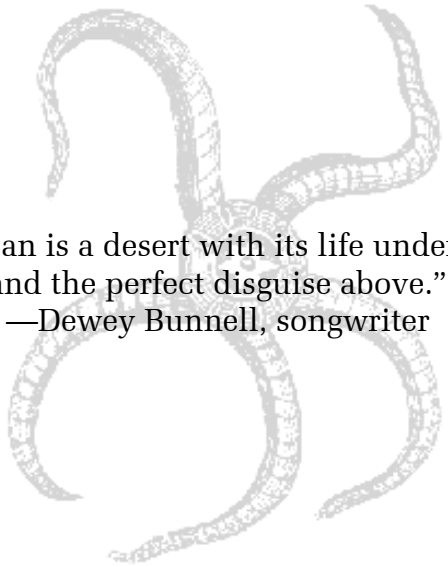
Gulf of Maine Marine Habitat Characterization and Mapping

A Workshop Report and Strategy for Ocean Mapping in the Gulf of Maine

October 21-23, 2001 • Sebasco Estates, Maine

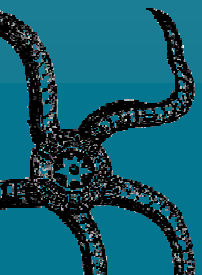
Prepared by the Gulf of Maine Council on the Marine Environment

with assistance from naturesource communications



"The ocean is a desert with its life underground
and the perfect disguise above."
—Dewey Bunnell, songwriter

On the cover
Clockwise from top left: Flounder, Anenome, Lobster, and Starfish. Images from the US Geological Survey.
Background: "Fishing Grounds of the Gulf of Maine," Chart from US Department of Commerce Bureau of Fisheries, 1929.



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This report is made possible by the

Gulf of Maine Council on the Marine Environment

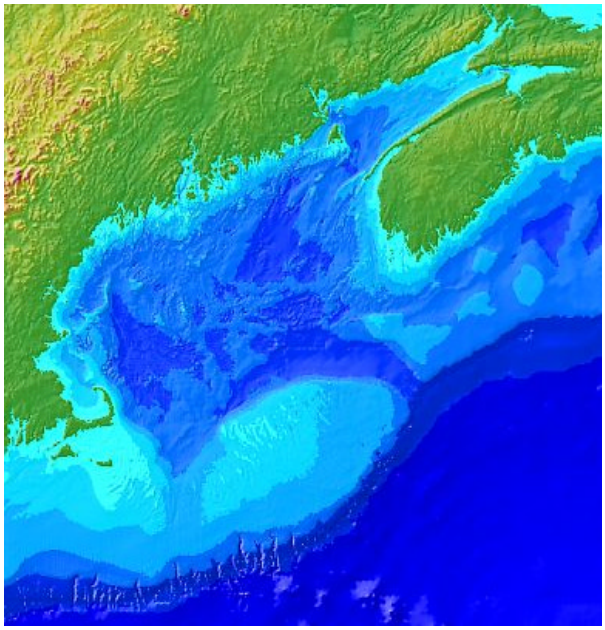
with support from

NOAA

Executive Summary

The Gulf of Maine Council on the Marine Environment (GOMC) with sponsorship from the National Oceanographic and Atmospheric Administration (NOAA) hosted the Gulf of Maine Marine Habitat Characterization and Mapping Workshop in Sebasco Harbor, Maine on October 21-23, 2001. The goal of the workshop was to develop a five-year regional strategy to map and characterize marine habitats in the Gulf of Maine. The workshop was organized in response to the Gulf of Maine Council on the Marine Environment's *Action Plan 2001-2006* habitat goal of developing a marine conservation strategy. To implement this goal, a clear plan is needed to provide guidance on coordinating the work of researchers, managers, educators, and other potential users of habitat data. The Workshop Steering Committee was composed of Brad Barr, NOAA; Paul Boudreau, Department of Fisheries and Oceans; Don Jagoe, SAIC; Slade Moore, Maine Department of Marine Resources; and Susan Snow-Cotter, Massachusetts Office of Coastal Zone Management.

For two days, over sixty individuals representing a diverse range of organizations participated including researchers, resource managers, nonprofit organizations, volunteers, government agencies, consultants, and private corporations. The first day focused on presentations and breakout groups on the existing body of mapping work that has been done in the region. Short case studies illustrating the use of a range of technologies helped participants to better understand the spectrum of work in the Gulf of Maine region. Representatives from academia, agencies, private industry, and nonprofit organizations presented short project overviews demonstrating the techniques and technologies used in ocean mapping and habitat characterization. Brief summaries of each presentation can be found in the Appendix. Presentations ranged from an introduction to existing and emerging technologies to case studies by both data producers and users. Afternoon breakout groups delved into questions such as how data are shared, how users access information, what gaps exist and how they could be filled. The second day focused on how the region could advance some of the needs identified the previous day. Participants broke out into groups to explore specific recommendations and rough-out implementation plans.



Color-enhanced undersea landscape of the Gulf of Maine (image courtesy of NOAA).

The overarching recommendation from those attending the Workshop was to map the entire Gulf of Maine Basin, as well as nearshore areas, utilizing standardized technologies and mapping strategies. Shortly after the Workshop, this project was entitled the Gulf of Maine Ocean Mapping Initiative or "GOMMI." The Gulf of Maine Council for the

Marine Environment endorsed GOMMI at its December 2001 meeting and agreed to serve as the host to this effort. Briefly stated, specific components identified to develop the Gulf-wide strategy are as follows:

1. Identify and engage potential user groups to assess ocean mapping needs and customize products.
2. Develop a habitat mapping classification framework.
3. Develop and implement a Gulf-wide mapping strategy.
4. Establish and maintain data management tools for ocean mapping products.
5. Establish a public- and private-sector partnership to promote emerging marine mapping technologies.

This Workshop report provides a brief summary of the workshop presentations, discussions, and recommendations. The Appendices includes the Workshop Agenda, Summary of Workshop Presentations, a listing of Workshop Participants, and a matrix of information about existing mapping projects in the Gulf of Maine.

Background

The 69,115 square miles or 165,185 square kilometers of the Gulf of Maine have been identified as one of the world's most dynamic, productive, and important ocean systems—often called a “sea within a sea.” Once considered a breadbasket of the New World, precipitous declines in the Gulf’s fishery resources have threatened not only the health of its ecosystems, but also the vigor and resilience of coastal communities. Other dramatic changes have emerged to threaten the Gulf’s integrity. Over 70 million people live in the Gulf of Maine watershed or work within a day’s drive of it. With urban sprawl, coastal areas have been impacted by some of the densest residential and commercial development in the region. Increases in activities such as aquaculture and utility development have further intensified the use of coastal resources. From coastal and fisheries management to research and permitting, marine habitat characterization and mapping information is essential for making informed decisions that drive balanced resource management. To meet the challenge of responsibly managing these resources, researchers and managers need complete and up-to-date habitat characterization and mapping information for informed decision-making.

The importance of habitat to marine biodiversity, fisheries productivity, and ecological integrity is well documented. The threat to habitat from a range of human activities, including fishing, pollution, aquaculture, construction of structures, and shipping is becoming increasingly evident. Based on the evolving understanding of potential human-induced impacts, coastal managers at the local, state/provincial, and federal levels attempt to protect marine habitat from these potentially damaging uses in several ways. Habitat is managed using fishing gear restrictions, marine protected areas, permit conditions, regulations, and restoration. Managers are severely handicapped in these attempts by the lack of comprehensive habitat maps along with an insufficient understanding of what impacts different types of uses have on various habitat types.

Traditionally, ocean-bottom mapping has focused primarily on geological information or bathymetry. During the Workshop, a common, shared bathymetry layer was identified as a priority for a base data layer. Researchers and resource managers also indi-

cated that they require habitat and biological community data to complement bathymetry. The goal of marine habitat characterization and mapping is to create a comprehensive picture of an ocean system. With the technologies currently available, a detailed portrait of the Gulf of Maine can be created and built upon and would include information such as sediment types and sources, water quality conditions, benthic (bottom-dwelling) flora and fauna, anthropogenic structures, and natural features. The resulting portrait would result in the holistic ocean mapping and habitat characterization for the entire Gulf.

Significant habitat work has been completed or is ongoing in the Gulf. However, there has been little sharing and synthesizing of data for diverse users. Further, many data gaps and areas where increased information is needed have been identified. A strategy is needed to identify and prioritize steps toward the eventual goal—complete mapping of the Gulf of Maine. The GOMMI strategic plan will also demonstrate a unified position and a collaborative plan to leverage funding and support for coordinated mapping work performed by organizations and agencies throughout the Gulf of Maine.

Data Collection Methods and Technologies

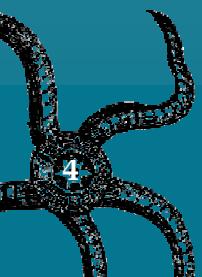
Numerous technologies can be employed for new and expanded purposes. Many of the organizations specializing in the development and deployment of these technologies are located in the Gulf of Maine.

Many types of marine data are obtained through a number of methods including "remote sensing" technologies such as satellites, sonar, and video cameras. It is often necessary to groundtruth data obtained through these methods. Groundtruthing is especially imperative for validating collected data in nearshore (sometimes referred to as shallow water) areas that represent a much more complex mosaic of different bottom types than offshore environments. In many nearshore areas where there has been little mapping work done, habitat assessments, water quality "grab" samples, and biomonitoring may be the only available or reliable methodologies to obtain characterization information.

Volunteer groups throughout the Gulf conduct tidepool and other nearshore activities including habitat assessment and biological monitoring. A further discussion of working with volunteers is included in the Challenges and Opportunities section of this report. Universities, agencies, nonprofits, and consultants have worked together to create detailed maps and inventories of the banks, channels, and offshore areas. A limited amount of mapping work has also occurred in the nearshore.

A variety of technologies are used for nearshore and offshore mapping. These methods and technologies—available through a variety of service providers—are utilized by agencies, universities, nonprofit and for profit organizations. This section offers short descriptions of some of the more common and emerging technologies.

Grab samples – are specimens taken from the ocean bottom and water column and can consist of benthic flora and fauna, sediment, and water. The samples provide in-depth information on species and conditions. Processing and analysis time increases with the level of detail. This collection method is especially useful for groundtruthing remote-



sensing data and for obtaining detailed information on biological, chemical, and geological information. This is one of the most appropriate methodologies in which volunteers can be trained to collect data.

Compact Airborne Spectrographic Imager – or CASI, offers spectral reflectance for nearshore waters and landforms. Global Positioning System and attitude data are obtained from aircraft fly-overs. The information can be used for bathymetry, mapping, water quality, algae detection, and coral reef monitoring. The technology can be limited by environmental conditions including the presence of suspended sediments, depth, and glare off the water from the sun.

Laser line scan – produces high resolution images and can be used to map large ocean bottom areas. The technology uses the small, focused beam of a laser to measure the reflectivity of bottom objects and can be used to create images of artificial structures such as sewer outfalls, telephone cables, and pipelines as well as natural features such as seafloor vents and benthic life forms. The technology can image millimeter- to centimeter-sized objects at higher ranges than conventional camera systems. The data are recorded as digital still or video images. Backscatter of light reflected off suspended sediment and other particles in the water has much less effect on image quality than with imagery systems requiring an array of underwater lights. Water clarity is still a restriction on the effective range of the laser line scan. As water clarity decreases, the laser system must be towed closer to the ocean bottom, covering a narrower swath of the bottom along each trackline, and increasing the risk of damage to the towed system in areas with rocky and irregular topography.

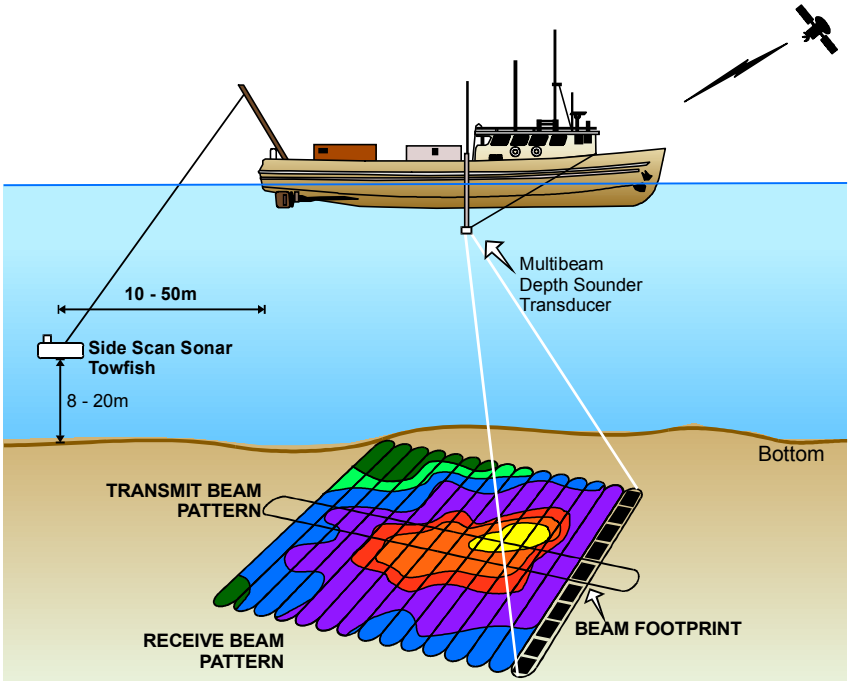
Survey Operations Showing use of RoxAnn™ and real-time video of sea floor (image courtesy of Maine Department of Marine Resources).

LIDAR remote sensing – or Light Detection and Ranging, measures aircraft-to-ground distance and can be combined with a Global Positioning System (GPS) device. LIDAR provides detailed topography, especially for beaches and intertidal areas. However, it is not as effective in rocky habitats. It is accurate to 20 centimeters but typically only provides linear sweeps resulting in "swaths" of information up to 300 meters wide. Multiple data types can be automatically generated. Special LIDAR units can be used to provide bathymetry. With the average cost about $1,000 per square kilometer, higher resolution may become cost-prohibitive. Turbidity and rough water limit water penetration. Images are affected or can be obscured by the presence of tree canopies. Strengths of the data include use for assessment of restoration efforts such as comparing pre- and post-storm conditions.

Multi-beam sonar – uses a series of beams to scan a wide swath of the ocean bottom in one linear path. The multiple receiving beams have sounding capabilities with high hori-

zontal and vertical resolution. Information on fish and particles in the water column is also possible with this three-dimensional technology, but has not traditionally been retained by the user. It is most often used in deeper water (+10 meters).

Satellite remote sensing – produces high-resolution images in clear or shallow water of conditions such as ocean color that can be interpreted in terms of temperature, chlorophyll, or algae densities and turbidity. Larger scale patterns reflect ocean circulation and regional hydrography. Some projects using the technology, such as SeaWIFS (Sea-viewing Wide Field of View Sensor), can measure the density of phytoplankton in the water as well as gauge seasonal changes in its distribution and map ice cover and surface water temperature. Satellites can also be used to map plumes of sediment from land-based runoff. A new lower-orbiting satellite, the Topex/Poseidon, can measure changes in sea levels to within five inches. False color is often added to enhance the contrast and quality of images. As this technology evolves, there will be further opportunities to refine its data collection capabilities.



Configuration used during NOAA Survey Operations (image courtesy of SAIC).

Sidescan sonar – uses a scanning device carried by a towed body that sends out a sound pulse and measures the reflection intensity from the bottom. From these measurements, interpretations of roughness of seafloor, orientation, and some geophysical properties of the target surface can be made. Large objects may block the signal from the ocean bottom. The blockage can obscure the shadows of objects that are needed to determine their size and shape.

Single beam sonar – can be used with ordinary GPS and outputs data as ASCII (or plain text) files to most personal computer systems. Displayed data provides bathymetry information and allows users to distinguish between areas of seabed that are acoustically unique. Applications have included mapping of community types, shellfish beds, subtidal vegetation in turbid conditions, and documentation of sediment transport. Some models (RoxAnn™) allow a user-defined calibration that allows operators to construct a

comprehensive library of bottom types unique to a given locale. Real-time monitoring of data collection affords the opportunity to validate or refine calibrations while mapping which enhances the accuracy of the mapping effort. These systems are relatively inexpensive, and can be readily fitted to "vessels of opportunity." The system is advertised to map depths of several hundred meters. Limitations include the relatively narrow sonar beam angle, which limits the area of bottom sampled by the equipment. Interpolation routines are used during post-processing to estimate or "fill-in the gaps"; as area size increases, so does the amount of interpolation between data points. Also, multiple, dissimilar bottom types can sometimes yield the same acoustic signal leading to misclassification if calibration/survey protocols are not strictly followed.

Video transects – are often used for nearshore surveys and for gathering data on seasonal habitat change. The technology offers real-time event recording and large-scale mosaic images of benthic habitats. Automated or remotely-operated vehicles (ROVs) can be used. Limitations include visibility and for ROVs, the requirement of an adequately-equipped vessel and support team. Diver-held video surveys offer detailed observations of seabed and biology in shallow waters. Bottom photographs increase the speed of analysis over using only grab samples.

Opportunities and Challenges

As mentioned in the Executive Summary, the Gulf of Maine is a well-studied area where many data have been produced. By collaborating with users, these data can serve as an example to identify, prioritize, and determine the appropriate and best methodologies to obtain further information. GOMMI can foster relationships, broaden partnerships, and expand ocean mapping in the region. Both data producers and users can work together to build on existing work by prioritizing information gaps and advise on research and development of new technologies.

One of the greatest challenges identified during the Workshop is the lack of knowledge of and access to existing data. Despite the large body of work in the region, there is a critical need for better information exchange. In some cases, researchers have spent years compiling work such as video transects but have not analyzed the data so they can be correlated with GIS or other mapping technologies and be translated into usable information. Whether or not the data have been processed into usable information, they are not only often inaccessible but their existence is not always known.

Those attending the Workshop agreed that technology is not the greatest obstacle to locating and accessing data—organizations and their cultures remain the principal challenge. The Internet can provide a centralized search function but it is only effective if people and organizations participate by posting data or announcing their existence. While a centralized data "hub" is possible through the Internet, it is not feasible for one entity or organization to provide a correlative organizational or cultural role. A network and partnership is necessary to share existing data, make it reasonably available, and create a means by which new work is publicized.

Proprietary treatment of data is another obstacle in this effort. Researchers must be willing to share their data or risk duplication, loss of the value of the work, and the po-

tential for further and expanded research. A large component of this issue is data management. Users should be able to locate the data that they need. The data must also be accessible and translated into usable information in common formats and platforms. The Internet potentially provides not only search tools to find data but also the ability to make most data universal in format. Online discussion groups on standardizing data formats for various parameters and guidelines can facilitate information sharing.

Translating data into usable information for a variety of uses is another challenge. There is a need for research translators to work with data producers and users. For example, the Gulf of Maine Council has contracted with a consultant to begin translating its Gulfwatch data into information for a variety of users. Other research organizations should implement similar projects for their data.

On the other side of the issue, additional training of data users will increase the value of existing data. Training producers may also result in increased understanding of both information gaps and data analysis. The emerging technologies are enormous tools but without further training, the resulting data may not be fully-utilized. XHTML technology offers another opportunity. Websites utilizing XHTML allow the information visitors view to be customized according to the browser's information needs profile.

Finger Sponge (image courtesy of US Geological Survey).

As both a challenge and opportunity, many private companies have enormous stores of data that they have generated for clients. While the data are the property of the clients who paid for it, the companies may be willing to disclose the information they have in return for promotional consideration (with the permission of their clients). Another strategy for accessing these data is to require that all mapping and habitat information obtained for the purposes of applying for permits become part of the public domain. In the case of military information, some may be or will be declassified and be part of the public domain. Current and future availability of this information should be explored and monitored.

"Data mining" is an opportunity to address the dual challenges of data management and accessibility. Interns or a service group such as AmeriCorps could be organized and recruited as part of a multi-year (and potentially ongoing) program to identify data sources and catalog them. The matrix described in the Executive Summary can be used as a base to compile metadata on all past, current, and planned mapping and marine

characterization projects and data in the Gulf of Maine. From this matrix, a bibliography can be built and maintained. To access this information, an Internet "metasite" could be built and maintained to house a bibliography with dynamic links to data sources. In time, data producers could be provided with the ability to upload to the site their own information. In the region, the Gulf of Maine Environmental Information Exchange or GOMINFOEX (www.gominfoex.org) is working to address similar issues. Supporting its efforts and providing the additional capacity to act as a partner in GOMMI may make possible a connection to the many other information management efforts in the region.

Fieldwork is an essential vehicle for furthering the use of existing and future research. Both professionals and volunteers collect data on benthic populations and conduct habitat assessments. While some dive surveys are performed in deepwater, most fieldwork is in nearshore areas, which includes exposed rocky coastline, beaches, and high tide pools. Monitoring activities include collection of water quality samples and biomonitoring surveys with plants, invertebrates, fish, and other animals, including invasive species. With the large area of the Gulf of Maine, it is not possible for paid staff to provide full coverage and in-depth surveys of the entire region. Volunteer programs offer the advantages of local knowledge and the ability to train a potentially large workforce. Challenges include inadequate funding, lack of agreement on protocols, perception of poor quality control during collection and processing, and insufficient professional support and guidance. Mobilizing large numbers of volunteers for activities such as storm events can be both a challenge and an opportunity. With coordination and communication, professional- and volunteer–generated data can complement one another. These data can provide both groundtruthing of remote technology and other information such as water samples and biomonitoring surveys with plants and animals.

As a vehicle or platform for research, commercial fishing vessels offer another opportunity. Fishing vessel-based research has produced data on a variety of habitats including benthic communities, sediment characteristics, water column parameters, as well as fish and prey selection. This research offers the advantages of local knowledge and collaboration and circumvents the costs of scientists and organizations maintaining vessels or paying for charters. Challenges associated with fishing vessel-based research include the difficulty of acquiring fishery-independent habitat data if a vessel does not deviate from its established routine. Other relevant areas of consideration arise when no scientific staff is aboard a vessel mounted with survey equipment. These may include the adequate operation, maintenance, and trouble-shooting of survey equipment malfunctions or irregularities.

As discussed in the Executive Summary, the Gulf of Maine is fortunate to have many mapping and data technology organizations in the region. The organizations producing these technologies can take advantage of an enormous opportunity by working with data users to refine and prioritize their research and development of new products.

Identifying cost-effective funding to fully map the entire Gulf of Maine is both a challenge and an opportunity. While the effort will require large-scale funding, the opportunity for developing GOMMI partnerships is enormous. These partnerships can provide the immense value of their collective wealth of expertise and services to make GOMMI a success.

Current Status of Ocean Mapping in the Gulf of Maine

As a prelude to the Workshop, participants were asked to provide information about mapping projects in the Gulf of Maine including latitude and longitude, when the survey was conducted and for what purpose, in what form are the data, how the work was funded, and if the project is complete or ongoing. The resulting matrix (see Appendix) is a work-in-progress that provides the information in a tabular form and serves as an indication of what work has been done along with how and why the products were undertaken.

While there has been a great deal of work done in the Gulf of Maine, there were several areas where a need for additional or different kinds of data was identified. Generally, nearshore areas from roughly 0-60 meters require further information to aid decision-making on aquaculture management, coastal development, essential fish habitat, and other anthropogenic effects. The information needed includes bathymetry, sediment, and habitat characteristics. It should begin with large-scale resolution with more detailed resolution in complex areas. Similarly, intertidal areas and coastal embayments were areas identified as needing additional habitat management information. These are areas where volunteer organizations could provide a great deal of valuable field work and analysis. Those areas with existing or proposed human impacts such as pipelines, mineral exploration, or cables were identified as requiring baseline data to gauge anthropogenic effects for resource management, regulatory, and enforcement decisions. Those involved in fisheries management indicated a need for additional information on Jeffreys Ledge, Georges Bank, and the Great South Channel. Additional information is also needed generally for the lower Bay of Fundy and coarse gravel lobster habitat.

In general, Marine Protected Areas and heavily regulated or closed areas including Georges Bank, (particularly the US portion), Stellwagen Bank, Cashes Ledge, and Fipennies were discussed as requiring additional information for fisheries management, oil and gas development, and evaluation of shipping transport impacts. Multibeam, water column, and ocean-bottom geology information along with animal behavior data are desired in these areas.

Recommendations

Understanding of the location, type, extent, and sensitivity of different habitats is critical to achieving sustainable management of marine habitats in the Gulf of Maine. As a result of recently developed technologies, the ability to map these areas is increasing each year. Coordination between researchers conducting much of the mapping in the Gulf of Maine and user groups such as coastal managers and educators should be strengthened. The Gulf of Maine Marine Habitat Mapping and Characterization Workshop was successful in convincing researchers and user groups to work together for mutual benefit. The overarching recommendation from the Workshop is to initiate Gulf of Maine-wide benthic mapping. To advance the knowledge of marine habitat, the Gulf of Maine Council agreed in December 2001 to serve as coordinator of the Gulf of Maine Ocean Mapping Initiative. GOMMI's key components are listed below:

Identify and engage potential user groups to assess ocean mapping needs and customize products. Coastal managers, educators, private consultants, researchers, and others

have interest in utilizing mapped products. Improved maps can lead to better decision-making by coastal managers as part of a suite of decision-making tools. It is essential that a needs assessment of different user groups be undertaken to identify the technical capabilities, work style, scale, and format that different users require. Creation and presentation of case studies, training, curriculum, and outreach may be required so that user groups can optimize their employment of ocean mapping products. Detailed maps will also improve the management of offshore marine resources. For example, defining habitats essential for recruitment of commercially and recreationally harvested fish will be greatly facilitated by these improved mapping products. Notably, the maps may also provide useful information in the formulation of hypothesis-driven research projects in the Gulf of Maine.

Progress to date: NOAA has provided funds to the GOMC to fund an assessment of state and provincial managers' marine habitat mapping needs and capabilities. The Massachusetts Office of Coastal Zone Management is hiring staff to develop a *Managers Guide to Using Marine Habitat Maps*.

2. **Develop a habitat mapping classification framework.** There are several classification schemes that have been developed to describe habitats, species associations, and interactions. These classification systems attempt to provide standard nomenclature that facilitates the use of maps for management purposes. A standard framework should be developed or adapted prior to embarking on major new mapping projects.

Progress to date: Department of Fisheries and Oceans is considering sponsoring a habitat mapping classification workshop later this year. In recent years, NOAA has also addressed development of a classification scheme.

3. **Develop and implement a Gulf-wide mapping strategy**. Based on direction set at the October Workshop, a Steering Committee of researchers and managers will develop a strategic plan to employ a range of technologies to map the bathymetry, sediment, and habitats in the Gulf of Maine. The plan will establish survey and mapping standards, identify preferred technology, and outline a timeline. An important component of this project will be identifying technologies capable of mapping the high-use, nearshore waters. Once the plan is drafted, GOMMI will create a consortium of partners to develop political support and identify funding to implement this ambitious mapping project.

Progress to date: A GOMMI Steering Committee composed of Brian Todd, Geological Survey of Canada; Page Valentine, US Geological Survey; Thomas Noji, NOAA; Paul Boudreau Department of Fisheries and Oceans; and Susan Snow-Cotter, Massachusetts Office of Coastal Zone Management has conducted a series of conference calls and meetings to scope out a plan. A five-page concept paper is under development. GOMMI abstracts have been submitted to two conferences in an effort to gain support for the Initiative.

4. **Establish and maintain data management tools for ocean mapping products**. The need for improved access to and sharing of existing data and maps has been identified as a significant barrier to effective use of ocean mapping information. "Data mining and rescue" is required to identify the wealth of video, hard copy, electronic file, and narrative historical data that have been completed in the Gulf of Maine and is housed in agencies' and researchers' libraries and offices. A sub-set of this data should be digitized and made available on the Internet. An Internet database should be established that serves as a clearinghouse to facilitate access to available information. Metadata standards need to be agreed upon and established. The Gulf of Maine Council created a matrix of existing ocean mapping projects of various scale and format as a first step prior to the Workshop. The matrix should be integrated with GIS coverage of mapped regions.

Progress to date: Based on the matrix prepared for Workshop, Brian Andrews, SAIC, is preparing a map of existing marine habitat projects in the Gulf of Maine.

5. **Establish a public- and private-sector partnership to promote emerging marine mapping technologies**. The Gulf of Maine is home to many of the private sector companies and university programs that develop cutting-edge mapping technologies. It is mutually beneficial for them to partner in testing technologies, identifying technology needs, and contracting for specialized mapping projects. Coastal managers are generally unaware of the extent that marine technology can be applied to their regulatory decision-making as well as to resource management assessment and planning. It is hoped that by working cooperatively, the private sector will be able to increase exposure of their products and the public sector will benefit by having access to new resource management tools.

Progress to date: Don Jagoe, SAIC will work with the Marine Technology Society to establish a private/public partnership to advance GOMMI.

Conclusion

As discussed in the Opportunities and Challenges section, organization of this effort will be challenging because of the scale of the work and the number of organizations and agencies on both sides of the international boundary. Partners and roles for mapping the Gulf of Maine should include:

- Private sector to provide mapping, surveys, and products so that researchers and resource managers can use the information for energy planning and development permit review, fisheries planning, and engineering;
- Government to provide leadership and support and to use the information for regulation and management;
- Academia to provide research, training, and products and to use the information for

further research and teaching;

- Environmental groups to provide advice and support and to use the information for outreach and research; and
- Government, academia, and environmental groups can also provide guidance and serve as beta-testers for technologies developed by industry.

While there are many challenges to a project of this scale, there are many opportunities as well. The combined resources of the people and organizations involved in mapping and characterization have enormous value.

The participants at the October 2001 Marine Habitat Characterization and Mapping Workshop demonstrated remarkable enthusiasm and a commitment to GOMMI. Attendees represented an impressive cross-section of data users and producers, researchers, resource managers, and others involved in ocean mapping. Participants expressed their commitment to working together on the common goal of complete and full ocean mapping and habitat characterization for the entire Gulf of Maine region.

Appendices

Marine Habitat Characterization and Mapping Workshop Agenda

October 21 - 23, 2001, Sebasco Harbor Resort, Sebasco Estates, Maine
Sponsored by NOAA and the Gulf of Maine Council on the Marine Environment

Sunday October 21, 2001

5:00 PM — Workshop Registration

6:00 PM — Opening Reception with exhibits and posters displaying a variety of habitat mapping and characterization projects

Monday, October 22, 2001

8:30 AM — Welcome and Introduction – **Susan Snow-Cotter**, *Massachusetts Office of Coastal Zone Management*

8:45 AM — Gulf of Maine Marine Mapping Overview: What work has been done? – **Brian Todd**, *Natural Resources Canada*

10:00 AM — Short project overviews demonstrating the range of techniques and technologies used to better understand and map marine resources in the Gulf of Maine. Each speaker will discuss the capabilities of the mapping and/or characterization technique, display graphic representation of work, discuss the applications and limitations of the data, and suggest areas of opportunity.

Citizen Monitoring (MA North Shore Tidepool Monitoring) – **Karen Young**, *Salem Sound 2000* & **April Ridlon,** *Massachusetts Audubon Society*

Video Transects (Video Techniques for Habitat Characterization and Coastal Marine Resource Inventory, Peter Lawton and Robert Rangeley) – **Peter Lawton**, *Department of Fisheries and Oceans*

Bottom Characterization Methodologies/Light Detection and Ranging (LIDAR) – **Mark Finkbeiner**, *NOAA Coastal Services Center*

Sidescan/Multibeam – **Larry Mayer and Andy Armstrong**, *NOAA/UHN Joint Hydrographic Office*

Remote Sensing/Satellite Imagery/CASI (Penobscot Bay Project) – **Anne Hayden**, *Resource Services*

Commercial Marine Surveys/Laser Line Scan (submerged towed system) – **Don Jagoe**, *SAIC*

Fishing vessel-based Research (Effects of Smooth Bottom Net Trawling Gear on Seabed) – **John Ryther Jr.**, *CR Environmental, Inc.*

CASI (Coastal Monitoring with the CASI System) – **Herb Ripley**, *Hyperspectral Data International, Inc.*

1:00 PM Updates from other related conferences

1:30 PM Charge to Break-out Groups – **Susan Snow-Cotter**, *MA CZM*
We will divide into break-out groups to discuss and come to consensus on a series of questions, which will initiate the development of a regional marine mapping and characterization strategy.

5:30 PM Adjourn

Tuesday, October 23, 2001

8:30 AM Report from Break-out groups – Facilitated by **Paul Boudreau**, *Department of Fisheries & Oceans*

9:15 AM Discussion - What are commonalities? What are differences? What are outstanding issues that need to be resolved or need further work or resources?

10:00 AM Implementation Strategy - What needs to be done to make this happen? Funding, coordination, political support, research opportunities etc.

12:00 PM Discuss specific next steps and who will lead and be involved in follow-up

Summary of Workshop Presentations

Brian J. Todd, Geological Survey of Canada [Atlantic], Dartmouth, NS
Over the last five years, the Geological Survey of Canada and the US Geological Survey have independently developed seabed habitat mapping programs throughout the Gulf of Maine. However, the organizations are developing more cooperative research and mapping projects through an interdisciplinary approach based on analysis of benthic life identified from seafloor photographs and integrated with interpretation of bathymetric data from multibeam along with other mapping information. Future work includes SeaMap, Canada's national marine mapping program proposal that will map the Canadian portion of the Gulf of Maine including the Bay of Fundy. A proposal to the National Science Foundation, spearheaded by the Woods Hole Oceangraphic Institution, will include multibeam surveys followed by habitat monitoring.

Karen Young, Salem Sound and April Ridlon, Massachusetts Audubon Society for Citizen Monitoring of Massachusetts's North Shore
The two organizations conducted a marine survey that monitored commercially-important resource areas. For twelve months, the project used underwater dives to produce baseline marine resource data at six sites with different habitats. Fish and invertebrates species data were recorded with 100 meter transects conducted one to two times each month for one year. A citizen wetland health assessment monitoring was also conducted to monitor salt marsh health at four wetlands sites. Volunteers were trained at six classes taught by scientists on plants, birds, benthic macroinvertebrates water chemistry, hydrology, and land use. Audubon's Adopt-a-Tidepool Program monitored flat exposed rocky and boulder/cobble coastline; sandy beaches with rocky outcroppings; and low, mid, and high tide pools for native and invasive species of plants and invertebrates.

Peter Lawton, Department of Fisheries and Oceans for Video Transects, Video Techniques for Habitat Characterization. The Crustacean Research Information System, CRIS, surveyed waters around the Fundy Isles, New Brunswick and Lobster Bay, Nova Scotia. CRIS used a shallow-water, remote video system complemented by groundtruthing to determine season habitat use and change. The video system offers real-time event recording using pattern recognition for large-scale image mosaics.

Mark Finkbeiner, NOAA Coastal Services Center for LIDAR remote sensing and for single-beam acoustic (RoxAnn)
LIDAR measures aircraft to ground distance and produces detailed topography, especially for beaches and intertidal areas. The RoxAnn system is synchronized with GPS to map shellfish beds, coral reefs, and hard-bottom communities to monitor anthropomorphic effects on habitats. Deployed on platforms such as small boats, RoxAnn's operational depth ranges from 1-30 meters deep at speed of about 8-12 knots (depending on local conditions). Although the data are limited to points, it is relatively inexpensive and requires little technical expertise or cost.

Andy Armstrong and Larry Mayer, Co-directors, NOAA/UNH Joint Hydrographic Office
Sidescan technology is deployed with a towed device called a "fish." Through measuring backscatter intensity, the technology characterizes roughness of the seafloor. Multi-beam technology uses a wide transit beam, similar to sidescan, except that the receiving beam has multiple sounding capabilities with high lateral and vertical resolution. Water column data are also possible with this three-dimensional imaging technology.

Anne Hayden, Resource Services, Penobscot Bay Project
Using satellite ocean remote sensing in collaboration with the Maine State Planning Office, Island Institute, and NESDIS/NOAA, the Project created an ecological characterization of Penobscot Bay. Information produced included geology, bathymetry, hydrography, circulation, intertidal classification, phytoplankton, red tide, fish habitat, remote sensing of SST, and ocean color to create a fisheries predictive model to be used as a lobster management application.

Don Jagoe, SAIC
SAIC conducts commercial surveys for a number of applications exploring construction of fiber optic cables, oil and gas pipelines, power cables, and outfalls. Other applications include mapping of underwater features, disposal sites for dredged materials such as oil fields, and events such as plane crash site underwater surveys. The firm has been contracted to provide hydrography for federal agencies and for private firms. Access to privately-funded data or contracts funded through NOAA are considered proprietary. SAIC indicated that full GIS coverage of the Gulf of Maine is needed so that all survey sources could be introduced and maintained.

John [Chip] Ryther, Jr. CR Environmental, Inc., fishing vessel-based research, effects of smooth bottom net trawling gear on seabed
CR Environmental, Inc. worked with fishing-vessels to conduct surveys of areas including Long Island Sound, Boston Harbor, Buzzards Bay, and the TWA Flight 800 crash site. Another project documented the real-time effects of six towns' runoff and discharges on soft bottom habitat including benthic communities, sediment characteristics, water column parameters, and fish and prey selection.

Herb Ripley, Hyperspectral Data International, Inc. for Coastal Zone Monitoring with CASI
Compact Airborne Spectrographic Imager, or CASI, uses spectral reflectance for mapping of nearshore and land-based features. The technology can also be used for bathymetry, mapping, water quality, algae detection, and coral reef monitoring.

Workshop Participants

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Sierra Club

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Ghost Nets

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Harry Upton
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Page Valentine
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UNH, Jackson Estuarine Laboratory

Karen Young
Salem Sound 2000

Matrix of Gulf of Maine Mapping Projects

Contact or lead researcher	Affiliation	Lat/long	When survey done	Methodology/ sampling technique	Purpose	Data form	Funding source	Ongoing or complete?
Boudreau, Paul	Department of Fisheries and Oceans		on-going	published literature	increase awareness and understanding of marine invertebrates	on-line: http://www.fundyforum.com/MIDI/	various	ongoing
Kelley, Joseph	University of ME	NH to NB, shoreline to 100 m isobath	> 100 surveys since 1989	5000 km side scan, 2000 bottom samples, submersible/rov dives, 5000 km seismic reflection lines	various	analogue, digital geophysics, GIS maps	minerals management service, Sea Grant, student theses	on-going
Moore, Slade	ME Department of Marine Resources	N44 33.196 W68 15.774	August 01	RoxAnn seabed classification system; video, sed. grab for ground truthing	characterization of benthic communities	text files	none	ongoing
Moore, Slade	ME Department of Marine Resources	Specific sites not yet defined but in vicinity of: N44 08.606 W69 00.633 N43 29.693 W70 19.689	November 01, April 02	RoxAnn seabed classification system; video, sed. grab for ground truthing	mapping of scallop habitat and possibly beds	text files	NE Consortium	slated for this November
Barker, Seth	ME Department of Marine Resources	43.0, -70.75;45.0, -67.0	1993-97	aerial photography	digital map of Eelgrass beds of Coastal Maine	GIS	MDMR.MDEP, MeSPO,MDC, NOAA	complete
Barker, Seth	ME Department of Marine Resources	43.0, -70.75;45.0, -67.1	2001-04	aerial photography	digital map of Eelgrass beds of Coastal Maine	GIS	NOAA,MDMR, MDEP	ongoing

Grizzle, Ray	Jackson Estuarine Laboratory	43 04.42'N 70 52.42'W	Oct-Nov 01	multibeam, videography, quadrats	development of improved monitoring techniques for subtidal oyster reefs	digital images	NH Sea Grant, CICEET	ongoing
Ward, Larry	Jackson Estuarine Laboratory	43 04.42'N 70 52.42'W	Oct-Nov 01	multibeam, videography, quadrats	development of improved monitoring techniques for subtidal oyster reefs	digital images	NH Sea Grant, CICEET	ongoing
Ward, Larry	Jackson Estuarine Laboratory	42 56.62'N 70 37.89'W	Mar-Aug 02	videography, bottom grab sampling	environmental monitoring of UNH Open Ocean Aquaculture field site	digital images	UNH CINEMar	ongoing
Grizzle, Ray	Jackson Estuarine Laboratory	42 56.62'N 70 37.89'W	Mar-Aug 02	videography, bottom grab sampling	environmental monitoring of UNH Open Ocean Aquaculture field site	digital images	UNH CINEMar	ongoing
Ellis, Sara	The Lobster Conservancy	44°03.2' 68° 38.9' to 40°53.5' 70° 32.0'	year-round at 2 sites, May-Oct at 23 sites	quadrat sampling along fixed transects	to determine patterns of abundance and distribution of young-of-the-year and juvenile lobsters	currently in Excel; to be transferred to relational database (Access)	foundations, state and federal government, individual donors	ongoing
Jagoe, Don	SAIC	Delaware Bay	4/01-11/01	multibeam, sidescan	Hydrographic survey in support of nautical charting	bathymetry and imagery	NOAA	ongoing

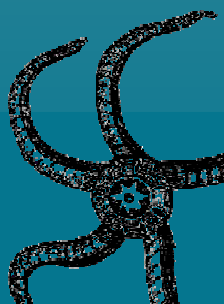
Contact or lead researcher	Affiliation	Lat/long	When survey done	Methodology/ sampling technique	Purpose	Data form	Funding source	Ongoing or complete?
Pederson, Judy	MA Institute of Technology, MIT Sea Grant College Program	20 sites, lat/long for each from Gloucester to Fall R.	Aug, 2000	scrape/identify	assessment of nonindigenous species (and native species on floating docks)	Species list, temperature, salinity.	NOAA, Sea Grant, MCZM, MBP	complete
Stuart, Sarah	Conservation Law Foundation			hierarchical framework for analyzing existing physiographic and oceanographic data	to create a seascape map of the GOM and Scotian Shelf to help formulate an MPA network for the GOM and Scotian Shelf		private foundations	ongoing
Mayer, Larry	CCOM	43 04 00, 70 42 30	April - Sept 2001	multibeam, LIDAR, video	system comparison, habitat mapping	many	many	ongoing
Costello, Charles	MADEP, Wetlands Conservancy Branch	41 15 00 - 42 50 00 and 69 55 00 - 71 00 00	Multi-yearly	aerial photo-based mapping	permitting support, change detection	ESRI polygon coverages	MADEP, CZM, CSC, etc	ongoing
Ferguson, Randy	NOAA/NCCOS, CCFHRB	41 40 00 - 42 05 00 and 70 00 00 - 70 40 00	One-Time	RoxAnn single-beam acoustics	habitat characterization	ESRI point coverage	MADEP/CSC	complete
Costello, Charles	MADEP	NA	May-October 94-97	aerial photo interpretation and extensive fieldwork using boat and underwater video camera	accurately map the *Zostera marina* (eelgrass) resource of the state.	digital data available from the MAGIS data library http://www.state.ma.us/mgis/eelgrass.htm or the NOAA Coastal Service Center Data Library	NOAA CCAP, MACZM, MADEP	complete

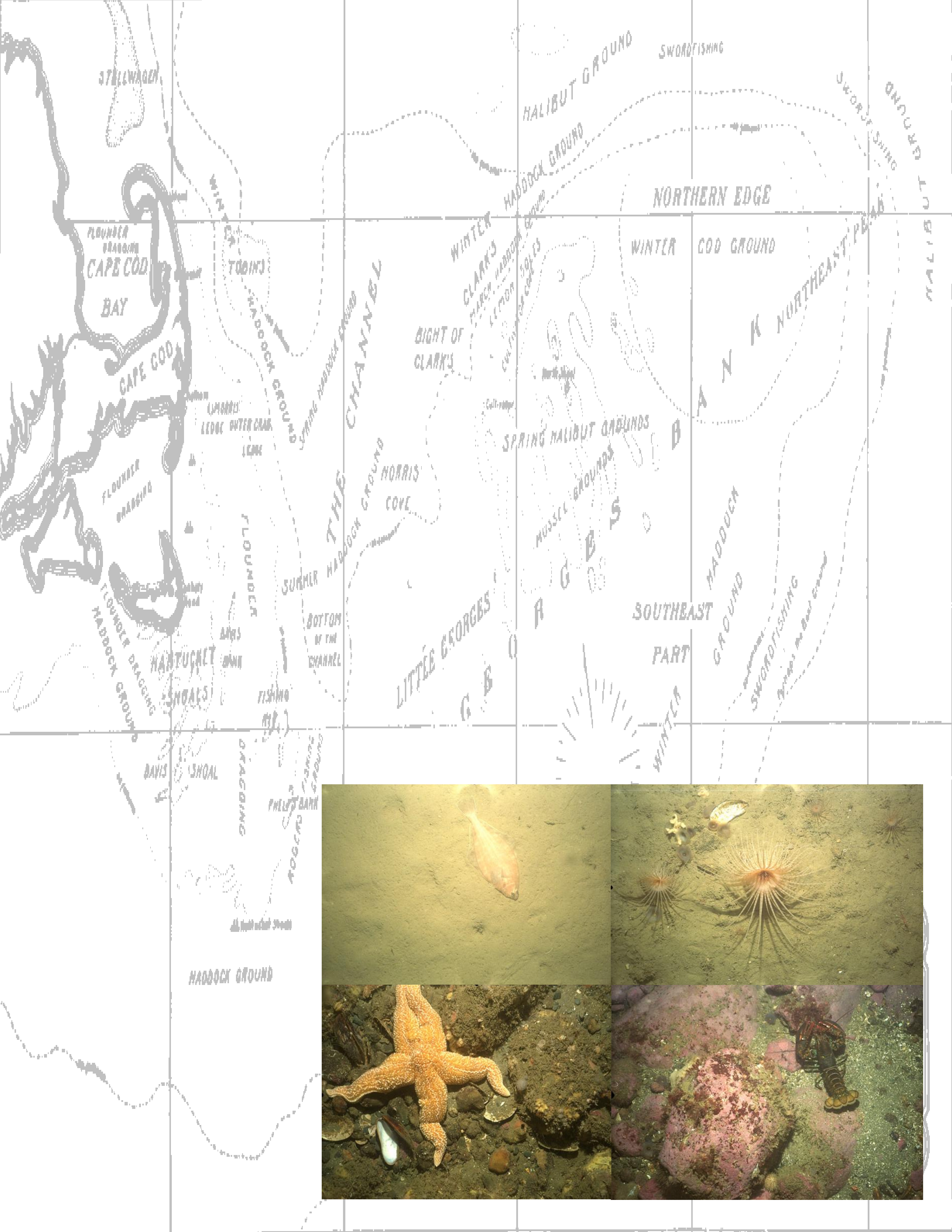
Farady, Susan	The Ocean Conservancy		Begun 1997; update completed 2001	GIS data collection and surveys	identify and assess conservation effectiveness of existing MPAs in the Gulf of Maine	ArcView	Grant	data collection is complete; publication in process.
Wilbur, Anthony	MA Office of Coastal Zone Management	41.90, 70.04; 41.65, 70.20	08/00	aerial photography, RoxAnn acoustic sampling, ground truthing	demonstrate capabilities of RoxAnn and aerial photography to characterize shallow water habitats	spatial and non-spatial	CZM Grant, Aquaculture competitive grant, DEP	complete
Wilbur, Anthony	MA Office of Coastal Zone Management	42.51, 70.77; 42.53, 70.85; 42.59, 70.67	11/98	sediment profile imagery	characterize seafloor environment at potential dredged material disposal sites	spatial and non-spatial	Massachusetts SeaPort Bond	complete
Meyer, Jill			N/A	remote sensing	ecological characterization		NOAA/NESDIS	
Rahmani, Aviva	Ghost Nets		ongoing	data design	visionary systems	visual and restoration	varies	ongoing
Huber, Ron			ongoing	video-aerial	baseline	video text	varies	ongoing
Williston, Martin	Dalhousie University		ongoing	ROV video	science			ongoing
Malkoski, Vincent	MA Department of Marine Fisheries			SCUBA	several			
Costello, Charles	Massachusetts Department of Enivironmental Protection			aerial photo; ground truthing	map seagrass distribution			

Contact or lead researcher	Affiliation	Lat/long	When survey done	Methodology/ sampling technique	Purpose	Data form	Funding source	Ongoing or complete?
Costello, Charles	MADEP		94-2001	establishment of thousands of geoferenced data points using high accuracy GPS and underwater video camera.	to establish a large number of accurate datapoints indicating: presence or absence of eelgrass, outer edge of eelgrass bed, or macroalgae	Digital data available from DEP Wetlands Conservancy Program, Boston, MA 617-292-5907	NOAA CCAP, EPA, MACZM, MADEP	ongoing. future mapping fieldwork will continue to produce more of this data.
Costello, Charles	MADEP	NA	May-October99-2001	aerial photo interpretation and extensive fieldwork using boat and underwater video camera	conduct a five-year change of the eelgrass resources of the state using the same mapping methods and protocols as the earlier mapping described above.	digital data available from DEP Wetlands Conservancy Program, Boston, MA, after March 2002 data will be available from MAGIS data library or NOAA Coastal Service Center http://www.csc.noaa.gov/crs/bhm/mass.html	NOAA Coastal Service Center, MA DEP, MACZM	ongoing.Cape Cod and Islands completed 2000, South Shore Boston Harbor and North Shore Completed 2002. Buzzards Bay to be completed Fall 2002.

Gulf of Maine Council on the Marine Environment

The Council's goal is “to maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations.”




STELLWAGEN
HALIBUT GROUND
SWORDFISHING
WINTER HADDOCK GROUND
NORTHERN EDGE
WINTER COD GROUND
NORTHEAST PEAK
FLOUNDER DRAGGING
CAPE COD BAY
CAPE COD
BIGHT OF CLARK'S
CLARK'S
THE CHANNEL
SPRING HADDOCK GROUND
HADDOCK GROUND
SPRING HALIBUT GROUNDS
MUSSEL GROUNDS
GEORGES BANK
MORRIS COVE
SUMMER HADDOCK GROUND
BOTTOM OF THE CHANNEL
LITTLE GEORGES
SOUTHEAST PART
WINTER HADDOCK GROUND
SWORDFISHING
NANTUCKET SHOALS
FLOUNDER DRAGGING
HADDOCK DRAGGING GROUND
DAVIS SHOAL
PHELPS BANK
HADDOCK GROUND