Summary of Completed Collaborative Research Projects funded by Northeast Consortium

Ecosystems and Oceanography
Groundfish – Closed Areas, Ecology and Habitats
Social Science, Outreach and Education

Volume 3 of 3
2000 – present
Dear Colleague:

The Northeast Consortium encourages and funds collaborative research and monitoring projects within the Gulf of Maine and Georges Bank, which involve effective, equal partnerships among fishermen, scientists, and other stakeholders. A central goal of the Northeast Consortium is that the results of collaborative research efforts be fully integrated into fisheries and ocean management through ensuring public accessibility to data, facilitating technical reviews of completed projects, and outreach to fishermen, scientists, and managers.

This publication summarizes funded collaborative research projects with final reports submitted to the Northeast Consortium. It is an easy reference guide that highlights the main conclusions and products of funded projects and what next steps are taking place or should take place. As this guide is updated periodically, it will grow as more projects are completed.

All interim and final reports and other project information are internet accessible through the Northeast Consortium’s Project Information Database. In addition, the Fisheries and Oceans Data Management System serves as a means of access to data from collaborative research projects funded by the Northeast Consortium.

We hope that this publication will help to communicate the results and products of our collective effort to support and engage in collaborative research in the Northeast region.

Sincerely,

Dr. Chris Glass
Director and UNH Representative
# Volume III
## Table of Contents

### Ecosystems and Oceanography

- **A biological study of sand lance in the southern Gulf of Maine**  
  Page 3
- **Development of video, exploration and mapping capability, tools and methods**  
  Page 3
- **Drifter study of a front in the Maine Coastal Current system off Penobscot Bay, Maine**  
  Page 4
- **Ecological role of adult and juvenile anadromous forage fish in downeast Maine estuaries: sea-run alewife and groundfish prey**  
  Page 4
- **eMOLT: Environmental monitors on lobster traps phases 1 - 4: temperature, salinity, data management, and drifters**  
  Page 5
- **Pilot project to assess need and initialize a methodology to groundtruth existing multi-beam and side-scan sonar seafloor charts**  
  Page 6
- **PULSE: A cooperative partnership for pelagic ocean ecosystem monitoring in the western Gulf of Maine**  
  Page 6
- **Regional proposal to test sensors for detecting the sea squirt (Didemnum sp. A) on Georges Bank**  
  Page 7

### Groundfish – Closed Areas, Ecology and Habitats

- **A pilot gillnet survey of the Cashes Ledge Closed Area**  
  Page 7
- **Activity and distribution of cod in the Ipswich Bay spawning area**  
  Page 8
- **An assessment of bottom habitat community recovery in the Western Gulf of Maine Closed Area**  
  Page 8
- **Comparison of environmental contaminants on Georges Bank and Stellwagen Bank**  
  Page 9
- **Design, development, and field testing of an innovative circular net pen to be used to assess bycatch mortality of Atlantic cod at sea**  
  Page 9
- **Determining groundfish species movement patterns in closed areas, including the Western Gulf of Maine Closure Area**  
  Page 10
- **Effects of the Western Gulf of Maine Area Closure on groundfish populations in rocky habitats**  
  Page 10
- **Evaluation of closed areas: Cashes Ledge as juvenile cod habitat**  
  Page 11
- **Field testing of a novel application to examine habitat use and migration patterns of spiny dogfish**  
  Page 12
- **Genetic identification of Atlantic cod spawning stocks in U.S. waters using microsatellite and SNP DNA markers**  
  Page 12
- **Identification of life history parameters for two exploited skate species (Amblyraja radiata and Malacoraja senta) in the Gulf of Maine: Strategies for fisheries management**  
  Page 13
- **Intensive study of the Western Gulf of Maine Closure Area**  
  Page 14
- **Pilot project to test the use of side-scan sonar to identify seafloor features associated with pre-spawning and spawning cod aggregations**  
  Page 14
- **Spawning movements and habitat use of winter flounder in the southern Gulf of Maine**  
  Page 15
Trophic ecology of Atlantic cod: Insights from tri-monthly, localized scales of sampling

Social Science, Outreach and Education

A fishing gear workshop by fishermen for non-fishermen

Adopt-a-Boat: Commercial fishing vessels in K-12 education

An atlas based audit of fishing territories, local knowledge, and community participation in fisheries science and management

Charting anecdotal information and oral histories on Stellwagen Bank from local commercial fishermen

Employment, income, working conditions and vessel safety in New Bedford before and after Amendment 13 to the Multispecies Fishery Management Plan

Institutionalizing social science data collection

Marine Resource Education Project (MREP)

Movement of New England Multispecies vessels and crew in New England and beyond from 1994-2004

Workshop on trawl selectivity and conservation

Definition of Abbreviations
Title: *A biological study of sand lance in the southern Gulf of Maine*  
*Funding:* 2004 - $129,238

**Participants:**  
Les Kaufman (Boston University), Briana Brown (BU), Olivia Free (MFP), Cliff Goudey (MIT), Bill Lee (F/V Ocean Reporter; Rockport, MA), Phil Michaud (F/V Susan C III; Provincetown, MA), and Bill Murphy (NEA)

**Summary:**  
Sand lances are a key link in the complex food webs of Stellwagen Bank and Massachusetts Bay. The purpose of this work was to learn more about the ecology of two species, *Ammodytes dubius* and *A. americanus*, through development of efficient sampling gear and effective husbandry techniques, and through comparisons of diets. The work produced a proven means of systematically capturing live sand lance for study. Methods of transporting sand lance after capture and husbandry techniques were refined and culminated in the exhibition of live sand lance at the New England Aquarium. Diet analyses revealed that *A. americanus* and small *A. dubius* eat similar prey items. Large *A. dubius* eat larger prey items, including predatory Hyperiid amphipods. Additional outcomes were achieved: morphological measurements to discern between the two species, an understanding of their prey capture mechanism, novel observations of sand lance behavior in the wild and in captivity, and new insight into fungal pathogens that proliferate in captivity. This work has led to a long-term collaboration among Boston University, our two research/fishing vessel captains, the Stellwagen Bank National Marine Sanctuary, the Whale Center, and the New England Aquarium to further explore questions related to the ecology of upwelling zones on Stellwagen Bank/Massachusetts Bay. Additionally, a second important outcome of this work has been the decision by COMPASS in collaboration with the Massachusetts Ocean Partnership to declare Stellwagen Bank-Mass Bay to be Pilot Zone 1 of a forage fishes modeling experiment in the development of tools to support ecosystem-based management.

The Northeast Consortium facilitated a technical evaluation of this project, the results of which were submitted to the NEFMC February 2010.

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Title: *Development of video, exploration and mapping capability, tools and methods*  
*Funding:* $24,000 (PD Award)

**Participants:**  
John Williamson (F/V Sea Keeper; Kennebunk, ME), Ben Cowie-Haskell (Stellwagen Bank National Marine Sanctuary), Lew Incze (USM), Les Kaufman (BU), Blaine Kopp (USGS), Bill Lee (F/V Ocean Reporter; Rockport, MA), Phil Michaud (F/V Susan C III; Provincetown, MA), Geoff Smith (TNC)

**Summary:**  
The project was designed to build upon work previously funded by the Northeast Consortium to further development of underwater video observation capability for research on bycatch and/or other research uses. We constructed and field-tested five inexpensive, easy-to-build video/lighting arrays to be loaned to fishermen, with which they could experiment, and from which to develop their own designs. Over a three-year period we met individually and with groups of fishermen, and other interested people, to demonstrate the gear, and/or to provide the loaner-arrays for use. Though many people where initially curious, few people went the next step of taking the opportunity to use the gear for their own experimentation. Two research endeavors successfully employed video technology supplied by this project; two fishermen succeeded in building their own designs after experimenting with gear loaned from this project. Several potential users complained that the inexpensive designs that we were providing did not function in sufficient depths of water (>150 feet) for their purposes. The invitation to experimentation with no specific experimental objective may have discouraged involvement as well. The project was terminated short of its original goals, but the five video arrays remain available for use in other research partnerships.
Title: Drifter study of a front in the Maine Coastal Current system off Penobscot Bay, ME

Funding: 2004 - $134,134

Participants: Lew Incze (USM/GMRI), Jim Manning (NOAA NEFSC), D. Brooks (Texas A&M), and Proctor Wells (F/V Tenacious; Phippsburg, ME)

Summary: Inexpensive satellite-tracked GPS drifters were used during summer 2005 to examine the residual near-surface circulation of water inshore of the 100 m isobath on the coastal shelf between the Pemaquid Peninsula and Matinicus Island, Maine. This area is near the confluence of the Eastern and Western Maine Coastal Currents (EMCC and WMCC, respectively), but inshore of GoMOOS Buoy E, which is the nearest to our study area. Details of circulation inshore of the GoMOOS buoys are of interest for understanding the transport of plankton, including larval fish and invertebrates and harmful algal species, closer to the coastal environment. We deployed drifters at up to four sites between July 28 and August 2, 2005, and recovered the last drifters on August 5. Drift was generally southwestward and consistent within each cluster (=date of deployment), ranging from 209-216°T over the entire data set. There were 14 successful drifter deployments. Net speeds (calculated from deployment to recovery locations) ranged from 1.7-16.1 cm/s and varied from day to day, with an over-all mean of 7.4 cm/s and SD of 4.1 cm/s. Drifter speeds were similar to speeds at Buoy E on some days, but the average velocity of the drifters (average drogue depth = 3 m) was about half (56%) of that recorded at 2 m depth at Buoy E. Average transit time through the study area was about one week. Retrospective modeling shows that summer 2005 was a “flow-through” year, with a generally strong connection between eastern and western portions of the coastal current system. Results were compared with 20 other drifters that passed through the study area in other years, mostly in 2004.

The Northeast Consortium facilitated a technical evaluation of this project, the results of which were submitted to the NEFMC February, 2010. Data contributed to two articles published in scientific literature.

Title: Ecological role of adult and juvenile anadromous forage fish in downeast Maine estuaries: sea-run alewife and groundfish prey

Funding: 2005 - $95,075

Participants: Karen Wilson (USM), Chris Bartlett (MESG), Mike Myrick (F/V Shannon Rose; Cushing, ME), Jeff Pierce (Alewife Harvesters of Maine), John Stoltz (Round Pond, ME), Christopher Taylor (ME), David Turner (Eastport, ME), Larry Wawier (USM), and Theodore Willis (USM/GMRI)

Summary: Historically, river herring (composed of alewife (Alosa pseudoharengus) and blueback herring (Alosa aestivalis)) were an extremely abundant seasonal resource in the nearshore Gulf of Maine, originally as a subsistence food and trade item for both Native Americans and European settlers, and later as a commercial commodity. River herring link marine and freshwater systems through the transfer of marine- and freshwater-derived nutrients up and downstream. Historical evidence suggests that river herring were an important forage fish for nearshore groundfish stocks; without prey fish restoration, the rebuilding of commercial fish stocks will be an incomplete, and likely unsuccessful process. This project addresses what we think is a key component of this system—the role of river herring in estuarine food webs before, during and after spawning runs. The objectives were to (a) assess the ecological role of river herring as prey in Maine estuarine food webs, and (b) to assess the relationship between spatial distribution, seasonal timing and densities of river herring in estuaries relative to their movement between freshwater and saltwater habitats. Four estuaries were sampled with low and high river herring returns and quantified predation on alewife by nearshore groundfish caught using hook and line. We analyzed diets from cod, pollock, sculpin and mackerel, developing a somewhat unique nearshore record of diets of these species. The most important results of this work were that (1) that, in contrast to historical reports, few to any large fish predators were present inshore during the time in which adult river herring would be moving up rivers to spawn (May/June), and (2) young-of-year (YOY) river herring were readily consumed by a variety of fish species and sizes when YOY river herring were present in the system in late summer or fall. We conclude that that river herring have the potential to provide important late summer forage for juvenile groundfish and other predators, and that, until large groundfish recover in the nearshore region, the most important predators of adult river herring are humans, seals and waterfowl.

The Northeast Consortium is facilitating a technical evaluation of this project.
Title:
eMOLT: Environmental monitors on lobster traps phases 1 – 6: temperature, salinity, data management, drifters, real-time temperature and bottom currents

Funding:
2000 - $82,000
2001 - $116,000
2002 - $79,775
2003 - $164,300
2006 - $90,000
2007 - $24,814
(PD Award)

Participants:
James Manning (NMFS NEFSC), Bill Adler (MALA), David Casoni (MALA), Charlene and Jeremy Cates (DLA), Charles Gregory (SMCC), Clare Grindal (DLA), Tom Long (SMCC), David and Patrice McCarron (MELA), Vitalii Sheremet (URI), David Sleeper (Spruce Head Fishermen’s Cooperative), Bonnie Spinazzola (AO LA), Pat White (MELA), 100+ commercial fishermen, and 15+ SMCC students

Summary:
This project monitors the physical environment of the GoM and the Southern New England shelf. Low-cost strategies to measure bottom water temperature, salinity, and currents, and surface current velocity have been developed with the help of nearly 100 lobstermen dispersed along the entire New England coast. The objective is to extend multi-year time series (as well as monitoring capabilities), continue integration with the GoMOOS and IOOS systems, and contribute to future monitoring systems developed for our region.

Participating fishermen are supplied with the latest in low-cost instrumentation sufficient for maintaining continuous time series of physical variables at fixed locations and depths. As of January 2006, the database consists of 1.8 million hourly records of temperature, 80 thousand hourly records of salinity, and 50 thousand satellite drifter fixes. The mission is primarily motivated by lobster science and the need to document background conditions, but the database is accessible to the general public (http://www.emolt.org).

The distribution of temperature and salinity probes in Phases 1 and 2 is complete. In Phase 3, the eMOLT project set up a regional database network, so that project participants can enter, download, document, and view their data. In a quest to minimize instrumentation costs, eMOLT has partnered with both the Marine Science Department at the SMCC and local engineers in the private sector. In Phase 4, gulf-wide surface current observations were made, documenting the degree of transport between basins, and demonstrating the dynamic exchange of water masses. Devices have been developed of interest to the oceanographic community, including a low-cost GPS drifter that implements the SENS technology with the GLOBALSTAR low-orbiting satellite system. These units have already logged more than 50 thousand kilometers of ocean. In Phase 5, a real-time bottom temperature sensor (attached to lobster traps) was created to wirelessly transmit data to a shipboard system as it is hauled on deck. The drifters are now fully operational and being used by several other research groups, but the wireless temperature sensor is still under development. In Phase 6, a low-cost method was developed to monitor bottom currents from lobster gear.

It is expected that the primary users of eMOLT data, aside from the lobstermen themselves, will be local ocean circulation modelers. The need for data in initialization, assimilation, and validation of their numerical simulations is becoming more and more obvious. The complex time-varying nature of the GoM system calls for incorporating as much data as possible in order to generate realistic flow fields. The eMOLT philosophy is that local fishermen already spend their days at sea, have the biggest stake in preserving our coastal marine resources, and are the most knowledgeable of the local waters. Their interest, curiosity, and enthusiasm are sincere. They should play an important part in our nation’s IOOS.

NOAA has deployed drifters based on this design at the Gulf of Mexico 2010 oil spill site.

The Northeast Consortium facilitated a technical mail evaluation of this Phases 1-4, the results of which were submitted to the NEFMC and ASMFC in April 2007. eMOLT data has contributed to several articles for scientific literature (four published and several in preparation) and has continued with funding received from the Northeast Consortium in 2009.
Title: Pilot project to assess need and initialize a methodology to groundtruth existing multi-beam and side-scan sonar seafloor charts
Funding: 2005 – $25,000 (PD Award)

Participants:
Sal Genovese (Northeastern University), Walter Barnhardt (USGS), BG Brown (F/V Kathryn Leigh; Gloucester, MA), Olivia Free (MFP), Madeleine Hall-Arber (MITSG), Anthony Wilbur (Mass. Coastal Zone Management)

Summary:
This project employed commercial fishermen’s knowledge of the ocean environment to evaluate the validity of existing USGS seafloor charts and develop a systematic method to groundtruth areas that require further substantiation. In two focus group meetings, commercial fishermen reviewed existing side-scan and multi-beam sonar charts of an area extending from Cape Ann to Jeffery's Ledge and marked areas on the chart that either conflict or correlate with their understanding of the seafloor environment. A sub-set of locations in state and federal waters, prioritized by fishermen, served as the pilot area to groundtruth the corresponding seafloor maps and to study physical properties of the seafloor. A meter-square quadrat with fixed video and lights was constructed and real-time video was fed to a digital video recorder on the fishing vessel. Due to the repeated failure of the drop camera (i.e. multiple flooding events), an ROV was deployed to collect data at 10 stations. Our data indicated good agreement with existing seafloor maps, while providing greater detail about the variability in substrate characteristics (sand/mud vs. cobble/rock and gravel size distributions) than can be discerned from existing seafloor maps.

The Northeast Consortium facilitated a technical evaluation of this project, the results of which were sent to NEFMC and ASMFC October 2011.

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Title: PULSE: A cooperative partnership for pelagic ocean ecosystem monitoring in the western Gulf of Maine
Funding: 2001 - $400,000
2002 - $143,431
2006 - $250,769

Participants:
Jeff Runge (GMRI), Erik Anderson (F/V Kris n’ Kev; Portsmouth, NH), Jeremy and Karen Davis (F/V Karen Lynn II and F/V Chutzpah; Kittery, ME), Bud Fernandez (F/V Rhiannon Rae; Kittery, ME), Olivia Rugo Free (MFP), Rebecca Jones (GMRI), Peter Kendall (F/V Kelly Rose and F/V Elizabeth Ann; Rye, NH), George Littlefield (F/V Lady Regina; Kensington, NH), Peter Marshall (F/V Venture; Essex, MA), Craig Mavrikis (F/V Marion Mae; Eliot, ME), Daniel Murphy (F/V Bantry Bay; Gloucester, MA), Portsmouth Fishermen's Cooperative, Dennis Robillard (F/V Julie Ann II; Eliot, ME), Lee Stevens (F/V Lynn Allison; Portsmouth, NH), and Alan Vangile (F/V Special K; Portsmouth, NH)

Summary:
This project demonstrates a successful partnership for a cooperative, industry-based contribution to monitoring of the coastal pelagic ecosystem in the western Gulf of Maine. The need for long-term biological data collection in the Gulf of Maine is critical in light of the potential for climate change and accompanying ecosystem change at both the regional and global scale. It is increasingly important for the fishing industry as decisions about fishery management shift from a single or multi-species to an ecosystem-based approach. In this final report, we describe the major results of a two year time series of hydrographic and zooplankton and ichthyoplankton data carried out during January 2007- December 2008 at five fixed stations in the western Gulf of Maine. These results are placed in the context of an overview of the entire five year time (2003-2008, excluding 2006) series collected as part of the PULSE project. The sampling for the 2007-08 time series was undertaken totally by the fishing industry, and analysis of samples was conducted at the University of Maine, Gulf of Maine Research Institute laboratory. This is the first recorded time series for the western Gulf of Maine showing both seasonal and interannual variability zooplankton and ichthyoplankton abundance and biodiversity. Major findings include evidence for a marked reduction of abundance of Calanus finmarchicus, a dominant Gulf of Maine planktonic copepod that is a primary prey for adult herring and the northern right whales, in 2004-2005, particularly in summer on Jeffreys Ledge, and seasonal and interannual variability in both ichthyoplankton and zooplankton species diversity. In addition to providing indicators of plankton abundance, the time series results serve fundamental data needs for coupled phio-biological models of coupling between climate forcing, physical circulation and mixing, plankton production and recruitment processes in the western Gulf of Maine.

Data has formed the basis of one article published in scientific literature. The NEC facilitated a technical evaluation of this project, the results of which were submitted to the NEFMC and ASMFC December 2010.
Title: Regional proposal to test sensors for detecting the sea squirt (Didemnum sp. A) on Georges Bank

Funding: 2007 - $50,000

Participants: Judith Pederson (MIT), Greg Booma (MIT), Troy Dwyer (F/V Isabella and Eva; Scituate, MA), Justin Eskesen (Brass Rat Solutions), Jim Ford (F/V ; MA), Ian Katz (MIT), Robert Kohl (fisherman; MA), Vincent Guida (NMFS), Seth Newbury (MIT), Victor Polidoro (MIT), William Schwaab (USGS), Michael Soroka (MIT), and Page Valentine (USGS)

Summary: Didemnum vexillum, a compound sea squirt, has been found in Georges Bank where it may cover between 50-90% of the sea floor in areas that were surveyed before 2009. The sea squirt may be impacting groundfish and scallops in the region for multiple reasons: it is not a preferred food for groundfish, restricts access of fish to polychaete worms, and prohibits bay scallops from settling on the sea squirt. To understand the scope of the impact, the challenge is to identify the spatial coverage of D. vexillum in its potential habitat, assess risk of spreading, and model predicted areas of coverage. High-resolution imagery has been the most reliable means of detection, but it has limitations in efficiency and areas surveyed. We are using the MIT Sea Grant College Program autonomous underwater vehicle (AUV) Odyssey IV to test sensors that will effectively and efficiently detect D. vexillum.

As a first step, we surveyed areas in Georges Bank, Massachusetts and Cape Cod Bays, Stellwagen Bank, and Nantucket Sound using our AUV platform. We tested an acoustic sensor that failed to provide sufficient detail to identify D. vexillum from the sea floor and subsequently are developing and testing a new optical sensor. Current results indicate that D. vexillum can die back during adverse periods and little or no D. vexillum were present in areas surveyed in Massachusetts Bay and Stellwagen Bank. Images of benthic organisms from the AUV deployment were recorded as well as measurements of conductivity, temperature, and depth.

We have been funded (by another source) to develop an optical sensor (radiometer) to see if we can detect a signal specific to D. vexillum. Preliminary results suggest that there is a unique signal from other spectra and we will be testing its efficacy in early autumn 2010. In addition, other investigators are examining ecological and biological aspects of D. vexillum to explore its potential to spread to new areas.

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**Groundfish – Closed Areas, Ecology and Habitats**

Title: A pilot gillnet survey of the Cashes Ledge Closed Area

Funding: 2004 - $25,000 (PD Award)

Participants: Kevin Kelly (MEDMR) and Mathew Thomson (F/V Shearwater II; Monhegan Island, ME)

Summary: This project tested the use of gillnets to inventory fish populations in the CLCA of the Gulf of Maine. The CLCA encompasses historically important fishing grounds which have been closed to groundfishing, by federal regulation, seasonally since 1999 and year round since 2002. Methods were developed by which groundfish abundance can be regularly monitored in the CLCA. The expected outcome of the project will be a sampling methodology using gillnets that will minimize damage to bottom habitat and sample a variety of species and habitats effectively. This project is needed to develop eventual long term standardized measures of relative abundance of groundfish in closed areas in collaboration with the commercial fishing industry.

The Northeast Consortium has facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in May 2008.
Title: Activity and distribution of cod in the Ipswich Bay spawning area

Funding: 2005 - $254,551

Participants:
Hunt Howell (UNH), Carl Bouchard (F/V Stormy Weather; Hampton, NH), Charles Felch, Sr. (F/V Lady Victoria; Seabrook, NH), David Goethel (F/V Ellen Diane; Hampton, NH), Pingguo He (UNH), Laughlin Siceloff (UNH) and Marc Stetliner (F/V Too Far; Portsmouth, NH)

Summary:
The activity and fine scale distribution of spawning cod in Ipswich Bay was examined using a combination of data storage tags (DSTs) and acoustic telemetry. In April and May of 2006, 200 mature, pre-spawning cod were caught and equipped with external DSTs that recorded depth and water temperature at 12-minute intervals for up to 175 days after release. Thirty of these same cod were also internally implanted with acoustic transmitters, and relocated manually using a directional hydrophone, as well as with six stationary acoustic receivers deployed across the spawning area. Tracking occurred from May through June, with 47 days devoted to manual relocation by boat.

To date, 31 DSTs have been returned (15.5%), and time at liberty has ranged from 8 to 757 days (mean 159). Recapture locations varied across the Gulf of Maine from 88km northeast to 48km southeast of their release sites, but fish recaptured in the summer of 2007 (~1 yr. at liberty) were caught near their release location in Ipswich Bay, supporting the previously reported spawning site fidelity of this group of cod. For several days after release, cod exhibited dramatic vertical movements, probably associated with recovery from barotrauma. After arriving at a consistent depth, vertical activity remained low, and depth remained consistent throughout the spawning period (May through early June). There was a dramatic shift to deeper water from mid-June onward, coupled with increased vertical activity, signaling that individuals had left the study area and changed their behavior. Cod showed daily vertical patterns in their depth profiles.

Positional histories and home ranges were estimated for each acoustically tracked fish. Data indicate that spawning activity, which peaked in May, was concentrated in a small (~35km²) area on the southern and western edges of an elevated feature in the northwestern corner of Area 133 known as “Whaleback”. The shallowest part of this ridge was 40 m deep; about 30 m shallower than the muddy flats south of it. Cod shifted eastward in June before vacating the study site altogether, coinciding with vertical activity changes in DST data. Stationary receivers captured abrupt eastward movements across the study area as some individuals exited, allowing estimates of migratory headings and swimming speed. These fine-scale movement and spawning data have implications for area closures, defining Essential Fish Habitat, and cod stock assessment.

The results of this study formed the basis of a graduate thesis. The Northeast Consortium facilitated a technical evaluation of this project, the results of which were submitted to the NEFMC April 2011.

Title: An assessment of bottom habitat community recovery in the Western Gulf of Maine Closed Area

Funding: 2002 - $168,896

Participants:
Cameron McLellan (F/V Adventurer, Newcastle, ME), Allen Gontz (UMO), Emily Knight (UMO), Joseph Kelly (UMO), Laura Taylor Singer (GMRI), and Les Watling (UMO)

Summary:
Within the last decade, MPAs have been designated in the Gulf of Maine to address concerns of declining groundfish stocks, with the hope that benthic communities affected by groundfish trawling may also recover in such areas. One such MPA, the WGOMCA, encompasses two regions that, as of 2004, had been closed to groundfish trawling for 6 and 4 years, respectively. In this project, changes in benthic community composition following the cessation of trawling were investigated by comparing community states of sites in the 4 and 6 year regions of the WGOMCA to sites in an actively trawled fishing ground known as the Kettle. The epifaunal and infaunal components of benthic communities were surveyed via remotely operated vehicle (ROV) and sediment grab sampling in sites of comparable depth and substrate each August from 2002 through 2004. Multivariate statistics were then used to analyze differences in benthic community composition within and between sites. Finally, family life history information for resident taxa was used to determine possible mechanisms driving observed differences between benthic community composition.
Multivariate analysis showed significant differences in benthic community composition between the Kettle and the WGOMCA, which we attributed to the cessation of chronic trawling disturbance. However, these differences cannot be conclusively attributable to one specific cause because of the lack of pre-closure samples and the distance (~30 nm) between the areas. In general, more disturbance tolerant, opportunistic families dominated benthic communities in the Kettle, while more disturbance intolerant, sessile families dominated communities in the WGOMCA. It appears that the infaunal and epifaunal components of benthic communities most likely recover at vastly different rates in open and closed areas.

The Northeast Consortium has facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in June 2007. This project formed the basis of one graduate thesis and an article is in preparation for publication in scientific literature.

**Title:**
Comparison of environmental contaminants on Georges Bank and Stellwagen Bank

**Funding:**
2001 - $129,130

**Participants:**
Emily Monosson (Montague, MA), David Lincoln (GFWA), Angela Sanfilippo (GFWA), and over 14 commercial fishermen

**Summary:**
This project investigated the potential for contaminant-induced effects on reproduction and development in both nearshore and offshore cod. Heavy metals, polychlorinated biphenyls (PCBs), and organochlorine pesticides (including DDTs) were measured in cod livers, gonads, and sediments from Stellwagen Bank, Georges Bank, and Wilkinson Basin. In general, concentrations of most contaminants were found to be near or below detection limits in cod gonads. Several contaminants were detected in the cod liver including PCBs and DDTs. However, concentrations from Georges Bank were drastically lower than previously published data and below concentrations linked with reproductive or developmental toxicity in fish. Analysis of heavy metals suggests that the concentrations of metals measured in this study, except for cadmium, are within range of those previously reported in cod. The vast majority of polycyclic aromatic hydrocarbons (PAHs) and metals detected in sediments were below NOAA’s Threshold Effects Levels and chlorinated pesticides were below detection limits in the sediments. No one chemical was consistently detected at concentrations suspected of causing adverse effects in cod or their offspring. It would appear that levels of exposure to the chemical contaminants measured are unlikely to have had a considerable impact on the nearshore or offshore cod fishery.

The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in July 2006. The Council used the data for the EFH Omnibus Amendment. Project results have formed the basis of one article published in scientific literature.

**Title:**
Design, development, and field testing of an innovative circular net pen to be used to assess bycatch mortality of Atlantic cod at sea

**Funding:**
2006 - $25,000 (PD Award)

**Participants:**
James Sulikowski (UNE), Angela Cicia (UNE), Charlie Felch (F/V Lady Victoria; Seabrook, NH), Travis Ford (UNH), Nathan Furey (UNE), Joe Jurek (F/V Mystique Lady; Andover, MA), John Mandelman (NEA),

**Summary:**
This project designed and tested an innovative open net system to study discard mortality at sea. The fundamental design of the net pen consists of a collapsible spherical column that floats at the surface and is weighted down but suspended above the seafloor. The net pen measures 3.3 m in diameter with a maximum net sock height of 20 fathoms. The bottom of the pen is designed as a pot with an opening akin to the codend of a trawl net. This free-floating net is then tended by a fishing vessel which is anchored to and floats with the net. The net pen was tested for a 24 hour period in September 2007. During this experiment, 40 trawl caught cod were placed in the net. A video camera was inserted into the pen and cod were actively seen swimming within the net. Moreover, it appeared that individual cod were using the net at different depths to recover from the trawling process. During the deployment times, the structural integrity of the net was maintained, even when the sea wave-height increased to 2-4 foot for an extended period of time and with the tethering vessel anchored to the sea floor. This net would be the first of its kind to address discard mortality of trawled cod under natural conditions, generating data that could be directly considered by the Stock Assessment Review Committee within the NOAA Northeast Regional Stock Assessment Workshop process for the cod.
**Title:** Determining groundfish species movement patterns in closed areas, including the Western Gulf of Maine Closure Area  

**Participants:**  
W. Hunt Howell (UNH), Vincent Balzano (F/V North Star; Portland, ME), Carl Bouchard (F/V Stormy Weather; Exeter, NH), Jim Ford (F/V Lisa Ann II; Newburyport, MA), David Goethel (F/V Ellen Diane; Hampton, NH), Frank Mirarchi (F/V Christopher Andrew; Scituate, MA), and Mike Morin (UNH)  

**Summary:**  
Two cod tagging projects have been funded, one that examines the effectiveness of the western Gulf of Maine rolling closures as a management tool (FY2000) and another that focuses on cod movements in and around the WGOMCA (FY2002). Mark and recapture techniques were used for both.  

During the first project, 91 tagging trips were conducted, making 555 tows in the four rolling closure areas. A total of 17,860 cod were tagged, as well as 1,138 haddock, 840 American plaice, 79 pollock, 41 wolf fish, 28 yellowtail flounder, 12 winter flounder, and 7 gray sole. A total of 1,086 cod (6.1%) were recaptured with enough information (exact location and date of recapture) to be usable in the study. All data have been entered, and the analyses have been completed. Overall, movement of Atlantic cod in the western Gulf of Maine appears to be associated with spawning. In the spring, cod were observed to move from offshore areas and aggregate inshore (area 133) to spawn. Post-spawning movements began in June and were characterized as a general dispersion offshore away from the spawning grounds. Cod were again observed to move inshore for spawning in December-January, suggesting the possibility of two distinct spawning groups. These spawning events were each associated with movements in and out of area 133. To determine if these were two distinct groups or the same group spawning twice, average lengths of the three observed spawning groups (spring 2001, fall 2001-winter 2002, and spring 2002) were compared.  

Results showed that both the spring 2001 and 2002 groups had a significantly larger average size than the winter spawning group, suggesting that these are two different age groups of fish. Genetic analyses of these fish, conducted by Kovach et al. at UNH, indicate that the two spawning groups are genetically different.  

For the second tagging project, a total of 59 days, between July 2002 and June 2003, were spent collecting and tagging cod in the WGOMCA and adjacent areas. A total of 6,953 cod were tagged. Of these, 230 (3.3%) were recaptured prior to January, 2004. Days at large ranged from 0 (recaptured the same day) to 421. Most (76.8%) were recaptured within 120 days of being tagged and released. Data analyses include movement, length, and abundance statistics. Results suggest that cod movements in this area are associated with spawning and that the time/area (i.e. rolling) closures, as currently configured, are appropriate for protecting spawning aggregations. Spawning cod moved relatively short distances (most <30 km). A low number of cod were recaptured from the WGOMCA, presumably because commercial fishing is prohibited in the area. However, the data suggests that this is not an area where adult cod are particularly abundant and that it is not an important spawning area. Nevertheless, the WGOMCA may be an important nursery area for cod. If so, then the combination of rolling closures designed to protect spawning cod, and the closure of the WGOMCA that may benefit juveniles, is probably contributing to the recovery of cod in the western Gulf of Maine.  

Results from these projects formed the basis of a graduate thesis and one article published in scientific literature. The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in June 2006.

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**Title:** Effects of the Western Gulf of Maine Area Closure on groundfish populations in rocky habitats  

**Participants:**  
Ray Grizzle (UNH), David Berlinsky (UNH), Hunt Howell (UNH), Peter Kendall (F/V Miss Alicia; Portsmouth, NH), Michael Leary (F/V Lori B; Hampton Falls, NH), and Krystin Ward (UNH)  

**Summary:**  
This project was designed to provide preliminary data on juvenile groundfish populations in rocky habitats inside the WGOMCA compared to similar habitats outside but near the closure, and to assess gillnets as
sampling tools. Very little information exists on the effects of the Closure on fish populations in rocky areas because nearly all sampling has been done using trawls and mainly over soft-bottom areas with low vertical relief. Identical gillnets (two 300-ft panels per net, 4-in stretched mesh) were set over five days (2 - 7 October 2005) for ~24-hour soak intervals at five pairs of sites; i.e., on each day one site was fished inside the WGOMCA and one outside. Contrary to what was expected, most of the fish caught were adults, including cod up to about 50 lb. Total groundfish biomass was ~3.5x greater at sites inside the closure compared to those outside. Hence, although little was learned about the nursery function of the rocky habitats for juvenile groundfish, the data suggested that the Closure may be having a significant effect on groundfish populations, perhaps contributing to stock re-building. The data also indicated that gillnets can be an effective sampling tool in rocky habitats.

Based on the results of this study, additional funding was obtained from the Northeast Consortium in 2006 to use bottom tending, multimesh (5 cm, 10 cm, and 20 cm stretched mesh) gillnets to sample sites on rocky bottoms. A total of 44 paired “in vs. out” samples (44 sites inside and 44 sites outside of the closure) were taken from August 2007 to July 2008. Mean total groundfish (cod, haddock, pollock, and hake combined) abundance (catch-per-unit-effort data: #/net/day) was nearly 2x greater inside the WGOMCA, and biomass (kg/net/day) was approximately 3x greater inside compared to outside. Nearly all of the larger cod (individuals > 10 kg) and pollock (> 2 kg) were caught inside the closure, and only juvenile pollock were caught in appreciable numbers in any area. On an individual groundfish species basis, pollock showed the greatest in vs. out difference, with nearly 6x the biomass (kg/net/day) inside compared to outside of the closure. Cod had ~3x greater biomass inside and haddock had ~1.5 x greater biomass inside. These data strongly suggest that the WGOMCA is functioning as a refuge for all three major groundfish species, but likely only functions as nursery habitat for pollock. Moreover, the fish data corroborate earlier findings indicating recovery of benthic invertebrate communities in some areas. The project also demonstrated the utility of gillnets for fish sampling. The effectiveness of different mesh sizes aimed at sampling a wide range of size classes of fish, was also demonstrated. The almost exclusive use of otter trawls in research and stock assessment work badly needs to be improved upon. Sonar methods are emerging as a powerful tool but other methods are also needed to allow sampling in as many habitat types as possible.

The Northeast Consortium facilitated a technical evaluation of this project, the results of which were submitted to the NEFMC June 2010.

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**Title:**

*Evaluation of closed areas: Cashes Ledge as juvenile cod habitat*

**Funding:**

2005 - $281,374

**Participants:**

Jon Grabowski (GMRI), Craig Brown (DFO), Julien Gaudette (DFO), Jane Johnson (UNE), Chris McGonigle (University of Ulster), Graham Sherwood (GMRI), Robert Steneck (UMO), Bob Tetrault (Robert Michael; Portland, ME), Matthew Thomson (F/V Shearwater II; Monhegan, ME), Matthew Weber (F/V Griffin; Monhegan, ME), Tom Weber (UNH),

**Summary:**

In the Gulf of Maine, more information is needed to determine how marine protected areas such as the CLCA influence fish population dynamics and subsequently the status of fishery stocks. Video surveys and multibeam sonar were used to quantify current habitats on Cashes Ledge. Seasonal surveys were conducted in 2006 and 2007 on the kelp, barren cobble, and mud habitats in the vicinity of Cashes Ledge using video, trap, and gill net sampling to quantify how habitat influences the abundance and distribution of Atlantic cod, *Gadus morhua*. Seasonal surveys identified that cod are still abundant on Cashes Ledge; however, their spatial and temporal distribution on Cashes Ledge is influenced by habitat and other species such as spiny dogfish, *Squalus acanthius*. These results are being compared with historic cod datasets that were collected prior to the inception of the closure, and predate extensive harvesting on Cashes Ledge in the early 1990’s, to determine if cod populations have recovered locally. Quantifying important ecosystem functions such as the provision of nursery habitat for commercially important fish species will assist managers in selecting the most appropriate areas for management action. This study will also provide baseline information that will be of value to ongoing efforts to monitor the impact of the Cashes Ledge Closure Area on rebuilding cod populations.

The funding for this project was extended into FY2006. A final report for the remainder of the work will be submitted.
Title: Field testing of a novel application to examine habitat use and migration patterns of spiny dogfish

Funding: 2005 - $23,925 (PD Award)

Participants: James Sulikowski (UNE), Walter Bubley (UNH), Angela Cicia (UNH), Nathan Furey (UNH), Mike Joncovic (ME), Joe Jurek (F/V Mystique Lady; Andover, MA), Brittany Palm (UNH), Paul Tsang (UNH), Andy Wargo (UNH)

Summary: This project tested the feasibility of using satellite tag technology to track spiny dogfish movement in the Gulf of Maine. Two of the most important questions regionally, is whether or not spiny dogfish in the Gulf of Maine should be considered as part of the NW Atlantic stock and what areas of the Gulf of Maine are represent essential fish habitats for this species. Satellite tags offer a means to study the real time movement patterns and how an animal utilizes its environment. PTT-100 Archival popup x-tags were used to track dogfish movements. After several tagging procedure tests, the appropriate method for attaching the satellite was to actually drill into the base of the dorsal fin. The satellite tag was placed on the dogfish in the pilot study remained on the animal for 3 months, before the animal mysteriously died. In the field, three dogfish were captured by hook and line and individually strapped to a wooden gurney and held underwater in a designated on-board live well. After attachment of the tags in the field, each individual dogfish was monitored for 30 minutes. No outward signs of stress were observed and all specimens were released back to the Gulf of Maine.

This study provided new information vertical and horizontal movement data for *S. acanthias* in the western North Atlantic and shows the feasibility of the x-tag for use on small elasmobranchs. Three variations of state space Kalman filter and auxiliary depth data were used to produce the first estimates of dogfish at liberty in the northwest Atlantic Ocean. The data returned from the three dogfish generated tracks to show enough information to present an interesting trend in the horizontal movement patterns of this species. All three sharks appeared to move east into offshore waters after tagging and then into southern waters off the coast of New Jersey, USA. This is in contrast to previous studies using conventional tags. Diel depth patterns were interesting in that each shark appeared to be equally active during both the day and night.

Based on the results of the current study, it would appear that the smaller x-tag can provide useful information on the movement patterns of relatively small species of sharks. This study acted as the catalyst for follow-on work funded by the NOAA Saltonstall-Kennedy Grant Program. The use of these techniques may be expanded to determine whether or not spiny dogfish should be considered a unit stock in Gulf of Maine and the determination of EFH for this species.

Title: Genetic identification of Atlantic cod spawning stocks in US waters

Funding: 2004 - $25,000 (PD Award) 2005 - $432,866

Participants: David Berlinsky (UNH), Ted Ames (PERC), Timothy Bretton (UNH), Carl Bouchard (F/V Stormy Weather; Hampton, NH), Steve Cadrin (UMass SMAST), Jeff Carver (F/V Saint Joseph; Scituate, MA), Heather Deese (NAMA), David Goethel (F/V Ellen Diane; Hampton, NH), Jeremy King (MADMF), Adrianne Kovach (UNH), Ken La Valley (UNH), Matt Lubicky (UNH), Chris Odlin (F/V Lydia and Maya; Portland, ME), Lorraine Maceda (NYU), Frank Mirarchi (F/V Christopher Andrew; Scituate, MA), David Salerno (MADMF), Mark Szymanski (MADMF), Proctor Wells (F/V Tenacious; Phippsburg, ME) and Issac Wirgin (NYU)

Summary: The project development award created a collaborative partnership to determine the utility of specific genetic techniques for detecting significant differentiation between cod stocks in the region. Microsatellite and single nucleotide polymorphism (SNP) DNA analyses were tested on the specific question of differentiating Atlantic cod from Georges Bank (GB) and the inshore Gulf of Maine (GoM) - are cod in these two regions a single or two genetic stocks? Where possible, we further addressed the question of whether stock subdivisions exist within the GoM and south of GB. Unlike previous efforts, this study focused on actively spawning cod, with spawning state confirmed through analysis of gonad biopsies. Additionally, the focus was on spawning aggregations thought most likely to display genetic differentiation, based on the best available information regarding ecological differences, movements, and expected stock delineations, and within the constraints of collecting new samples during winter 2004/2005.
The sampling focused on winter-early spring spawning cod from GB and winter and spring spawning cod from inshore western GoM. Based on experience with genetic cod stock identification in Atlantic Canada, Europe, and recent work within U.S. waters, six informative microsatellite loci and three SNP loci (Pan I, AHR2, and ARNT2) were tested for distinguishing stock structure in this region. Two of the polymorphic SNP loci (AHR2 and ARNT2) were newly isolated and characterized in this project. The project also collected, recorded and synthesized information on the location and timing of cod spawning aggregations in the GoM, GB, and south of GB, as a resource for future collaborative research projects, including a broader, longer-term project to identify stock structure utilizing genetic techniques. Highly significant differences were found among many, but not all, stocks in this study. Cod from GB were significantly different from those collected in Ipswich Bay during the spring months, but not from those collected in the winter. Most interestingly, the spring collection from Ipswich Bay was significantly different from that made at the same location during the winter along with all other collections made in the study. Fish collected from wrecks off Long Island, New York, were significantly different from the GB collection, but not those from Chatham MA or Stellwagen Bank. In summary, for the first time a highly significant genetic difference has been demonstrated between a collection of spawning cod from GB and a collection of spawning cod from the inshore GoM. The genetic results support the morphological observations of stock differences between cod collected during the winter and spring months in Ipswich Bay.

A follow-up project, funded in 2005, further determined the level of genetic similarity among cod spawning aggregations throughout the GoM and GB. Ten microsatellite and 6 SNP markers were used to characterize the population genetic structure of cod in U.S. waters. We found significant differentiation among temporally and spatially divergent populations of cod (global $F_{ST} = 0.0044$, $G^*ST = 0.0144$), primarily stemming from two non-neutral loci, and strong evidence for a population structure that contradicts the current two-stock management model. Results indicate that cod in U.S. waters are broadly structured into three groups: 1) a northern spring spawning coastal complex in the Gulf of Maine (GOM), 2) a southern complex consisting of winter-spawning inshore GOM, offshore GOM and sites south of Cape Cod, MA, and 3) a Georges Bank population. The strongest differentiation occurs between populations in the northern and southern complex ($F_{ST} = 0.0054$ - 0.0156), some of which spawn in the same bays in different seasons. This population genetic structure is stable over a 5-year period. We suggest a model of population structure that is maintained by geographic and seasonal differences in larval recruitment and differential adult life history strategies; local ecological adaptations may also be important. Findings contribute to a growing body of knowledge that cod and other marine fish populations are structured on a finer scale than previously thought and that this structure supports biocomplexity and locally adapted populations. As such, it may be warranted to re-evaluate current management units and tailor management plans toward this finer scale.

Project results have formed the basis of one article published in scientific literature.

<table>
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<tr>
<th>Title:</th>
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<tr>
<td>Identification of life history parameters for two exploited skate species (Amblyraja radiata and Malacoraja senta) in the Gulf of Maine: Strategies for fisheries management</td>
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<table>
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<tr>
<th>Funding:</th>
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<tbody>
<tr>
<td>2001 - $200,000</td>
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<table>
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<tr>
<th>Participants:</th>
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<tr>
<td>Paul Tsang (UNH), Joe Jurek (F/V Mystique Lady; Andover, MA), and James Sulikowski (UFL)</td>
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<tr>
<th>Summary:</th>
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<td>The primary objective of the study was to foster a partnership between commercial fishermen and research scientists in order to quantify the life history parameters essential to the development of a fisheries management plan for the thorny skate, Amblyraja radiata, and smooth skate, Malacoraja senta, in the Gulf of Maine. For the thorny skate, we found that this species grows slowly (k=0.11 for males, and k=0.13 for females), is long lived (16+ years for both males and females), reaches sexual maturity at a late age and size (50% maturity occurs at a total length of 860 mm and near 11 years of age for males and a total length of 875 mm and around 11 years of age in females), and is reproductively active all year round. While the data for the smooth skate is still being analyzed, our results suggest that like the thorny skate, this species reproduces continuously throughout the year. More research will be needed to ascertain the essential fish habitats and movement patterns for these species.</td>
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Project results formed the basis of a graduate dissertation and seven articles published in scientific literature. The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in October 2006. The Council’s skate PDT are incorporating the information in their work, such as in the “Skate Annual Review,” presented to the NEFMC meeting in September 2006. The information will likely be used in upcoming groundfish assessments and revisions to management plans.
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<th><strong>Title:</strong></th>
<th><strong>Funding:</strong></th>
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<tr>
<td>Intensive study of the Western Gulf of Maine Closure Area</td>
<td>2002 - $204,340</td>
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<th><strong>Participants:</strong></th>
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<tr>
<td>Raymond Grizzle (UNH), Jason Driscoll (F/V Karen Lynn; Exeter, NH), Mark Dowell (UNH), Peter Kendall (F/V Miss Alicia; Rye, NH), Michael Lesser (UNH), Greg Mavrikis (F/V Marion Mae; Eliot, ME), Larry Mayer (UNH), Rob Robertson (UNH), Andy Rosenberg (UNH), and Larry Ward (UNH)</td>
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<th><strong>Summary:</strong></th>
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<td>This project was an interdisciplinary investigation of ecological and social issues related to the WGOMCA. It represented the initial stages of a longer-term program to determine various ecosystem-level impacts of the closure, and included gathering new and existing data from satellite imagery available on the web, multibeam sonar, direct sampling of the seabed, and public surveys. New maps are in production based on individual and combined datasets focused on a 400 km² (150 mi²) study area located along the western boundary of the closure area. At the time of final report submission, all data had not been analyzed, but four major conclusions were drawn. (1) Habitat types ranged from mud bottom in deep water (&gt;100 m) dominated by deposit-feeding infauna to hard bottom (gravel and boulders) in water &lt;80 m dominated by epifaunal organisms. (2) Some bottom characteristics and benthic community characteristics correlated strongly with water depth, suggesting that the new multibeam bathymetry map can be used to construct high-resolution maps of bottom habitat types. (3) Maps of some benthic community characteristics had patterns indicating substantial differences when comparing sites within to similar sites outside the Closure area. (4) Preliminary statistical analyses indicated significant differences for some infaunal and epifaunal benthic community characteristics for sites within the Closure compared to similar sites outside. Conclusions 3 and 4 suggest that there has been dramatic recovery of some habitat types in the 8 years since establishment of the Closure. Additional funds for the project were obtained from the NOAA/UNH CINEMAR.</td>
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The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC December 2008. Data has formed the basis of two articles published in scientific literature and a graduate thesis.

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<th><strong>Title:</strong></th>
<th><strong>Funding:</strong></th>
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<tr>
<td>Pilot project to test the use of side-scan sonar to identify seafloor features associated with pre-spawning and spawning cod aggregations</td>
<td>2005 – $24,988 (PD Award)</td>
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<th><strong>Participants:</strong></th>
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<tr>
<td>Kathryn Ford (MADMF), Seth Ackerman (USGS), Walter Barnhardt (USGS), Dan Blackwood (USGS), Olivia Free (MFP), Chris Hein (BU), Bill Hoffman (MADMF), W. Hunt Howell (UNH), Peter Marshall (F/V Venture; Essex, MA), Sam Novello (Commercial Fisherman; Gloucester, MA), and Mike Pol (MADMF)</td>
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<th><strong>Summary:</strong></th>
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<tr>
<td>It has been hypothesized that cod aggregate on an annual basis in the winter time in the Cod Conservation Zone managed area in Massachusetts Bay. Research conducted by the MADMF from December, 2005 to February, 2006 identified cod repeatedly in several specific locations. This data was corroborated by local commercial fishermen. The present study focused on determining if habitat characteristics were correlated to the site fidelity of cod. Using USGS multibeam datasets from the area and empirical information offered by commercial fishermen, sites with very similar habitats as measured by aspect, depth, and backscatter value but with contrasting cod site fidelity were identified. At these sites, correlations between cod presence and absence and seafloor characteristics (grain size, organic carbon content, and macrofauna) were analyzed using grab samples and still photos collected in June, 2006 aboard the F/V Venture. Cod were found at sites with significantly different habitats across the Cod Conservation Zone, but no seafloor features measured could be correlated to the presence or absence of cod.</td>
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This project contributed data to doctoral dissertation and was done in association with the USGS mapping of Massachusetts waters, which is a state-federal partnership. USGS provided equipment and personnel for this project. The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC January 2008.
Title: Spawning movements and habitat use of winter flounder in the southern Gulf of Maine

Funding: 2007 – $243,616

Participants:
Elizabeth Fairchild (UNH), Michael Armstrong (MADMF), Carl Bouchard (F/V Stormy Weather; Hampton, NH), Charles Felch, Sr. (F/V Lady Victoria; Seabrook, NH), David Goethel (F/V Ellen Dianne; Hampton, NH), Bill Hoffman (MADMF), Hunt Howell (UNH), Laughlin Siceloff (UNH)

Summary:
With the exception of fish in the Georges Bank stock, it is widely believed that adult winter flounder (*Pseudopleuronectes americanus*) move inshore into estuaries and coastal embayments to spawn. During February 1 through May 31, dredging is prohibited shallow waters ≤ 5 m to protect the sticky, demersal eggs. However, there have been many indications that this paradigm may not apply in the Gulf of Maine (GOM). To understand winter flounder spawning movements and habitat use in the southern GOM more clearly, 40 pre-spawning adult fish were acoustically tagged offshore and tracked in 2009. In addition, a bottom trawl survey was conducted in the offshore study area to quantify how the reproductive status of the general population changed over time. Peak spawning of winter flounder in Ipswich Bay occurred in late April to early May. Only six fish (16%) were detected entering estuaries between the end of April and August indicating that the majority of the tagged fish did not spawn in estuaries but remained in deeper, coastal waters. Surveys made within a NH estuary when one tagged female was present (May-June) revealed that all adults present had already spawned and were actively feeding.

As of September 2011, conventional tagging returns (395 fish tagged, 5% return rate) show both long and short movements. Fish have been recaptured approximately 0.6 to 57.2 km from their tagging sites in depths of 2 to 75 m. Days at liberty range from 33 to 453 days, with an average of 171 days. Spawning site fidelity is evident from inter-annual recaptures of tagged winter flounder. However, relocations of fish well outside of Ipswich Bay suggest mixing of populations of winter flounder is likely. Based on the results of this study, consideration should be given to extending EFH for GOM winter flounder eggs to deeper waters to protect the predominant coastal spawning populations.

Project results have formed the basis of two articles for scientific literature, one in preparation and one submitted.

Title: Trophic ecology of Atlantic cod: Insights from tri-monthly, localized scales of sampling

Funding: 2001 - $125,475
2002 - $76,250

Participants:
Frank Almeida (NMFS NEFSC), Theodore Ligenza (F/V Riena Marie; South Chatham, MA), Jason Link (NEFSC), and Brian Smith (NEFSC)

Summary:
The project examined the small scale variation of Atlantic cod feeding based upon tri-monthly stomach sample collections from a nearshore, localized region off Cape Cod, Massachusetts. The first objective was to relate any detectable changes in cod diet and amount of food eaten with changes in temperature, spawning, prey abundance, and major weather events, filling the information gap between broad scale and in vivo laboratory studies. The second objective was to work collaboratively with the fishing industry to transform anecdotal information into quantitative data. Results suggest that the amount of food eaten by cod is generally stable throughout the year, except when pelagic forage fish migrate through the area. This corresponds to critical periods in the life history of cod. The temporal variation in diet composition remained remarkably consistent each year over the 28-months of the project, suggesting important feeding periods for cod, which correspond to environmental and biological cues. The diet is comprised primarily of several species of forage fish (e.g. Atlantic herring, sand lance, Atlantic mackerel, ophiuroids, Cancer crabs, and other small crustaceans). Additionally, these results confirm the preference cod exhibit for prey such as herring, sand lance, and crabs. It is inferred that cod generally eat local forage fish and benthic macro-invertebrates and supplement their diet by gorge feeding upon migrating pelagic species.

The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC in July 2007. Project results have formed the basis of one article published in scientific literature.
# Social Science, Outreach and Education

<table>
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<tr>
<th>Title</th>
<th>Funding</th>
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<tr>
<td><strong>A fishing gear workshop by fishermen for non-fishermen</strong></td>
<td>2004 - $27,510</td>
</tr>
<tr>
<td><strong>Participants:</strong> Pingguo He (UNH), Erik Anderson (F/V Kris n’ Kev; Portsmouth, NH), David Goethel (F/V Ellen Diane; Hampton, NH), Joe Jurek (F/V Mystique Lady; Andover, MA), and Tom Lyons (F/V Marion J, Hampton, NH)</td>
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<td><strong>Summary:</strong> In the past decade, fishing gear and harvesting related issues have become topics among those who have interests in fisheries but are not commercial fishermen. This group of people includes federal and state scientists and scientists who work with fishermen in collaborative research projects, staff and volunteers working for various fishing and ocean related organizations, fisheries managers, representatives of conservation organizations, and staff who work for various committees, councils, commissions and Congressional delegations. While they have various strengths in their respective professions, a lack of knowledge about fishing gear and their operations is evident. This project organized a pilot three-day workshop for sixteen such participants so that they will have a better understanding of fishing gear, operational methods, and conservation issues of commercial fishing gear used in New England. The workshop was primarily instructed by active commercial fishermen with at-sea and on-the-dock components. Two trawl skippers and two gillnet skippers were involved in instruction, discussions, practical demonstrations of gears, and fishing demonstrations at sea. Very positive feedback was received from the participants. A second workshop of a similar nature was conducted during the summer of 2006. It was organized by NHSG and funded by NMFS NCRPP. Since 2004, 59 individuals have participated in the workshops.</td>
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<tr>
<td><strong>Adopt-a-Boat: Commercial fishing vessels in K-12 education</strong></td>
<td>2001 - $193,000</td>
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<tr>
<td><strong>Participants:</strong> Cliff Goudey (MITSG), Phil Averill (Ocean Adventure!, Inc.; Bristol, MA), Kenneth Ekstrom (MITSG), Dean Goodwin (Kimbball Union Academy; Meriden, NH), Robert Groman (WHOI), Robert Kohl (F/V Glenna and Jacob; Marston’s Mills, MA), Grace Lee (MITSG), Cameron McLellan (F/V Adventurer; Portland, ME), Brandy Moran (MITSG), and Craig Pendleton (NAMA)</td>
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<td><strong>Summary:</strong> The Adopt-a-Boat program is a collaboration between the MITSG, the fishing industry, and several individuals and organizations involved in education and outreach. The goal is to use commercial fishing boats as a vehicle for teaching the complexities of marine resource utilization, marine ecology, and life as a fisherman to K-12 students. By offering this program, authentic learning opportunities are provided to students. A balanced picture of commercial fishing is presented, helping to build an enlightened citizenry regarding marine resource utilization and its importance to coastal communities. During year one of Adopt-a-Boat, ten classroom/vessel partnerships were built and their collaborative activities were supported with state-of-the-art technologies. A variety of approaches were used to inquiry-based learning and curricula and lesson plans were developed that follow national and state educational frameworks. The project received continued funding from the Northeast Consortium in 2002, which expanded the Adopt-a-Boat program significantly and evaluated the curricula developed in year one. Since its initiation, Adopt-a-Boat has grown into a region-wide program involving approximately 50 fisherman/classroom partnerships in four New England states. Based on its success, new Adopt-a-Boat programs have been formed or are being developed in three other locations across the country. To date, over 2,000 school children have benefited from the program.</td>
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Title: An atlas based audit of fishing territories, local knowledge, and community participation in fisheries science and management

Funding: 2001 - $168,953

Participants:
Kevin St. Martin (Rutgers University), Rodney Avila (F/V Trident; New Bedford, MA), Tove Bendickson (S. Dartmouth, MA), Tom Brancaleone (Commercial Fisherman; Gloucester, MA), Rene Gagne (Chatham, MA), Ellen Goethel (Hampton, NH), Madeline Hall-Arber (MITSG), Jim Kendall (Commercial Fisherman; New Bedford, MA), Jen Levin (NAMA), Jay Michaud (F/V International Harvester; Marblehead, MA), Joe Orlando (F/V Padre Pio; Gloucester, MA), John Pappalardo (CCCHFA), Steve Robbins III (Stonington Lobster Cooperative; Stonington, ME), Rob Snyder (Commercial Fisherman; Rockland, ME)

Summary:
The purpose of this project was to produce a digital atlas and Geographic Information Systems (GIS) database for the Gulf of Maine and Georges Bank. The atlas, focuses on the social geography of the region and was produced in cooperation with fishermen and community-based researchers. Areas of primary fishing effort by communities were mapped and characterized using NOAA Fisheries data. These maps then formed the basis for interviews with fishermen who work in the locations defined by the maps to verify and correct the maps and to assess the range of environmental information available from fishermen and the conditions under which they are willing to share this information. Data demonstrates that there are distinct and consistent “territories” of use by fishing communities and/or gear sectors. In addition, fishing communities utilize and maintain significant local knowledge about such locations. This project documents these findings in the form of detailed maps and interview narratives. The result is a valuable resource for both fisheries managers/scientists and fishing communities.

The project has produced seven articles in scientific literature. The interim final report and the articles were shared with ASMFC and NEFMC in January 2009. The Northeast Consortium has facilitated a technical evaluation of the project, the results of which were submitted to ASMFC and NEFMC March 2010.

Title: Charting anecdotal information and oral histories on Stellwagen Bank from local commercial fishermen

Funding: 2004 - $84,550

Participants:
Madeline Hall-Arber (MITSG), Christian Adams (MIT), Ed Barrett (F/V Phoenix; Marshfield, MA), David Bergeron (MFP), Dave Casoni (Commercial fisherman; Plymouth, MA), Bill Crossen (Commercial fisherman; Gloucester, MA), Tom DePersia (Commercial fisherman; Marshfield, MA), Olivia Rugo Free (MFP), Jay Michaud (F/V International Harvester; Marblehead, MA), Phil Michaud (F/V Susan C III; Provincetown, MA), Judith Pederson (MIT), and Rhonda Ryznar (MIT)

Summary:
The goal of this project was to document the extent and value of fishing activities on Stellwagen Bank over three decades and to see how this may have changed over time. Specific objectives were to involve fishermen in the data collection, charting and analysis in order to tap into their local knowledge and experience; to develop charts that depicted seasonal fishing grounds by gear sectors, target species, economic value, and sea floor characteristics on Stellwagen Bank; and to build working relationships among the commercial and recreational fishing and scientific communities.

High-resolution charts were developed that depict seasonal fishing grounds by gear sectors and target species. Interviews elicited information about the significant economic value of fishing on the Bank to multiple fishing sectors and obtained some information about sea floor characteristics. The project found that the combination of charts and interviews were an extremely valuable, non-threatening method to obtain and present information of interest to both the fishing industry and to managers. Finally, the project accomplished the goal of documenting the patterns associated with three decades of the use of Stellwagen Bank by commercial and recreational fishermen. That clusters and patterns could be discerned for the different gear groups and target species suggest that the information recorded was accurate.

The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC and ASMFC in December 2008.
Title:
Employment, income, working conditions and vessel safety in New Bedford before and after Amendment 13 to the Multispecies Fishery Management Plan

Funding:
2005 - $102,731

Participants:
Daniel Georgianna (UMASS Dartmouth), Debra Shrader (Shore Support), and over ten industry members

Summary:
This project studied the recent socioeconomic impacts, within New Bedford, Massachusetts, of implementing Amendment 13 to the Multispecies FMP, a major, regional groundfish management plan. Data was collected from fishing crews, settlement houses, and the NMFS NEFSC. This study offers evidence that supports the economic decline for New Bedford’s dragger fleet that the Environmental Impact Statement the Amendment predicted would result from a 40% reduction in Days At Sea per year. There was a decline in the number of vessels and fishermen’s income between 2003 and 2005 and an increase in hours of work per watch between 2004 and 2006. It cannot be concluded, however, that Amendment 13 was the sole cause of these changes because other factors, such as stock characteristics, operating costs, and fish prices, were not considered in the analysis. While trends in accidents since the start of Amendment 13 were not estimated, fishing continues as a very dangerous occupation. Almost every crew reported some accident while fishing over the past 10 years, and 16 % of the sample of crewmen interviewed had survived a sinking. Twenty-seven percent of the sample said that they suffer from some chronic injury. Thirty of 45 crews responded positively to the question “Do you feel that the provisions of Amendment 13 have caused you to make decisions that reduced your safety?” On the brighter side, almost all of the crew members we interviewed in 2006 reported that they have attended safety courses within the last two years.

The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the NEFMC and ASMFC in December 2008.

Title:
Institutionalizing social science data collection

Funding:
2001 - $113,700

Participants:
David Bergeron (MFP), Jennifer Brewer (Clark University), Nancy Colbeth (Beals Island, ME), Madeline Hall-Arber (MITSG), Bonnie McCay (Rutgers University), Jay Michaud (F/V International Harvester; Marblehead, MA), Sarah Robinson (Harvard University), and Lahny Silva (BU)

Summary:
This project explored the potential for community-based data collection and analysis to help address the scarcity of social science data on the fishing industry and fishing communities. Community panels were established for Jonesport/Beals Island, Maine and Gloucester and the South Shore, Massachusetts. Each panel was comprised of 10 to 12 individuals, a cross section of harvesters, processors, shore-side businesses, and other members of the fishing communities. The groups identified issues of concern to their ports, and with the help of coordinators and the PIs, gathered data through interviews and focus group meetings, and drafted and reviewed reports.

A major goal was to provide management agencies with information about the potential impacts of regulatory changes on fishing communities so that adverse impacts could be mitigated. Consequently, each of the Panels reported on the potential impacts of Amendment 13 to the Multispecies FMP and the Panels in Massachusetts reported on the economic needs of both their fleets and shore-side businesses to a Governor’s Seafood Task Force. Another goal was to establish a community-based, participatory and on-going research platform in each of the communities, and the Panels can be and have been reconvened for special topics, such as the environmental justice focus group of the Beals Island Panel.

One of the issues of major concern raised in each of the panels was the status of the fishing industry infrastructure. Elements that each panel considered essential for the sustainability of their industry were considered. The panels also documented some of the benefits of the industry to their communities, as well as the threats or constraints on their continued viability. The understanding of infrastructure and its continued importance to both the fishing fleets and the communities, now and in the future when fishing stocks have
rebuilt, has influenced harbor planning in Gloucester, and helped preserve infrastructure and access in Plymouth, Cohassett and Swampscott.

Other results that have already been used to support “fishing-industry friendly” decisions in various communities are:

- Information provided in the Gloucester Harbor Planning process formed the basis for the preservation of fishing industry infrastructure and access in the working harbor.
- The only lobster pound and docking access for 30 lobster vessels in Cohassett, MA was retained.
- Commercial vehicle parking access for 150+ fishermen in Plymouth, MA was retained.
- Retained waterfront access to a net hanging facility for 12 gillnet fishermen in Swampscott, MA.
- Provided a report and recommendations to the Governor’s Seafood Task Force on the distribution of $5.5 million in federal disaster assistance funding in 2002.

Among the initiatives emerging from the Community Panels Project are:

- A project promoting safety training and incentives, funded by the NOAA CRPP, results expected in 2007.
- MFP is utilizing project data in strategic planning to develop appropriate responses to needs such as: fishing industry characterization; data on the infrastructure in 52 Massachusetts fishing ports for municipal, state, and coastal zone planning; improving the market for locally harvested seafood through labeling; utilizing best safety practices to lower insurance and labor time costs; and expansion of health insurance for fishing families in other states.

In 2003, the Saltonstall-Kennedy program funded a companion project that formed three Community Panels in Portland, ME; New Bedford, MA; and Pt. Judith, RI. Reports for both projects are accessible on the web at www.mass-fish.org. Two articles are in preparation for publication in scientific literature. The Northeast Consortium facilitated a technical mail evaluation of this project, the results of which were submitted to the ASMFC and NEFMC in March 2008.

Title: Marine Resource Education Project (MREP)

Funding:

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<tr>
<th>Year</th>
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<td>2001</td>
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<tr>
<td>2002</td>
<td>$232,092</td>
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<td>2003</td>
<td>$142,714</td>
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<td>$197,518</td>
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<td>$113,562</td>
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<td>2006</td>
<td>$100,000</td>
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Participants:
Mimi Larsen-Becker (UNH), Laura Taylor Singer (GMRI), John Coon (UNH), David Goethel (F/V Ellen Diane; Hampton, NH), Andy Rosenberg (UNH), Mary Beth Tooley (East Coast Pelagics’ Association), and John Williamson (Industry representative; Kennebunk, ME)

Summary:
The objective of the Marine Resource Education Project (MREP) is to take bring fishermen, scientists and managers together into a neutral setting to build trust and positive respectful relationships by exploring their common goals and their differences away from the pressure of the regulatory process. The program involves participants from the commercial fishing industry, conservation and nonprofit organizations, and state and federal governments in bi-annual six-day intensive seminars on the science and management of the fisheries resource in New England. The curriculum provides a baseline of information about the marine ecosystem and their respective communities. Since the spring of 2002, MREP has held a total of twelve 6-day courses, about every six months, involving over 300 marine resource professionals to date, including over 190 commercial fishermen.

Tangible results from the project include: improved communication among stakeholders, the development of fishermen-scientist research partnerships, more effective participation of fishermen in fisheries science and management, improved problem solving skills, and increased trust and resource stewardship amongst stakeholders. In the early years, MREP was administered at UNH, but continued in 2005 and 2006 at GMRI. MREP continues with funds from the Northeast Consortium in 2007 and other sources.
Title: Movement of New England Multispecies vessels and crew
Funding: 2003 - $63,535

Participants:
Jennifer Brewer (Clark University), David Bergeron (MFP), Cheryl Briscoe (Homeward Bound Co., Inc.), Don King (F/V Scotia Girl; Gloucester, MA), Gina LeDuc-Kuntz (F/V Resurrected; Freeport, ME), Nina Groppo (MFP), Sarah Robinson (Harvard), Christine Sherman (F/V Lady Jane; Gloucester, MA), Jim Wilson (UMO)

Summary:
This project examined patterns of mobility and immobility in two sets of New England fishing businesses involved in the multispecies groundfishery: those with vessels for which Gloucester, Massachusetts was principal port in 2003, and those with vessels for which Portland, Maine was principal port in 2003. In addition to patterns of mobility and immobility, the project examined social structures and practices that may influence related business decisions. Scientific and fishing industry collaborators collected and analyzed quantitative and qualitative data pertaining to these questions through interviews conducted with random samples of industry members in the two ports. Years of research interest were primarily 1983-2004.

During the time period studied, groundfish permit holders with Portland as their home-port have maintained core business operations locally, with limited use of ports outside Maine. It is possible that some changes are occurring within this pattern. Crew followed somewhat more varied patterns with respect to place-based decision making. In Gloucester, the analytical unit was fishing business, defined as an individual or group of individuals owning and controlling a vessel or set of vessels. The structures of these businesses in 2003 and their fishing and mobility strategies in 2003 are explored and described. Findings indicate that about one-half the businesses in Gloucester in 2003 did not use mobility as a strategy in 2003. Those using mobility as a strategy, however, appeared to be doing so as a means of maintaining a kind of fixity, that is, as a means of remaining as a groundfishing business in Gloucester.

The Northeast Consortium has facilitated a technical evaluation of this project, the results of which were submitted to ASMFC and NEFMC March 2010.

Title: Workshop on trawl selectivity and conservation
Funding: 2001 - $24,885
2002 - $41,691
2003 - $24,992
2004 -

Participants:
Pingguo He (UNH) and about 100 commercial fishermen, scientists, and others (68% were commercial trawl fishermen)

Summary:
Between December 2001 and May 2010, six custom-designed trawl gear workshops were held at the Center for Sustainable Aquatic Resources of Memorial University of Newfoundland. Groups of eleven to twenty people from the commercial fishing industry, Sea Grant, and state and federal agencies from the three states around Gulf of Maine participated. The five-day workshops were based at the world’s largest fisheries flume tank, at the university, where various trawl gears and components are demonstrated and examined. Demonstrations focused on gear performance and conservation, such as selectivity grids and seabed-friendly trawls. The workshops enhanced participants’ knowledge of trawl gear and stimulated interest in engaging in collaborative research related to trawl gear selectivity in the Gulf of Maine. The workshops have been well received by the participants and have resulted in several collaborative project proposals.
## Definition of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AOLA</td>
<td>Atlantic Offshore Lobstermen's Association</td>
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<td>ASMFC</td>
<td>Atlantic States Marine Fisheries Commission</td>
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<td>BU</td>
<td>Boston University</td>
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<tr>
<td>CCCHFA</td>
<td>Cape Cod Commercial Hook Fishermen's Association</td>
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<tr>
<td>CINEMAR</td>
<td>Cooperative Institute for New England Marine Fisheries and Aquaculture</td>
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<tr>
<td>CLCA</td>
<td>Cashes Ledge Closed Area</td>
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<tr>
<td>COMPASS</td>
<td>Communication Partnership for Science and the Sea</td>
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<tr>
<td>DLA</td>
<td>Downeast Lobstermen’s Association</td>
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<td>EFH</td>
<td>Essential Fish Habitat</td>
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<td>FMP</td>
<td>Fishery Management Plan</td>
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<td>GFWA</td>
<td>Gloucester Fishermen’s Wives Association</td>
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<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
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<td>GOMOOS</td>
<td>Gulf of Maine Ocean observing System</td>
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<td>GPA</td>
<td>Global Positioning System</td>
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<td>GMLF</td>
<td>Gulf of Maine Lobster Foundation</td>
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<td>GMRI</td>
<td>Gulf of Maine Research Institute</td>
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<td>IOOS</td>
<td>Integrated Ocean Observing System</td>
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<td>MADMF</td>
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<td>MELA</td>
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<td>MESG</td>
<td>Maine Sea Grant</td>
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<td>Massachusetts Fishermen’s Partnership</td>
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<td>MIT</td>
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<td>MITSG</td>
<td>Massachusetts Institute of Technology Sea Grant College Program</td>
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<td>MPAs</td>
<td>Marine Protected Areas</td>
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<td>NAMA</td>
<td>Northwest Atlantic Marine Alliance</td>
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<td>New England Aquarium</td>
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<td>NEFSC</td>
<td>Northeast Fisheries Science Center</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<td>NMFS</td>
<td>National Marine Fisheries Service</td>
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<td>NYU</td>
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<td>PDT</td>
<td>Plan Development Team</td>
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<td>PERC</td>
<td>Penobscot East Resource Center</td>
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<td>ROV</td>
<td>Remotely Operated Vehicle</td>
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<td>SMAST</td>
<td>School of Marine Science</td>
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<td>Southern Maine Community College</td>
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<td>The Nature Conservancy</td>
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<td>University of Florida</td>
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<td>University of Massachusetts</td>
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<td>University of Maine at Orono</td>
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<td>USGS</td>
<td>United States Geological Survey</td>
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<td>USM</td>
<td>University of Southern Maine</td>
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<tr>
<td>WHOI</td>
<td>Woods Hole Oceanographic Institution</td>
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<td>WGOOMCA</td>
<td>Western Gulf of Maine Closure Area</td>
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