean and bird species. In addition to its diverse biology and fishery, numerous underwater shipwrecks found within the sanctuary are a valued cultural heritage.

Pollution issues have plagued cities and towns since the colonial time. Depending on how they are classified, there are over 37 coastal watersheds with over half the landmasses in Massachusetts and half of the larger systems originating outside Massachusetts. Water use and watershed management concerns may be addressed regionally. Boston Harbor sits within Massachusetts Bay, where it is fed by several rivers, including the Charles River, and dotted with many islands owned and managed by the City of Boston, Commonwealth of Massachusetts, and National Park Service. Nearly two-thirds of the Commonwealth's residents live in and around Boston where pollution issues in the Harbor were notorious.

In recent decades less populated areas along the New England coast have experienced population growth impacting the regional marine ecosystem. Although Massachusetts continues to enjoy a strong economy, the cumulative impacts of growth, pressure on extraction of natural resources, and the projected effects of climate change, present challenges to continued prosperity and growth for the future. Our strategy is to place our research and outreach efforts in the context of Massachusetts and the regional ecosystem.

### **The Local Landscape - The Commonwealth of Massachusetts**

The Commonwealth of Massachusetts has a rich and colorful maritime history and a significant part of the Commonwealth's economy remains dependent on the sea. Massachusetts boasts 1,980 miles of coastline with an estimated 6.5 million people, making it one of the most densely populated states in the USA. Coastal and marine-related industries such as tourism, shipping, and commercial fishing contribute an estimated \$42.5 billion to the Massachusetts economy each year. Development in these industries, however, can threaten the state's marine ecosystems upon which their existence depends. Negotiating the wise use of the Commonwealth's maritime resources requires comprehensive, accurate scientific information. MIT Sea Grant pledges to make scientific and technical information available to constituents, managers and policymakers to help sustain and conserve the ocean's resources today and for future generations.



Figure 2. Rivers, lakes, reservoirs, and marine resources are depicted on the Massachusetts map, above. Image courtesy geology.com, <http://geology.com/lakes-rivers-water/massachusetts.shtml>.

For years the coastal waters around Boston were used for waste disposal and by the 1980s, Boston Harbor was considered one of the dirtiest harbors in the country. The cod and lobster fishery, once abundant in nearshore waters continued to be productive fisheries in Stellwagen and Georges Banks, but today the cod fishery is greatly reduced. Clean up efforts have made the harbor significantly cleaner and resulted in five south Boston beaches ranked among the cleanest urban beaches in the country. However, water quality, sustainability of natural resources, preservation of cultural resources, and continued pressure to develop coastal areas will continue to challenge managers and policy makers as they balance growth and sustain resources.

### **Our Host Institution - The Massachusetts Institute of Technology**

MIT was founded in 1861 as an independent educational institution relevant to the national transformations brought on by the industrial age. From its inception the Institute has been guided by the philosophy that professional competence is best fostered by coupling academics with research and by focusing on real-world problems and contemporary issues.

The mission of MIT is to advance knowledge and educate students in science, technology, and other areas of scholarship that will best serve the nation and the world in the 21st century. The Institute is committed to generating, disseminating, and preserving

knowledge, and to working with others to bring this knowledge to bear on the world's scientific, engineering and technological challenges. Artificially intelligent underwater vehicles, new kinds of subsea communications, open access databases, oceanographic models, and sophisticated solutions to biological issues are made possible by the intellectual resources and environment of the Institute. MIT encourages broad collaboration among the Institute, industry, and government in order to promote education, research, and service to the larger community.

President Rafael Reif and the MIT Environmental Research Council issued a report in 2012, titled “Implementing the MIT Global Environment Initiative” which outlines the Institute’s areas of engagement as Climate, Oceans, Water, Ecological Resilience, Contamination Mitigation and Sustainable Societies. This initiative’s alignment with Sea Grant’s focus areas and objectives is striking.

### **Stakeholders and Advisors**

Beyond the university, MIT Sea Grant collaborates closely with a number of local, state, national, and international groups with whom we share interests. In particular, we partner with the Woods Hole Sea Grant Program (WHSG) in planning and selecting our research and coordinating and collaborating on Advisory activities.

Our planning and oversight committees, the State Industry Council, MIT Faculty Committee and Marine Advisory Services Review Panel are served by state and federal agencies, non-government organizations, educators, academic institutions, museums and maritime industry representatives. We have partnered with over 280 groups, and work very closely with the Massachusetts Office of Coastal Zone Management, Massachusetts Water Resources Authority, Massachusetts Bays Program, Northeast Fisheries Management Council, as well as town managers in Kingston, Scituate, and Gloucester.

### *Regional Collaborations*

This strategic plan focuses on issues of concern in Massachusetts, but many problems are shared throughout the region. Although there is a strong collaborative relationship among the Northeast Sea Grant Directors, funding regional projects was often piecemeal and did not necessarily address issues holistically. Through funding from the National Sea Grant Office, two regional projects, The Gulf of Maine Regional Ocean Science Initiative (GOM ROSI) and the New York Bight Regional Ocean Science and Information Initiative underscored the need for more formal agreements.

Seven Sea Grant Programs (ME, NH, MIT, WH, RI, CT, and NY) created the Northeast Sea Grant Consortium (NESGC) in 2009, which funds research projects that address regional concerns. The NESGC is dedicated to advancing research, education, outreach and diversity of programming for regional projects and to seek additional funds to support the projects. Funds are pooled every two years to support two or more research programs. To date six projects have been funded addressing issues that impact

fisheries and non-native species, marine mammals, and social and legal issues associated with marine spatial planning and ecosystem services. In addition to identifying and supporting regional projects, the NESGC has entered into a memorandum of understanding with another active regional organization, the Northeast Regional Ocean Council that represents state and federal agencies within the Gulf of Maine.

## **Creating Our Strategic Plan**

The National Sea Grant College Program's strategic plan for 2014-2017 is committed to "Sustaining our nation's ocean, coastal and Great Lakes resources through university-based research, communications, education, extension, and legal programs". Four strategic approaches are identified in achieving this mission: (1) support science-based information on ecosystem functions and impacts of human activities, (2) develop an informed citizenry, (3) provide sound information to managers, decision makers, and citizens as they evaluate trade-offs between human and environmental needs, and (4) incorporate social science in ecosystem-based management decisions.

Four focus areas were identified as central to addressing the core of the Sea Grant mission and vision:

- Healthy Coastal Ecosystems
- Sustainable Fisheries and Aquaculture
- Resilient Communities and Economies
- Environmental Literacy and Workforce Development

These focus areas reflect current needs and are consistent with NOAA's goals and objectives identified in their New Generation Strategic Plan: climate adaptation and mitigation, weather-ready nation, healthy oceans, and resilient coastal communities and economies. With guidance from our National Sea Grant Program and NOAA, each Sea Grant program is tasked with developing a strategic plan to address priority issues identified by stakeholders. In preparation for selecting goals and preparing our strategic plan, MIT Sea Grant solicited input from our advisory committees, our networking partners and liaisons with local, state, federal, and regional agencies and organizations.

### *MIT Sea Grant Stakeholder Input*

MIT Sea Grant is committed to meeting the priorities of our constituents. Staff liaises and networks with state and federal agencies, local communities as well as regional organizations. Workshops, conferences, symposia, and meetings, as well as informal discussions with scientists, business leaders, managers, and non-government organizations, raise complex issues and new insights enhance our efforts to respond to public concerns.

As part of our ongoing collaboration with Woods Hole Sea Grant and our commitment to capturing concerns throughout the state, the two Sea Grant programs

jointly developed a survey to assess priorities, given below. As expected there are overlaps and similarities in the stakeholder priorities identified by each of the two approaches.

Throughout 2011-2012, MIT Sea Grant organized Stakeholder Forums around funded research and outreach projects. Our close working relationship with Massachusetts Coastal Zone Management, Massachusetts Bays Program, National Marine Fisheries Science Center, Division of Marine Fisheries, and Massachusetts Water Resources Authority ensures ongoing dialogue and awareness of issues of concern.

Responses from our constituents are similar to those who responded to the Massachusetts Sea Grant survey but also reflect local specific concern that may not have been captured in the survey. Ecosystem health and sustainability were identified as top priorities. Coastal issues that are a high priority across Massachusetts are: (1) water and sediment quality degradation from all sources including pharmaceuticals and personal care products, (2) non-point source pollution, (3) red tides, (4) beach closures, (5) protection of ecosystem services (fisheries and biota to support fisheries, etc.), (6) groundwater flow problems in urban and less-populated areas, and (7) prevention and eradication of marine invasions. The issues are interrelated and complex requiring a collaborative effort between scientists, engineers, and our Advisory Services. Specifically mentioned was the need for models to predict near-shore currents, new technologies to monitor effectively and efficiently in of support policy decisions, and research to integrate information from various disciplines to improve our ability to manage ecosystems. An active extension program to translate scientific issues for the public and enhance ocean literacy was highlighted.

Sustainability of a safe seafood supply is a high priority for managers and the public and includes issues that integrate human dimensions with fishery management. Some of the issues are: documenting the social impacts of regulatory change associated with fisheries management, rebuilding of fish stocks, economic support for fishing communities during periods of lower catch, supporting and expanding community supported fisheries and other approaches that sustain fisheries. Also highly rated were the need for outreach materials to explain benefits of consuming seafood to the public and public institutions, and ensuring seafood is safe for consumption.

The vitality of communities, addressing hazard resilience, and supporting economic well-being in coastal regions are priorities that integrate a number of issues. Among the issues identified were understanding and documenting frequency and intensity of storms, develop a forecasting system for coastal towns, ensuring that built infrastructure is not located in flood prone zones, minimizing construction in vulnerable areas, developing evacuation plans and support for basic necessities during storms, and communicating risk, adaptation options, and technologies that support managers and citizens. Advanced technologies such as platforms and sensors to monitor storms, improved models for local communities to adapt to intense storms, and development of networking systems for early warning were needed along with an outreach program to make information available to constituents.

Education was highlighted as essential for enhancing ocean and environmental literacy. Specific issues identified were: developing informal and formal engineering and environmental programs for K-12 students to promote Science, Technology, Engineering, and Math that meet the needs of the Navy, maritime, shipping, computer and other technology driven industries, and that train teachers to meet new standards in science and engineering. Research and technology development opportunities should be made available to undergraduate and graduate students and post-doctoral fellows. Innovative programs that build on our engineering programs will engage students and encourage their studies in engineering and science.

### *Massachusetts Sea Grant Survey*

To expand the scope of influence among constituents, in partnership with WH Sea Grant, we conducted an internet-based survey seeking input on priority issues for the Commonwealth of Massachusetts. The survey was distributed widely through our programs' and partners' listservs, newsletters, web-sites, Facebook and other social media, and by direct email. Survey respondents answered the following questions by selecting multiple choices and/or typing a response.

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 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?

Highlighted below are responses to the survey questions, which identified priorities similar to solicited stakeholder concerns and which inform and support the goals of the MIT and WH Sea Grant strategic plans. Respondents deemed three areas more important: Cape Cod and the Islands, Boston Harbor and the North Shore; others selected the South Shore, Buzzards Bay and Mount Hope Bay. The three primary interests identified were preserving the coast, providing stewardship, and making wise use of resources. Two issues highlighted in the area of coastal hazards were coastal flooding and shoreline erosion. A concern for monitoring to support management decisions was underscored along with a need to share timely information.

Protection and management of fisheries also emerged as high priorities along with concern for contaminants in seafood. From a socio-economic perspective, fisheries ranked highest followed by alternative energy, the human dimensions of coastal issues, and preservation of working waterfronts.

Water quality was identified as important for tourism, seafood safety, and aesthetics. The major concerns impacting water quality were run-off and human activities, followed by ocean acidification due to climate change, and pharmaceuticals in the water. In terms of useful data, water quality and biological data ranked high, followed by physical, socioeconomic, geological, and biogeographic datasets.

STEM-related marine education concerns focused on three areas: biology, biogeophysical processes and engineering. The last set of questions related to how information is accessed and how it could be made most useful. Websites were viewed twice as favorably as workshops, newsletters or newspapers as sources of accurate, timely information. For environmental literacy, websites, workshops, public events and reports were the top four categories.

## **MIT Sea Grant Strategic Plan**

Broadly speaking, our Focus Areas and Goals are aligned with those of the National Sea Grant Office, while our Objectives and Outcomes are dictated by stakeholder input. Within the framework of the four focus areas, the following sections include a brief discussion of the top priorities identified for Massachusetts as well as MIT Sea Grant's past and present research and outreach activities. Within each focus area, MIT Sea Grant's performance measures are listed under the National Sea Grant Program's goals. The National Sea Grant Program's Performance Measures are included in each focus area as appropriate; several performance measures are cross-cutting and therefore are affiliated with more than one focus area.

## **FOCUS AREA: HEALTHY COASTAL ECOSYSTEMS (HCE)**

Under the rubric of the Healthy Coastal Ecosystems (HCE), communities are expected to be both healthy and aesthetically pleasing, providing diverse commercial and recreational opportunities for residents and visitors. However, there are a variety of stressors that may affect the health of communities, including degradation of water quality from nutrients, contamination of seafood from red tides and wastes, invasive non-native species, acidification, sedimentation, and alteration of habitats. MIT Sea Grant addresses issues that impact coastal and marine waters through development of tools, platforms and technologies as well as conducting innovative research to assist managers with decisions that will ensure long-term viability of coastal ecosystems.

MIT Sea Grant has a long history in supporting improved water quality, particularly in urban areas such as Boston Harbor. MIT Sea Grant researchers and engineers partnered with the Massachusetts Water Resource Authority on a \$4 billion dollar wastewater treatment facility; billions of dollars were spent subsequently on cleaning up combined sewer overflows and storm drains. MIT Sea Grant researchers contributed to the science that was the foundation of placing an outfall to disperse wastes, modeling circulation and effluent from combined sewer overflows and supporting two long-term research projects that addressed issues relating to the source, transport, fate and effect of contaminants in water and sediments.

In parallel, innovative technologies and tools that supported the clean-up, most notably, the development of autonomous underwater vehicles (AUVs), were successful in providing a platform for sensors. MIT Sea Grant funded-Research on sensors led to devices for locating objects underwater, detection of contaminants in real times, and communication networks that shared data. A second six-year Marine Center Research Program dealt with the 300-year legacy of contaminated sediments and their disposal from a Boston Harbor dredging project. Constituents benefitted from the improvements to water quality and marine literacy with MIT Sea Grant's outreach and education efforts.

Recent funded projects include supporting development of an environmental sensor to assist with detecting red tide events, using autonomous underwater vehicles as a platform for sensors to detect oil leakage, non-native species, and pollution sources, and developing sensors that improve measuring effects. Other studies have examined behavior and effects of contaminants in sediments, water, and organisms, measured submarine flow, and studied microbial populations. Our outreach efforts seek to create opportunities for exchange of information among researchers, Advisory staff, and our stakeholders to support ecosystem-based management. We do this through convening and sponsoring workshops with other Sea Grant Programs and organizations on topics of interest to government and citizens. Development of databases for local and international users, high risk indicators for introduction of non-native marine species, tools to assess vulnerability of marshes, and communicating with constituents are among the support that we provide to stakeholders.

Research on developing inexpensive new technologies for improved groundwater flow measurements, refining water quality models, using social science visioning tools to work towards a consensus, translating biological adaptations (e.g., flapping of turtle limbs) for autonomous underwater vehicles, and evaluating legal issues related to Marine Spatial Planning are examples of currently funded research projects. Outreach efforts include working with communities to reduce beach closures, developing a teacher training marine water quality course, conducting workshops, mapping the range and distribution of non-native marine species; working with towns to restore wetlands through dam removal, and developing and using models that indicate suitable eelgrass restoration habitats.

***HCE Goal 1: Ecosystem services are improved by enhanced health, diversity and abundance of fish, wildlife and plants.***

*MIT Sea Grant Performance Measure:* Investigators and advisory staff will develop tools, technologies, research and outreach materials in support of healthy communities and marine spatial planning.

***HCE Goal 2: Ecosystem-based approaches are used to manage land, water and living resources.***

*MIT Sea Grant Performance Measure:* Researchers and outreach staff will develop tools for communities to assist with decision-making approaches in support of ecosystem-based management.

***HCE Goal 3: Habitats are protected, enhanced or restored.***

*MIT Sea Grant Performance Measure:* Through a variety of approaches, habitats will be protected, enhanced or restored.

*National Sea Grant Cross Cutting Performance Measure 1:* Number of tools, technologies, and information services that are used by state and federal partners and our stakeholders to improve ecosystem-based management.

*National Sea Grant Cross Cutting Performance Measure 2:* Number of ecosystem-based approaches used to manage land, water and living resources in coastal areas as a result of Sea Grant activities.

*National Sea Grant Cross Cutting Performance Measure 3:* Number of acres of coastal habitat protected, enhanced or restored as a result of Sea Grant activities.

## **FOCUS AREA: SUSTAINABLE FISHERIES AND AQUACULTURE (SFA)**

Massachusetts and the Northeast region have long been associated with thriving commercial and recreational fisheries that land an amazingly diverse number of species including groundfish (e.g., cod, haddock, flounders), lobsters and shellfish. The decline of some of the favored fish stocks, including cod, has led to efforts to reduce waste and support sustainable fisheries. Although the public's perspective is simple, namely sustain a safe supply of seafood, achieving this goal is complicated.

Within the Sustainable Fisheries and Aquaculture (SFA) focus area, MIT Sea Grant's efforts in the past have focused on fisheries engineering, offshore aquaculture, and integration of social science as part of fisheries management efforts. Fisheries-supported research contributed to gear improvements that improved sustainability and reduced by-catch and explored ways to add value to non-target fish species. Our highly visible and successful education programs have been replicated throughout the country, including Adopt-A-Boat, which matches fishing vessel captains with K-12 students.

Currently, MIT Sea Grant focuses on supporting the development of community supported fisheries, contributing social science components to fishery regulatory impact assessments, and developing business plans, as well as collaborating with regional and national Sea Grant programs to promote selective gear and other tools that promise to contribute to sustainable fisheries. Moving forward, additional efforts will support understanding population dynamics of shellfish, developing an indicator for detecting endocrine disrupters in seafood, developing outreach materials on the value of consuming seafood, and advocating for fisheries as part of working waterfronts.

***SFA Goal 1: A safe, secure and sustainable supply of seafood to meet public demand.***

*MIT Sea Grant Performance Measure:* Incorporating human dimensions into ecologically sound fisheries management approaches (e.g., encouraging community supported fisheries, assessing the effectiveness of regulations, and developing outreach materials) supports a sustainable supply of seafood that will be made available to consumers.

***SFA Goal 2: Informed consumers who understand the health benefits of seafood consumption and how to evaluate the safety and sustainability of the seafood they buy.***

*MIT Sea Grant Performance Measure:* Outreach approaches promoting health benefits from seafood consumption will be developed and disseminated.

*National Sea Grant Cross Cutting Performance Measure 4:* Number of fishermen, seafood processors and aquaculture industry personnel who modify their practices using knowledge gained in fisheries sustainability and seafood safety as a result of Sea Grant activities.

*National Sea Grant Cross Cutting Performance Measure 5:* Number of seafood consumers who modify their purchases using knowledge gained in fisheries sustainability, seafood safety and the health benefits of seafood as a result of Sea Grant activities.

### **FOCUS AREA: RESILIENT COMMUNITIES AND ECONOMIES (RCE)**

Over the last thirty years or more, coastal areas have seen increased growth in development and tourism. The development along the coast has brought increased runoff, sedimentation, nutrients and contaminants, and degradation of habitats. The public is concerned about climate change and sea level rise and its potential impacts including increased flooding, more intense and frequent storms, and increased coastal erosion and beach closures. Constituents want data on inundation, changes to communities and natural resources, and ways to adapt and mitigate impacts.

Several funded efforts led to pioneering industries that support the goals of Resilient Communities and Economies (RCE). MIT Sea Grant Autonomous Underwater Vehicles Lab research was spun off to form Bluefin, a multimillion dollar local company. Recently a sensor for mapping objects has been adapted to map in 3-D the inside of an ear for manufacturing individualized hearing aids, an estimated \$30 million industry.

MIT Sea Grant outreach efforts have focused on sponsoring train-the-trainer workshops on climate change, a workshop on using models to determine local inundation, developing a web-based climate change tools and resources site, supporting the clean-up of five urban beaches, working with towns on reducing non-point pollution, and supporting a national working waterfront workshop. Past research efforts in Resilient Communities and Economies (RCE) have supported developing tools to predict hurricane strength, using a science-based approach to support marine renewable energy siting, developing mapping tools, and using a community-based decision tool that brings together public agencies and stakeholders.

Future efforts involve assessing the vulnerabilities of climate change, understanding the legal implications of marine spatial planning decisions, developing an outreach program in conjunction with a numerical model adapted for local use to assess vulnerability of inundation due to sea level rise. Outreach staff will work with a local

community on dam removal, support efforts to develop a harbor walk focusing on historical use of the harbor, assist towns with identifying vulnerable areas due to sea level rise, and develop a database to support decisions on adapting to climate change.

***RCE Goal 1: Development of vibrant and resilient coastal economies.***

*MIT Sea Grant Performance Measure:* Advisory staff will collaborate with towns to support their efforts to create new tourist attractions that support local economies.

***RCE Goal 2: Communities use comprehensive planning to make informed strategic decisions.***

*MIT Sea Grant Performance Measure:* Staff will develop tools and use visioning approaches involving citizens and managers that result in comprehensive plans.

***RCE Goal 3: Improvements in coastal water resources sustain human health and ecosystem services.***

*MIT Sea Grant Performance Measure:* Advisory staff will partner with state agencies, local communities and non-government organizations to identify sources of pollution and options for eliminating or reducing pollution, to reduce beach closures.

***RCE Goal 4: Resilient coastal communities adapt to the impacts of hazards and climate change.***

*MIT Sea Grant Performance Measure:* Research and Advisory staff will create a scavenger hunt app to encourage the identification of vulnerable areas likely to be impacted by hazards and, through workshops and meetings, support adaptive management of vulnerable areas identified by citizens and insurance claims.

*National Sea Grant Cross Cutting Performance Measure 6:* Number of communities that 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.

*National Sea Grant Cross Cutting Performance Measure 7:* Number of communities that implemented hazard resiliency practices to prepare for, respond to or minimize coastal hazardous events as a result of Sea Grant activities.

## **FOCUS AREA: ENVIRONMENTAL LITERACY AND WORKFORCE DEVELOPMENT (ELWD)**

The recent adoption by many states of new science and engineering standards for K-12 education underscores the need to provide teachers with information, tools, experiences, and creative activities to achieve these goals. Past efforts in the Environmental Literacy and Workforce Development (ELWD) Focus Area by MIT Sea Grant include development of aquaculture-in-the-classroom activities, coordinated an eelgrass program for classrooms, developed an Adopt-a-Boat program, and developed and instituted workshops for teachers and students on issues related to all focus areas. Building on MIT Sea Grant's experience with underwater vehicles, a Sea Perch educational program that uses a student-built, remotely operated vehicle was developed to introduce engineering design and physics to middle and high school students. The program has been adopted in Greece, Thailand, France, and Cyprus and throughout the U.S. The success of the informal, but highly engaging K-12 education programs have resulted in students pursuing engineering and science in college. Similarly students that have participated in our Undergraduate Research Opportunity Program, graduate students and post-doctoral fellows graduate to positions in STEM related fields.

President Obama and Massachusetts Governor Patrick have specifically identified workforce development in technology industries a high priority; our future efforts will address this challenge. MIT Sea Grant educators are committed to developing an informal K-12 engineering program for teachers and students to introduce engineering design principles, and provide teachers with background information on physics and biological science relevant to engineering in the ocean environment.

Through our stakeholder science forums, MIT Sea Grant-funded researchers present their projects to staff, state and federal managers, and others to foster technical transfer of information; all constituents are welcome to attend and participate in discussions. We will continue to reach out to the Boy Scouts, Girl Scouts, museums and the public, as well as provide ocean exploration experiences for high school students in the summer. Other activities include supporting a regional academic Ocean Science Bowl and developing a summer program for minority students which incorporates biology, chemistry, engineering, physics and public policy.

A training workshop on water quality and environmental topics supports the call for trained technical workers to meet the future workforce needs. Citizen science water quality data will be collected and entered into a database that includes weather and impacts of climate change which can be used by stakeholders including resource managers in communities across the Commonwealth.

***ELWD Goal 1: An environmentally literate public supported and informed by a continuum of lifelong formal and informal engagement opportunities.***

*MIT Sea Grant Performance Measure:* Develop a teacher training program in water quality, support public events, provide information on ocean and environmental issues to citizens and support citizen scientists by providing a user friendly database.

***ELWD Goal 2: A future workforce reflecting the diversity of Sea Grant programs, skilled in science, technology, engineering, mathematics and other disciplines critical to local, regional and national needs.***

*MIT Sea Grant Performance Measure:* Develop an informal ocean engineering program that provides fundamental knowledge in engineering design and related topics for teachers to support their efforts to develop curricula to meet new science and engineering standards.

*MIT Sea Grant Performance Measure:* Develop an outreach effort and ocean engineering-based program for inner city students in Sea Grant education programs, including collaboration with MIT Minority Introduction to Engineering and Science.

*MIT Sea Grant Performance Measure:* A tracking mechanism will be put in place to track undergraduates, graduate students, post-docs, and fellowship students.

*MIT Sea Grant Performance Measure:* Researchers and staff will actively seek economic opportunities, including patents, new business creation and retention of older businesses.

*MIT Sea Grant Performance Measure:* MIT Sea Grant-funded researchers will publish in peer-reviewed journals, reviewed papers and chapters, and collaborate with Advisory staff to prepare outreach materials as print and electronic media, videos, and presentations.

*National Sea Grant Cross Cutting Performance Measure 8:* Number of Sea Grant facilitated curricula adopted by formal and informal educators.

*National Sea Grant Cross Cutting Performance Measure 9:* Participation in Sea Grant supported informal education programs.

*National Sea Grant Cross Cutting Performance Measure 10:* Number of Sea Grant-supported graduates who become employed in a career related to their degree.

*National Sea Grant Cross Cutting Performance Measure 11:* Economic (market and non-market; jobs and businesses created or retained) benefits derived from Sea Grant activities.

*National Sea Grant Cross Cutting Performance Measure 12:* Number of peer-reviewed publications produced by the Sea Grant network, and number of times each peer reviewed publication is cited.

## Summary

MIT Sea Grant College Program is committed to scientific and technical leadership to address priority issues for the Commonwealth of Massachusetts. MIT Sea Grant has and will continue to innovate and develop game-changing technologies and systems to address environmental issues of greatest concern and to achieve goals of sustaining resources, communities and economies in the future. Climate adaptation, energy demands and impacts on coastal communities, shorelines, and ecosystems will continue to be of concern to the public and government.

Four focus areas address the core of the National Sea Grant College Program mission and vision, and these frame our goals and performance measures: Healthy Coastal Ecosystems, Sustainable Fisheries and Aquaculture, Resilient Communities and Economies, and Environmental Literacy and Workforce Development. These focus areas reflect current needs and are consistent with goals and objectives identified in NOAA's New Generation Strategic Plan: climate adaptation and mitigation, weather-ready nation, healthy oceans, and resilient coastal communities and economies. MIT Sea Grant solicited input from our advisory committees, networking partners and liaisons with local, state, federal, and regional agencies and organizations, and the general public (with an internet-based survey), in creating our strategic plan for 2014-2017.

High among constituents' concerns are fisheries, water quality, ocean acidification, ecosystem preservation, biodiversity, and management of natural resources,

all of which support tourism and other maritime-related industries that are the economic engine of the state. MIT Sea Grant will continue its commitment to developing platforms, *in situ* sensors and probes, oceanographic models, and socio-political decision-making support tools for critical public commitments. Key information is shared with stakeholders, policy makers and the public by all Marine Advisory Services staff at seminars, forums, and conference presentations. Peer-reviewed publications are published monthly, which together with digital and print materials enhance our constituents' grasp of research accomplishments and impacts. Technologies designed at MIT Sea Grant have led to new business creation and we expect this pattern will continue to create jobs and generate revenue for the Commonwealth.

Our commitment to education from K-12 to adult learning will integrate our research in technologies, especially the autonomous underwater and surface vehicles, communication systems, and instrumentation, into programs and support for teachers to meet new science and engineering standards. Mentoring undergraduate students and supporting MIT graduate students and post-doctoral fellows involved in cutting-edge research builds capacity for a trained workforce in science and engineering, a recognized need at both the state and national level.

MIT Sea Grant College Program is committed to providing the best science and innovating new technologies to address local, state, regional and national issues. Through collaboration and engagement with faculty across MIT and local universities, and alliances with partners including regional Sea Grant programs, MIT Sea Grant taps intellectual and financial resources to tackle major environmental issues. Our marine advisory staff conduct research and develop programs and materials that transfer technology and scientific information to decision makers to encourage stewardship as leaders strive to balance growth and sustainability of resources. MIT Sea Grant's funded research projects in marine natural sciences, ocean engineering and technology will support the priorities of the Commonwealth of Massachusetts.