Integrating Seafloor Mapping & Benthic Ecology Into Fisheries Management in the Gulf of Maine

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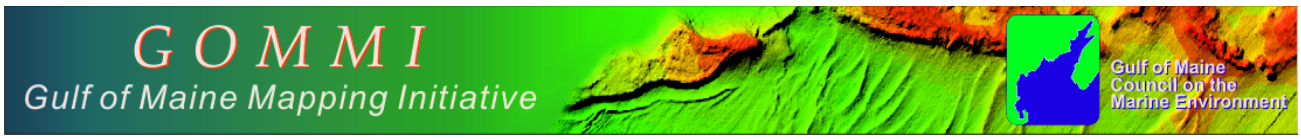

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FUNDING:

- Maine Sea Grant College Program
- Massachusetts Institute of Technology (MIT) Sea Grant College Program
- New Hampshire Sea Grant College Program
- Woods Hole Sea Grant College Program
- National Oceanic and Atmospheric Administration (NOAA) Office of Atmospheric Research (OAR) and National Marine Fisheries Service (NMFS)
- U.S. Geological Survey
- Maine Coastal Program

STEERING COMMITTEE:

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Support:

- Gulf of Maine Research Institute
- Gulf of Maine Council on the Marine Environment

Sea Grant

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This publication was made possible through the support and funding contributions of the Gulf of Maine Council on the Marine Environment, the Northeast Regional Sea Grant College Programs, National Oceanic and Atmospheric Administration Awards #NA07NMF4630157 and #NA06OAR4600185, U.S. Geological Survey, Gulf of Maine Research Institute, and Maine Coastal Program. The Gulf of Maine Council on the Marine Environment was established in 1989 by the Governments of Nova Scotia, New Brunswick, Maine, New Hampshire, and Massachusetts to foster cooperative actions within the Gulf watershed. Its mission is to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations.

Gulf of Maine Council on the Marine Environment

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Integrating Seafloor Mapping & Benthic Ecology Into Fisheries Management in the Gulf of Maine

EXECUTIVE SUMMARY

This workshop focused on current and future applications of seafloor mapping for fisheries management in the Gulf of Maine. Thirty-five fisheries scientists and managers, geologists, and benthic ecologists met at the Gulf of Maine Research Institute on April 15-16, 2009 to examine ways that seafloor geophysical and habitat maps can be integrated with ecological and fisheries research data in order to address pressing fisheries management priorities in this region. The workshop was convened by the Gulf of Maine Research Institute (GMRI) and Gulf of Maine Mapping Initiative (GOMMI) with funding and contributions from the Maine, New Hampshire, Woods Hole, and MIT Sea Grant College Programs; NOAA National Marine Fisheries Service and Office of Atmospheric Research; U.S. Geological Survey; Gulf of Maine Research Institute; Maine Coastal Program; and Gulf of Maine Council on the Marine Environment.

This two-day workshop brought fisheries managers and scientists together with the mapping community in a unique opportunity to collectively explore how seafloor maps can be used to address regional fisheries management objectives (Objective 3 & 4). Introductory presentations provided perspectives from the fisheries management, fisheries science, and seafloor mapping communities on current and potential uses of seafloor mapping data in regional fisheries management (Objective 1 & 2). Case-study presentations provided examples from coastal and offshore locations throughout the Gulf of Maine and Georges Bank of practical efforts to integrate fisheries management, seafloor mapping, and benthic ecology (Objective 1). A subset of these presentations is available on-line (see links below). In two breakout sessions, participants identified the specific opportunities and barriers that must be addressed to enhance the use and efficacy of seafloor mapping for fisheries management in this region (Objective 3).

Throughout the workshop, the presentations provided insights regarding the utility of the different techniques and types of maps for current and emerging ecosystem-based approaches to fisheries management (Objective 1). Three of the most common methods used for substrate and/

Objectives

1) Summarize the status of seabed mapping & its current use in regional fisheries management

2) Define the importance and potential uses of seabed geophysical and habitat maps in Gulf of Maine fisheries management

3) Convene fisheries managers and benthic and fisheries scientists to collectively define priorities (and obstacles) for applying seafloor substrate and habitat maps in Gulf of Maine fisheries management

4) Enhance communication and collaboration between mapping, fisheries research, and management entities

or fish habitat mapping purposes include underwater imagery or video, multibeam acoustic swath sonar, and sidescan sonar, although uses of other techniques are emerging such as Light Detection and Ranging (LIDAR) and airborne hyperspectral imaging systems (see presentation by Dr. Tom Weber for more information about each technique). Presenters and participants discussed the advantages and disadvantages of using these various technologies to serve the purposes of fisheries managers. Dr. Craig Brown pointed out that, while there is no absolute or standardized methodology for mapping benthic habitats, nor likely to be one anytime soon, one of the advantages of multibeam and sidescan sonar surveys is that they provide 100% swath coverage, whereas maps based on video and grab samples require extrapolating from a limited number of point samples. However, several participants noted that video surveys can be used effectively to map the bottom when applied rigorously (e.g., see the SMAST video survey by Harris and Stokesbury, p. 20). Moreover, Dr. Brown noted that these different approaches are often complimentary because video and grab surveys enable scientists to groundtruth the seabed classifications derived from acoustic backscatter analysis.

Participants also focused on the types of maps and map products that would be of greatest use to fisheries management. In his presentation on how to make maps that are useful to fisheries management, Dr. Page Valentine (USGS) motivated discussion around whether a single map is capable of combining the geological, biological, and other information necessary to define Essential Fish Habitat (EFH) and assess its vulnerability for a managed species, or if scientists and managers should be developing several thematic maps that focus on different factors that determine a species' distribution. The less comprehensive nature of thematic maps could potentially make them easier to produce and interpret. For example, a geological substrate map could be used to predict a species' distribution if specific geological substrate requirements are known, whereas a seabed ruggedness map could be used to determine habitat accessibility to specific gear types. Meanwhile, a seabed disturbance map along with the above two types of maps might collectively be used to assess habitat vulnerability and design management areas. Furthermore, fisheries scientists could overlay fish survey data on each of these types of maps to examine fish habitat associations in the context of geological substrate, seabed disturbance, etc. This approach highlights the need for significantly improved and formalized communication between the seafloor mapping, ecology, and fisheries management communities since different types of maps could be developed by each community. Participants also noted that mapping products in general would be greatly enhanced by including the level of uncertainty of the data, scale, resolution, and its appropriate uses for managers.

Overall, the workshop revealed how seafloor geophysical and habitat information could be utilized more effectively in fisheries management in the U.S. and Canadian waters of the Gulf of Maine as fisheries management systems evolve in the direction of ecosystem-based management approaches (Objective 2). Three general areas were highlighted: (1) assessments of the vulnerability of seafloor habitat features to fishing or other impacts, (2) identification of essential fish habitat (EFH), including the use of area closures to protect EFH, and (3) integration of habitat information into fishery stock assessment models.

The participants of the workshop determined that existing seafloor data from high-resolution acoustic multibeam surveys would be of greatest immediate use to the New England Fishery Management Council (NEFMC)'s Habitat Plan Development Team (Habitat PDT). Presently, benthic habitat data from the Gulf of Maine, Georges Bank, and the northern portions of the

Mid-Atlantic Bight are being used by the Habitat PDT to develop a spatial model that compares the geographic distribution of vulnerable benthic habitats with patterns of fishing gear use. The goal is to provide the NEFMC with a tool for evaluating the effects of fishing gear on EFH. This assessment will also provide insights on the effects of area-based fishing restrictions and gear modifications on seafloor habitat.

Members of the Habitat PDT attending the workshop noted that their assessment of the vulnerability of seafloor habitat to fishing impacts is hampered by a lack of substrate information, especially in the Gulf of Maine. While existing video survey and sediment grain size sample data were used to map habitat types as a part of the assessment, high-resolution acoustic seabed data were not. Workshop participants identified that information from multibeam acoustic surveys was not used in the assessment of fishing impacts on habitat, in part, because the data have not been made readily available and don't exist region-wide at a scale that is applicable to fisheries management. However, multibeam bathymetry and, in some cases, interpretive maps now exist for many of the prominent ledges and banks in the Gulf of Maine, including portions of Jeffreys Ledge, Stellwagen Bank, Cashes Ledge, Fippennies Ledge, and Platts Bank. Participants recommended that, as an outcome of this meeting, the workshop organizers convene a working group to inventory and evaluate existing seafloor datasets to determine which could be used for current and future efforts by the Habitat PDT. Inconsistent data collection (i.e., variable calibrations and resolutions) and a lack of groundtruth data (needed to adequately interpret substrate types from acoustic backscatter data) were noted as key factors currently limiting the usefulness of acoustic data for habitat vulnerability assessments and other efforts. Participants concluded that identifying standardized procedures for collecting, groundtruthing, and processing multibeam data would help achieve the longer term goal of making acoustic data more readily available for use in fisheries management initiatives.

It was noted that habitat data were not used by the NEFMC in 1998 to map EFH. Instead, the Council relied on a long time series of survey data to define areas with high catch rates of each managed species and life stage, on the presumption that there is a correlation between numbers of fish and habitat quality. Similarly, seafloor substrate and habitat data were not used in designing management measures to minimize the adverse effects of fishing on habitats. However, several of the case-studies at the workshop demonstrated how acoustic and video seafloor data have been utilized effectively by scientists to examine fish habitat associations for federally managed species. It was noted that many of these and other fish habitat studies in the Gulf of Maine were conducted recently, and therefore may benefit future efforts by fishery managers to redefine EFH.

Acoustic and video data were not available when many of the fishery closure areas in the Gulf of Maine and Georges Bank were designated in the 1990's. Acoustic seafloor information now exists for portions of the Western Gulf of Maine and Cashes Ledge Closure Areas, as well as the Stellwagen Bank National Marine Sanctuary. Video data are now available for much of Georges Bank and southern New England, and encompass the fishery closures in this region. These data, combined with fish biology and groundtruth data (e.g., photography and direct sampling), are currently being used by scientists to study fish habitat associations in these closure areas. It is envisioned that relevant results from these studies will be made available to fisheries managers in

order to enhance their ability to manage the closure areas. This would be a positive step in addressing a key issue pinpointed during the workshop: area closures displace fishing effort into open access areas, but the existing substrate data is not always adequate for understanding the habitat consequences of these shifts in effort.

The lack of seafloor acoustic and groundtruth habitat information for this entire region is a serious impediment to ongoing and future efforts to designate EFH and design effective closures. Specifically, the lack of comprehensive high-resolution habitat information impedes managers' ability to assess the efficacy of the current closures, examine their boundaries, and determine if and where current closures need to be maintained or additional closures need to be designated. Similarly, only limited habitat information exists for several of the Habitat Areas of Particular Concern (HAPCs) that were were approved in 2006 and 2007 through Phase I of the NEFMC's second EFH Omnibus Amendment. One of the longer term needs identified by the workshop participants is to develop a comprehensive set of high-resolution geophysical and interpretive maps based on acoustic and groundtruth survey data for the Northeastern U.S. region.

Members of the workshop commented that the primary vehicle by which fisheries are managed currently is through the use of stock assessment models to assess biological reference points such as maximum sustainable yield or total allowable catch for fish stocks and fisheries. These models currently do not contain habitat parameters, and therefore, current stock assessments do not include fish habitat association data or assess the importance of habitat to stocks. Incorporating the importance of habitat features into a stock assessment model would require what the NOAA guidelines for implementing the Magnuson Fishery Conservation and Management Act (MFCMA) refer to as Level III or IV EFH information (i.e., information that identifies habitats where growth and survival are high, or habitats that enhance resource productivity). One component of developing Level III and IV EFH information is identifying the locations of habitats that enhance resource productivity, growth, and survival through a more holistic set of habitat classification maps produced at the scale at which stocks are managed. Developing such maps would require greatly increased acoustic survey coverage, corresponding groundtruth surveys, data processing, and the development of maps that display this information spatially. Finally, developing Level III and IV EFH information would involve coupling habitat information with fish habitat use data. The current lack of Level III and IV EFH data and comprehensive high-resolution seafloor maps makes it unlikely that acoustic seafloor information will be of use to stock assessment models in the near future. Several workshop participants suggested proxies to provide fisheries managers with habitat information while funding for comprehensive seabed mapping in the U.S. Gulf of Maine is lacking. For example, a habitat template model presented by Vladimir Kostylev predicts the locations of species with specific life history traits utilizing existing oceanographic data to assess habitats according to their vulnerability to disturbance and fish productivity. One of the long-term goals identified at the workshop is to develop a more quantitative understanding of biological and geological seafloor characteristics through improved mapping and targeted research in order to develop EFH information that could eventually be used in stock assessment models.

Scientists and managers at the workshop discussed seafloor mapping priorities in the Gulf of Maine (Objective 3). Members of the workshop agreed that, while it is important to understand

seafloor data priorities for fisheries management, the impetus to undertake future acoustic mapping efforts for the remaining portions of the Gulf of Maine is not likely to come from fisheries managers alone. Therefore, participants concluded that a wider conversation about mapping priorities is needed, which incorporates the range of environmental, ecological, and socioeconomic concerns associated with habitats of the Gulf of Maine. Related to this need, the Gulf of Maine Mapping Initiative convened a meeting among federal and state managers, planners, and scientists on May 22nd, 2009 to develop a list of seafloor mapping priorities that accommodates a range of marine spatial planning needs in the New England region (e.g., fisheries science, wind energy, offshore oil exploration, navigation, etc.). GOMMI submitted the resulting list of regional seafloor mapping priorities to U.S. Senators on behalf of the New England states, fulfilling a request for information related to a federal appropriations request to support seafloor mapping in top priority areas throughout New England.

At the workshop, participants discussed the possibility of convening a second workshop that integrates mapping needs more broadly into an ecosystem management context. Four members of the workshop (Jonathan Grabowski, Brian Todd, Page Valentine, and Tracy Hart) are currently organizing a Technical Workshop at the upcoming Gulf of Maine Symposium in St. Andrews in early October 2009 on *Seafloor Mapping for Ecosystem Management in the Gulf of Maine*. Participants at the workshop identified a variety of next steps that could be utilized to catalyze better integration of seafloor mapping, benthic ecology, and fisheries management in the Gulf of Maine region. Several ideas included publishing in industry magazines; producing an introductory chapter for NEFMC documents; publishing a workshop technical report; developing a marketing talk; and marketing examples that demonstrate the utility of habitat maps. Participants at the workshop also articulated that there would be value in synthesizing the current state of knowledge regarding the role of seafloor mapping in fisheries management, and a number expressed interest in working with others to develop a peer-reviewed manuscript. The co-organizers of the workshop are currently organizing interested participants to work on this manuscript. The article will discuss the current status of seafloor mapping and identify what is needed to manage fish habitat more effectively. It will also clarify and illustrate the characteristics of effective versus poor quality seafloor maps for fisheries management.

The final objective (4) of the workshop involved enhancing collaboration and communication between mapping, fisheries research, and management communities. In addition to the immediate communication initiated by the workshop, the co-organizers of the workshop have received emails from participants after the workshop asking for contact information for particular attendees or to be included in any follow-up efforts that are generated by the workshop. Workshop participants also suggested several ways in which communication among these communities could be improved, resulting in more effective management of fish habitat in the Gulf of Maine. For example, it was pointed out that the seafloor mapping community in New England is unaware of what data would be most be useful for fisheries managers. Meanwhile, fisheries managers in New England could benefit from a greater understanding of how acoustic seabed information is collected and how it could be utilized in definitions of EFH, designations of closure areas and HAPCs, or assessments of habitat vulnerability to gear impacts. In order to increase the information exchange between communities, participants at the workshop concluded that the NEFMC Habitat PDT would benefit from adding an acoustic seabed mapper to facilitate

its ongoing efforts to assess the vulnerability of seafloor habitats in the Northeast region (North Carolina to Maine). The Habitat PDT is now considering the addition of a new member to assist in exploring how existing high-resolution seafloor information could be incorporated into their ongoing vulnerability assessment. On 10 July 2009, Grabowski also presented major findings from the workshop to the Habitat Committee of the Atlantic States Marine Fisheries Commission, the primary regulatory body that manages interstate marine fisheries issues between Florida and Maine.

In summary, this workshop addressed objectives to define the status, importance, potential uses, obstacles, and priorities for integrating seafloor geophysical and habitat data with benthic ecology data, fisheries resource assessments, and regional fisheries management approaches. The event also brought key representatives of the mapping, ecology, fisheries science and management communities together to work toward a better integration of efforts for the benefit of regional fisheries management.

Integrating Seafloor Mapping & Benthic Ecology Into Fisheries Management in the Gulf of Maine

WORKSHOP AGENDA ***Wednesday, April 15***

8:30 AM **Breakfast**

9:00 **Welcome and Overview**

9:30 **Fisheries Management Overview: Presentation & General Discussion**

- Habitat mapping needs under the EFH provisions of the Magnuson-Stevens Act
  Dr. David Stevenson, NOAA-NMFS Northeast Regional Office &
  Chad Demarest, New England Fishery Management Council
- Habitat science & seafloor mapping for fisheries management at the NOAA Northeast Fisheries Science Center (NEFSC)
  Dr. Vincent Guida, NOAA-NMFS Northeast Fisheries Science Center

10:30 **Coffee Break**

10:45 **Mapping Basics: Panel Discussion**

- Benthic habitat mapping: a synopsis of methodologies and approaches
  Dr. Craig Brown, University of Ulster, Northern Ireland
- Seafloor mapping: methodologies for getting the data
  Dr. Tom Weber, University of New Hampshire Center for Coastal & Ocean Mapping
- How can seabed information be mapped to make it useful to fishery managers?
  Dr. Page Valentine, U.S. Geological Survey Woods Hole Science Center

12:30 PM **Lunch at GMRI**

1:30 PM **Case-Study Presentations & General Discussion**

How have seafloor mapping efforts in the Gulf of Maine been applied to fisheries management?

- High-resolution seafloor mapping and an assessment of the effectiveness of the western Gulf of Maine closure area (WGOMCA)
  Dr. Raymond Grizzle, Mashkoor Malik, & Dr. Larry Ward, University of New Hampshire
- Utility and applications of seafloor mapping for fisheries management on Georges Bank, German Bank, and the Bay of Fundy Canada
  Dr. Brian Todd, Geological Survey of Canada (Natural Resources Canada)
- Habitat template approach for seabed habitat mapping
  Dr. Vladimir Kostylev, Geological Survey of Canada (Natural Resources Canada)
- Evaluating local population dynamics of the American lobster with geo-referenced trap arrays, mark-recapture methods and seabed mapping
  Dr. Richard Wahle, Bigelow Laboratory for Ocean Sciences

3:30 PM **Coffee Break**

3:45 **Breakout Groups – Questions to be Addressed:**

- What needs exist in fisheries management for seafloor substrate and habitat spatial data?
- How are geophysical and fish habitat maps being used now in Gulf of Maine fisheries management?
- What currently limits the use of seafloor geophysical and habitat maps in fisheries management?

5:30 **Informal Poster Session**

THURSDAY, APRIL 16

8:30 AM **Breakfast & Review of Day 1: Summary of Major Lessons Learned**

9:00 **Case Study Presentations & General Discussion**

- Applications of seafloor mapping in fisheries management in Massachusetts
  Dr. Kathryn Ford, Massachusetts Division of Marine Fisheries &
  Daniel Sampson, Massachusetts Office of Coastal Zone Management
- The SMAST Video Survey
  Bradley Harris & Dr. Kevin Stokesbury, School for Marine Science and Technology (SMAST) at the University of Massachusetts Dartmouth

10:00 **Coffee Break**

10:30 **Breakout Groups – Questions to be Addressed:**

- What is the path forward to further integrate seafloor substrate and habitat maps in fisheries management?
- What steps are needed, from start to finish, to develop and apply maps in management of species or areas?

12:00 PM **Lunch: Reporting out of Breakout Groups**

- Discuss breakout group plans for integrating seafloor geophysical and habitat information with fisheries management efforts and relevant research.

1:30 **Concluding Discussion: Long-range Vision for Use of Maps in Fisheries Management**

- Identify timeline for moving forward on central manuscript and any other relevant products (partnerships, mapping, proceedings, etc.) that should result from the workshop
- Discuss how to achieve better communication and collaboration between marine geologists, fisheries ecologists, and management communities

3:00 *Adjourn*

INTEGRATING SEAFLOOR MAPPING & BENTHIC ECOLOGY INTO FISHERIES MANAGEMENT IN THE GULF OF MAINE

PRESENTATIONS & ABSTRACTS

SECTION 1: Workshop Introduction

- **Introductory Presentation by Workshop Co-Chairs**

  Dr. Jonathan Grabowski, Benthic Ecology Research Scientist, Gulf of Maine Research Institute & Tracy Hart, Coordinator, Gulf of Maine Mapping Initiative

SECTION 2: FISHERIES SCIENCE & MANAGEMENT

Overview of Fisheries Management Needs for Benthic Spatial Information

This section featured an overview of the current uses of seafloor maps in regional fisheries management and the region's fisheries science priorities. Presentations by the New England Fishery Management Council (NEFMC) and NOAA-NMFS Northeast Regional Office (NERO) highlighted requirements for minimizing adverse impacts to EFH under the Magnuson-Stevens Act (MSA). The presentations featured the types of information, products, and communication that would increase the utility of high-resolution seabed data for management of fishing and non-fishing impacts to EFH and stock management. A presentation by the NOAA Northeast Fisheries Science Center (NEFSC) provided information about the strategies of the center to provide applicable products for current fisheries and EFH management, while providing the science to evolve fisheries management systems in the direction of ecosystem-based management approaches.

- **Fisheries Management Needs for Habitat mapping needs under the EFH provisions of the MSA**

  Dr. David Stevenson, NMFS NERO, Marine Habitat Resource Specialist & Chad Demarest, Habitat Plan Coordinator, NEFMC

  The EFH provisions in the MSA require fishery managers to designate areas as essential fish habitat, and to minimize to the extent practicable the adverse effects of fishing on that habitat. We explained, very briefly, how the NEFMC and the NERO are working to meet these objectives, and how habitat mapping may play a critical role in both. We discussed how maps can be used by fisheries managers to maintain a productive resource base and how these maps need to be customized to some extent depending on the type of activity in question. The primary focus of the talk was on using maps as a tool for managing fishing impacts to EFH, but the effects of non-fishing activities were also

discussed to emphasize that the habitat mapping needs of fisheries management require information on what habitat features are affected by activities like harbor dredging or wind farms.

Link to Presentation: David Stevenson
Link to Presentation Notes: David Stevenson
Link to Presentation: Chad Demarest

Additional Resources:
Links to EFH Descriptions & Existing Maps:

- http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/GIS_inven.htm;
- http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index_GIS.htm;
- http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/fish_manage_index.htm

♦ Habitat Science & Seafloor Mapping for Fisheries Management at the NOAA Northeast Fisheries Science Center

Dr. Vincent G. Guida, Research Fisheries Biologist, U.S. Department of Commerce, NOAA-NMFS NEFSC, J.J. Howard Laboratory

NEFSC is developing concepts and techniques to meet the technical challenges of mapping data collection and its integration with other data for habitat modeling, always with an eye to interim products for management. Ultimately our goal is to produce habitat models that will predict fish stock responses to spatial resources and environmental conditions, even in the face of multiple human uses and climate change.

♦ Presentation & Discussion Summary:

Fisheries Management:

- In a fisheries management context, the goal of habitat management is to enhance resource productivity, but the current status of information limits the use of EFH designations to broader habitat protection goals. To enhance resource productivity, fisheries managers need to know what habitat features support increased productivity, where they are located, and how they are affected by different kinds of human-induced and natural disturbance. Better information is required about the types and geographic locations of the habitat and physical characteristics (sediment, depth, temperature, salinity, etc.) that comprise the EFH for a given life stage and species.
- Presently, high-resolution multibeam seabed data are not used in resource management decisions, i.e., to restrict fishing activity in sensitive habitat areas. Seafloor habitat data will not be utilized significantly in resource management until they are part of a larger data package that identifies important areas for growth, reproduction, survival, and productivity of managed species (i.e., Level III and Level IV data). Level III and IV data are currently lacking for managed fish species in New England.

- Currently, seabed data may be most applicable to MSA requirements to minimize adverse impacts of non-fishing activities (LNG, cables, wind farms, etc.) on EFH.
- Presently, benthic habitat data are being used by the NEFMC Habitat PDT to develop a spatial model that compares the geographic distribution of vulnerable benthic habitats with patterns of fishing gear use. The goal is to provide the NEFMC with a tool for evaluating the effects of area-based fishing restrictions and gear modifications on EFH. Video survey and sediment grain size sample data were used to map habitat types, but not high-resolution acoustic seabed data.
- Acoustic substrate and habitat data were not used to identify and describe EFH in current fishery management plans (FMPs) or to assess habitat vulnerability to gear impacts. Assessments of fishing impacts on habitat do not currently use multibeam bathymetric data because it hasn't been made readily available and doesn't exist coast-wide on the scale needed for fisheries management.
- There is a need for better communication/more interaction between fisheries managers, fisheries scientists, and the mapping community.
- An audience member pointed out that the NEFMC presentation didn't address the level of uncertainty associated with their habitat modeling efforts. He suggested this becomes important in areas where high-resolution multibeam data are used in conjunction with fishing distribution data that are mapped using vastly different spatial resolutions. Both show up equally on the map and will be treated equally in decision making if uncertainty isn't clear and understood by managers.

Fisheries Science:

- The traditional fisheries management approach that is focused on federally managed stocks is an approach that directs management actions at only ~0.01% of the Gulf of Maine's total ecosystem production. Current stock assessment models do not incorporate ecosystem productivity, are not spatially explicit, and cannot predict cyclic nor large-scale changes in trophic interactions.
- NEFSC's goal for fisheries science is to produce habitat models that will aid in predicting fish stock responses to spatial resources, even in the face of multiple human uses and climate change. Achieving this goal will involve detailed investigation (including mapping) of EFH for important stocks and vulnerable habitats; integrating with other science (e.g., climate change), studying the influences of physical variables, invasive species and fishing disturbances on habitat use, and groundtruthing acoustic data.
- Over the next five years, NOAA will establish a comprehensive Integrated Ocean and Coastal Mapping (IOCM) program that supports fully coordinated data acquisition and management efforts both within NOAA and with other agencies.

Section 3: PERSPECTIVES FROM THE SEAFLOOR MAPPING COMMUNITY

Overview of Seafloor Mapping Techniques & Applications of Seabed Maps for Fisheries Management

This section provided an overview of the state of seafloor mapping and the potential short-term and long-term applications of these data to Gulf of Maine fisheries management. Presenters discussed and compared mapping technologies, scale and resolution, and the process of map creation. Presenters also discussed the seafloor features that are described by various types of seafloor maps and the potential uses of this information by fisheries managers.

♦ **Benthic habitat mapping: a synopsis of methodologies and approaches**

Dr. Craig J. Brown, Senior Lecturer in Marine Ecology, University of Ulster, Northern Ireland

This presentation was intended as a summary of the current methodology used for the production of seafloor habitat maps, covering a range of the main techniques and approaches over several different spatial scales. The intention was to provide a synopsis of the science behind this approach for audience members not familiar with this emerging field of research.

Link to Presentation: Craig Brown

Additional Resources:

- Mapping European Seabed Habitats (MESH) (http://www.searchmesh.net/)
- University of Ulster Habitat Mapping Pages (http://www.science.ulster.ac.uk/ccmr/cmr/mapping.html)

♦ **Seafloor mapping: methodologies for getting the data**

Dr. Tom Weber, Research Assistant Professor, Center for Coastal and Ocean Mapping, University of New Hampshire

This presentation provided a brief overview of acoustic and optical techniques for collecting data that can be used for seafloor characterization.

♦ **How can seabed information be mapped to make it useful to fishery managers?**

Dr. Page C. Valentine, U.S. Geological Survey, Woods Hole Science Center

It is difficult to portray multiple seabed characteristics and processes (e.g., substrate type, ruggedness, sediment dynamics) in a geologic or habitat map. Perhaps it would be useful to compile derivative maps of seabed attributes that more clearly address the information needs of fishery managers and scientists.

Link to Presentation: Page Valentine

♦ Section 3: Presentation & Discussion Summary:

- While effective benthic habitat mapping relies on the ability to separate one habitat type from another, we are lacking spatial delineation in the marine realm.
- Scale and resolution are crucial factors, and interpretations can only be made at a level consistent with the scale and resolution of the mapping.
- Examples of seafloor mapping technologies include single beam, sidescan, multibeam, hyperspectral, LIDAR, bottom samples, and underwater imagery.
- The use of acoustic backscatter for substrate classification is relatively new and improving. The mosaic created from multibeam backscatter provides grain size, impedance, and roughness data, which is used to characterize the substrate. Groundtruthing (e.g., grabs, trawls, photo, video, cores) is needed to verify/assign classifications derived from acoustic information and to link substrate data with biological information (i.e., associated epifauna & infauna). Multibeam sonar can also provide water column information including fish distribution data and kelp coverage.
- In examples from Europe, acoustic backscatter processing and semi-automated classification predicted benthic habitat with >70% accuracy in one case-study based on multibeam surveying in hard sediments; and with 78% accuracy in another case- study in which complex terrain was mapped using sidescan backscatter.
- Comparing the technologies: Traditional seabed mapping via in-situ sampling provides a great amount of detail about a small area, but deriving an image of the bottom from these data requires significant interpolations and introduces error. Single beam surveying has less error, but doesn't provide complete coverage. Multibeam and sidescan acoustic sonar (e.g., acoustic swath systems) provide complete ensonification/coverage, but data cleaning and processing for swath backscatter is much more complex than with single beam Acoustic Ground Discrimination Systems (AGDS). Multibeam sonar acquires bathymetric information and backscatter information. Underwater photographic imagery can provide high-resolution images of areas sampled, but cannot provide complete coverage. Airborne optical techniques (e.g., LiDAR and hyperspectral) are limited to shallow water mapping. Hyperspectral imaging provides bathymetry data and can also delineate eelgrass beds and macroalgae mats.
- Acoustic facies maps (i.e., maps of distinct seafloor substrate types discriminated via acoustic backscatter data) can potentially be used to develop Level III & IV EFH data. If these maps are coupled with fish data, it may be possible to look at fine-scale relationships between substrate and fish biology.
- Types of seafloor maps: 1. Basic reflectivity and topography map based on acoustic imagery; 2. Geological map based on sonar and groundtruthing; 3. Derivative maps (interpretive maps) such as dominant sediment texture, sediment mobility, ruggedness, seabed features, disturbance, distributions of managed species, and habitat maps.
- How can these maps be used in fisheries management? Substrate type maps provide information to predict what species can live where. For example, piled cobble bolder gravel substrates provide stable substrate for epifauna to remain attached and voids between boulders can protect fragile organisms. Seabed dynamics maps (immobile vs. mobile substrates) provide additional information about species substrate associations. Derivative maps of substrate hardness/roughness can be used to predict areas where you

would find attached epifauna and to model currents and sediment transport. From ruggedness maps one can determine accessibility and vulnerability to various gear types. One can produce a seabed disturbance map based on trawl marks and storm damage and use it to identify undisturbed habitats versus areas disturbed via natural phenomena or fishing, to select management areas, and as one component of habitat vulnerability analyses.

- A habitat map defines the physical, chemical, and biological boundaries of species. Combining all of these attributes in one map is difficult. We need to consider if we want one habitat map for a species depicting all physical and biological attributes or many maps showing particular attributes of species' habitats geared toward particular management questions.
- The mapping community isn't clear about what fishery managers want and need. Mappers are speculating on how to develop maps for their use. Mappers are not generally thinking about how the information can be used for management purposes. This represents a communication problem.
- Mapping doesn't always have to go all the way to the production of the habitat map to be useful for fisheries management. In some cases, thematic maps (e.g., maps of roughness) might be more useful.
- Mapping standardization is not necessarily the answer because it would lead to discarding useful data.

Section 4: CASE-STUDIES

How Seafloor Mapping Is Being Integrated With Benthic Ecology & Fisheries Science and Applied to Fisheries Management in the Gulf of Maine Region

This section featured regional examples of seafloor mapping efforts with fisheries management applications. The presentations covered a range of goals, geographic areas, seafloor mapping techniques, and management applications. Presenters were asked to provide an overview of the program, its timeline and costs, and the challenges encountered or overcome relating to the integration of benthic mapping data with ecology data and fisheries management efforts. The examples highlighted efforts to assess the efficacy of fisheries closure areas; emerging methods for delineating habitat types; video surveying for substrate mapping and stock assessments; mapping programs leading to effort reductions and the development of new fisheries; an alternative approach enabling predictions of the distribution of species according to habitat function and vulnerability; and state-level use of comprehensive acoustic and groundtruth surveys for protection of fisheries resources and habitat.

- **High-resolution seafloor mapping and an assessment of the effectiveness of the western Gulf of Maine closure area (WGOMCA)**

  Dr. Raymond E. Grizzle, Department of Biological Sciences and Jackson Estuarine Laboratory, University of New Hampshire; Mashkoor A. Malik, Center for Coastal and Ocean Mapping, University of New Hampshire & Dr. Larry G. Ward, Center for Coastal and Ocean Mapping, Department of Earth Sciences, and Jackson Estuarine Laboratory, University of New Hampshire

  This case-study described a multidisciplinary, collaborative project involving multibeam sonar, underwater video, extractive seafloor sampling, gillnet sampling of groundfish, and fishing vessel activity in a 515 km^2 study area, half inside and half outside of the WGOMCA. Maps resulting from a variety of datasets were constructed and the data analyzed to infer the impacts of the closure on benthic macrofauna and groundfish. The most important and consistent findings were in rocky habitats: epifauna communities had substantially and significantly greater densities and taxonomic richness inside the closure compared to outside, and total groundfish (cod, haddock, pollock, and hake) biomass was about 3 times higher inside. Overall, this study suggests substantial recovery of some benthic invertebrate communities and groundfish populations inside the WGOMCA.

  Link to Presentation: Ray Grizzle
  Link to Presentation Notes: Ray Grizzle

- **Utility and Applications of Seafloor Mapping for Fisheries Management on Georges Bank, German Bank, and the Bay of Fundy**

  Dr. Brian Todd, Research Scientist, Geological Survey of Canada (Natural Resources Canada)

A ten-year program of multibeam sonar and ground truth data collection in the Gulf of Maine has been completed by Natural Resources Canada. In cooperation with Fisheries and Oceans Canada, interpretation of this information is ongoing to apply this knowledge of the seafloor to fisheries management.

♦ Habitat template approach for seabed habitat mapping

Dr. Vladimir Kostylev, Habitat Ecologist, Geological Survey of Canada (Natural Resources Canada)

Creation of habitat maps is commonly based on defining regions with similar chemical, physical and biological characteristics. Traditionally the boundaries between habitat types rest on arbitrary chosen levels of physical variables and on approximation of spatial location. In high-resolution habitat mapping the boundaries are decided following empirical analysis of biological and geological data, and defining relationships between datasets. The resulting maps suffer from a number of implicit assumptions, the most important set of which relates to animal-sediment coupling. Additionally, management implications of habitat maps are not immediately evident from both traditional habitat classification and high-resolution mapping. Here we demonstrate a practical methodology for creating seabed habitat maps using the habitat template approach to integrate multiple environmental fields into a single map. The resulting map shows distribution of habitats where organisms with particular life history traits are likely to flourish and provides an interpretation of habitat sensitivity to adverse impacts for integrated management of ocean uses. A case-study for the Scotian Shelf and eastern Gulf of Maine in the northwest Atlantic Ocean illustrates that the parsimonious nature of the modeling approach allows prediction of spatial patterns in benthic habitat types based on readily available oceanographic data.

Link to Presentation: Vladimir Kostylev
Link to Presentation Notes: Vladimir Kostylev

Additional Resources:

- http://www.ecovector.com/publications.html
- Kostylev, V.E., and C.G. Hannah. 2007. Process-driven characterization and mapping of seabed habitats. In: B.J. Todd and H.G. Greene (eds.), Mapping the seafloor for habitat characterization. Geol. Assoc. Can. Spec. Pap. 47, pp. 171-184.

♦ Evaluating local population dynamics of the American lobster with geo-referenced trap arrays, mark-recapture methods and seabed mapping

Dr. Richard Wahle, Senior Research Scientist, Bigelow Laboratory for Ocean Sciences

Combining habitat mapping, spatially referenced trap arrays and mark recapture modeling can be a powerful approach to characterize population dynamics of lobsters and crabs on geographic scales of 1-100 square km. A proof-of-concept study is described

that develops and tests the approach to evaluate the dynamics of lobster populations on four 1-km-scale study areas in coastal Maine. Mark-recapture-based abundance estimates from these trap arrays were validated by concurrent diver visual surveys in the study areas. Impact assessments are prime applications of the method. A study is described to assess the impact of sediment disposal on spatial and temporal trends of lobster and crab abundance and movement during the weeks immediately following one such perturbation in Penobscot Bay, Maine.

Link to Presentation: Richard Wahle

♦ The SMAST Video Survey

Bradley P. Harris and Dr. Kevin D. E. Stokesbury, Department of Fisheries Oceanography, School for Marine Science and Technology (SMAST) at the University of Massachusetts Dartmouth

In 1999 we started a cooperative video survey with the U.S. commercial scallop fleet aimed at collecting data suitable for spatially specific scallop stock assessments and for mapping megabenthos and substrates. The survey now covers more than 70,000 km^2 of the U.S. continental shelf from Norfolk Canyon in the Mid-Atlantic to the Northern Edge of Georges Bank annually. To date, we have analyzed 183,402 geo-referenced video quadrat samples collected on 106 video surveys conducted aboard 23 different commercial vessels. Six classes of benthic substrate and 53 megabenthos taxa groups are identified in each sample, yielding 1.3 million geological and 9.7 million biological records to date. The scallop data are being used in NEFMC stock assessments, and substrate and megabenthos data are being used in the NEFMC Omnibus Habitat Amendment. Ongoing work includes shelf-scale substrate mapping, geostatistical analysis of scallop bed spatial structure, and modeling of scallop meta-population connectivity and benthic boundary flow conditions.

Additional Resources:

- www.smast.umassd.edu/Fisheries
- Stokesbury, K.D.E., B.P. Harris, M.C. Marino II, and and C. E. O'Keefe 2009 Using technology to forward fisheries science: the sea scallop example. In, Species Management Challenges and Solutions for the 21st Century, *In Press*
- Tian, R.C., Chen, C.S., Stokesbury, K.D.E., Rothschild, B., Cowles, G., Xu, Q.C., Harris, B. P., and Marino, M.C. 2009. Sensitivity analysis of sea scallop (Placopecten magellanicus) larvae trajectories to hydrodynamic model configuration on Georges Bank and adjacent coastal regions. Fisheries Oceanography. doi:10.1111/j. 1365-2419.2009.00506.x
- Stokesbury, K.D.E., B.P. Harris, M.C. Marino II. 2009 Astonishment, Stupefaction, and a Naturalist's Approach to Ecosystem-Based Fisheries Studies. In R.J. Beamish and B.J. Rothschild (eds.), The Future of Fisheries Science in North America, 113 Fish & Fisheries Series, Springer Science + Business Media B.V. 2009

- Tian, R. C,Chen, C., Stokesbury, K.D.E., Rothschild, B.J., Cowles, G.C., Xu, Q., Hu, S., Harris, B. H., and Marino II., M.C. 2009. Modeling the connectivity between sea scallop populations in the Middle Atlantic Bight and over Georges Bank. Marine Ecology Progress Series 380: 147-160
- McGuire C. J. and B. P. Harris. 2008. Rights-Based Fisheries and Ecosystem-Based Management: Maybe Scientists and Fishermen Know the Way? American Bar Association - Marine Resource Newsletter. 12(1): 18 – 21.
- Harris B. P. and C. J. McGuire. 2008. Operational issues in U.S. fisheries management: What are some of the major scientific, political and legal hurdles to implementing ecosystem-based management? American Bar Association - Marine Resource Newsletter. 11(2): 5 – 6.
- Adams, C.F., B.P. Harris and K.D.E. Stokesbury. 2008. Geostatistical comparison of two independent video surveys of sea scallop abundance in the Elephant Trunk Closed Area, USA. ICES Journal of Marine Science. 65(6):995-1003.
- Stokesbury, K. D. E., B. P. Harris, M. C. Marino II and J. I. Nogueira. 2007. Sea Scallop Mass Mortality in a Marine Protected Area, Mar. Ecol. Prog. Ser. 349:151-158.
- Marino II, M.C., F. Juanes and K.D.E. Stokesbury. 2007. Effect of closed areas on populations of sea star *Asterias* spp. on Georges Bank. Marine Ecology Progess Series. 347: 39-49.
- Harris, B.P. and K.D.E. Stokesbury. 2006. Shell growth of sea scallops (*Placopecten magellanicus* Gmelin, 1791) in the southern and northern Great South Channel, USA. ICES Journal of Marine Science. 63:811-821.
- Stokesbury, K.D.E., and B.P. Harris. 2006. Impact of a limited fishery for sea scallop, *Placopecten magellanicus*, on the epibenthic community of Georges Bank closed areas, Mar. Ecol. Prog. Ser. 307:85-100.
- Stokesbury, K.D.E., B.P. Harris, M.C. Marino II and J.I. Nogueira. 2004 Estimation of sea scallop abundance using a video survey in off-shore USA waters. J. Shellfish. Res. 23:33-44.

♦ Applications of seafloor mapping in fisheries management in Massachusetts

Dr. Kathryn Ford, Fisheries Habitat Project Coordinator, Massachusetts Division of Marine Fisheries and Daniel Sampson, GIS Analyst, Massachusetts Office of Coastal Zone Management (CZM)

Massachusetts CZM has partnered with the USGS to generate full coverage acoustic maps of the seafloor of all state waters. An overview of the seafloor mapping program and current status, as well as how this work contributes to fisheries resource and habitat management in Massachusetts was presented.

Link to Presentation: Kathryn Ford

Additional Resources:

- http://woodshole.er.usgs.gov/project-pages/coastal_mass/html/current_map.html
- http://www.mass.gov/dfwele/dmf/programsandprojects/seafloor_mapping.htm#menu

INTEGRATING SEAFLOOR MAPPING & BENTHIC ECOLOGY INTO FISHERIES MANAGEMENT IN THE GULF OF MAINE

BREAKOUT SESSIONS

I. Breakout Session 1: April 15, 2009

What seafloor information is available and what is needed for Gulf of Maine fisheries management now and in the future?

The first breakout session challenged participants to weigh the diverse perspectives delivered by presenters and participants and develop a concise list of the seabed substrate and habitat data that is needed to address the most pressing Gulf of Maine fisheries management priorities currently and in the future. Breakout groups were asked specifically to define needs, gaps, and barriers related to the integration of seabed mapping and benthic ecology in Gulf of Maine fisheries management. The participants were divided into three pre-assigned groups, each representing a mix of disciplines, organizational types, and geographic areas. The groups were provided with three guiding questions (Fig. 1) and charged with the task to complete a table with the following information:

- What additional seafloor data, analysis and products are needed and what form should they take (e.g., data needs, level of analysis, geographic coverage, product formats, integration needs)? Rank in order of priority
- Which data/products related to this need are currently available to fisheries managers and how are they used?
- Which needs are unmet and what data are inadequate?
- What currently limits the use of this information in fisheries management? What are the barriers?

Figure 1. Guiding Questions

1. What needs exist in fisheries management for seafloor substrate and habitat spatial data in order to address the most pressing Gulf of Maine fisheries management priorities, with consideration to current management strategies, as well as emerging ecosystem-based and spatial management approaches to fisheries management?
   - How can seabed & spatial habitat data help in identifying, defining or evaluating the condition of essential fish habitat?
   - How can they help in selecting, amending, and evaluating the effectiveness of fishery closure areas?
   - How can substrate and habitat maps inform gear restriction decisions?
   - What additional information, analysis and attributes would be useful if integrated with geophysical or habitat classification maps (e.g., trawl data, benthic ecology, fish ecology)?
2. How are geophysical and fish habitat maps being used now in GOM fisheries management and how could these maps be used in the future more effectively?
3. What currently limits the use of seafloor geophysical and habitat maps in fisheries management?

Each group was facilitated by a member of the workshop steering committee and a rotating facilitator that moved among the groups. Following a 1 ½ hour discussion, each group was asked to summarize its findings using a power point presentation template.

Breakout Session #1 Results				
		Group 1	**Group 2**	**Group 3**
What's Needed? *What seafloor data, analysis and products are needed and what form should they take? Priority ranking 1-5.*	**1**	**Building better political will--** Need to involve industry. Utilize the political momentum of alternative energy, e.g., offshore wind, LNG, etc. The primary limitation is political will in the U.S. Need enhanced dialog. Europe multibeamed the whole area and is now AUV'ing to 1 cm resolution. Canada multibeamed all but deepest areas. The scallop industry funded and participated in the mapping. This is possible in the U.S.	**Refine EFH--**NEFMC needs habitat maps to reduce adverse effects of fishing w/effort reduction, gear restrictions, and area closure tools. This is only role that maps play in fisheries mgt. now. Now, managers need to know if stocks are overfished. EFH doesn't relate to these decisions. If EFH designations were based on Level 3 & 4 maps, use of habitat info in stock mgt. would increase. Long-term: need radically enhanced habitat maps to improve EFH designations.	**Integration**-- will create better habitat maps. Long term goal is integration of broad data sets. Short term goal is to use available data about biology to identify biodiversity hot spots.
	2	**Enhanced coordination** between government agencies, NEFMC and stakeholders	**Understand relationships between habitat & population dynamics**: Need small-scale, coast-wide habitat maps to look at substrate and pop dynamics. Acquire data to support causal relationships–e.g., why don't all cobble patches function the same? Driver for this data--spatial planning, ecosystem-based mgt. Won't be driven by fisheries mgt. needs.	**Sonar:** Need to produce regional scale map of geological physical structure of seafloor (e.g., like Brian Todd's data for Canada). Baseline bathymetry and backscatter data.
	3	**Better articulation of what's needed:** With a better articulation of needs we could be more proactive in collecting habitat and other important data layers that focus not only habitat impacts, but also on fish production, etc. Would enable us to be more strategic instead of opportunistic about site selection for ocean development.	**Evaluate closure areas:** Are closures doing what we need them to do? In some cases there is opportunistic data, but no rigorous evaluation process. Area closure evaluations require information about the closure area plus areas where effort is being re-directed. Do we have information to make decisions about which areas should be more intensely fished?	**Geological Maps:** Groundtruthing (i.e., acquiring grab samples for sediment texture and video imagery) is of vital importance. More discussion is needed about what types of geological information are more important.

	4	**Map entire Gulf of Maine:** Multibeam survey of whole area, then AUV/sidescan mosaic, then video/photos/grabs. Canada has shown this is possible. Inshore fisheries examples in US, but a long way to go for offshore. If can't multibeam entire GOM, next best thing is to map hotspots. Need proxies, i.e., Kostylev's habitat template model. Olex data from fishing vessels can serve as the poor man's multibeam. Cheaper and faster way to get higher resolution info than topo maps. Would high quality habitat information serve the pop dynamics/stock assessment groups? Can't achieve level 4 EFH w/o knowledge of existing habitat. Hard to integrate EFH into stock assess models if don't know about productivity or habitat.	**Evaluate gear impacts**	**Hydrology--**Energetic/Natural Disturbance regime; Temperature. Water column information. Not just about the benthos. Can't evaluate impacts of human activities without information about the energy regime of the system.
	5	**Identify hotspots to be groundtruthed and model remaining areas.** Be careful about introducing bias. Current closed areas were chosen driven by the management not the biology.	**Uncertainty maps**—the uncertainty level of the data behind the map needs to be spelled out more clearly in the map so that all maps, and all of the data in them, are not given the same weight in decision making.	**Biological data--**e.g., Biogenic habitats; fish data; distribution data; life-stage specific habitat associations; benthic invertebrates. (Biology actually comes in at each of the other priorities, therefore the list is not really a linear ranking)
Other needs discussed		Don't have the resolution in seafloor maps that we now have for the other data inputs. Need fish productivity information. Need maps of physiographic factors. Take fine scale studies and build synoptic view of the whole area. High-resolution habitat maps can help achieve effort reductions. Less time/area fished equals less disturbance.	Identify data needs. Need to work at Fishery Management Plan scale (i.e., broad scale; fine scale/small area studies are not useful). Create a report from this workshop for the cooperative research committee who controls the funding. Send to foundations and legislators of the ocean & envir. committees. NEFMC and staff members need to know how to better read the maps. Mapping is being done for shellfish aquaculture. NOAA is developing a 10-yr plan now. Offshore mapping is a huge part of siting for offshore aquaculture. Conduct outreach to demonstrate the importance of mapping for aq.	Need to define appropriate areas for particular gear types, i.e., define habitat vulnerability by particular gear types. Info needed in developing habitat friendlier gear. VMS data tells where habitat damage is occurring at a scale that's relevant to managing fisheries and you can focus data for particular questions. Physical energy models. Focused studies to define how easy it is to damage areas and how easily the area recovers. The GOMMI coverage map gives the basis for understanding fine-scale studies. Need to develop mapping standards and make following these standards a condition of permitting for wind farms, etc. Need some way to rate the accuracy of data, appropriate uses.

What's Available? *What data/ products related to this need are currently available to fisheries managers and how are they used?*		There is a lot of information on the Gulf of Maine, but not a lot of spatially explicit information	* Limited multibeam, fish distribution and benthic data available; *Broadly define habitat closures and EFH	**A. Sonar:** -See GOMMI coverage map. Some vessels-of-opportunity transmit spatially referenced seabed info. NRCAN data. Derived products (i.e., slope, rugosity, roughness, aspect). **B. Geological:** Grab sample data--USSeabed data; various local/regional surveys (grain size analysis for some); EMap. Photo/video: SMAST video survey. Grizzle data. NURP submersible cruises. MCZM. HABCAM. Fishing Effort: VTR, VMS, Observers. Fishing Impact studies: local scattered. **C. Hydrology--**Energetic/Natural Disturb Regime data: Models – Shear stress & tidal model (SMAST/USGS); Wave models?; Temp. data: Satellite, NOAA buoys, GoMOOS. **D. Biology--**Biogenic data: Aerial & subsurface imagery. Fish- Distrib/ Life stage specific habitat associations: Systematic and functional classifications; fed & state trawl surveys. Benthic invertebrate data: Theroux and Wigley data base. Fed & state trawl surveys. SMAST video. Grizzle data. NURP submersible cruises. MCZM. HABCAM. EMap. NEFSC "Legacy datasets"
What Isn't Available? *Which needs are completely unmet? Which data are inadequate?*			*Biological link – species habitat relationships/ why is a cod where it is & what is it doing; *Data that will support causal inferences; *Multibeam mapping of the continental shelf; *Water flow/ shear stress/oceanographic modeling needs to be connected; *Benthic ecology *Nested strategy--Maps and Vladimir's method provides broad scale template for making nested, finer-scale decisions. Include data from other surveys (wind farms, etc.) *Habitat vulnerability by gear type	* Priorities & protocols for large scale integration *Widened use of vessel-of-opportunity data. * Dedicated multibeam survey in GOM. * Established protocols for sonar surveys *Fishing impact data. *Need to groundtruth energetic/natural disturbance models. *More subsurface temp data. *Info about Trophic interactions (prey/predators).
What are barriers? *What limits the use of seabed information in fisheries management ?*		Spatial resolution of the fishing effort and oceanographic data serving to quantify natural disturbance far outstrips what we have for habitat maps; don't have the resolution of seafloor maps that we now have for the other data inputs	*Lack of understanding of the relationship between habitat and fish distribution and productivity; *Ecological benefits of habitat closures are not understood	**Sonar:** -Cost. (e.g., groundtruthing); Unequal coverage; Some backscatter data "compromised"; Automated vs. manual classification; Setting criteria; Prioritizing areas to be surveyed. **Grab Samples:** Unequal coverage **Photo &video imagery:** Standardized format. Unequal coverage. **Fish Distribution/ habitat association data & benthic invert data:** Trawl unable to sample certain locations b/c too rough. Life stage specific info missing for some spp.

♦ Summary: Commonalities & Range of Responses

1. **Greater coverage, higher resolution, broader scale:** The call for greater acoustic mapping coverage spanned the three groups, with two groups emphasizing the importance of dedicated high-resolution multibeam mapping of the entire Gulf of Maine. Various methods for increasing acoustic coverage were discussed, in addition to ideas for addressing data gaps, increasing data utility, and improving the availability and integration of other data types (biological, hydrological, and fishing data). The list included**:**
    - building on the momentum of alternative energy development to increase political will;
    - making permitting for alternative energy projects contingent upon funding for mapping;
    - setting geographic priorities for mapping;
    - developing a nested strategy;
    - building a synoptic view from fine-scale studies;
    - groundtruthing hotspots and modeling remaining areas;
    - using proxies & making greater use of Olex/VMS data;
    - developing criteria, standards and/or protocols for sonar surveys, and specifically improving standards for backscatter collection to improve the utility of multibeam data for substrate characterization.

2. **Groundtruthing acoustic data:** A number of groups discussed the need for groundtruthing of acoustic data to enable the creation of substrate type maps for use in habitat delineation. One group prioritized the stages of mapping and data collection beginning with integration of existing data, followed by sonar surveying, groundtruthing for the development of geological maps, hydrology data collection, and lastly collection and integration of biological data. One group stated that habitat and seafloor maps need to have greater spatial resolution, matching the resolution of the data currently available to quantify fishing effort and natural disturbance. To increase the use of spatial data in fisheries management, one group suggested that mapping and benthic ecology research needs to be conducted at the scale of the Fishery Management Plans (i.e., broad scale). One group discussed the need for maps that clearly spell out the uncertainty level of the data behind the map so that all maps are not given the same weight in decision making.

3. **Defining the connection between fish productivity & habitat – refining EFH:** All groups highlighted the need for increased understanding of the relationship between habitats and the distribution, abundance, and productivity of managed fish species (i.e., the relationship between habitat and fish population dynamics; level 4 EFH). One group explained that the NEFMC will be unable to use habitat information in stock assessment until Level 4 EFH information is available throughout the Gulf of Maine. Until then, habitat data will continue to be used only in a limited context, such as to minimize the adverse effects of fishing on EFH. The groups called for a variety of information and actions that may be needed to illuminate the relationship between habitat and fish population dynamics and productivity, including: (1) integration of data sets; (2) small-

scale, coast-wide habitat maps to examine the relationships among substrate and fish population dynamics; (3) data to support the study of causal relationships between fish and habitat characteristics; (4) more stage-specific life-history information in a habitat context; (5) trophic interactions data; (6) fish distribution data; (7) the use of the habitat template model presented by Vladimir Kostylev that defined habitat based on ecological function; (8) habitat vulnerability by gear type; (9) development of energetic/natural disturbance models; (10) groundtruthing/benthic sampling; (11) benthic invertebrate data; (12) use of available biological data to identify biodiversity hotspots; and (13) geological substrate information.

4. **Enhanced communication, coordination, integration, and articulation of needs:** Workshop participants also discussed the human component that hinders improved integration of seafloor substrate information, benthic ecology, and fisheries management. There was a general call for enhanced communication and coordination between the mapping community, benthic ecologists, fisheries scientists, and fisheries managers. Additionally, participants highlighted the need for these communities to work together to better integrate available information, and articulate and coordinate the needs of each sector. One group noted the need for greater political will to achieve better spatial coverage of acoustic mapping information in the Gulf of Maine. Greater coordination among the scientific and management communities would enable a more coordinated and strengthened approach to political marketing.

5. **Evaluating closure areas and gear impacts:** Two groups pointed out that the fishery closure areas in the Gulf of Maine were largely selected during the management process without sufficient biological information to determine if these areas will affect fish productivity. In general, there is a lack of understanding of the relationship between habitat characteristics and fish productivity, which greatly impairs the ability of managers to manage and protect EFH. Currently, the ecological benefits of habitat closures are not well understood, and data on habitat associations of fish inside the closures are limited. There is currently no rigorous evaluation process of the efficacy of the existing closures. Area closure evaluations require information about the closure area, as well as areas where effort is being re-directed, which is rarely considered. Moreover, one group asked rhetorically whether we have the necessary information to make decisions about which areas should be more intensely fished. Ideally, efforts to manage fishing effort in the Gulf of Maine would consider the impact of each gear type individually in order to minimize their impacts on EFH and motivate development of habitat friendlier gear types.

Links to the groups' presentations:
Breakout Session 1, Group 1
Breakout Session 1, Group 2
Breakout Session 1, Group 3

II. Breakout Session 2: April 16, 2009

In this breakout session the three groups worked to develop a plan that prioritizes future seafloor mapping efforts in a fisheries management context. The groups were provided with Guiding Questions (Figure 2) and asked to outline steps for improving:

1. Fisheries management use of seafloor mapping and benthic ecology data;
2. Seafloor mapping products and utility;
3. Data availability;
4. Communication, information transfer and collaboration

The results of these discussions were presented by each breakout group and are included here.

Figure 2: Guiding Questions

1. How do we address unmet needs in fisheries management for spatial seabed substrate and habitat information? How (and by whom) should this information be developed and integrated into the management process?
   - How do we overcome existing barriers?
   - What mapping technologies will be useful for the path ahead?
1. How do we make currently available map products and data more applicable to fisheries management priorities? How do we design these maps to be of value to ongoing management activities at the state and federal fisheries management levels?

2. How can maps be applied to emerging fisheries research and management approaches?

❖ Breakout Session #2 Results

♦ Group 1:

How do we better integrate mapping efforts with fisheries management?

Steps for Improving Communication

- Communication of the current state of knowledge and its applications needs to emanate up from each of us and cut across agencies, but especially in management circles.

- Educate top managers about habitat mapping capacity, what it costs, etc. so that managers can allocate and shift funds in non-traditional ways to fund mapping. Educational presentations targeting managers could potentially be effective.

- Managers need maps/case-studies and mappers need to know managers needs.

- Bioscience and geoscience working together results in a really strong product. Do these scientists have a good handle of what the fisheries managers need?

Steps to demonstrate the utility of maps

- Nothing will get done unless we demonstrate the utility of habitat maps. Highlight examples to demonstrate the value of habitat maps (e.g., (a) Nantucket Light Ship story – the bottom used to be much more amenable to yellowtail but now is finer sand and no longer is utilized by yellowtail; (b) the scallop industry's use of habitat maps in Canada to

reduce effort, gear damage, and habitat damage is also an example (see Brian Todd's presentation). But what about the use of habitat maps for other fisheries?

- How do you utilize the cases from around the world to convince managers and funders that the Gulf of Maine needs to be mapped? How did Norway and other countries convince their managers/federal agencies to map the entire territorial sea? How did they generate political will from above? Bring in people that can enhance the discussion with technical information about mapping capacity. The 2001 GOMMI initiation meeting brought in people from outside the region to articulate why ocean mapping is important.

- The current funding climate is a major impediment. Transboundary issues such as oil exploration will create an impetus for mapping. Geoscience is needed for ocean management and management of shared ocean space – from scallops to wind farms you need topographic maps to move forward.

- What do we develop that is proof positive that habitat maps are useful to fisheries management? Can we pull out an area that is large enough to be useful?
    - John Anderson/Don Gordon's haddock example is a really nice example of how to use habitat and fisheries data together.
    - Monkfish canyon example (2005 Amendment 2 of the Monkfish Fishery Management Plan) – maps of specific coral habitats filtered up and were used to set up a closure.

Steps for addressing information gaps

- Understanding the spatial dynamics of the system is key. Within a habitat there is a lot of variance in terms of which habitat patches are important for specific fish; but you will never obtain a more holistic understanding without complete habitat information. Interpolation of sediments could be greatly improved by building in seabed topography.

- The current paradigm for research is too focused/fine scale. Case-studies such as the Massachusetts example can be utilized to open the door to mandate a systems approach. The NOAA Northeast Fisheries Science Center could be re-tooled to lead these discussions.

- Developing relationships between habitat blocks and population dynamics in areas such as Great South Channel is a good starting point for evolving EFH and cutting across habitat and pop dynamics scientists.

Steps for integrating habitat information in fisheries management

- Short term – Right now better information is needed to assess fishing impacts (only avenue that seafloor maps currently play in fisheries management is in the adverse effects of fishing on EFH components; habitat is factored in EFH designation using existing limited knowledge). Assessments of fishing impacts on habitat currently are not using multibeam bathymetric data b/c it hasn't been made available and doesn't exist coast

wide on the scale fisheries management needs it. Habitat PDT needs a multibeam mapper to help integrate multibeam data into current assessment of habitat vulnerability.

- Mid term – EFH source documents could include more habitat information; currently complete data is not available; high quality substrate maps would enhance this process. Most of the literature on fish use of habitat comes from hot spots such as Stellwagen bank. Maps of the hotspots are not used currently in fisheries management.

- Long term – The habitat side of fisheries management is limited to designating EFH and minimizing adverse impacts to EFH. Habitat information is not used by population dynamics groups and habitat maps don't play a role in determining whether fish stocks are overfished. Therefore, there is a the disconnect between population dynamics/stock assessment approach & habitat approach to managing fish. Stock assessments would benefit from information on habitat so that models could include whether specific habitats/life history phases are limiting. EFH could be radically enhanced with habitat maps (starting at a low base). Currently the lack of data limits the use of habitat maps.

- Longest term – mapping for ecosystem-based management (EBM), i.e., marine spatial planning for multi-jurisdictional approaches. EBM & marine spatial planning are moving forward and will be the most likely to drive political will and the use of habitat information. The primary drive will not come from fisheries management and mapping needs won't be met by fisheries.

Steps for enhancing the use of habitat information in selecting and managing closures

- Area-based management continually becomes more and more complex. We move fishing effort around in a spatially explicit manner without the substrate data to understand the habitat consequences of the shifts. Area closures actually inhibit the validity of the population dynamics assumptions of the stock assessment. Scales are largely incongruent (i.e., closures are much smaller than stock structure delineation). The statistical areas and area closures used to manage fish stocks in federal waters may not make sense – habitat mapping could be used to reshape the management boxes.

- Area closures should include consideration of not only the areas within the closure, but also where the fishing effort is moving to. Area closures should include the active selection areas to more intensively fish as effort is displaced out of the closure area. Currently closure areas impact stock structure by selecting for individuals that don't migrate.

♦ Group 2:

Steps for Improving Fisheries Management Use of Seafloor Mapping Data

- Develop a primer for using seafloor maps to provide training (e.g., MREP).

- Include interpretation of maps in training efforts. Have a mapper involved in management discussions to provide interpretation of maps and possibly available to the Council for consultation.
- Produce maps that match the domain/scale of the management question.
- Provide maps to management and ensure that maps remain readily available and easily accessible to management.
- Begin to integrate seafloor mapping with existing methods for doing stock assessments
- Create a demonstration project of habitat-based, species-specific mapping surveys

Steps for Improving Products/ Making Products More Applicable to Fisheries Management

- Money
- Publish what's available (develop a list of data sources and print hard copies of sources such as the GOMMI coverage map and IOCM website being developed for NOAA data
- Peer review process
- Integrate with existing efforts, e.g., National Fish Habitat Action Plan from USFWS needs a link to fishery management.
- Send report of this meeting to CRPI, Resource Steering Committee, funders, legislators

Steps for Improving Data Availability

- Need to collect new data (benthic & mapping). More use of video rather than grab samples even realizing some loss in substrate info and epifauna info.
- Publish data – peer review through publications. Put shape files on Ecological Archives so managers have access to data, but also publish peer reviewed journal articles about the data and its limitations.
- Advertise – websites, industry publications
- Initiate dialogue with the stock assessment community

Steps for Improving Communication

- Look for collaborators – CCOM, USGS
- Mapping for coastal and ocean development (e.g. shellfish aquaculture, energy siting)
- Education (i.e. training)
- Developing personal relationships/academic partnerships
- $$$
- Start dialogue with assessment community
- Work with the fishing industry
- Put mappers on PDTs and management teams

♦ Group 3:

Steps for Improving Fisheries Management Use of Seafloor Mapping Data

Create a common vision of Gulf of Maine habitats

(a) Identify existing datasets
(b) Convince group of experts – prepare a paper?
(c) Evaluate what needs to be done to "integrate" data
(d) Mosaic of habitat maps of different quality and corresponding information about the "quality" and appropriate uses of the map
(e) Prioritize mapping: 1st priority--areas that are important, but with little information. 2nd priority: areas with more information, but may not be so important. 3rd priority: reas that are important with good information already.

Steps for Improving Products/ Making Products More Applicable to Fisheries Management

Develop partnerships to:

(a) Enhance data collection – get industry more involved in data collection; e.g., Clearwater
(b) Promote political will for habitat mapping
(c) Create mechanism for data sharing/ updating techniques
(d) Conduct outreach, e.g., Councils

Steps for Improving Data Availability

Establishment of:

(a) Data oversight group (e.g., work with GOM Ocean Data Partnership to establish some consistency and standardization of procedures)
(b) Data collection/ analysis/ mapping protocols – consistency, standardization (?)
(c) Emergent technologies:
    - Sediment Profile Imaging (SPI)
    - Acoustic Doppler Current Profiler (ADCP)
    - Synthetic Aperture Sonar

Steps for Improving Communication/ Information Transfer/Collaboration

Form an implementation group to advise users and work with user groups on:

(a) How to use maps
(b) Communication: Why are maps so useful?
(c) Target different audiences
(d) NE Regional Ocean Council (NROC) could help
(e) Contributing data to other existing databases/ portals
(f) How do we market all this? GOMMI? Others?

III. Concluding Discussion: Long-range Vision for Use of Maps in Fisheries Management

The concluding discussion focused on priority outcomes for the workshop. Participants were asked to identify a long-range vision, next steps, and a timeline for the workshop's suggested products. The following are individual comments on this theme.

Proposed Products:

- Develop both a glossy brochure to raise the profile of the value of seafloor maps, as well as a manuscript. One participant's response: GOMMI has already produced a glossy brochure (Mapping the Undersea Landscape) and it hasn't succeeded in convincing U.S. funders and policy makers of the need for mapping. A brochure won't influence those who make policy or give money. Instead publish in industry magazines. A lot more bang for buck. These get the scientific word out to industry.
- Produce an introductory chapter in documents for the NEFMC that describes the attributes of seafloor data that are useful for fisheries management, what data are currently available, and what is missing. Also provide this information as a Power Point.
- The RARGOM report on ocean observing was very informative for the formation of GOMOOS. A similar technical report could be produced for this workshop, laying out clear next steps. Develop papers on: 1) scientific approach: explain what good quality maps of the seafloor are and what poor quality maps are and status of mapping—not an exhaustive analysis; 2) a marketing approach—(e.g. "seafloor maps are important for integration into fisheries management, ocean zoning, ocean management, energy development, etc.)—launch a short version with NROC or the Ocean Data partnership to get movement on the action items the group at this workshop has come up with. Participant response: Google Oceans could be great marketing. It highlights how little we have captured compared to Google Earth. GOMMI SC member response: GOMMI should write up notes from this meeting and if it wants to take it forward, it should work with the ocean data partnership. GOMMI is an initiative. It's difficult for GOMMI to publish things. GOMMI serves to bring audiences together. If GOMMI can keep operating at a low level to keep people talking and push entities like the ocean data partnership to move integration forward then it has completed its role. Seafloor mapping has been embraced by just about every country. In the U.S., work needs to be done on the political side of things. An organized group asking for money makes a lot of sense as an outcome of this workshop.
- Product of this workshop should be a call of interest to convene experts.
- Create a map gallery for all maps created in Gulf of Maine. Participant response: Could use Google Earth technologies for this. It is a popular way to disseminate info to the public. Participant response: This is already the charge of the ocean data partnership: promoting access and use of disparate data sets.
- GOMMI's list of priority mapping areas was primarily sediment mapping (see GOMMI User Needs Assessment and/or Summary of 2006-2008 Planning Workshop). Also need biology layers and fish use of habitat information.
- Do the proceedings, but then wait to see how we can fit into what is called for from spatial planning initiatives, NROC, energy initiatives, eco-regional assessment, etc.

Proposed Actions & Ideas for Partnership Building:

- An outcome of this workshop should be to build a stronger coalition.
- Use the Northeast Regional Ocean Council (NROC) to disseminate data. Educate NROC about what needs to be mapped next. They need to know this. The landscape is changing b/c of ocean developments. Regional initiatives that are gaining momentum. This is a real opportunity.
- Look at the link between GOMMI and the Northeast Regional Association of Coastal Ocean Observing Systems (NERACOOS).
- The Gulf of Maine Council on the Marine Environment, etc. needs to go to hill and ask for money. We need a regional delegation. NROC put together a delegation request, which asked for $1.5 million in funding for seafloor mapping research in the New England region. The request also included funds for LiDAR, the Sea Grant programs, data management, and the Gulf of Maine Ocean Data Partnership. GOMMI can be more active in asking for appropriations in this way.
- Need to foster a relationship/two-way communication between the seafloor mapping community and scientists and managers doing the stock assessments. This is a tractable approach. You only need one population dynamics person and one mapper to get it started. Participant response: This would be a step forward! The assumptions being made about habitat in population dynamics models aren't based on information from high-resolution surveys. Consider a traveling road show idea in which you approach population dynamics scientists, habitat managers, and fishermen to give a talk on habitat mapping. We could accomplish this if we all contributed to the development of this canned talk. Then pick one person in each state to do this outreach.
- How to reach audiences: Fishermen organized by port. Also need to work at the political end to keep education about seafloor mapping going b/c the political environment is always changing.
- Marine spatial planning is driven by energy needs. Canada has completed 7 years of marine spatial planning, and is now focusing on energy. TNC is currently conducting marine spatial planning in the northwest Atlantic. GOMMI needs to be nimble enough to use that momentum to draw out the importance of seafloor mapping. Fisheries management is one component. Move GOMMI on to support marine spatial planning efforts. Pitch to marine spatial planning how mapping will solve all of your problems. In June TNC will roll out their work on eco-regional assessment and talk about greater spatial planning needs.
- Make data more useful!! With the small amount of data that are available it is now only useful to look at habitat for species with high site fidelity that are specific to sites with data.
- Habitat-fishery production links are of interest to the Council in long-term. Fisheries won't solve that data need. Conservation organizations will be the biggest push for habitat data because basic understanding of the system is needed to maintain broad ecosystem function.
- Hard to build public interest without really good maps; however, as a communication tool, the current resolution of existing maps is good enough.
- The fishing industry is evolving rapidly. Their ability to lobby for themselves is growing.
- Two initiatives are needed (one that hits at a high level to articulate what we need and the other that speaks to specific fisheries needs).

IV. Outcomes and Conclusions

The overarching priority identified by participants throughout the workshop is the need to increase the availability and utility of high-resolution mapping products to fisheries managers. A three-pronged approach emerged: (1) enhanced communication and collaboration between mapping, management, and research communities to develop and maintain targeted seafloor mapping and distribution approaches; (2) partnership and coalition building to conduct marketing, raise funds, and increase political will at the regional level to achieve critical mapping needs; and (3) greater seabed mapping coverage, at the scale and resolution of use to fisheries managers, and integrated with fish use, hydrographic, and ecological data.

The workshop highlighted that acoustic seafloor mapping and groundtruth data are used to a very limited extent in current regional fisheries management approaches for a number of reasons. First, the lack of interaction between acoustic mappers and fisheries managers was noted as a serious impediment. Inclusion of an acoustic mapper on the New England Fisheries Management Council's Habitat PDT would facilitate incorporation of existing habitat data into ongoing habitat vulnerability assessments. Second, there was a paucity of studies available that coupled habitat maps with fisheries data when the EFH source documents (e.g., the NOAA Technical Memos that summarize all available information on habitat requirements, range, etc. for each federally managed species and the 1998 Omnibus EFH Amendment that implemented the original EFH designations) were created. There is not enough research relating habitat characteristics with fish distribution data, and studies establishing causative links between them are especially limited. Even where habitat preferences are known, there is not enough mapping data to delineate bottom habitats with those features. Several of the ongoing and recent studies highlighted at this workshop will be of great value in efforts to update EFH designations, both the written descriptions and EFH maps. Third, spatially-explicit fish habitat data are required if area closures in the Gulf of Maine and Georges Bank are to be based on a more systematic, data-driven approach to defining the "best" areas to protect from the adverse impacts of fishing. . Fourth, habitat data will not be useful for stock assessment models until scientists have a better understanding of how habitat influences fish productivity. Achieving this goal will likely require more holistic maps of the northwest Atlantic coupled with research that identifies causative links between habitat characteristics and fish productivity at the spatial scales at which fisheries are managed. Overcoming these obstacles will likely require years to decades and substantial collaboration and effort among fisheries scientists, mappers, and managers. By identifying these barriers and outlining the three-pronged approach listed above, we envision this workshop as a critical early step in enabling the use of high-resolution acoustic seafloor information to enhance fish habitat management in the Gulf of Maine.

Several outcomes of this workshop are aimed at increasing the availability and utility of high-resolution mapping products to fisheries managers. First, this proceedings document will be distributed widely and made publicly available as an educational and communication tool. In addition to the text summarizing the issues raised and lessons learned at the meeting, this document contains links to many of the informative presentations given at the meeting and content summarizing the major points of the presentations. These presentations include background information about fisheries science and management in the U.S., acoustic mapping

as a tool, and case-studies demonstrating how acoustic mapping can be useful for fisheries. Collectively, they provide a primer on acoustic mapping as a tool for fisheries management that will help educate other scientists, managers, and the general public. The proceedings document also contains information about and links to other sources on seafloor mapping; linkages between fisheries management, research, and seafloor mapping; management in the Gulf of Maine & U.S. fish habitat; and geographic seafloor mapping priorities in the Gulf of Maine. Second, participants at the workshop are convening a Technical Workshop at the upcoming Gulf of Maine Symposium in St. Andrews in early October 2009 on Seafloor Mapping for Ecosystem Management in the Gulf of Maine. Third, the Gulf of Maine Mapping Initiative convened a meeting among federal and state managers, planners, and scientists on May 22nd, 2009 to develop a list of seafloor mapping priorities that accommodates a broad range of marine spatial planning needs in the New England region (e.g., fisheries science, wind energy, offshore oil exploration, navigation, etc.), and submitted the list to U.S. Senators on behalf of the New England states. Fourth, Grabowski presented the major findings of this workshop to the Habitat Committee of the Atlantic States Marine Fisheries Commission on July 10, 2009. And fifth, the Gulf of Maine Research Institute, with the assistance of the Gulf of Maine Mapping Initiative and interested participants, will pursue the development of a manuscript highlighting how high-resolution mapping is currently used in fisheries management and how it could be enhanced. This information will be of value to anyone who wishes to learn more about how habitat mapping is being coupled with fish habitat research to enhance fisheries management in the Gulf of Maine.

The Gulf of Maine Research Institute and Gulf of Maine Mapping Initiative wish to thank all of those involved in planning, funding, and attending this workshop.

Appendix A. ABOUT THE HOST ORGANIZATIONS

The **Gulf of Maine Mapping Initiative (GOMMI)** formed in 2001, as a subcommittee of the Gulf of Maine Council on the Marine Environment, to address needs for seafloor mapping in the region. GOMMI is a voluntary partnership of U.S. federal and state agencies, Canadian government agencies, and academic institutions working together to accelerate the availability and use of seafloor mapping products in Gulf of Maine ocean management. Our mission is to facilitate the production and availability of maps of seafloor topography, geology, and habitat that are essential for Gulf of Maine resource management, planning, and many commercial activities. In the seven years since its inception, GOMMI has determined the extent and nature of user needs for mapping products, raised regional awareness of the importance of seafloor mapping, and directed resources toward multi-institutional mapping of high priority areas in New England and maritime Canada. GOMMI serves as a central coordinating agent within the mapping community, garners financial and logistical support for expanded mapping, and provides a bridge between researchers, managers, and stakeholders to enhance the use of seafloor maps in Gulf of Maine management. GOMMI's website (http://www.gulfofmaine.org/gommi) features a coverage map showing areas of the Gulf of Maine mapped using high-resolution bathymetric surveys, a user needs assessment report, our strategic plan *Gulf of Maine Mapping Initiative: A Framework for Ocean Management*, an overview of mapping technologies, as well as links to seafloor mapping information, fact sheets, copies of our newsletters, and a list of the steering committee membership.

The **Gulf of Maine Research Institute (GMRI)** catalyzes community dialogue, interdisciplinary research, and science literacy to realize the natural and human potential of the Gulf of Maine bioregion. Our goal is to position the Gulf of Maine community to emerge at the forefront of a new era of maritime innovation, embracing creative strategies to harness the ocean's productive capacity while sustaining the bioregion's vitality and character for future generations. Our scientists partner with fishermen, environmentalists, and state and federal fishery managers to build knowledge of commercial fish species, critical habitats, fishing gear technology, and human behaviors to enable more effective fishery management in the Gulf of Maine. Our education programs engage students with the scientific method and encourage them to learn about Maine's fresh and saltwater ecosystems. Our community programs help to identify emerging challenges and opportunities in New England fisheries and foster a climate of cooperation among a diverse mix of marine stakeholders. Our lab serves as a node of collaborative marine research activity in the heart of northern New England's working waterfront.

Appendix B. POSTER SESSION

- *Evaluation of image-based multibeam sonar backscatter classification for benthic habitat discrimination and mapping at Stanton Banks, UK,* Chris McGonigle, University of Ulster, Northern Ireland

- *Benthic Habitat Classification and Mapping*, Mark Anderson & Geoffrey Smith, The Nature Conservancy

- *Coastal and Marine Ecological Classification Standard (CMECS),* Kathryn Ford, Massachusetts Department of Marine Fisheries

- *Canada Healthy Oceans Network*, Paul Snelgrove, Memorial University, Newfoundland

- *Bay of Fundy Multibeam*, Brian Todd & Vladimir Kostylev, Natural Resources Canada

- *German Bank*, Brian Todd & Vladimir Kostylev, Natural Resources Canada

- *GOMMI Multibeam Data*, Gulf of Maine Mapping Initiative Steering Committee

Appendix C. List Of Participants

First Name	Last Name	Organization
Mark	Anderson	The Nature Conservancy
Michelle	Bachman	New England Fishery Management Council
Seth	Barker	Maine Department of Marine Resources
Craig	Brown	University of Ulster, Northern Ireland
Peter	Colosi	NOAA Fisheries
Chad	Demarest	New England Fishery Management Council/NOAA NEFSC
Sara	Ellis	Gulf of Maine Area Program of the Census of Marine Life
Kathryn	Ford	Massachusetts Division of Marine Fisheries
Steven	Fromm	NOAA Northeast Fisheries Science Center
Jonathan	Grabowski	Gulf of Maine Research Institute
Ray	Grizzle	University of New Hampshire
Vince	Guida	Northeast Fisheries Science Center & GOMMI Steering Committee
Brad	Harris	School for Marine Science and Technology, University of Massachusetts Dartmouth
Tracy	Hart	Gulf of Maine Mapping Initiative
Lew	Incze	Gulf of Maine Area Program of the Census of Marine Life & University of Southern Maine
Peter	Jumars	University of Maine
Vladimir	Kostylev	Geological Survey of Canada, Natural Resources Canada
Sarah Walsh	Laporte	NOAA Marine Fisheries Service, Protected Resources Division
Marissa	McMahan	Gulf of Maine Research Institute & University of Maine
Vincent	Malkoski	Massachusetts Division of Marine Fisheries
Chris	McGonigle	University of Ulster, Northern Ireland
Linda	Mercer	Maine Department of Marine Resources
Betsy	Nicholson	NOAA Coastal Services Center, National Ocean Service
Geoffrey	Smith	The Nature Conservancy
Matt	Nixon	Maine Coastal Program, Maine State Planning Office
Paul	Snelgrove	Memorial University, Newfoundland
David	Stevenson	NOAA Fisheries, Northeast Regional Office
Jason	Stockwell	Gulf of Maine Research Institute
Brian	Todd	Geological Survey of Canada, Natural Resources Canada
Page	Valentine	U.S. Geological Survey
Rick	Wahle	Bigelow Laboratory for Ocean Sciences
Larry	Ward	University of New Hampshire Center for Coastal & Ocean Mapping
Tom	Weber	University of New Hampshire Center for Coastal & Ocean Mapping
John	Williamson	The Ocean Conservancy, New England Office
Nick	Wolff	University of Southern Maine

Appendix D. Workshop Background Information