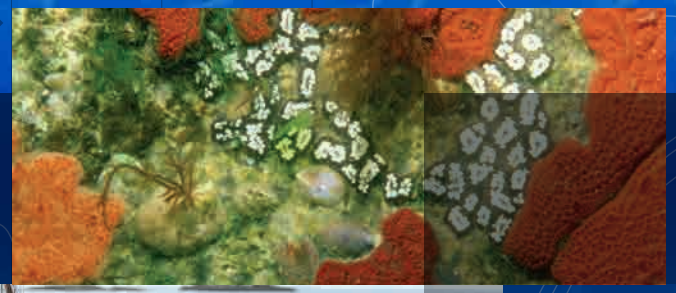
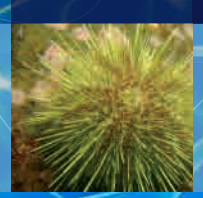
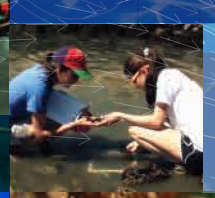
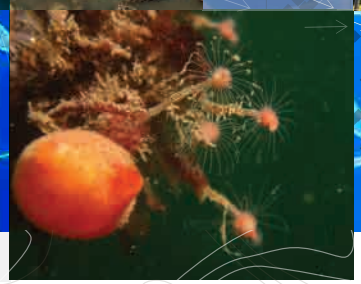
MIT **Sea Grant** College Program







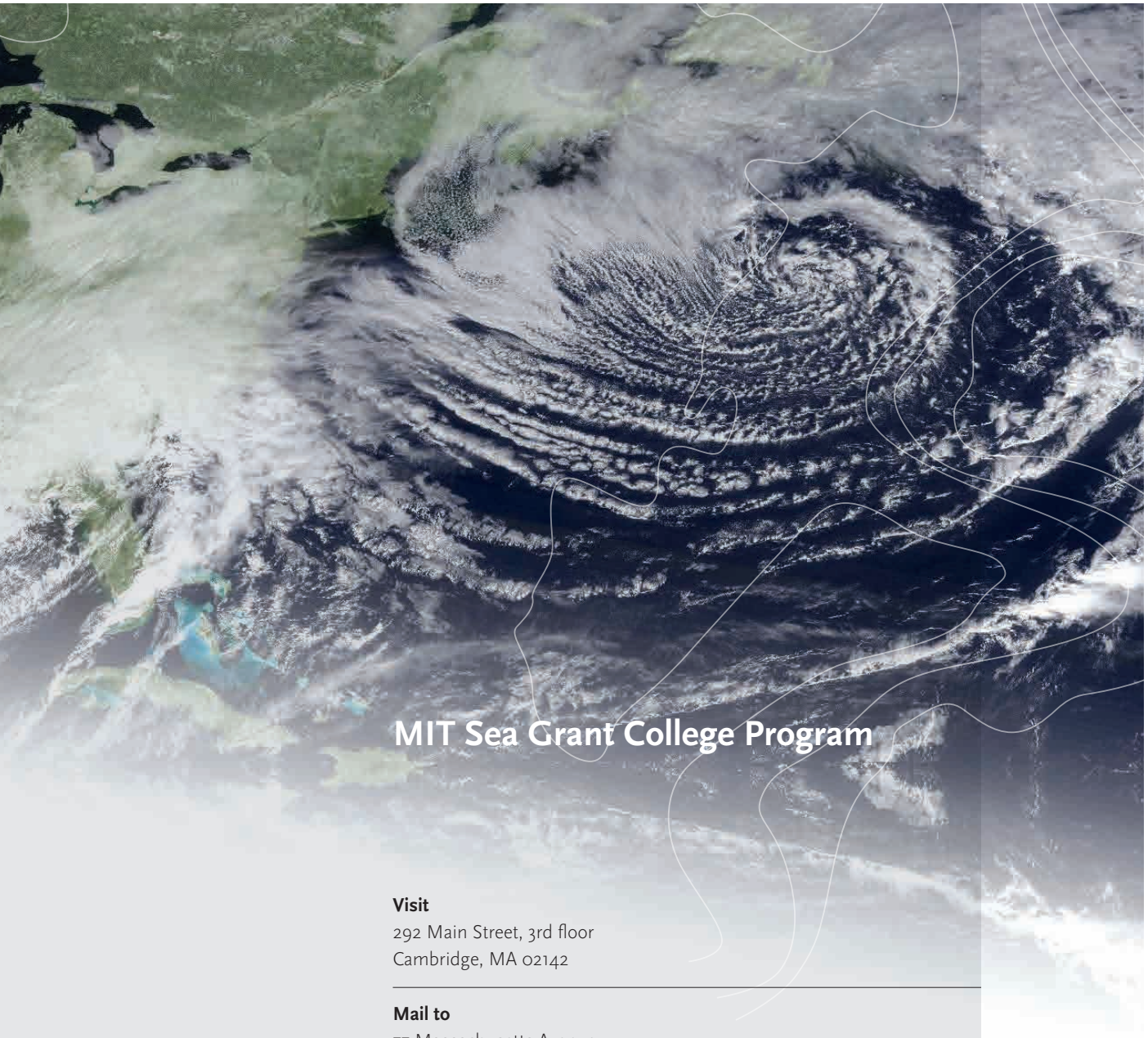
Where ocean science meets cutting edge technology

Sea Grant Massachusetts Institute of Technology

NOAA

MIT

Publication No. 13-02



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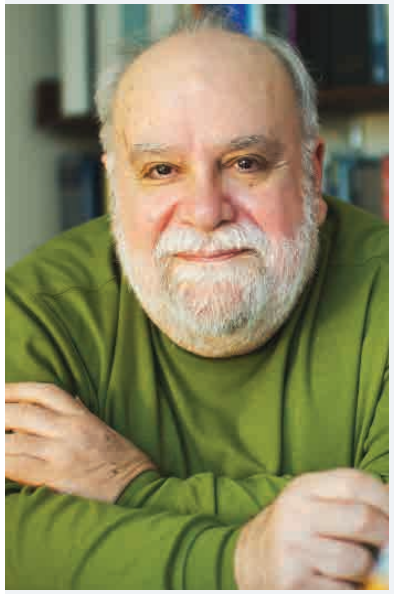
Letter from the Director



For over 40 years, the MIT Sea Grant College Program has brought the expertise of the Massachusetts Institute of Technology to bear on ocean-related challenges. Collaborating with researchers and academics from other Massachusetts universities and institutions, we apply knowledge and creativity to address relevant and timely issues.

MIT Sea Grant funds research and outreach that support the wise use and conservation of marine resources. For example, some of our earliest work on clean water supported the highly successful Boston Harbor clean-up. Our advisory service continues in this tradition, focusing on water quality, invasive species, fisheries, and other issues vital to coastal communities as the climate changes.

Early efforts to build inexpensive autonomous underwater vehicles (AUV) became a commercial success story. Our innovative engineering then led to the development of Robotuna, resulting in further improvements for AUV propulsion.

Our education programs include hands-on training and mentoring of high school and college students to become the next generation of ocean science and engineering researchers.

Community partners and our advisory committees drawn from academic circles, non-government organizations, industry leaders, and state and local government, help us establish priorities and shape our research program. Together we are able to provide our constituents — the coastal communities of Massachusetts and beyond, the harvesters and consumers of seafood, our fellow ocean scientists and engineers, and all who rely on the world's oceans for sustenance, energy, recreation, travel, and wonder — with innovations in ocean engineering and marine science.

Chrys Chryssostomidis
Director

MIT Sea Grant College Program: Science and Technology Serving the Massachusetts Coast

The National Sea Grant College Program

MIT Sea Grant is part of a nationwide network of 33 university-based Sea Grant programs that promote environmental stewardship, long-term economic development and responsible use of America's coasts, oceans, and Great Lakes. Established by Congress in 1966, the National Sea Grant College Program is funded by the National Oceanic and Atmospheric Administration.

MIT Sea Grant College Program

MIT was designated a Sea Grant College Program in 1976. To date, MIT Sea Grant has funded nearly 1,000 marine science research projects, produced over 1,600 scientific and informational publications leading to informed policies and established an internationally acclaimed autonomous underwater vehicle (AUV) laboratory. Our Marine Advisory Services (MAS) staff guides our science and technology transfer effort. In addition to creating education and outreach programs, MAS conducts research and offers training and workshops in areas including marine bioinvasions, water quality, climate adaptation, and the impacts of policy change on fishing communities.

The state of Massachusetts is unique in hosting two Sea Grant programs. We enjoy excellent partnerships with the Woods Hole Sea Grant Program, based at the Woods Hole Oceanographic Institution on Cape Cod.

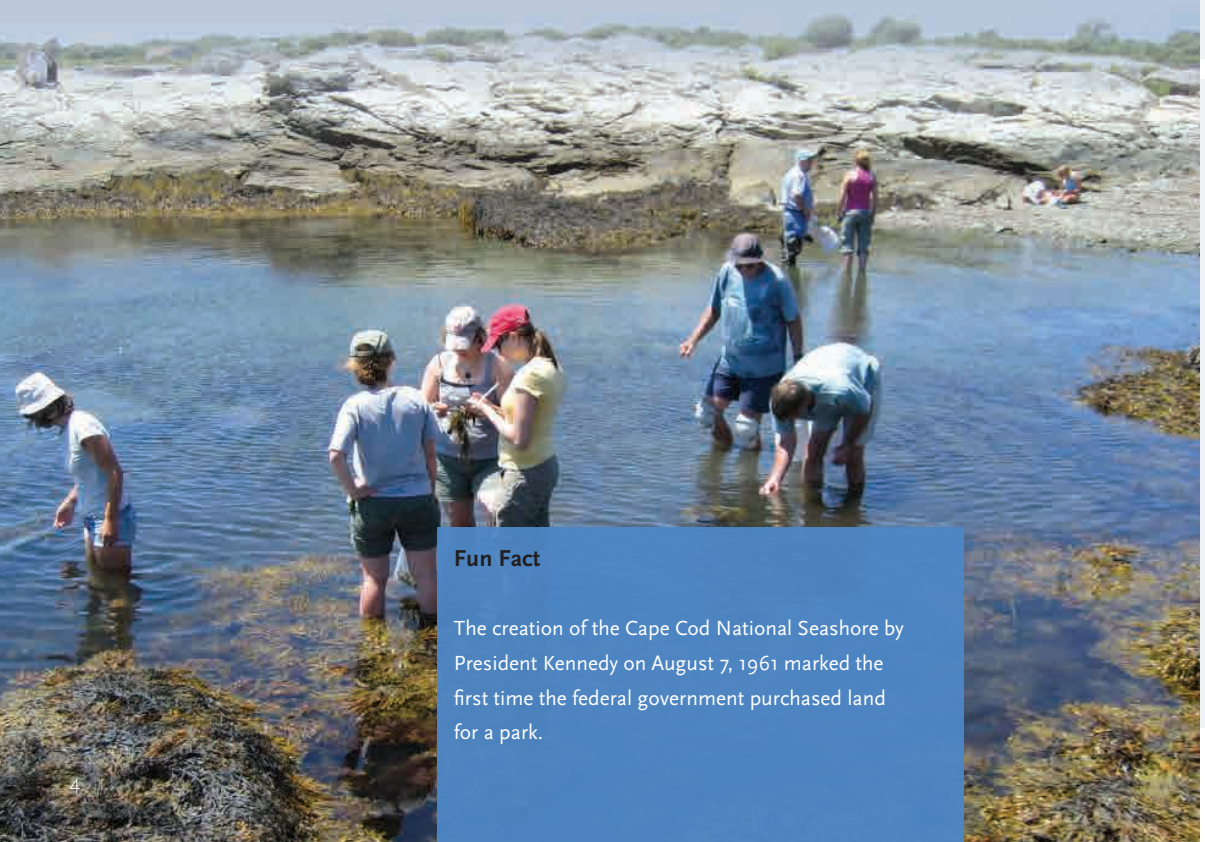
Kids test-drive MIT Sea Grant remotely operated vehicles (ROV) at the Family Science Days event as part of the 2013 annual meeting of the American Association for the Advancement of Science (AAAS)

Massachusetts Citizens at Sea and on the Coast

Massachusetts is situated along the Northeast US Continental Shelf Large Marine Ecosystem (NES LME), which extends from the Gulf of Maine to Cape Hatteras, and is bounded on the east by the Gulf Stream. This highly productive and complex ecosystem supports a vast diversity of marine life from microbes and plankton to marine mammals. For hundreds of years, commercial fishing and shipping have been mainstays of the Massachusetts economy. Today, coastal communities support a number of additional marine-related businesses such as tourism, recreational boating, resource extraction, and energy production. Marine-based enterprises form one of the chief economic engines of the region.

With the second-highest concentration of technology jobs in the nation, and an abundance of institutions of higher learning supporting it, the technology industry of Massachusetts is a significant driver of the state's economy. MIT Sea Grant fuels this trend through innovative ocean science, technology research, and education.

Scientists surveying for non-native species in Salem, Massachusetts



Fun Fact

The creation of the Cape Cod National Seashore by President Kennedy on August 7, 1961 marked the first time the federal government purchased land for a park.

Research Program

MIT Sea Grant strives to seek solutions to the complex questions raised by citizens and managers of coastal communities in the Commonwealth. Innovative research projects are supported through our annual funding competition for Massachusetts academic investigators.

Technology

Research efforts produce new tools, instruments, and pioneering technologies. Autonomous underwater vehicles (AUV) developed by MIT Sea Grant are used to explore underwater worlds from the polar ice caps to the tropics. Investigators Michael Triantafyllou and his MIT colleagues are mimicking the use of lateral sensor lines in fish to improve the efficiency of AUVs. Douglas Hart and his team at MIT developed a 3D sensor capable of resolving surface profiles for underwater inspection and mapping. This technology resulted in the design of a device that produces an image of the human ear canal and a local start-up business is transforming the audiology market. Milica Stojanovic and her colleagues at Northeastern University continue to develop underwater acoustic communication networks. If successful, this research could revolutionize the ability to communicate with unmanned vehicles deep within the ocean to repair underwater platforms, pipelines, and other structures with voice-activated commands.

Human Health and Safety

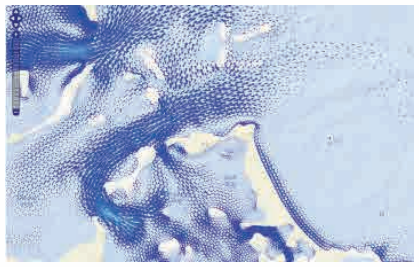
Human health and safety are concerns that motivate many researchers' efforts. To provide valuable, real-time information on shellfish safety both to the fishing industry and to consumers, Donald Anderson and his team at Woods Hole Oceanographic Institution are developing innovative technology to detect and quantify, in situ, paralytic shellfish toxins in phytoplankton, also known as "red tide."

Pharmaceuticals, personal care products, and other chemicals that are excreted or dumped down a drain enter sewer and septic systems on their way to the ocean. These chemicals are implicated as causes of anomalies in marine animals, contaminating food supplies, and detrimental to human health. MIT researcher Philip Gschwend is measuring estrogens, including their halogenated derivatives, in chlorinated sewage effluents and coastal seawater to test their bioactivity. These projects and other related research contribute crucial data on how such contaminants may disrupt marine ecosystems and damage the food supply and human health.

Donald Anderson's Environmental Sample Processor (ESP) that detects harmful algal blooms

Research at Work: Water Quality Forecasting for Ecosystem-Based Management of Massachusetts Coastal Waters

MIT Sea Grant researchers developed a forecasting system that empowers communities to manage coastal resources based on scientific data and ecosystem-based management modeling.



Currents in the Boston Harbor region computed using the Mass Coastal FVCOM

Challenge

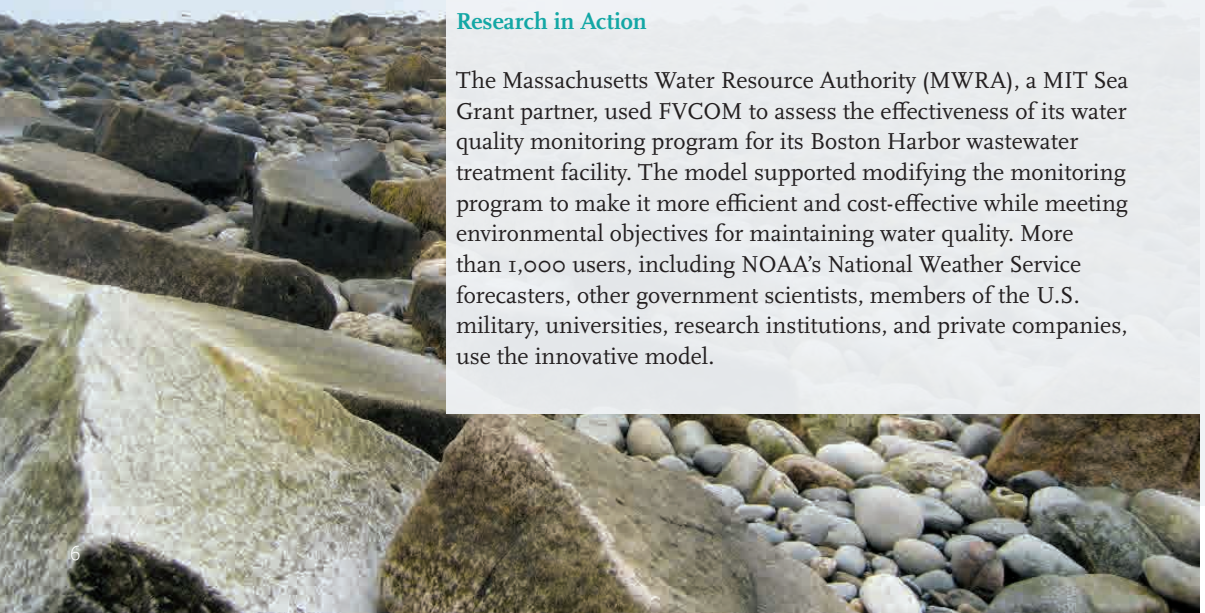
The ability to predict shifts in a complex ecosystem is key to effective management of fisheries as well as to maintaining beach health and near-shore water quality. The goal of this project was to create a water quality assessment and forecasting system for Massachusetts coastal waters that would provide research and management communities with accurate forecasts of short-and long-term ecological shifts.

Response

Changsheng Chen from the University of Massachusetts Dartmouth and Robert Beardsley from the Woods Hole Oceanographic Institution, have developed the Finite-Volume Community Ocean Model (FVCOM) to track the shifting conditions and currents in Massachusetts waters. FVCOM provides a visual representation of coastal changes in support of effective ecosystem-based management.

Research in Action

The Massachusetts Water Resource Authority (MWRA), a MIT Sea Grant partner, used FVCOM to assess the effectiveness of its water quality monitoring program for its Boston Harbor wastewater treatment facility. The model supported modifying the monitoring program to make it more efficient and cost-effective while meeting environmental objectives for maintaining water quality. More than 1,000 users, including NOAA's National Weather Service forecasters, other government scientists, members of the U.S. military, universities, research institutions, and private companies, use the innovative model.



Research at Work: An Assessment of the Tidal Kinetic Energy Resource off the Massachusetts Coast and the Potential Impacts of Extraction

MIT Sea Grant researchers explored tidal in-stream energy conversion to support science-based decision-making by local planning and management agencies.

Challenge

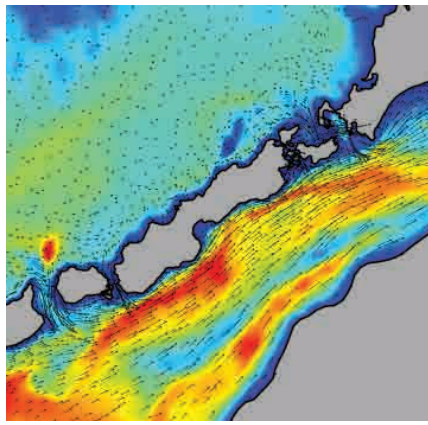
Extracting tidal energy is a complex technical and engineering problem that impacts the environment and local communities. Although the need for alternative energy sources is generally accepted, the proposed siting of offshore turbine arrays in Massachusetts is of concern to agencies, homeowners, fishermen, non-government organizations, and other stakeholders.

Response

Geoffrey Cowles from the University of Massachusetts Dartmouth and his team developed a model to evaluate the impact of large-scale marine renewable energy installations on coastal hydrodynamics and sediment transport. Using a high-resolution ocean model, they examined the potential impact of tidal in-stream energy conversion devices and estimated the amount of energy that can be extracted at a given site.

Research in Action

Cowles' model is being used to evaluate the potential effects on local hydrology and sediments of a proposed tidal power project in Muskeget Channel off the east coast of Martha's Vineyard. Teams at the Bedford Institute of Oceanography and Acadia University in Nova Scotia are using the model to evaluate the effects of a proposed Bay of Fundy tidal energy project. As a member of the technical advisory board for the Barnstable County Ocean Management Planning District of Critical Planning Concern (DCPC) for renewable energy, Cowles was able to apply his knowledge of the tidal energy resource, relevant regulations, and existing projects to analyze the energy potential of sites within DCPC boundaries. His results informed the Massachusetts Clean Energy Center white paper on marine hydrokinetic projects and regulations in Massachusetts.



Currents and bathymetry in Vineyard Sound, MA during flood tide computed using the FVCOM Massachusetts Tidal Energy Model

Fun Fact

The Massachusetts state marine mammal is the Right whale.

Marine Advisory Services: Outreach & Education

"Seafood Throwdown" for community-supported fisheries

Lobstermen sign up for the USDA Trade Adjustment Assistance Program

A roomful of lobstermen writing business plans, a coastal ecologist knee-deep in marsh grass assessing climate-induced sea-level rise, and an international group of scientists and students hanging off of Boston Harbor pontoons collecting and counting life forms clinging to the pilings – this is MIT Sea Grant Marine Advisory Services (MAS) at work. An essential element of all Sea Grant programs, MAS offers scientific guidance, training, workshops, access to databases, and informational materials to stakeholders.

Pollution, introduced marine non-native species, reduced fish stocks, climate-induced sea-level rise, and conflicting demands for use of offshore space are just some of the issues that challenge our coastal communities and ecosystems. Coastal residents and businesses also face threats to their properties and income due to the increased frequency and severity of storms. Fishermen and their families respond to complex, changing regulations and deal with regional and international competition for an uncertain supply of fish.

MAS staff includes specialists in marine ecology and biology, coastal policy, social sciences, education, communication, and geospatial and data management, and meets these challenges head-on with marine engineering and ocean literacy education, workshops, and publications that promote the wise and informed use of our ocean and coastal resources.

Fun Fact

The first lighthouse in what is now the United States was built on Little Brewster Island in Boston Harbor in 1716.

Marine Advisory Services Program Areas

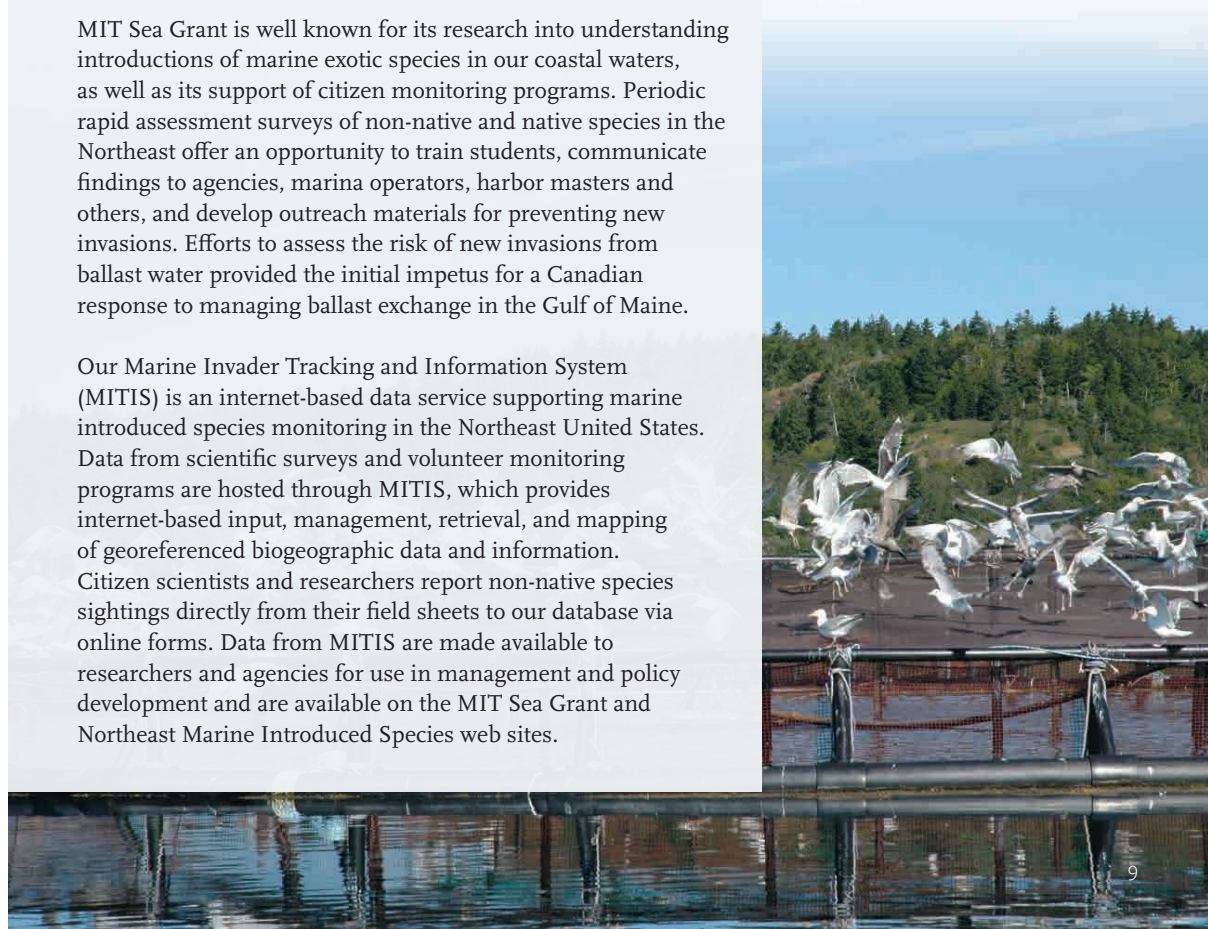
Climate Adaptation

Public safety and infrastructure in coastal communities are threatened by climate change impacts such as rising sea levels, warmer winters, hotter summers, and increased severity of storms and storm surges. MIT Sea Grant is working to help communities adapt to negative impacts on coastal ecology, waterfront properties and infrastructure, and the fishing industry by providing information, advice, and on-the-ground (and in-the-sea) research. Examples include the Climate Change Tools and Resources guide, workshops on communicating climate change, and surveys of salt marshes on the south coast to study habitat quality and vulnerability to sea level rise. The results of these surveys were made available through a web-based mapping tool, providing both homeowners and municipal planners with information to support adaptive management and land-use decisions.

Marine Non-Native Species and Data Services

MIT Sea Grant is well known for its research into understanding introductions of marine exotic species in our coastal waters, as well as its support of citizen monitoring programs. Periodic rapid assessment surveys of non-native and native species in the Northeast offer an opportunity to train students, communicate findings to agencies, marina operators, harbor masters and others, and develop outreach materials for preventing new invasions. Efforts to assess the risk of new invasions from ballast water provided the initial impetus for a Canadian response to managing ballast exchange in the Gulf of Maine.

Our Marine Invader Tracking and Information System (MITIS) is an internet-based data service supporting marine introduced species monitoring in the Northeast United States. Data from scientific surveys and volunteer monitoring programs are hosted through MITIS, which provides internet-based input, management, retrieval, and mapping of georeferenced biogeographic data and information. Citizen scientists and researchers report non-native species sightings directly from their field sheets to our database via online forms. Data from MITIS are made available to researchers and agencies for use in management and policy development and are available on the MIT Sea Grant and Northeast Marine Introduced Species web sites.



Continue from Marine Advisory Services Program Areas

Fisheries

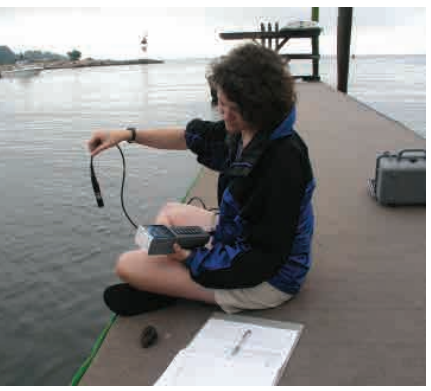
The commercial fishing industry is coping with new regulations intended to rebuild stocks, and is facing increased demands on uses of marine resources. New and changing uses, even if meant for the public good, may negatively impact fishing communities and families. Through collaborative research with fishing industry members and coastal communities, MIT Sea Grant has sought effective stakeholder participation in decision-making processes. The results of involving potentially affected groups in both policy and mitigating action can help lead to reasonable compromise. One successful mitigation effort helped launch a community-supported fishery in Gloucester with benefits to the community, the fishing industry partners, consumers, and the ecosystem.

Fishing vessel, "Resilience", in New Bedford, Massachusetts

Clean Water

Through the years MIT Sea Grant has consistently supported research and outreach activities to assess and report the health and productivity of our coastal waters. MIT Sea Grant provided scientific input supporting the clean-up of Boston Harbor in the 1980s, and more recently the costly but effective elimination of pollution from South Boston beaches, notably among the cleanest urban beaches in the United States.

MIT Sea Grant collaborates with partners and local communities to develop ocean literacy and environmental stewardship. Partnerships support citizen and student water quality monitoring and assist in identifying potential sites of pollution. Researchers and outreach staff address non-point sources of pollution, survey groundwater flows that may carry pollutants, model bacterial contamination, and develop risk assessments of sea level rise for communities to insure safe clean water.



Scientist collecting water quality data for environmental studies

Education

MIT Sea Grant is helping to meet the state and national need for quality science, technology, engineering, and math (STEM) education in addition to increased ocean literacy. A suite of innovative, hands-on, educational programs in marine ecology, ocean engineering, and underwater robotics offer exciting learning experiences for young people in support of STEM principles. MIT Sea Grant's formal and informal education programs for students, professional development opportunities for K-12 teachers, and published educational materials aim at reaching broad audiences. These programs are often produced and distributed in collaboration with partners. Signature programs include the internationally acclaimed Sea Perch underwater robotics program, the summer Ocean Engineering Experience (OEX), the statewide high school ocean science Blue Lobster Bowl competition, and various internship opportunities.

Volunteers collecting litter along the Charles River

Spreading the Word

The communications staff ensures that research findings and outreach programs reach the broadest possible audience. Fellow scientists and engineers, stakeholders and the general public are apprised of MIT Sea Grant research and activities through digital and print media, technology demonstrations, research seminars, and other outreach events. An attractive and content-rich website, a bimonthly e-newsletter, printed materials and scholarly publications are some of the vehicles used to convey MIT Sea Grant news and programs to the world. Other innovative strategies for bringing new audiences to our work include art installations, online videos featuring exciting projects and educational activities, and public service in the form of educating and coordinating volunteers for the annual Earth Day Charles River Cleanup.

Massachusetts area highschool students compete in the 16th annual Blue Lobster Bowl organized and hosted by MIT Sea Grant at MIT

Publications

MIT Sea Grant makes scientific information on coastal and oceanographic processes available to the public. Our free publication library includes over 1,600 journal reprints, technical reports, informational brochures, manuals, conference proceedings, and more.

Funding & Awards

In addition to our annual request for proposals, we offer a number of fellowships and awards that directly support students and faculty who are pursuing studies and careers in marine research. Student projects have ranged from spatial modeling of yellowtail flounder population dynamics by a National Marine Fisheries Fellow sponsored by MIT Sea Grant, to a study of submarine groundwater discharge in Cyprus by an MIT undergraduate working with Sea Grant through the Undergraduate Research Opportunities Program.

Fun Fact

The Boston Tea Party reenactment takes place in Boston Harbor every December 16th.

Students

- NOAA Coastal Management Fellowship
- NOAA Sea Grant National Marine Fisheries Fellowship
- Dean John A. Knauss Marine Policy Fellowship
- Dean A. Horn Award for Undergraduate Study in Marine Research
- Undergraduate Research Opportunities Program (UROP) for MIT and Wellesley College students

MIT Doherty Career Development Chair

Endowed by the Henry L. and Grace Doherty Charitable Foundation, the Doherty career development chair is awarded annually to a non-tenured junior MIT faculty member. The award provides $25,000 per year in research support for two years to address marine-related question, whether social, political, environmental, economic or technical. Recent studies include an investigation of nano-engineered surfaces for hydrate mitigation in subsea oil and gas operations, and the engineering of hybrid biological-electrical systems with two-way interfaces between abiotic and biotic systems.

MIT Sea Grant Committee Members

Committees provide valuable guidance in shaping MIT Sea Grant research and advisory programs.

MIT Faculty Committee

Robert Armstrong, Chevron Professor of Chemical Engineering, Dept of Chemical Engineering; Deputy Director, MIT Energy Initiative

Dara Entekhabi, Bacardi Stockholm Water Foundations Professor, Dept of Civil & Environmental Engineering and Dept of Earth, Atmospheric and Planetary Sciences; Director, Earth System Initiative

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E. Eric Adams, Senior Research Engineer & Lecturer, Dept of Civil and Environmental Engineering, ex officio

Chryssostomos Chryssostomidis, Doherty Professor of Ocean Science and Engineering, Dept of Mechanical Engineering; Director, MIT Sea Grant College Program, ex officio

Continue from MIT Sea Grant Committee Members

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Jella Atema, Professor of Biology, Boston University

Bruce Carlisle, Director, Massachusetts Office of Coastal Zone Management

John Blair, Private Consultant; Lecturer in Ocean Engineering, MIT (Emeritus); National Sea Grant Review Panel, NOAA (Emeritus) Private Consultant

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Bill Hubbard, Chief, Evaluation Branch New England District, U.S. Army Corps of Engineers

Carlton D. Hunt, Research Leader, Battelle

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with contributions
from the archives of
NOAA
SMAST/UMASS Dartmouth
WHOI
MIT Sea Grant

Publication No. 13-02

Funding provided by:
National Sea Grant College Program
National Oceanic & Atmospheric Administration
(grant no. NA10OAR4170086)

First Printing: March 2013

Printed on recycled paper in the USA

Fishing boats in New Bedford Harbor