

# MIT Sea Grant Program Summary

For over 40 years, MIT Sea Grant has brought the expertise of the Massachusetts Institute of Technology (MIT) to bear on ocean-related problems. Our rigorous research program, dedicated outreach programs and integrated education program projects support the wise use and conservation of marine resources along the Massachusetts coastline and are helping to create the coastal stewards of tomorrow.

MIT has internationally renowned achievements in innovative tools and technology, so it is not surprising that some of our biggest accomplishments lie in the development of these. Massachusetts has the second highest concentration of technology jobs in the nation and, with an abundance of institutions of higher learning supporting it, the technology industry is a significant driver of the state's economy. MIT Sea Grant fuels this trend through innovative ocean science, technology research, and education. In the administration of our own program, we have computerized the competitive grant process from the initial request for proposals, into the review process and through the reporting cycle. eSG is being successfully used by eight other Sea Grant programs.

## Research (51% of federal funding)

MIT Sea Grant remains committed to funding cutting edge research: over half of our federal funding is spent on competitive research. We awarded 27 competitive grants to investigators from seven different institutions through our competitive Sea Grant funding program. If you include matching and leveraged funds, research accounts for 65% of our overall expenditure. During this reporting period, we received 9.5 million dollars in leveraged funds for in-house projects in the Autonomous Underwater Vehicle (AUV) Lab, and in the Design Lab for Naval Architecture and Systems.

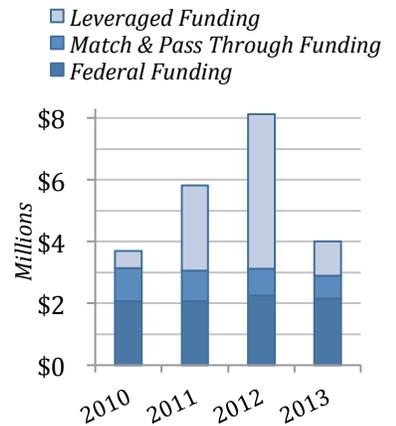
## Marine Advisory Services (21% of federal funding)

MIT Sea Grant's Advisory Service offers science-based guidance, training, and workshops, in addition to databases and informational materials to our stakeholders—coastal community residents, managers, businesses, teachers, and policy makers. Unlike most programs, we are not connected to a university-based cooperative extension program; rather we depend on the expertise of our own staff, and on our network of collaborators at state agencies, other universities and local organizations.

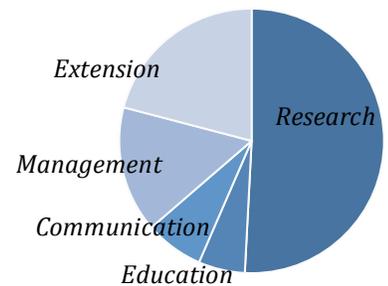
## Education (6% of federal funding)

MIT Sea Grant is helping to meet Massachusetts' and the nation's critical need for quality science, technology, engineering, and math (STEM) education and increased ocean literacy. We offer innovative, hands-on, educational programs in marine ecology, ocean engineering, and underwater robotics. Signature programs include the internationally acclaimed Sea Perch underwater robotics program; the summer Ocean Engineering Experience; and a state-wide, high school, ocean science quiz bowl known as the Blue Lobster Bowl, as well as internship opportunities.

## Program Funding



## Federal Funding by Functional Area



## Economic Benefits

- Over 70 million in economic benefits
- 46 jobs created or retained

## Outreach

- 110 Tools and technologies developed, of those, 96 are in use
- 12,000 Volunteer hours
- 15 Hazard Resiliency workshops
- 435 Resource managers who use EBM
- 150,000 people reached through presentations

## Education

- 166 graduate and undergraduate students supported
- Over 100,000 K-12 students reached
- 93 Curriculum developed

## 500+ Partnerships

## MIT Sea Grant College Program

### Focus Area: Safe and Sustainable Seafood Supply

MIT Sea Grant spends 11% of our effort in the Safe and Sustainable Seafood Supply focus area. MIT Sea Grant does research and outreach work to support the goal of assuring that seafood is a part of a diverse food supply in the U.S. while remaining safe, sustainable and affordable.

Highlights include:

- Helped develop Cape Ann Fresh Catch as a model for direct-to-customer, community-supported fisheries increasing profits for fisherman.
- Developed a Trade Adjustment Assistance program to help Massachusetts lobstermen become competitive with imported seafood bringing revenue back into the state.
- Provided the New England Fishery Management Council's Herring Plan Development Team with a social impact assessment enabling more informed decision-making by fisheries regulators.
- Promoted marine safety and facilitated hands-on fishing vessel safety training in various ports in Massachusetts and Rhode Island.
- MIT Sea Grant extends effective communication about its work, regionally and nationally, through participation on such committees as the Atlantic States Marine Fisheries Commission on Economics and Social Science and California's Ocean Protection Council's Science Advisory Team.

**Total budget from 2010-2013:**

**\$800,000 federal**

**2.6 million overall, including federal, matching and leveraged funds**

### Supporting sustainable and affordable seafood

Fishing communities struggle to catch and sell enough fish to make a good living within the constraints of fishing regulations, the dangers of going to sea, and the power of wholesalers to set prices. MIT Sea Grant helped local fishermen earn more by putting safe and sustainably-caught seafood straight onto the dinner plates of Massachusetts citizens using a direct-to-customer distribution model for community-supported fisheries. From modest beginnings, Cape Ann Fresh Catch, that MIT SG helped to launch, now serves customers in 17 Massachusetts communities. The business model provides fishermen with greater flexibility and a higher profit from their catch, as well as encouraging sustainable fishing and minimization of waste. Fresh Catch customers, who pre-purchase a catch share for the season, now have access to fresh seafood handled according to rigorous safety standards. This business model has spread to other states on the East Coast and to the West Coast, contributing to a sustainable seafood supply and resilient coastal communities.

Prices and production of American lobster in Massachusetts were negatively affected by foreign imports in 2009, leading to the loss of a number of small businesses. After helping write a petition for Massachusetts Lobstermen's Association participation in the US Department of Agriculture Trade Adjustment Assistance (TAA) program, MITSG worked with the other Sea Grant programs in the region to develop and record eight, 3-hour-long courses designed to help lobster fishermen prepare and improve their business models. The courses were taught in person and also made available online. About 800 lobstermen in Massachusetts completed 12 hours of training and received about \$1200 in direct financial benefit. About 90% of these also worked

with a consultant to prepare a business plan that was accepted, and for which they received \$2000 each. Later evaluations indicated that participants considered the time well-spent and beneficial to their businesses.

### **Identifying social impact of fisheries regulation**

An understanding of the human dimensions of natural resource management is essential to the maintenance of a sustainable supply of seafood. MITSG's research and outreach has sought a balance among social, economic and ecological concerns, working to address data gaps and foster improved communication among stakeholders. MITSG developed a social impact assessment for the New England Fishery Management Council's Herring Plan Development Team to assess the effect of their plan on life in our fishing communities. Decision-makers and other stakeholders benefited from learning about the results of multidisciplinary, regional and bicoastal research that focuses on alternative management techniques, marine spatial planning, and waterfront use.

MITSG worked with an interdisciplinary team to develop a framework for evaluating the ecological, economic, and social impacts of U.S. West Coast and New England catch-share programs in fisheries management. The team also worked to develop program success measurement methods, as well as finding ways to help identify unintended consequences associated with this new form of management. To the latter end, MITSG continues to work with organizations to identify the impacts on small-scale fisheries, locally, regionally and internationally.

### **Helping the fishery become safe and sustainable for fishermen**

Sustainable seafood maintenance also requires safe fishermen. In collaboration with commercial fishing organizations, fishing communities, the U.S. Coast Guard, and recreational users, MITSG promoted marine safety by facilitating hands-on fishing vessel safety training in various ports in Massachusetts and Rhode Island.

### **Informing management to promote sustainable fisheries**

*Didemnum vexillum*, a non-native tunicate found in Georges Bank could seriously impact the multi-million dollar commercial scallop industry in the region, but its distribution and abundance are not well-documented. MITSG used a remotely operated vehicle equipped with a video camera (HabCam) to survey the tunicate off Massachusetts' coast. As a result of our work, NMFS managers established observational priorities for *D. vexillum* on the annual scallop and groundfish surveys, so its presence is now regularly noted. At the teacher workshops, the HabCam materials were presented as lesson plans on the impact of invasive species including.

Analysis of sound plays an important role in two different MITSG research projects. In one, Sea Grant-funded scientists at the University of Massachusetts at Amherst demonstrated the use of sound source localization methods to identify tautog, an important fish species in the region, as the producer of the sound. This work confirms the significance of the soundscape for tautog, information that managers need to evaluate the potential impact of noise pollution on the species. In another project focused on sound, MIT Sea Grant-funded scientists at the University of Massachusetts Amherst developed the FishLocator program, a MATLAB-based graphical interface that enables loading, filtering, and time windowing of multi-hydrophone acoustic signals. The methods and software developed for these projects contribute to the study of fish behavior and their habitat requirements, as well as biological sensing and flow useful to the national Ocean Observing Systems.

# PIER PRP Program Focus Area Report

## MIT Sea Grant College Program

### Safe and Sustainable Seafood Supply

**Program Focus Area:** Safe and Sustainable Seafood Supply

#### Program Goals

1. A sustainable supply of safe seafood that meets public demand at an affordable price

#### JUMP TO REPORT SECTION

[Full Text of Impacts](#)

[Program Performance Measures](#)

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#### Impacts and Accomplishments toward Program Goals

##### 1. Program Goal: A sustainable supply of safe seafood that meets public demand at an affordable price

###### Impact(s)

- o [19484](#) - Northeast Sea Grant researchers use optical sensor and AUV to quantify spatial extent and impact of invasive tunicate
- o [19483](#) - Socioeconomic Impacts of Herring Management in the Northeast US
- o [17936](#) - Identification of OCS Renewable Energy Space-Use Conflicts
- o [17886](#) - Community-supported Fisheries
- o [17626](#) - Impacts and Accomplishments of Didemnum Project
- o [15937](#) - Trade Adjustment Assistance Training for Lobstermen
- o [14644](#) - MIT Sea Grant helps local fishermen increase earnings with a direct "catch to customer" distribution model of safe, sustainably caught seafood

###### Accomplishment(s)

- o [19813](#) - Rapid Assessment Survey Identifies Non-native Species from Maine to Rhode Island
- o [19771](#) - Sea Grant Scientists Deploy Assay to Detect Paralytic Shellfish Toxins In Situ
- o [19744](#) - Retrieved and delivered physical samples of deep-water corals to NOAA and partner universities
- o [18446](#) - Directory of Marine Social Scientists
- o [17860](#) - Sea Grant Scientists Develop Methods for Detection of Paralytic Shellfish Poisoning Toxins In Situ
- o [17852](#) - MIT Sea Grant Develops Game to Educate Next Generation of Marine Scientists, Engineers, and Managers
- o [17850](#) - Documenting the Presence of Tautog with Sound Source Localization and Underwater Video
- o [17847](#) - Development of "FishLocator" Software to Locate Fish Sounds in 3-D and Track Movements of Vocal Fishes
- o [17826](#) - Monitoring Eelgrass and Assessing Status
- o [16029](#) - Geospatial Applications "From Desktop to Dynamic Services"
- o [16006](#) - Developing a Methodology and Indicators for Evaluating Catch Shares
- o [15973](#) - GOM Regional Ocean Science Initiative stimulated formation of Northeast Sea Grant Consortium
- o [15971](#) - Risk Assessment Characterization of the Spread of Invasive Marine Species from Vessels Arriving in Northeastern U.S.
- o [14897](#) - White Plague disease in corals and concomitant changes in their microbial communities (microbiome)
- o [14896](#) - Three-dimensional Imaging for in-situ Biological Sensing and Flow Velocimetry
- o [14893](#) - DeepFSL - a low cost bimodal observation system for deep sea ecosystem research
- o [14890](#) - Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems
- o [14887](#) - Incorporation of a Compact Digital Holographic Plankton Camera into Gliders and Drifters
- o [14874](#) - Marine Social Sciences

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#### Full Text of Impacts and Accomplishments

##### 19813 - Rapid Assessment Survey Identifies Non-native Species from Maine to Rhode Island

Non-native species are impacting our native communities, fisheries and ecosystem functions. A 2013

Rapid Assessment Survey was conducted by taxonomic experts, students and others to identify non-native and native species on floating docks from Maine to Rhode Island. There were 34 introduced species four of which had not been reported previously in earlier surveys and 2 summer ephemerals. Several species appear to be moving northward, two are expanding their range southward. The results suggest that there are more warm water species moving northward and that hull fouling may continue to introduce new species and facilitate their spread. A report is in press and will be made available to harbor masters and port authorities.

**RECAP:** Survey shows that marine non-native species are moving northward, and species are spreading north and south.

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#### **19771 - Sea Grant Scientists Deploy Assay to Detect Paralytic Shellfish Toxins In Situ**

Through support by MIT Sea Grant, researchers deployed the Environmental Sample Processor (ESP) with a newly developed assay designed to extract and detect Paralytic Shellfish Poisoning (PSP) toxins in situ. Despite low ambient cell concentrations of the target organism *Alexandrium fundyense* at the mooring in the Gulf of Maine in Spring 2013, the assay was able to detect trace levels of the dinoflagellate's PSP toxins, demonstrating the success of the assay's development, adaptation for the ESP architecture, first field deployment aboard the ESP, and near real-time transmission of toxin data to shore. With a few recent modifications to the assay and ESP's mechanics, to improve both sensitivity and accuracy, scientists at WHOI, NOAA, and MBARI are currently preparing to deploy the assay for a second time in the Gulf of Maine in Spring 2014 - this time aboard two moored ESPs. The near real-time, in situ toxin data provided by the ESP are expected to benefit the overall goals of protecting natural shellfish resources and human health and expanding our understanding of harmful algal bloom dynamics and toxin production. Videos of ESP operation can be seen at <http://www.mbari.org/ESP/>.

**RECAP:** An Environmental Sample Processor uses a newly developed assay that detects toxins in situ even at low levels produced by *Alexandrium fundyense*, the red tide phytoplankton in near real time.

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#### **19744 - Retrieved and delivered physical samples of deep-water corals to NOAA and partner universities**

Deep-water corals contain a history of ocean climate, and are therefore of enormous interest to climate scientists. While our colleagues at U. Conn. and NOAA had high-quality photographic evidence of the corals in Gulf of Maine, they did not have the ability to collect physical samples. Using a remotely operated vehicle with a manipulator, we collected samples of soft corals for further analysis. The samples we recovered are of great value to researchers as they plan for a recovery expedition this year. The DNA analysis ongoing at U. of Louisiana and U. of Maine will further help them understand how coral populations in the Gulf of Maine relate to populations elsewhere.

**RECAP:** Deep-water coral samples that we retrieved helped our partners advance their understanding of ocean climate change.

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#### **19484 - Northeast Sea Grant researchers use optical sensor and AUV to quantify spatial extent and impact of invasive tunicate**

**Relevance:** One challenge to preventing, managing, and controlling marine invasive species is the lack of quantified ecosystem and societal impacts. Techniques which permit relatively rapid assessments of distribution, abundance and spatial scales of target species are needed to help quantify these impacts.

**Response:** With MIT Sea Grant funding, Northeast Sea Grant researchers collaborated on a novel approach for assessing habitat distributions and spatial scales of *Didemnum vexillum* infestation. Since 2002, this invasive colonial tunicate has overgrown vast sections of critical fish habitat on Georges Bank off the New England coast.

**Results:** Optical methods and algorithms for the automated mapping of *Didemnum* colonies were designed and tested using an autonomous underwater vehicle (AUV). An optical sensor for the in situ detection of *Didemnum* in nearshore and coastal waters was developed and adapted for AUV use; reflectance spectral data for *Didemnum* were measured in situ and integrated using an autonomous underwater vehicle (AUV), facilitating rapid large-scale assessment surveys. Complementary ecological studies investigated life history attributes of *Didemnum*, the effect that the presence or absence of *Didemnum* mats had on the composition of benthic species, and what factors influenced colony fragmentation and spread. While tidal currents were determined unlikely to produce sufficient drag to cause colony fragmentation, other mechanisms (e.g., vessel speed, dredge activity) could cause dislodgement. The increasing weight of *Didemnum* tendrils growing from colonies suspended from docks could also cause breakage. *Didemnum* mats were determined to positively affect benthic species richness and abundance by reducing predator access to economically important benthic invertebrate and demersal fish prey. This predation barrier could adversely affect commercially-important species in the affected regions. Peer reviewed publications document these findings.

**RECAP:** The integrated research resulted in an optical technology to detect and invasive sea squirt on the sea floor and identified the special characteristics of the species that may serve as a predation barrier to commercially important fish in affected regions.

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#### **19483 - Socioeconomic Impacts of Herring Management in the Northeast US**

**Relevance:** According to NOAA Fisheries scientific assessments, herring is not overfished, nor is overfishing occurring in the herring fishery in the Northeast U.S. Nevertheless, conflicting demands for

access to herring make careful management a high priority. Herring is the bait of choice for Maine's lobstermen. A plethora of species, including humpback whales, seabirds, groundfish, striped bass and squid, forage on herring. Humans too have an appetite for this pelagic species. When developing regulations as part of the Herring fishery management plan, managers attempt to achieve a balance among the competing demands for the species while assuring that the stocks are sustainably fished. In addition, managers are required by law to include a social impact assessment (SIA) when they develop new regulations with the goal of mitigating negative impacts on humans while maintaining a healthy fishery.

**Response:** Rarely does anyone look at prior SIAs to determine if they correctly anticipated the effects of past management efforts or helped lead to mitigation of negative impacts. Researchers at MIT Sea Grant and UMass-Boston led a two-year collaborative research effort to analyze Amendments 1-4 to the Herring FMP funded by the National Marine Fisheries' Saltonstall-Kennedy grant program. The research team of two the principal investigators, three students and five community researchers conducted 61 stakeholder interviews. Stakeholders included 13 scientists, 21 herring fishing vessel captains or owners, five managers; six lobster fishermen, three bait dealers; 10 groundfish or other commercial species fishermen; two charter boat captains, one gear manufacturer and a recreational fishing representative. In addition, data from interviews with one processing plant manager, one herring vessel captain, and two tuna fishermen conducted for another project are incorporated into the final report. The project illuminated the importance of recognizing the complex web of stakeholders involved in fisheries that may affect the effectiveness of regulations as well as outcomes for both fish stocks and communities.

**Results:** Through our research and outreach efforts, we provided fisheries managers with information that will enable them to more accurately anticipate the social impacts of future regulations of herring and other species. Results from the research immediately informed the development of new regulations in the herring management plan through MIT Sea Grant's participation on the Herring Plan Development Team. The results of the project in the long run will benefit fishermen, fishing communities, consumers and others with an interest in herring.

**RECAP:** Through MIT Sea Grant's research and outreach efforts, we provided managers with information that enables them to more accurately anticipate the social impacts of their regulations thereby leading to improvements in fisheries management. [Back to Goals](#)

#### **18446 - Directory of Marine Social Scientists**

**Relevance:** With an increase in National Sea Grant funding dedicated to social science projects, peer reviewers with social science expertise were needed.

**Response:** MIT Sea Grant responded to the demand by developing a directory of Marine Social Scientists. The directory is accessible through the MIT Sea Grant website, as are forms to submit changes, e.g., contact information, so it can be easily kept up to date.

**Results:** The directory offers those seeking collaborators on projects, expertise in other fields, and peer reviewers for projects or articles sources of information about individuals with social science expertise. The information is expected to help graduate students who need mentors or managers who have issues that would benefit from addressing social-cultural factors or other aspects of human dimensions. Access the online directory: [http://seagrant.mit.edu/fishing\\_comm.php#dss](http://seagrant.mit.edu/fishing_comm.php#dss).

**RECAP:** An interactive directory provides easy access to marine social scientists for collaborations or reviews, help with human dimensions issues and for identifying mentors for students. [Back to Goals](#)

#### **17936 - Identification of OCS Renewable Energy Space-Use Conflicts**

**Relevance:** Marine renewable energy (MRE), a relative newcomer to the ocean and coastal context, challenges coastal fisheries and fishing communities. Looking for places where MRE might be developed unhindered by other uses, state and federal agencies have focused on potential space-use conflict and standard mitigation measures for loss of access to that space.

**Response:** MIT Sea Grant collaborated with colleagues to conduct ethnographic research that included interviews and meetings with fishery participants and other community members. A report was submitted to the Bureau of Energy Management (BOEM) and is downloadable from their website.

**Results:** This research revealed the need for a more nuanced consideration of the use of marine areas. Marine space use is dynamic and multi-dimensional, with important linkages within and across fisheries, communities and other interests, as well as across the land-sea interface. An important point, consistently and independently made by the whole range of stakeholders, was that there is virtually no space that is unutilized in our EEZ. This finding means that it is essential for agencies and new users to work closely with existing users to negotiate space sharing. Other agencies, such as the Northeast Regional Ocean Council (NROC), have found the report on our research useful as a baseline for further evaluation of areas of interest.

**RECAP:** Research on space-use conflicts in the Outer Continental Shelf supports planning for renewable energy that will lessen the negative impacts on traditional users of marine space. [Back to Goals](#)

#### **17886 - Community-supported Fisheries**

Relevance: Efforts to assure that fishing remains at sustainable levels has led to strict regulations on the amount of fish that fishermen are permitted to land. In consequence, many fishing communities have become interested in direct marketing that promotes sustainable fishing while generating higher prices for the fish sold.

Response: MIT Sea Grant collaborated with Gloucester Fishermen's Wives Association and Northwest Atlantic Marine Alliance (NAMA), to ensure the continued success of Cape Ann Fresh Catch, a community-supported fisheries (CSF) out of Gloucester, MA. CSFs are modeled on community-supported agriculture (CSA), programs that allow consumers to buy local, seasonal food directly from farmers.

Results: MIT Sea Grant wrote and/or edited documents useful to CSF start-ups. These documents have proven useful to a number of new CSFs, including someone who helped organize the first CSF in the U.K. and used these resources to help fishermen in Brighton & Chichester start their CSFs.

**RECAP:** Written documents on how to start a community-supported fishery have been used by individuals and organizations on both coasts of the United States, as well as in the United Kingdom.

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### **17860 - Sea Grant Scientists Develop Methods for Detection of Paralytic Shellfish Poisoning Toxins In Situ**

Methods were developed for the extraction and detection of Paralytic Shellfish Poisoning (PSP) toxins that will be subsequently adapted for the Environmental Sample Processor (ESP). Development is nearly complete, with the benchtop optimization of an efficient extraction method and cELISA; methods are currently being transferred onto the ESP platform in anticipation for the new module's deployment in Spring 2013. Currently, the ESP is capable of identifying and enumerating the cells of targeted species, such as those of *Alexandrium fundyense*, the "red tide" or harmful algal bloom species responsible for recurrent outbreaks of PSP in New England waters. The near real-time, in situ toxin data provided by the ESP are expected to benefit the overall goals of protecting natural shellfish resources and human health and expanding our understanding of harmful algal bloom dynamics and toxin production.

**RECAP:** Sea Grant scientists develop methods for detection of paralytic shellfish poisoning toxins in situ.

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### **17852 - MIT Sea Grant Develops Game to Educate Next Generation of Marine Scientists, Engineers, and Managers**

In 2012, the MIT Sea Grant College Program in collaboration with the Consortium for Ocean Leadership, developed and released a Web-based game that quizzes students on their knowledge of ocean science, and encourages them to further their education and passion for the field. The quiz engages students in timed, and competitive game play as well as through contribution of questions which, following vetting by experts, are used directly in the quiz.

The National Ocean Science Bowl's (NOSB) regional completions are often dominated by schools with a long history of involvement. The nature of the game structure can make it difficult for new teams to get involved and perform competitively. The online Ocean Science Quiz (OSQ) was developed as a tool to help students practice online as well as learn by writing their own quiz bowl questions. The OSQ currently offers both single and double player mode and has reached over 5000 students in 2012. This tool will help underrepresented schools and newer teams confidently join the Blue Lobster Bowl and other NOSB regional bowls thus enabling more students to learn ocean science and technology.

To date, 5,721 new users have played the game, 36 percent of whom returned to play more than once -- an impressive retention rate. A third phase of the game is currently in beta testing. This new mode of play will allow students to compete against each other across the internet, track their rank on a leaderboard, and engage each other in discussions on marine science topics.

**RECAP:** MIT Sea Grant College Program in collaboration with the Consortium for Ocean Leadership, developed and released a Web-based game that quizzes students on their knowledge of ocean science, and encourages them to further their education and passion for the field.

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### **17850 - Documenting the Presence of Tautog with Sound Source Localization and Underwater Video**

Sea Grant funded scientists at the University of Massachusetts at Amherst have demonstrated the use of sound source localization methods as a tool to validate the identification of an unknown fish sound. Unknown sounds recorded on Cape Cod, Massachusetts were determined to be produced by the tautog an important fishery species in New England waters. Documentation of sound production in this species confirms the importance of the soundscape in the species ecology. Resource managers require this information to evaluate the potential impact of noise pollution on this and other species. Identification of the sounds produced by tautog will enable future researchers to use methods developed by the UMass scientists to study tautog behavior and to use passive acoustics to study its habitat requirements.

**RECAP:** Scientists have used sound source localization together with underwater video to document the sounds produced by the tautog.

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### **17847 - Development of "FishLocator" Software to Locate Fish Sounds in 3-D and Track Movements of Vocal Fishes**

Sea Grant funded scientists at the University of Massachusetts Amherst have developed acoustic software to track the 3-D locations of known and unknown sound sources with high accuracy within a small spatial area (10 m), and 2-D locations within larger spatial areas (>100 m). The FishLocator program is a MATLAB-based graphical interface that enables loading, filtering, and time windowing of multi-hydrophone acoustic signals and outputs sound source location for selected sounds and sound sequences for tracking.

**RECAP:** Sea Grant funded scientists have developed acoustic software to track the 3-D locations of known and unknown sound sources with high accuracy within a small spatial area, and 2-D locations within larger spatial areas. [Back to Goals](#)

### **17826 - Monitoring Eelgrass and Assessing Status**

MIT Sea Grant collaborated with state and federal agencies to assist with assessing the status of eelgrass beds along the Massachusetts coast. Eelgrass beds have not recovered since the 1930s when they were first affected by a fungus and subsequently by excessive nutrients from land-use activities that limit light availability for their growth. This pilot project tested the efficacy of using the Hybrid Underwater Vehicle, Reef Explorer (REX)I to take images of eelgrass and seek *Didemnum* and other non-native species growth on eelgrass blades. Environmental data such as photosynthetic active radiation (PAR), dissolved oxygen, temperature, salinity, turbidity and depth were collected. PAR values and Secchi disk measurement, suggest suitable habitats without eelgrass are slightly more turbid than areas with eelgrass.

**RECAP:** Although the currents were too high for operating the REX vehicle, other approaches will be used to assess status of eelgrass beds, efficacy of auger-type anchors, and environmental conditions of restored and failed restoration areas. [Back to Goals](#)

### **17626 - Impacts and Accomplishments of *Didemnum* Project**

Relevance: *Didemnum vexillum*, a non-native tunicate found in Georges Bank impacts the commercial scallop industry, but its distribution and abundance are not well-documented.

Response: We have presented our data on the impact of *D. vexillum* on the commercial scallop industry at several meetings of the New England Fishery Management Council including the scallop SARC series of meetings in April-June 2010, and the 2011 scallop PDT. We submitted a statement to the Council to heighten the awareness of the potential impact of *D. vexillum* and have addressed many questions from Council members. Because of these efforts, *D. vexillum* research is now a priority in the NOAA Research Set Aside program.

We worked with NOAA NMFS managers to establish observational priorities for *D. vexillum* on the annual scallop and groundfish surveys. The presence of *D. vexillum* is now noted with regularity on these surveys.

This project has supported our involvement in the Invasive Species Workshop in Woods Hole, and in two major teacher workshops in 2011 where HabCam materials have been presented as lesson plans to teachers throughout the Northeast. Predator-prey interactions and the impact of invasive species including *D. vexillum* were discussed.

Results: The impact of *D. vexillum* on the commercial scallop industry was presented at the New England Fishery Management Council and related meetings. Because of these efforts, *D. vexillum* research is now a priority in the NOAA Research Set Aside program and NOAA NMFS managers.

**RECAP:** Using a remotely operated vehicle equipped with a video camera (HabCam), a non-native tunicate, *Didemnum vexillum*, was surveyed off the Massachusetts coast. Data were used to document impacts on scallops, and information was used to increase surveillance by NOAA:NMFS and also translated for the general public. [Back to Goals](#)

### **16029 - Geospatial Applications - From Desktop to Dynamic Services**

MITIS is the oldest and most robust of our services, and has provided much of the architecture upon which our other systems are based. From the web-based service's inception in 2007 through 2011, the number of organizations contributing to MITIS has grown from a few governmental and Sea Grant collaborators to 15 constituent organizations from government, non-profit, and education sectors. Over 200 individuals contribute data, each volunteering hours of their time -- a total economic benefit of tens of thousands of dollars annually.

In 2011, the year-over-year growth of data records in the database grew by 38%. The number of new records is important for us in indicating database use and increases our influence on metadata clearinghouses. For the same time period, the number of query "hits" on our database from the Nonindigenous Species Database Network (NISbase) ran at over 300 per month. In addition, the substantial size of our database has enabled us to partner with the Ocean Biogeographic Information System (OBIS), the largest global marine biogeographic data clearinghouse, serving tens of millions of data records from over 1000 datasets.

Our database systems expanded to support two MIT Sea Grant ongoing research efforts. In 2009, the Sea Perch Digital Ocean was launched. Using tools and data models derived from MITIS, the Digital Ocean turns students into citizen-scientists who collect data in the field and then enter and interact with data through a map-based interface. In addition, a new visualization tool was developed for the project, allowing users to dynamically create graphs of water quality variables. The Digital Ocean

project is now in its second phase, in which we have developed a more sophisticated database architecture that accommodates more robust data from scientific as well as citizen-science endeavors, and integrates more closely with other MIT Sea Grant programs.

To investigate *Didemnum vexillum* in Massachusetts coastal waters, MIT Sea Grant and partner scientists are utilizing Autonomous Underwater Vehicles (AUVs) to conduct surveys to map the extent and spread of the organism and developing new tools for its detection. To support this effort, we have developed systems to georeference and process AUV payload data and make it available through our MITIS service. In addition to species presence and ancillary water quality data, we have added services for viewing and sharing seabed imagery.

**RECAP:** MIT Sea Grant databases serve a large community of coastal managers, students, and the public. [Back to Goals](#)

#### **16006 - Developing a Methodology and Indicators for Evaluating Catch Shares**

Catch share programs for assuring sustainable fisheries and fishing communities management have caught the imagination of NOAA Fisheries, various managers, environmentalists, and fishermen alike. However, some stakeholders believe that catch share programs are unnecessary, and that they may lead to over-consolidation, negative impacts on small communities, and other unintended consequences.

This project works to develop a framework for the evaluation of the ecological, economic, and social impacts of U.S. West Coast and New England catch share programs in fisheries management. MIT Sea Grant is developing this framework in collaboration with a team of experts in fisheries ecology, economics and social sciences, and the Marine Conservation Initiative of the Gordon and Betty Moore Foundation. One of the program's main tasks is to collaborate with local, regional, and federal fisheries managers and participants to determine management goals and objectives for each participant catch share system.

The team is also working to develop program success measurement methods, as well as finding ways to help identify unintended consequences associated with this new form of management. Ultimately, research will be conducted to analyze the effects of catch shares so that fisheries management will have an empirical basis for their decisions in the development of regulations.

**RECAP:** MIT Sea Grant with a team of experts is working with local, regional and federal fisheries managers on the East and West Coasts to analyze the effects of catch shares on fisheries and provide an empirical basis for fisheries managers decisions in the development of regulations. [Back to Goals](#)

#### **15973 - GOM Regional Ocean Science Initiative stimulated formation of Northeast Sea Grant Consortium**

The President's National Ocean Policy recognizes the need for regional projects to promote stewardship of our coasts and marine waters. Several regional organizations serve various functions in the Gulf of Maine and Northeastern U.S. The Sea Grant-supported Gulf of Maine Regional Ocean Science Initiative developed a Regional Science Plan, adopted in 2009 that formed the basis for research and supported two regional projects. The GOM Regional Science Plan was used by the Gulf of Maine Council in drafting its regional needs. In conjunction with the New York Bight Regional Ocean Science Initiative, the Northeast Sea Grant Consortium (NESGC) was formed to facilitate funding for regional projects and other research efforts, identify research needs, and develop a regional presence with organizations such as the state/federal, private/public Northeast Regional Ocean Science Council and others. This past year the NESGC has entered into a memorandum of understanding with NROC on behalf of both the GOM and NYB Regional Ocean Science Initiatives and supported four social science projects focused on regional issues.

**RECAP:** The Gulf of Maine Regional Ocean Science Initiative, in conjunction with the New York Bight Regional Ocean Science Initiative, formed the Northeast Sea Grant Consortium to facilitate identifying regional priorities and funding for regional projects. [Back to Goals](#)

#### **15971 - Risk Assessment Characterization of the Spread of Invasive Marine Species from Vessels Arriving in Northeastern U.S.**

Introduced marine species are frequently spread by shipping vessels and pose a major threat to marine ecosystems worldwide. Using ballast water discharge and ship arrival data from 2004-2011, MIT Sea Grant created a geographically referenced risk assessment method to predict sources of invasive species into the Northeastern United States coastal waters. Eight species were studied in more depth to predict the likelihood of their introduction to the region. Of these species, the sea squirt *Clavelina lepadiformis* and the red alga *Heterosiphonia japonica* were most likely to establish and spread in the Northeastern United States as a result of shipping. The riskiest sources of introduced species, based on ballast data, were from ships having exchanged ballast in (a) North Sea or (b) Carolinian region, which is located along the coast of the Southeastern United States. The results of our study will support management decisions and policy on strengthening ways to prevent new invasions by targeting coastal shipping practices that discharge ballast water within the exclusive economic zone.

**RECAP:** Assessment of potential risk from ballast water discharge and vessel traffic indicates that a sea squirt, *Clavelina lepadiformis*, and a red alga, *Heterosiphonia japonica*, are most likely to invade, establish and spread in Massachusetts coastal waters. [Back to Goals](#)

#### **15937 - Trade Adjustment Assistance Training for Lobstermen**

**RELEVANCE:** Prices and production of American lobster in Massachusetts were negatively affected by foreign imports in 2009, leading to the losses of a number of small businesses.

**RESPONSE:** MIT Sea Grant helped Massachusetts Lobsterman's Association (MLA) file a petition to participate in the USDA Trade Adjustment Assistance (TAA) program on behalf of the Commonwealth's lobster industry. In collaboration with the other Sea Grant programs in the region, eight 3-hour long courses geared specifically to the lobster industry were developed, including one by MIT Sea Grant on "Changing your business model." Each course was taped and test questions developed for online courses. Each program shared the eight courses and offered lobster TAA participants the opportunity to take any of the 8 courses in-person.

**RESULTS:** Over 950 individuals in Massachusetts completed the required orientation within the 90 days. The second phase, (four courses of 12-hours of workshop time, has been completed by 572 Massachusetts' participants and 39 others are working on them. The third phase, a very brief business plan, has been completed by 513 Massachusetts' participants. In the fourth (and final) phase, participants are assigned a business consultant who works with them individually to develop a business plan. Two-hundred, thirty-five Massachusetts' participants have completed their long-term business plan.

**RECAP:** Through concerted and coordinated outreach efforts in Massachusetts, as well as collaboration with other Sea Grant programs, 513 lobster industry participants have received intensive training and financial benefits (approximately \$1200 each) from the TAA to improve their businesses despite competition from imports. Of these, 235 participants have completed the program and received additional financial benefit (about \$2000 each). [Back to Goals](#)

#### **14897 - White Plague disease in corals and concomitant changes in their microbial communities (microbiome)**

We have recently completed a study of microbial communities in corals that has important implications for developing bio-indicators of healthy corals. The study identified a "core" set of microbial populations in corals demonstrating that this set of core populations is substantially altered in diseased corals. This finding will assist managers to protect the reef habitat that provides a living to subsistence and commercial fisheries. This research was presented at two international conferences (the American Society for Microbiology General meeting and the International Society for Microbial Ecology) and a publication has been submitted to an international journal.

**RECAP:** To better understand how environmental conditions trigger outbreaks of pathogens in marine ecosystems, we are developing tools to identify microbial biomarkers for threatened coral reefs where the incidence of disease has accelerated in the past thirty years. [Back to Goals](#)

#### **14896 - Three-dimensional Imaging for in-situ Biological Sensing and Flow Velocimetry**

This effort is to develop a new technology for instantaneous three-dimensional (3D) flow measurements in a fluid volume using light field imaging and synthetic aperture refocusing. Using multiple cameras aimed at the scene, the images can be reconstructed to produce an intensity volume, which can be interrogated for 3D particle image velocimetry (PIV) measurements with application to biological and multi-phase flows. Applications to biological and oceanic flows will be addressed in subsequent years.

The technical approach is to merge the techniques of light field imaging and synthetic aperture refocusing to enable 3D velocity measurements in fluid flows. By fusing methods from the imaging community with concepts that drive experimental fluid mechanics, we developed a technique for measuring 3D velocity fields that overcomes many of the inherent challenges of 3DPIV. Efforts of this nature are warranted by the need for quantitative experimental data in 3D flow fields in topics as varied as docking and recovery, vehicle hydrodynamics, biorobotic propulsion, fluid/structure interaction, and other complex 3D flows.

Significant progress developing and characterizing the 3D imaging system has been made. A camera array was constructed and has been tested on a canonical fluid vortex ring, including the application of the system to bubbly flows, where bubbles are used in lieu of biological organisms. Results show positively that this method is more than viable for PIV; development of camera auto-calibration algorithms and the first release of a suite of codes were achieved in 2010. Further efforts to determine maximum resolution, occlusion density, and in situ applications are underway. Two MIT graduate students were trained in these techniques, and a refereed journal article published in 2010.

**RECAP:** Innovative technology development for instantaneous 3D flow measurements with broad implications in design for docking and recovery systems, vehicle hydrodynamics, biorobotic propulsion, and other areas of fluid/structure interaction. [Back to Goals](#)

#### **14893 - DeepFSL - a low cost bimodal observation system for deep sea ecosystem research**

Resource managers are faced with the fundamental problem of acquiring and analyzing data; one major component of the marine ecosystem that is especially poorly understood is the deep sea soundscape which is particularly vulnerable to increasing anthropogenic noise. Low cost passive acoustic instruments that provide sound source validation can advance the field of passive acoustic research on deep sea ecosystem function. Our ultimate goal is to develop instrumentation, software and methodologies that combine video and passive acoustic technologies to aid in situ observation of soniferous fish and invertebrate behavior and validation of sound source identities.

We tested configurations of portable arrays with different hydrophone spacing and deployment conditions (surface, mid-water and bottom), and, based on our field trials and extensive consultation with manufacturers, we designed a prototype Remotely Operated Fish Sound Locator (ROFSL) for use in shallow water. The ROFSL consists of a six hydrophone 3-D array in a square diamond configuration mounted on a rigid square frame together with two cameras and a lighting system controlled by a manned recording and monitoring system contained in a weather tight Pelican case. The user can program lighting, video and audio recording options for time-lapse recording, or control them manually during real-time recording. Fish are attracted into the array boundary and within the camera view through the use of bait and the lights. Software to localize three-dimensional sound sources was developed; ROFSL design is readily transferable to deep sea applications after adapting for autonomous recording and deep sea environmental conditions (i.e., pressure housing and deep water platform). This project supported a UMASS-Amherst undergraduate student.

**RECAP:** Design and build a new oceanic instrument, DeepFSL (fish sound locator), capable of collecting both conventional video and passive acoustic data for use in studies of the deep sea ecosystem.

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#### **14890 - Using Technology to Assess the Invasive Sea Squirt, *Didemnum vexillum*, Impacts on Fisheries and Ecosystems**

In response to the need for regional research to address concerns identified in the Gulf of Maine Regional Ocean Science Plan, namely impacts of invasive species, support for fisheries, and technology development to support research, investigators from MIT, University of Maine and University of Connecticut collaborated in the effort to identify and monitor the invasive sea squirt *Didemnum vexillum*. At MIT, the autonomous underwater vehicle (AUV), Odyssey IV had a major upgrade of the RTU (Rotational Thruster Unit) and its functionality verified. A total of 15 days in the field captured 45,000 images of the sea floor, some of which included *D. vexillum*. One of the co-PIs, Emmanuel Boss, University of Maine, modified a radiometry for in-situ measurements of *Didemnum vexillum* reflectance and fluorescence. The modified radiometer will be used on the AUV for surveying *Didemnum* quickly and efficiently. In addition, Robert Whitlatch, University Connecticut, conducted a number of field experiments examining how variations in density and species diversity of other fouling species influenced the growth and survival of *Didemnum*. These research findings contributed to a workshop held November 3, 2010 at MIT Sea Grant, "Impacts of *Didemnum vexillum* on Fisheries and Coastal Ecosystems" that facilitated relevance of the impacts of *Didemnum* to coastal and fisheries managers and was attended by nearly two dozen regional managers and research scientists. A wiki was created to facilitate shared materials, help clarify coordinated research efforts, and streamline production of a white paper (see <https://wikis.mit.edu/confluence/display/didemnum/Sea+Grant+Didemnum+group>).

**RECAP:** The regional, integrated research effort on the invasive sea squirt *Didemnum vexillum* proceeded along two research paths simultaneously: modifying an optical sensor for detecting *Didemnum* and adapting it for use on the MIT Sea Grant Reef Explorer II hybrid autonomous underwater vehicle, as well as continuing to use photography and grab samples to evaluate the impact of *Didemnum* in hard substrate habitats to support fisheries management.

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#### **14887 - Incorporation of a Compact Digital Holographic Plankton Camera into Gliders and Drifters**

High-resolution spatio-temporal data collection on plankton size and taxonomic composition responds to a fundamental need in the study of aquatic ecosystems. Ocean observing systems are being developed to gather high-resolution data in time and space, but they lack the critical sensors necessary for taxonomic determination. New automated optical imaging systems provide high-resolution data on size and taxonomic composition of plankton, but these systems are large and ship deployed. Autonomous Lagrangian sampling platforms (e.g., gliders, drifters) are an important component of emerging ocean observing systems, but existing optical imaging systems for plankton are too large to be deployed on these platforms. Digital holographic imaging is a new method that provides compact, low power, large volume, high-resolution imaging capability and is well suited for incorporation into gliders and drifters.

Conceptual designs for modification of our prototype small autonomous low-power underwater digital holographic camera (Holocam) for imaging plankton and particles in the size range of microns to centimeters were completed. Rapid autonomous methods for processing the holograms were developed that allow an operator to survey a hologram in a manner similar to using a microscope to explore a real volume of water. The Holocam and identification methods are being transitioned for in-situ image capture and automatic plankton identification for use in gliders and drifters; the profiling float has been designed and tested and the holocamera will be mounted on it later this year. One MIT graduate student was trained in ocean technologies.

**RECAP:** High-resolution spatio-temporal data collection on plankton size and taxonomic composition responds to a fundamental need in the study of aquatic ecosystems.

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#### **14874 - Marine Social Sciences**

This advisory outreach agenda in marine social sciences addressed the human dimensions data gaps that constrain effective natural resource management to better foster collaborative research with stakeholders in fishing and coastal communities. This approach seeks a balance among social, economic

and ecological concerns, as exemplified with participation in the Plan Development Team social impact assessment for herring on Amendments 4 and 5. Decision-makers and other stakeholders were informed with the results of multidisciplinary, regional and bicoastal research that focuses on alternative management techniques, for example, with options for marine spatial planning and waterfront use. In collaboration with commercial fishing organizations, fishing communities, the U.S. Coast Guard, and recreational users we promoted marine safety and also facilitated basic fishing vessel safety training in various ports in Massachusetts and Rhode Island. Lastly, we collaborated with commercial fishing interests and community organizations to develop programs in support of sustainable seafood and coastal communities, like Cape Ann Fresh Catch, a community supported fishery, to draw attention to the potential benefits of this form of seafood marketing that benefits the fishermen, the community (Gloucester, Mass.), the marine ecology, and consumers. A petition for the Massachusetts Lobstermen's Association participation in the US Department of Agriculture Trade Adjustment Assistance (TAA) program was written; Massachusetts lobstermen were subsequently deemed qualified and over 1,000 registered in 2010.

**RECAP:** Worked with fisheries, coastal managers, fishermen, fishing families, fishing community members and members of the public to identify problems and seek solutions that balance fishing communities' needs with the critical goal of sustainability.

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#### **14644 - MIT Sea Grant helps local fishermen increase earnings with a direct "catch to customer" distribution model of safe, sustainably caught seafood**

**RELEVANCE** - Fishing communities struggle to catch and sell enough fish to make a good living within the confines of fishing regulations, the dangers of going to sea, and the power of wholesalers to set prices. Community Supported Fisheries (CSF) is a new economic model, based on the Community Supported Agriculture model that has transformed urban locations into thriving produce markets.

**RESPONSE** - Starting in 2009 Cape Ann Fresh Catch (CAFC) established an initial CSF operation for a few locations on the Massachusetts North Shore, modeling their efforts after a similar operation in Maine. With the help of MIT Sea Grant, they expanded into the far larger markets of Boston and surrounding areas. Going beyond industry practices, CAFC established safe handling requirements for member boats to ensure high quality seafood.

**RESULTS**- From modest beginnings, the CAFC now serves thousands of customers in 17 Massachusetts communities. The CAFC's business model provides fishers with greater flexibility and a much higher share of the profit (3 -5 times) from their catch. The approach encourages sustainable fishing and minimizes waste. CAFC customers, who pre-purchase a catch share for the season, now have access to fresh seafood handled according to rigorous safety standards. The business model has spread to other states on the East Coast, notably North Carolina and also to the West Coast.

**RECAP:** MITSG helps local fishermen earn more by putting safe and sustainably-caught seafood straight onto the dinner plates of Massachusetts citizens using a direct-to-customer distribution model.

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### **Program Performance Measures (2010 - 2013)**

<b>Program Performance Measure</b>	<b>Program Plan Target (2010-2013)</b>	<b>Reported</b>	<b>Program Comments</b>
Number of fishery managers trained: Tools and training for accurate evaluation of planktonic food resources as they relate to climate change and other factors delivered to NMFS, MA DMF, and other state and local agencies	5	195	
Number of groundfish sectors adjusting annual plans: Groundfish Sectors receive reports on the actual effects of catch share-based management on the important groundfish ports of Gloucester, Scituate and New Bedford businesses and communities.	19	0	
Number of groundfish sectors receiving information: Reports needed by newly-formed Groundfish Sectors on catch share-based management's potential effect on their businesses and communities to assist in planning	19	25	
Number of new fish sensors developed: Capacity to detect schools of fish using new lateral-line sensor	1	3	
Number of new Massachusetts communities recruited to the CSF model	5	2	2013 - This effort has expanded due to other programs

			taking this on, not Sea Grant efforts eg, new delivery locations for existing CSFs and new program offered in Chatham, MA lead by Sea Grant partner organization, NAMA.
Number of new subscribers recruited to the CSF model	200	950	2013 - This effort has expanded due to other programs taking this on.

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### Program Objectives (2010 - 2013)

Program Objective	Achieved (yes/no)	Program Comments
Educational outreach activities will facilitate interaction of fishing industry participants with shareholders/customers and increase awareness of sustainable fishing practices and the value of diversity in the fishing industry.	Yes	
Expansion of the Community Supported Fisheries (CSF) program to other Massachusetts communities; work with regional Sea Grant programs to transfer the business model to other states.	Yes	
New technologies and tools are created and introduced to fisheries researchers and managers that improve assessment and prediction accuracy	Yes	
Support decision-making of the New England Fishery Management Council by providing an analysis of outcomes and impacts of proposed regulations on fishing communities. Help managers and stakeholders understand the socio-economic issues raised by catch-share based fisheries management and mitigate the potential negative impacts of this new form of management.	Yes	