The MIT Sea Grant College Program

And

The NOAA/NMFS Northeast Fisheries Science Center

Present A Conference On

Geographic Information Systems and Ocean Mapping in Support of Fisheries Research and Management

April 11, 2006

Massachusetts Institute of Technology
Tang Center, Wong Auditorium
Cambridge, Massachusetts, USA

Sponsored by:

MIT
Sea Grant College Program

NOAA/NMFS
Northeast Fisheries Science Center

Contents

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With help from Cathy Noonan and Tom Noji (NOAA/NMFS/NEFSC)

Conference Overview

The importance of ocean mapping to support the management of living marine resources, conserve habitats, and protect biodiversity has been thoroughly reviewed and promoted by government organizations and independent commissions (e.g. U.S. Commission on Ocean Policy, NOAA Fisheries Service, and Pew Oceans Commission). The need to coordinate mapping initiatives has motivated the Massachusetts Institute of Technology Sea Grant College Program and the NOAA/NMFS Northeast Fisheries Science Center to convene this conference. In recent years, advances in collecting oceanographic data, new applications of ocean mapping, and expanding digital communication technologies have provided many new opportunities to integrate vast amounts of information in managing natural resources. This conference will focus attention on the areas where communication can facilitate data integration, so that marine resource scientists and managers can better utilize emerging technologies to make accurate, informed decisions.

This conference will provide a forum where researchers, scientists, and managers from around the Northeast Regional Ecosystem (Cape Hatteras through the Gulf of Maine) may present and discuss the application of geographic information systems (GIS) and ocean mapping as tools that support fisheries science and management. The objective is to identify opportunities for coordinating the use of oceanographic data, ocean mapping tools, internet technologies and innovative data sharing techniques to support fisheries science and integrated ocean management, through discussion of the following:

1. Describe current GIS databases and how they are being used;
2. Identify scientific and management data needs for the next 5 years;
3. Prioritize data gaps and identify mapping needs;
4. Develop strategies and methods for meeting identified data needs;
5. Formalize these in a report for NOAA and other agencies, with the aim of providing a document useful for leveraging synergies, fostering collaboration, and program planning.

Speakers will address these topics within the context of the Northeast Regional Ecosystem. A poster session will encourage those working in the areas of GIS, ocean mapping, data sharing, and/or fisheries research and management, to share current and emerging work. The day will conclude with a panel discussion focusing on how to foster cooperative research among participants and establish an Ocean Mapping Network for the Northeast. A document will be prepared that summarizes the presentations, poster information, and discussions to provide

NOAA and other agencies with insights gained from the conference that can be applied to enhanced collaborations and integration of technologies, data access, and GIS applications with management needs.

Organizations and individuals have submitted posters addressing fisheries management applications of their work. The topics of interest for the posters include:

- Geographic information systems and data products;
- Data collection methods;
- Ocean mapping projects;
- Data sharing & communication technologies;
- Visualization and display techniques;
- Marine data analysis applications;
- Ocean management & decision making techniques.

Application areas of interest include:

- Competing usages of marine habitats in the Northeast Regional Ecosystem;
- Fisheries activity and impacts on marine ecosystems;
- Distribution of cold-water corals and other species and habitats of concern;
- Effects of marine protected areas on ecosystems services including the role of MPAs for fisheries and biodiversity conservation;
- Essential fish habitat and habitat areas of particular concern.

Agenda

April 11, 2006 — *Massachusetts Institute of Technology, Tang Center (Building E51)*

8:00am **Registration**, coffee and muffins — *Ting Foyer*

8:30am **Welcome and Introductions** — *Wong Auditorium*
Chryssotomos Chryssostomidis, Director, MIT Sea Grant College Program
John Boreman, Director, Northeast Fisheries Science Center, NOAA/NMFS

8:45am **Overview of Integrated Ocean Mapping** — *Wong A uditorium*
Richard Pickrill, Director Marine Environmental Geoscience, Geological Survey of Canada
National Seafloor Mapping Strategies in Canada

9:30am **Fisheries Management: Habitats, Stocks, and Data Needs** — *Wong Auditorium*

9:30am Dan Furlong, Executive Director, Mid-Atlantic Fishery Management Council

9:50am Paul Howard, Executive Director, New England Fishery Management Council

10:10am John Boreman, Director, Northeast Fisheries Science Center
Fisheries Research Needs in Support of Management

10:30am Break — *Ting Foyer*

11:00am **Regional Ocean Mapping Initiatives & Oceanographic Data** — *Wong Auditorium*
John Haines, Program Coordinator, USGS Coastal and Marine Geology Program

Roger Parsons, Director, NOAA Office of Coast Survey
Integrated Ocean and Coastal Mapping - the NOAA Perspective

12:00pm Boxed Lunch and **Poster Session** — *Ting Foyer*

2:15pm **Integrated Data, Mapping, and Data Access** — *Wong Auditorium*

2:15pm Patrick Halpin, Professor of Geospatial Analysis, Nicholas School of the Environment, Duke University
From data to decisions: Making ocean biogeographic data useful for marine ecosystem-based management

3:00pm Philip Bogden, CEO, Gulf of Maine Ocean Observing System
Sharing Oceanographic Data on the Web

continued…

3:45pm **Ocean Mapping: A Case History** *Wong Auditorium*
Peter Auster, Science Director, National Undersea Research Center, and Associate Research Professor, Department of Marine Sciences, University of Connecticut at Avery Point
Deep Coral Reefs and Mapping Special Areas

4:30pm Break *Ting Foyer*

5:00pm **Panel Discussion on Next Steps** *Wong Auditorium*
Moderated by Ronald Baird, former Director, National Sea Grant Organization

6:00pm **Summary & Concluding Remarks** *Wong Auditorium*
Thomas Noji, Chief, Ecosystems Processes Division, Northeast Fisheries Science Center, NOAA/NMFS

6:30pm Reception *East Dining Room, MIT Faculty Club*

Internet Access

Those who wish to display online work alongside their poster are invited to take advantage of MIT's wireless network service. Limited Visitor access is allowed, for one to five days at a time, up to 14 days per year. Simply turn on your laptop, enable the wireless card, join the MIT network, and open a web browser. You should see a page that lets you select the type of access. Follow the instructions to register your machine on the network. It will take 10-15 minutes for the network connection to be activated. If you have trouble, make sure your computer's network settings are setup for DHCP (automatic IP), and that the wireless card is selecting the MIT network, and that you do not have a firewall running on your machine.

Dining Options

There are many great options for eating in the area, a few of which are highlighted below.

Legal Seafoods
Seafood, $$
Main Street and Ames Street near Kendall Square (MIT Building NE25)

The Blue Room
Mediterranian, $$-$$$
One Kendall Square (Hampshire and Portland Streets)

Cambridge Brewing Company
American & Brewery, $
One Kendall Square (Hampshire and Portland Streets)

Central Kitchen
Eclectic/New American/Bistro, $$
567 Massachusetts Avenue (Central Square)
Also check out the "Enormous Room" upstairs (next door) for bar & tapas.

Helmand
Fine Afghan Cuisine, $$
143 First Street (near the Galleria Mall)

Local Maps

MIT Campus (East Side) and Kendall Square

1. Tang Center (MIT Building E51)
2. Entrance for Wong Auditorium (Wadsworth and Amherst Streets)
3. Kendall/MIT "T" Stop (MBTA's Red Line) and Kendall Square (Main Street)
4. The Kendall Hotel
5. Marriott Parking Garage (Enter from Broadway or Ames St)
6. Cambridge Marriott Hotel
7. MIT Sea Grant Offices (292 Main Street, MIT Building E38-300)

Note: Main Street, Broadway and Memorial Drive are divided and/or one-way streets in places. If they lead you across the Longfellow Bridge into Boston, just go around the traffic circle at the end and return across the bridge onto Main Street and Broadway.

Full campus map on next page

A	B	C

MIT Campus Map

Welcome to MIT

All MIT buildings are designated by numbers. Under this numbering system, a single room number serves to completely identify any location on the campus. In a typical room number, such as 7-121, the figure(s) preceding the hyphen gives the building number, the first number following the hyphen, the floor, and the last two numbers, the room.

Please refer to the building index on the reverse side of this map, if the room number is unknown.

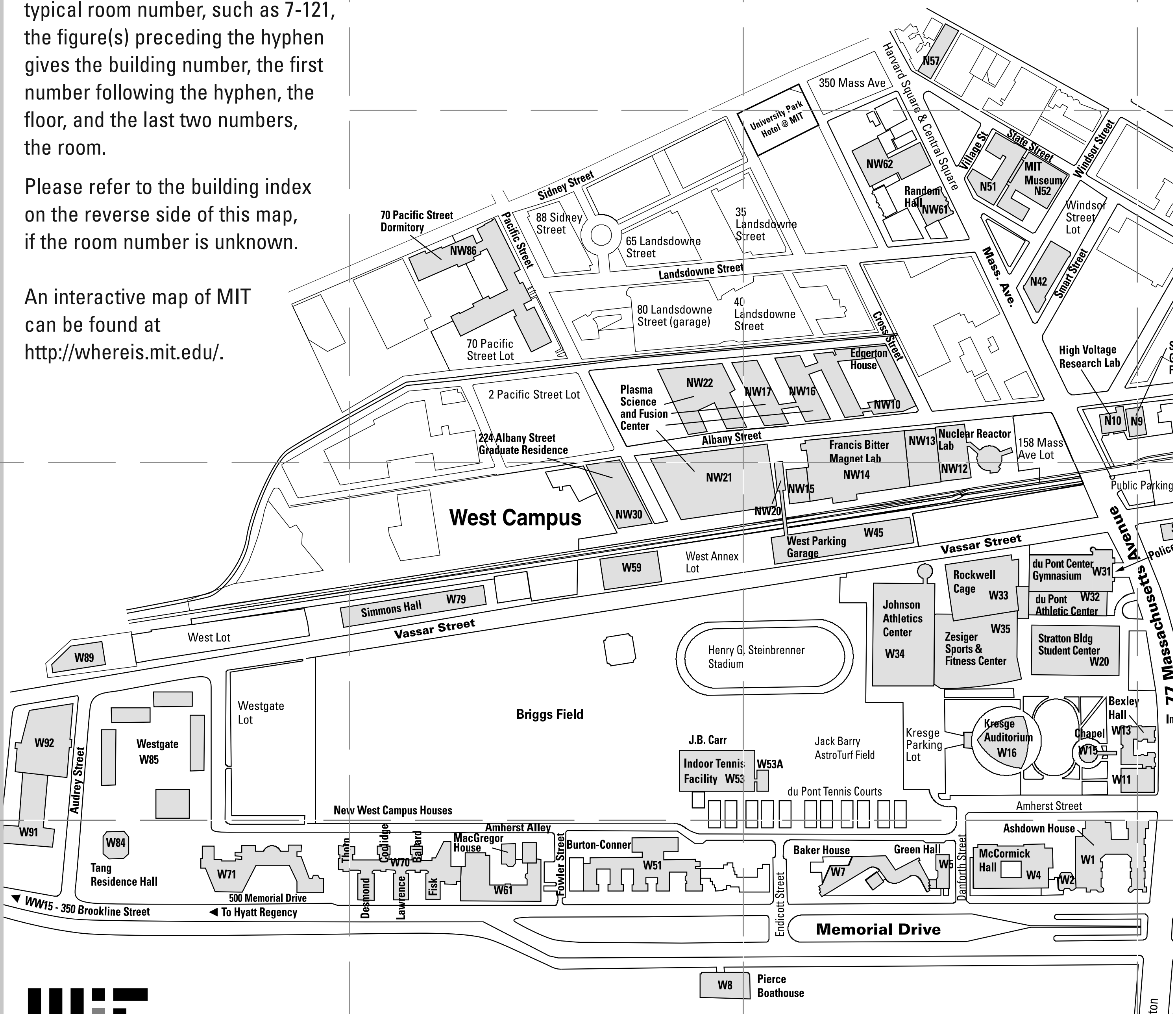
An interactive map of MIT can be found at http://whereis.mit.edu/.

1

2

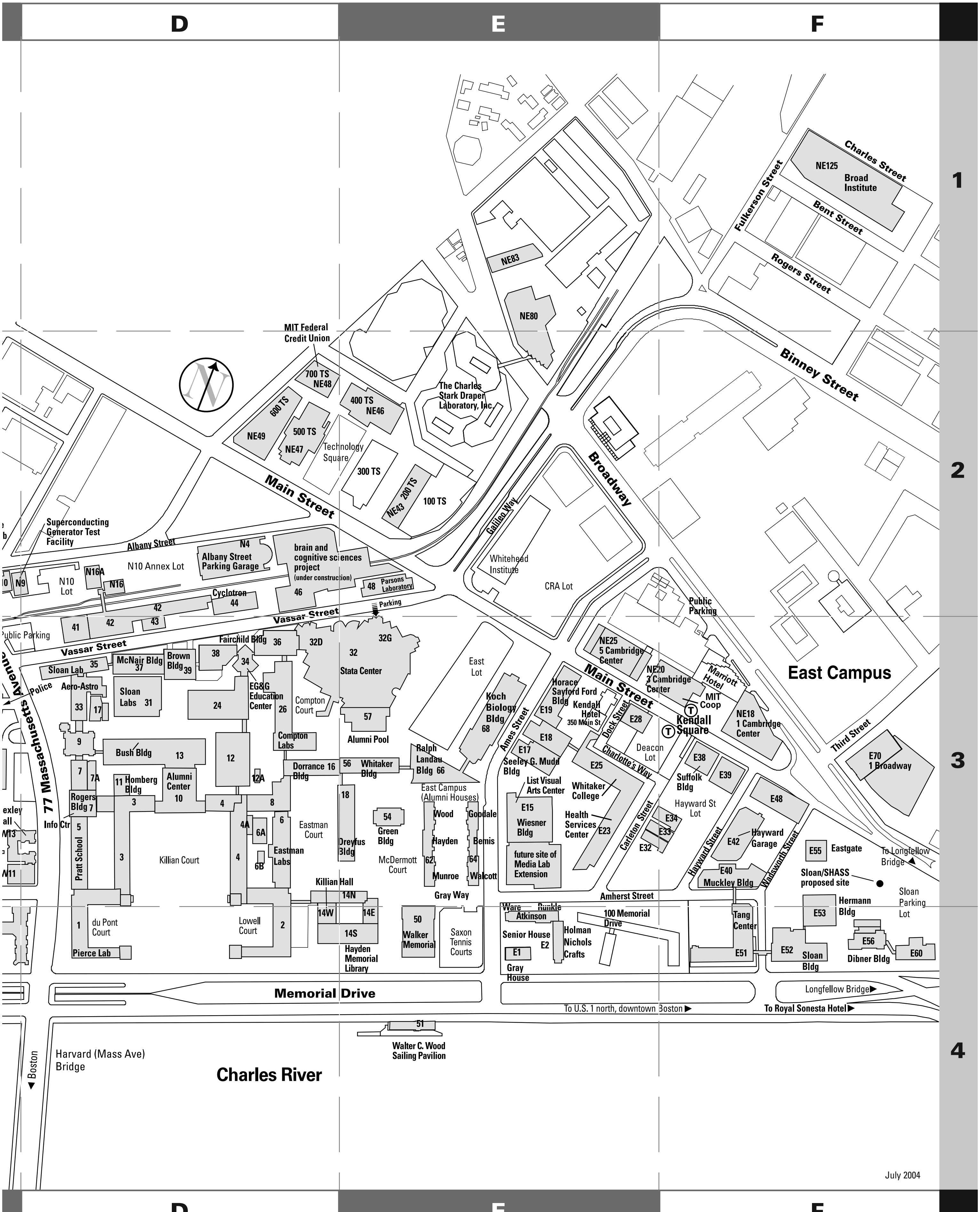
3

4



Massachusetts
Institute of
Technology

A	B	C


D
E
F
1
2
3
4
Charles Street
NE125
Broad Institute
Fulkerson Street
Bent Street
Rogers Street
NE83
NE80
Binney Street
MIT Federal Credit Union
700 TS
NE48
400 TS
NE46
The Charles Stark Draper Laboratory, Inc.
600 TS
NE49
500 TS
NE47
Technology Square
300 TS
200 TS
NE43
100 TS
Broadway
Main Street
Galileo Way
Whitehead Institute
CRA Lot
Superconducting Generator Test Facility
Albany Street
N4
Albany Street Parking Garage
brain and cognitive sciences project (under construction)
N10 Annex Lot
N9
N10 Lot
N16A
N16
48
Parsons Laboratory
46
Cyclotron
44
42
41
43
Vassar Street
Parking
Public Parking
Public Parking
Fairchild Bldg
36
32D
32
32G
Stata Center
38
34
McNair Bldg
37
Brown Bldg
39
35
Sloan Lab
Police
Aero-Astro
EG&G Education Center
Sloan Labs
31
24
Compton Court
26
57
Alumni Pool
33
17
9
Bush Bldg
13
12
Compton Labs
East Lot
Koch Biology Bldg
68
Ralph Landau Bldg 66
Dorrance 16 Bldg
56
Whitaker Bldg
7
7A
11
Homberg Bldg
Alumni Center
10
12A
Rogers Bldg 7
3
4
8
Info Ctr
5
Pratt School
3
Killian Court
4A
6A
6
6B
4
Eastman Court
Eastman Labs
18
Dreyfus Bldg
54
Green Bldg
McDermott Court
East Campus (Alumni Houses)
Wood
Hayden
62
Munroe
Goodale
Bemis
64
Walcott
Gray Way
Killian Hall
14N
14W
14E
14S
Hayden Memorial Library
50
Walker Memorial
Saxon Tennis Courts
1
du Pont Court
Pierce Lab
Lowell Court
2
77 Massachusetts Avenue
exley all
M13
M11
NE25
5 Cambridge Center
NE20
3 Cambridge Center
Marriott Hotel
MIT Coop
Kendall Square
NE18
1 Cambridge Center
East Campus
Public Parking
Horace Sayford Ford Bldg
E19
Kendall Hotel
350 Main St
Dock Street
E28
E18
Ames Street
E17
Seeley G. Mudd Bldg
Deacon Lot
Charlotte's Way
E25
List Visual Arts Center
E15
Wiesner Bldg
Whitaker College
Health Services Center
E23
future site of Media Lab Extension
Carleton Street
E34
E33
E32
Suffolk Bldg
E38
E39
Hayward St Lot
E48
Hayward Street
E42
Hayward Garage
E40
Muckley Bldg
Wadsworth Street
Third Street
E70
1 Broadway
E55
Eastgate
To Longfellow Bridge
Sloan/SHASS proposed site
Sloan Parking Lot
Amherst Street
Ware
Runkle
Atkinson
Senior House
E2
E1
Gray House
Holman Nichols Crafts
100 Memorial Drive
Tang Center
E51
E52
Sloan Bldg
E53
Hermann Bldg
E56
Dibner Bldg
E60
Memorial Drive
Longfellow Bridge
To U.S. 1 north, downtown Boston
To Royal Sonesta Hotel
51
Walter C. Wood Sailing Pavilion
Boston
Harvard (Mass Ave) Bridge
Charles River
July 2004
D
E
F

Steering Committee Members

Chryssostomos Chryssostomidis
Director, MIT Sea Grant College Program

Judith Pederson
Director, Center for Coastal Resources, MIT Sea Grant College Program

Christiaan Adams
Research Engineer & GIS Specialist, MIT Sea Grant College Program

Jonathan Kramer
Director, Maryland Sea Grant College Program

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Chief Scientist, Woods Hole Field Center, USGS

Larry Mayer
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John Williamson
Former Council Member, New England Fishery Management Council

Lewis Incze
Chief Scientist, Gulf of Maine Census of Marine Life; Senior Scientist, Bioscience Research Institute, University of Southern Maine

Leslie Ann McGee
New England Fishery Management Council

Poster Abstracts - by Category

The extended abstracts for the posters have been organized into a number of subject categories, as listed below. These are only general categories, as many posters cover a range of overlapping topics.

DATA MANAGEMENT, ACCESS, AND TECHNOLOGY

GEOLOGY AND HYDROGRAPHY

HABITATS

FISHERIES MANAGEMENT – GENERAL

FISHERIES MANAGEMENT – SPECIAL APPLICATIONS

Poster Abstracts - by Author

The abstracts are listed below, alphabetically by the last name of the first author.

GULF OF MAINE SPATIAL DATA PROJECT: SHARING AND INTEGRATING MAPS OF THE GULF OF MAINE IN SUPPORT OF RESOURCE MANAGEMENT

Tom Shyka[1], Dr. Philip Bogden[1] and Dave McIlhagga[2]

[1]Gulf of Maine Ocean Observing System, tom@gomoos.org, bogden@gomoos.org

[2]DM Solutions Group Inc., mcilhagga@dmsolutions.ca

ABSTRACT

Overview

Maps are a critical source of information for resource managers and decision makers. Today, many federal, state, academic and non-government organizations routinely collect geo-spatial data about the Gulf of Maine that are ultimately incorporated into maps. Additionally, initiatives like GOMMI are planning to coordinate the collection of large detailed geo-spatial datasets that will be used to develop maps to address fishery and other resource management issues in the Gulf of Maine. The advent of Geographic Information Systems (GIS) has made maps interactive and dynamic. The recent coupling of GIS with web technologies holds the promise of a disturbed and dynamic system for on-demand access to the geospatial data required to address the issue at hand. In order for this to occur and for all the data sets to be effectively and efficiently used by many organizations there is a need to implement a set of standards for sharing geospatial data over the web.

This need was recognized by a consortium of organizations (see listing below) throughout the Gulf of Maine, which applied for and was awarded a grant from the Federal Geographic Data Committee (FGDC) and GeoConnections Canada under the Cooperative Agreements Program. The Gulf of Maine Ocean Observing System (GoMOOS) and DM Solutions Group were the lead organizations on the Gulf of Maine Spatial Data Project. One of the primary goals of the Gulf of Maine Spatial Data Project was to implement a technical and institutional capacity for organizations to share and integrate maps online while maintaining their own data sets.

The capacity to integrate and share Gulf of Maine maps over the web was accomplished by implementing the Open GIS Consortium (OGC) Web Mapping Service (WMS) standard. By implementing web mapping services, multiple organizations utilizing different map making and serving technologies have enabled their maps to be shared and integrated over the web.

This project has resulted in the development of a institutional and technical framework to create a truly dynamic and distributed system for sharing and integrating

geospatial information in the Gulf of Maine. This capacity will benefit fishery managers as well as other resource managers across the Gulf of Maine and beyond.

Project Products

GoMMaP (Gulf of Maine Mapping Portal)
http://www.gommap.org
GoMMaP provides stakeholders users with a place to view Gulf of Maine maps that are served through mapping services. Additionally, GoMMaP serves as a resource for organizations that would like to publish their data using web mapping services or would like to add mapping content to a website.

Gulfwatch mapping application
Draft version available at http://dev.gomoos.org/chameleon/gulfwatch/
The final version will be at http://www.gulfofmaine.org/gulfwatch/
This demonstration application makes the Gulfwatch data available for the first time in a interactive mapping tool that also utilizes dynamic map layers made available through the project.

Project Partners
Bedford Institute of Oceanography (BIO)
Canadian Hydrographic Survey (CHS)
Census of Marine Life - Gulf of Maine Program
Geologic Survey of Canada (GSC)
Gulf of Maine Council on the Marine Environment
Gulf of Maine Mapping Initiative (GOMMI)
Massachusetts office of Coastal Zone Management
me3 Technology Consultants
National Oceanic and Atmospheric Administration (NOAA) - Coastal Services Center
National Oceanic and Atmospheric Administration (NOAA) - Northeast Fisheries Science Center
United States Geological Survey (USGS) - Woods Hole Field Center

Contacts: Tom Shyka, GoMOOS

THE GULF OF MAINE OCEAN DATA PARTNERSHIP: BUILDING A REGION-WIDE INFORMATION SYSTEM TO SUPPORT GULF OF MAINE RESOURCE MANAGEMENT

Tom Shyka[1], David Mountain[2], Evan Richert[3], and Philip Bogden[1]

[1]Gulf of Maine Ocean Observing System, tom@gomoos.org; bogden@gomoos.org

[2]NOAA, NMFS, NEFSC, Woods Hole, MA 02543, david.mountain@noaa.gov

[3]Census of Marine Life Gulf of Maine Program, erichert@usm.maine.edu

ABSTRACT

Overview

How do you find, access and integrate geospatial data related to the Gulf of Maine to use for resource management decision making? The Gulf of Maine Ocean Data Partnership (GoMODP) hopes to simplify the answer to that question in the near future.

The GoMODP is comprised of 21 organizations that collect and manage environmental data within the Gulf of Maine and its watershed. Members include federal, state, provincial, university and research organizations in the US and Canada. Most of the data collected by the partners has a geospatial component to it and could eventually be used within a GIS framework to support resource management activities. The goal of the partnership is to make each partner's long term datasets discoverable, accessible, and eventually interoperable through tools available on the internet. The partnership intends to use standards and protocols already in use by the various disciplines represented wherever possible. With regard to geospatial data, the GoMODP is promoting the use of the Open Geospatial Consortium services, which allow data providers and users to dynamically share and integrate geospatial data over the web.

To fulfill that goal, partners have filled out detailed surveys regarding their data. This information, which is available to the other partners, will assist in creating guidance on developing interoperability. As a first step, metadata training and assistance are being provided to partners to aid in establishing a common set of practices in the design and publishing of metadata and to make data discoverable through the American Geospatial One Stop, The Global Change Master Directory (GCMD) and/or the Canadian GeoConnections Discovery Portals on behalf of the data partnership and the individual organizations.

Developing data discoverability, accessibility, and interoperability without making the task overwhelming for the partners is challenging for such a diverse set of organizations. Each year a work plan is established with clear goals and a governing board and technical committee ensure that the goals are accomplished during the year. The partnership continues to add members and hold annual meetings.

A CASE STUDY OF DISTRIBUTED DATA ACCESS IN THE GULF OF MAINE OCEAN OBSERVING SYSTEM'S (GOMOOS'S) NORTHERN SHRIMP DATA PROJECT

Chance Yohman[1], Dr. Philip Bogden[2], Tom Shyka[2], Dr. Bruce MacLeod[1]

[1]University of Southern Maine (USM), yohman@cs.usm.maine.edu, macleod@usm.maine.edu,

[2]Gulf of Maine Ocean Observing Systems, bogden@gomoos.org, tom@gomoos.org

ABSTRACT

Overview

The Northern Shrimp Data Project (NSDP) provides shrimp fisheries information to resource managers and fishermen using Internet-based GIS mapping technology. Two sources of this data are the New England states port sampling programs via the Maine Department of Marine Resources (DMR) and the shrimp trawl surveys from the New England Fisheries Science Center (NEFSC/NMFS). The goal of this work is to investigate and implement standard and scalable data access technologies for the NSDP to support real-time, demand-driven data access.

The NSDP currently relies on FTP and manual database downloads to acquire recent fisheries data. DMR and NEFSC periodically provide GoMOOS with a formatted text file export of the data via FTP or email. The data is then extracted using the text processing capabilities of the Perl scripting language and inserted into the NSDP's tables in the GoMOOS database using Perl's database interface.

Data providers such as DMR and NEFSC should provide authenticated access to datasets for ensuring secure retrieval. This access should be on-demand from the remote clients. Data gatherers like GoMOOS integrate datasets from providers and facilitate standards in the data in an automatic manner, ideally. Overall the steps in Figure 1 of the Appendix should be reduced. An example view of data access is Figure 2 of the Appendix.

Our poster explores technologies for automating and simplifying data access. We consider a number of distributed data access technologies including the Open-Source Project for a Network Data Access Protocol (OPeNDAP), Web Feature Services (i.e. Open Geospatial Consortium), and the Distributed Generic Information Retrieval (DiGIR) with its descendant the Taxonomic Database Working Group Access Protocol for Information Retrieval (TAPIR). We evaluate the relative merits of each and develop recommendations of usage. . Ultimately, our goal is to support the needs of the Gulf of Maine Ocean Data Partnership, which is an entity, hosted by GoMOOS and designed to support distributed data sharing for the Gulf of Maine region.

Application to Fisheries Research and Management

Resource managers and fishermen use the data in a mapped format to look at populations and discover where the shrimp are. Unfortunately, analysis is hindered by data obsolescence and strained human resources due to the manual data access efforts above. Technologies explored will provide preliminary findings for solving the integration of distributed data sources in the NSDP. These findings will be collected in a *Lessons Learned* document to aid the integration of other data in the Gulf of Maine Ocean Data Partnership.

Figures

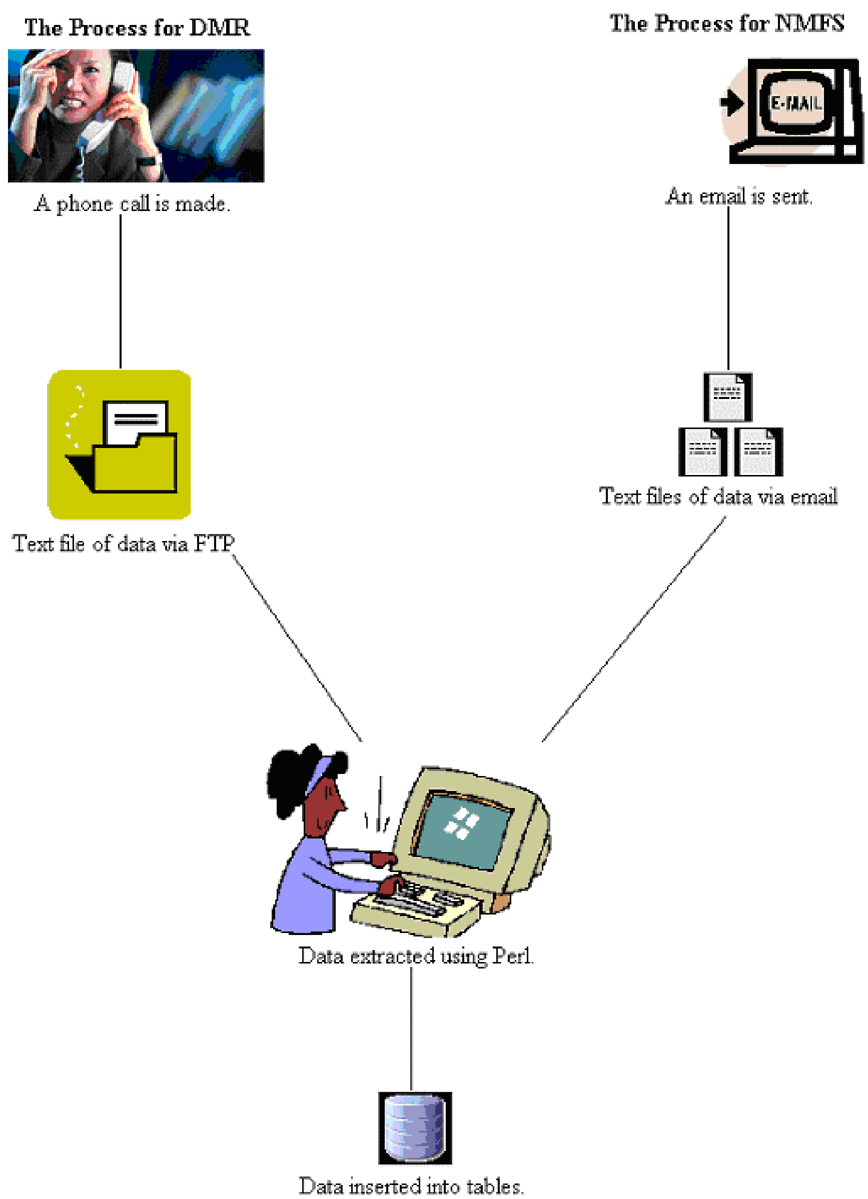

Figure 1- Current Data Access for the NSDP

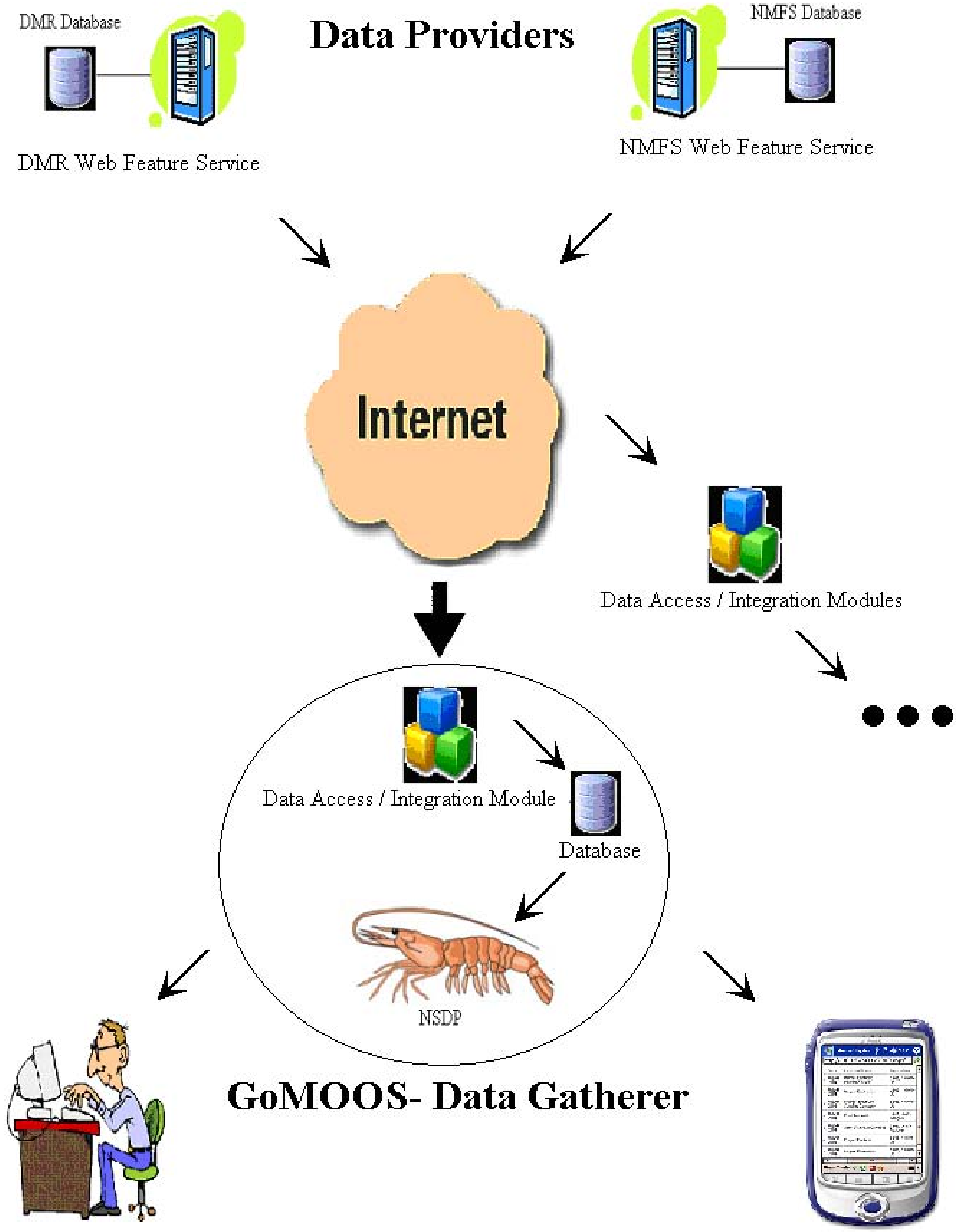

Figure 2- Example Data Access for the NSDP

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MAP SERVER INTERFACE FOR THE NORTHEAST CONSORTIUM FISHERIES AND OCEAN DATA MANAGEMENT SYSTEM

C.A. Manning[1], R.C. Groman[2], M.D. Allison[2], P.H. Wiebe[2]

[1]142 Morse Hall, University of New Hampshire, Durham, NH 03824, chris.manning@unh.edu

[2]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543

ABSTRACT

The Northeast Consortium administers nearly $5M annually from the National Oceanic and Atmospheric Administration to fund cooperative research conducted in the Gulf of Maine and Georges Bank regions. The research projects involve fishermen-scientist partnerships, and have focused on fish biology, gear selectivity, stock assessments, habitat/ecosystem monitoring, and socioeconomic/outreach studies. The Northeast Consortium has created the Fisheries and Ocean Data Management System (F&ODMS; http://www.northeastconsortium.org/data.shtml) to provide centralized public access to data generated by these projects. Located at the Woods Hole Oceanographic Institution, the F&ODMS uses the JGOFS/GLOBEC (U.S. Joint Global Ocean Flux Study/GLOBal Ocean ECosystem dynamics) data management software to enable database access with any standard web browser. Much of the data gathered by researchers and stored in the F&ODMS are georeferenced, so a GIS-type map interface would be a powerful visual aid in presenting data from multiple projects. Currently, a MapServer interface is being developed which will enable the user to overlay the locations of various data types (e.g., temperature, tag-recapture, stock assessment) on an area of interest. An interface of this type would efficiently display available data from multiple projects, increasing the usefulness of the F&ODMS for scientists, managers, educators, the fishing industry, and other user groups.

MANAGING SEAFLOOR MAPPING DATA USING THE ARC MARINE DATA MODEL

Brian Andrews

U.S. Geological Survey, Woods Hole Science Center, Woods Hole, MA 02543, bandrews@usgs.gov

ABSTRACT

Overview

The U.S. Geological Survey (USGS) in cooperation with the Massachusetts Office of Coastal Zone Management (CZM) is conducting geologic mapping of the seafloor to characterize the surface and subsurface geologic framework of nearshore environments in coastal Massachusetts. The primary objective of this program is to provide geologic information and a suite of seafloor maps for the management of coastal and marine resources (Barnhardt and others, 2005). Managing and distributing the large amounts of marine spatial data associated with this project is challenging because there are few database structures that are designed specifically for the unique characteristics of marine data.

Common Database Model

To meet that challenge, a group of geographic information scientists from the academic, federal, and commercial sectors, along with the Environmental Systems Research Institute (ESRI), are developing an object-oriented database structure. It is based on the ArcGIS personal geodatabase, and specifically designed for marine data (Wright, and others, 2006). This database schema, called the *Arc Marine data model*, establishes common attributes, relationships, and data types for most types of biologic, geologic, and oceanographic data collected in the ocean realm. The goal of Arc Marine is to provide a common structure or geodatabase template for managing, sharing, and publishing marine data that will facilitate multidisciplinary research such as seafloor habitat characterization.

The marine data collected as part of the USGS/CZM cooperative is serving as an Arc Marine case study for managing, and publishing, marine survey data and geological seafloor characterizations. The Arc Marine schema provides a basic framework of data types such as Profile Line and Instantaneous Points. Additional attributes and subtypes were also used to meet the needs of the USGS/CZM collaborative. For example, the basic Profile Line feature class in Arc Marine was expanded for this case study to include DeviceID which further divides the survey lines into 4 types based on the acquisition device used (Interferometric sonar, sidescan sonar, chirp seismic sonar, and video tracks) (Figure 2).

Application to fisheries management

The use of an object-oriented database structure, such as Arc Marine, that *models* the behavior of marine data has improved the survey operation, data processing, data analysis, for the characterization of the regional geologic framework of the inner continental shelf between Nahant and Gloucester, Massachusetts. The use of the Arc Marine data model in this project will hopefully facilitate further collaboration between physical and biological scientists for multidisciplinary characterization of the seafloor for fisheries management, and benthic habitat applications.

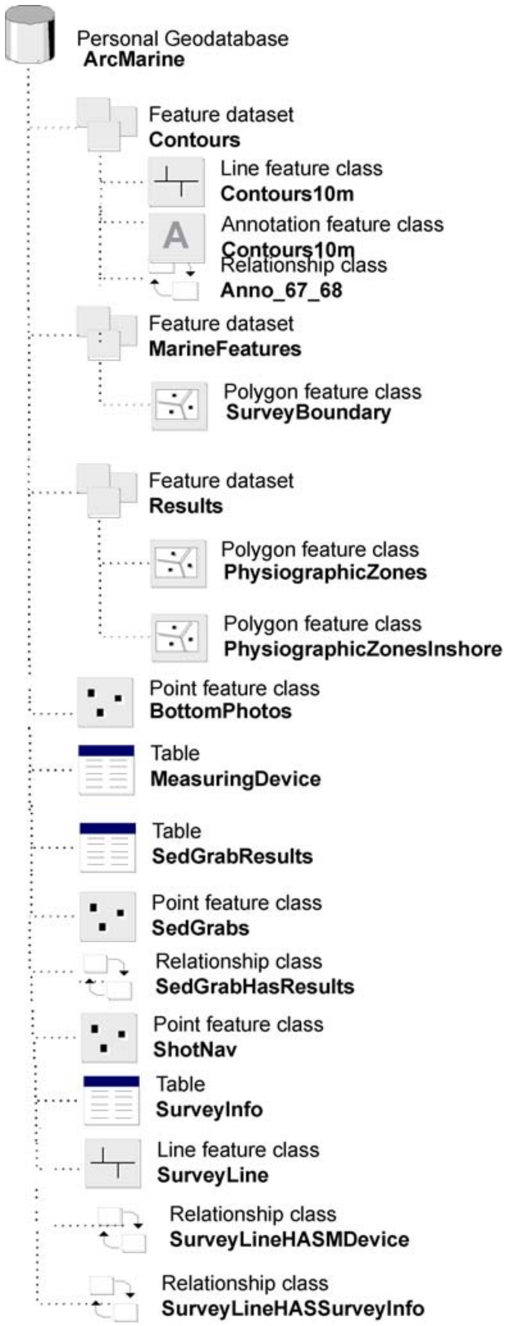

Figure 1.Simplified geodatabase tree showing the feature datasets, feature classes and table objects in USGS Arc Marine implementation.

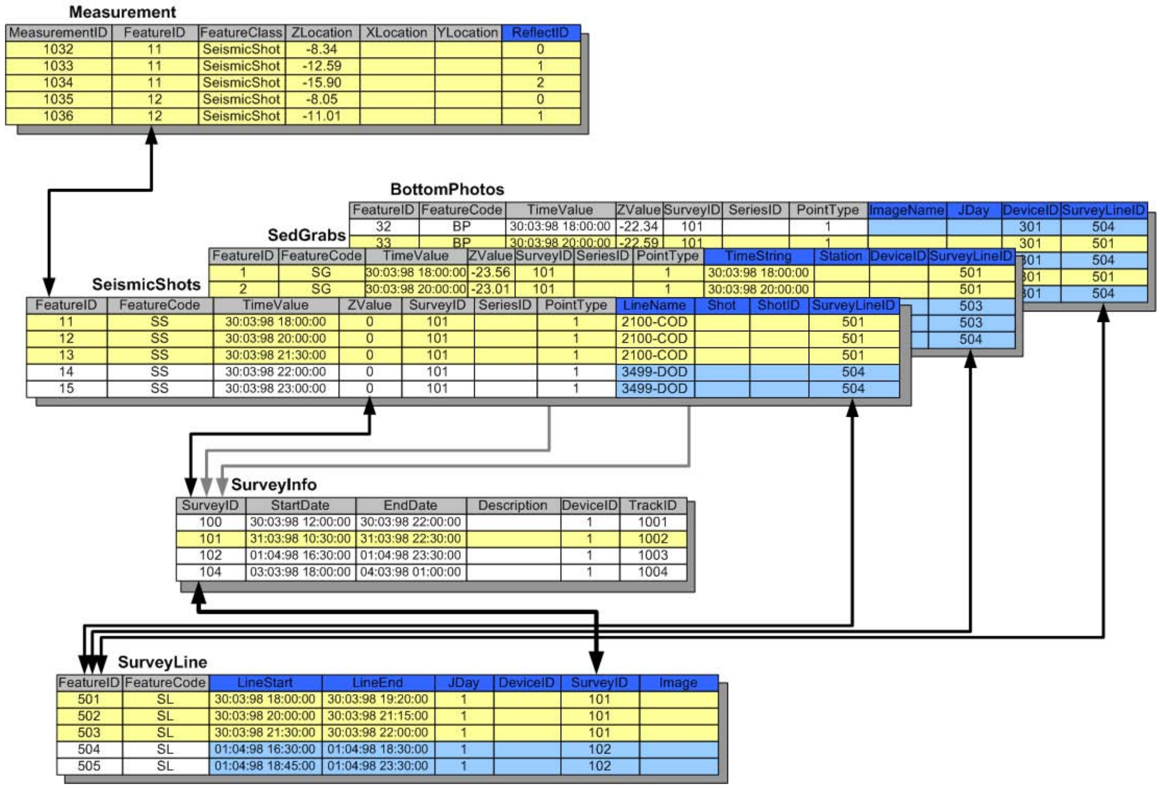

Figure 2. General diagram showing the feature classes and relationships in the USGS Arc Marine case study (Source M. Blongewicz ArcMarine working group/Danish Hydraulic Institute.

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A GIS WEB MAPPING PORTAL TO REAL-TIME OCEANOGRAPHIC AND METEOROLOGICAL OBSERVATIONS AND NOAA FORECASTS

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ABSTRACT

NOAA's National Ocean Service (NOS) has developed and implemented a Geographic Information Systems (GIS)-based Web mapping portal called *nowCOAST* (http://nowcoast.noaa.gov) to provide the marine community with a centralized Web site to discover and display real-time coastal environmental observations and NOAA forecasts for any region in the coastal United States and Great Lakes. The portal serves as a one-stop shopping solution for users to view real-time meteorological, oceanographic, hydrologic, and water quality information from numerous federally-operated networks as well as mesonets and regional ocean observing systems. *NowCOAST* also provides access to NOAA forecast products including forecast guidance from NOAA's operational numerical ocean, lake, river, and weather prediction models, National Weather Service's (NWS) forecast discussions, NWS' general weather and marine weather forecasts, and NOS' Harmful Algae Bloom forecasts. Recently, the portal has been enhanced to provide on-map display of near-real-time satellite cloud imagery, weather radar reflectivity, and surface meteorological and oceanographic observations.

NowCOAST uses GIS technology to manage the storage and Web display of its geospatial observation and forecast data. A spatially aware database contains information about the observing systems and forecast products *nowCOAST* links to, including locations, types of information offered, and Web addresses, as well as the on-map datasets displayed in nowCOAST. The user is able to interactively specify their exact area of interest as well as which nowCOAST layers to overlay on the map with a customized map viewer. The portal's map viewer or user interface (Figure 1) accommodates both the novice and the experienced GIS user, allowing both to quickly view environmental conditions for any U.S. coastal area. In addition, the portal uses a 'Databrowser' for users to view and browse forward and backward through websites displaying the observations and forecasts that they locate through the map viewer. The Databrowser integrates directly with the map viewer.

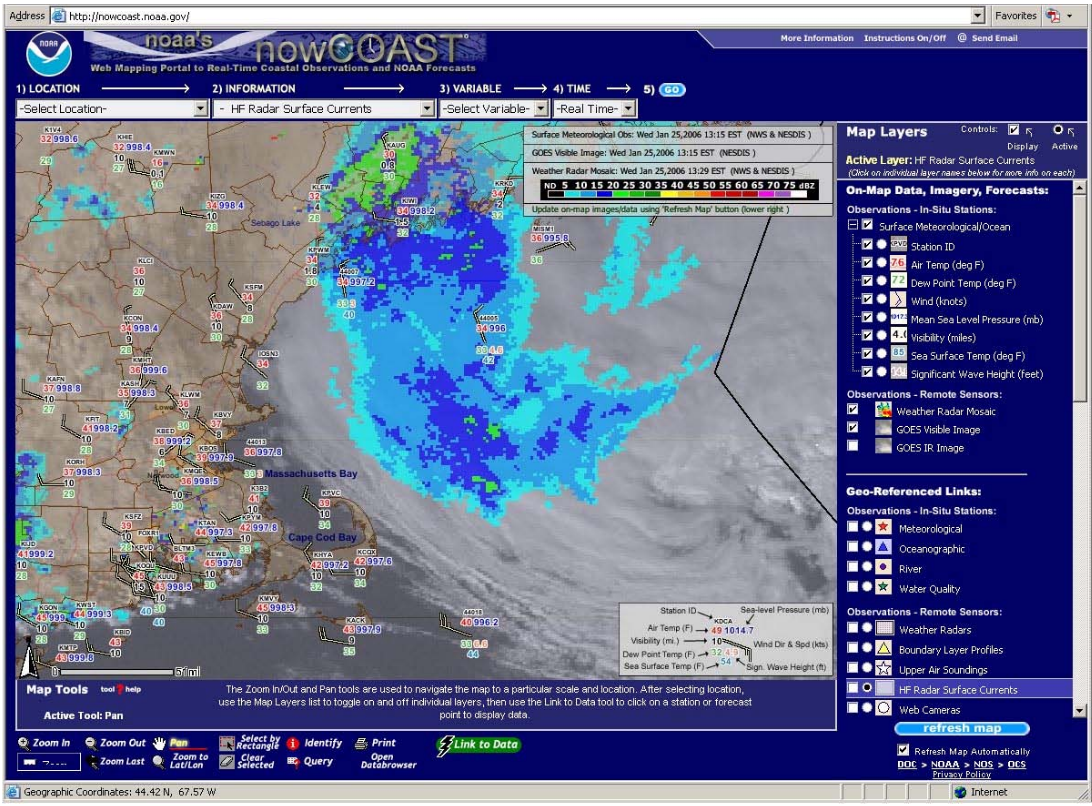

Figure 1. The nowCOAST Map viewer in a Web browser displaying surface meteorological and oceanographic observations, weather radar reflectivity, and cloud satellite imagery for the Gulf of Maine on January 25, 2006.

Specifically, the portal uses Arc Internet Map Server (ArcIMS) combined with Dynamic HTML (DHTML) and Java Enterprise Edition (J2EE) Web programming technologies including Java Servlets and Java ServerPages for its dynamic GIS mapping capability. *NowCOAST* is built upon the Java Connector API for ArcIMS, allowing for customization of the map functionality and appearance. Detailed information on the construction of *nowCOAST* can be found in Wengren et. al (2005) and Allard et. al (2006).

NowCOAST continues to be enhanced to serve other parts of the marine community including those involved in commercial and recreational fishing and fisheries management and research. In the near future, the portal will display the latest NWS daily global sea surface temperature analysis and also the latest marine weather forecasts (i.e. winds and waves) from the NWS National Digital Forecast Database (NDFD). An example of the NWS sea surface temperature analysis displayed in *nowCOAST* is given in Figure 2.

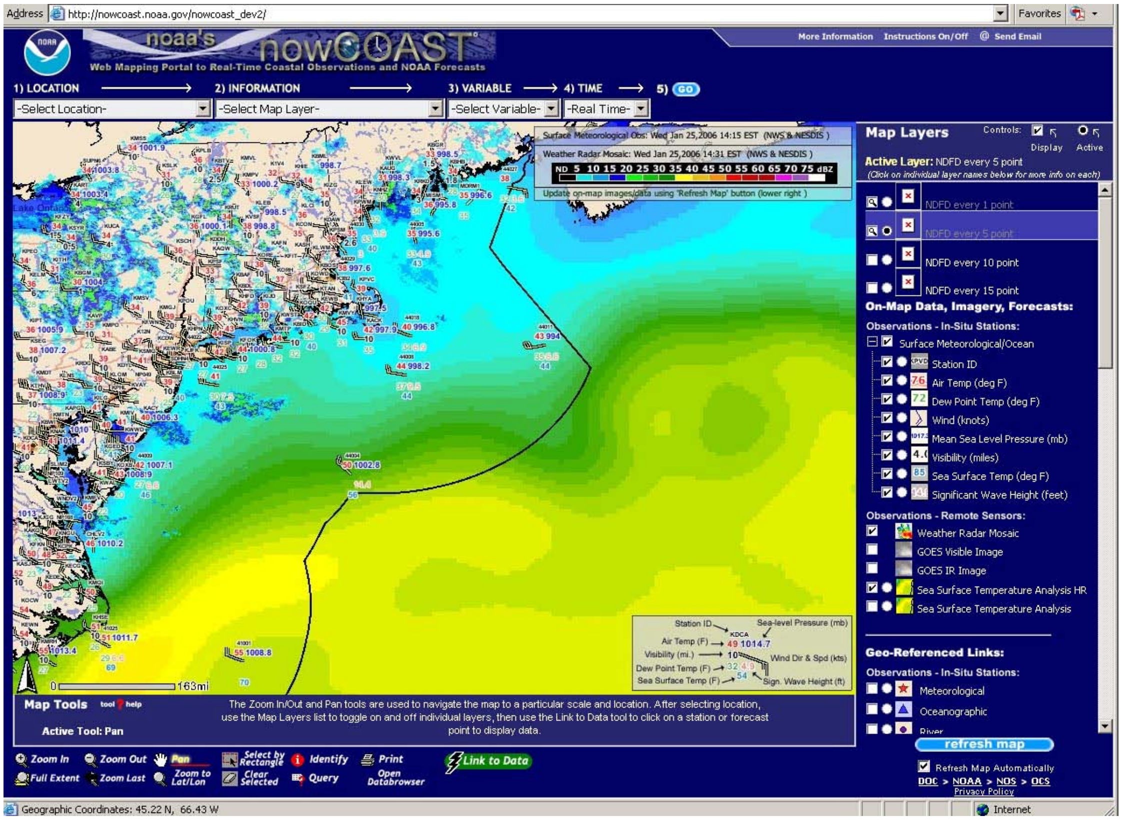

Figure 2. An example of NWS' Daily Sea Surface Temperature Analysis (1/12 deg resolution) displayed in nowCOAST along with surface in-situ meteorological and SST observations and weather radar reflectivity data on January 25, 2006.

The *nowCOAST* development team is considering other types of information to display on the portal that would be of interest to personnel involved in fisheries research and management, as well as functionality enhancements for this community. Suggestions can be sent to nowcoast.team@noaa.gov.

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USING NOAA HYDROGRAPHIC DATA FOR HIGH-RESOLUTION GEOLOGIC MAPPING OF THE SEAFLOOR: BOSTON HARBOR AND APPROACHES

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ABSTRACT

In 2003, the Massachusetts Office of Coastal Zone Management (CZM) and the U.S. Geological Survey (USGS) began a cooperative program designed to map the geology of the Massachusetts inner shelf. The long-term goal of this partnership is to create a comprehensive series of high-resolution geologic maps of the seafloor demonstrating the varied topography and surficial sediment distribution in nearshore state waters. The new seafloor mapping data will increase our understanding of the region's geologic framework and habitat environments, enabling better management of ocean resources. Three nearshore areas were initially identified, each using different acquisition strategies and techniques: Boston Harbor, which will be the focus of this presentation, made use of existing National Oceanic and Atmospheric Administration National Ocean Service (NOAA-NOS) data, while two other nearshore areas (Nahant to Gloucester and Cape Ann to Salisbury Beach) were mapped using newly collected geophysical data.

In 2000 and 2001, the NOAA Ship *Whiting* and its launches conducted four hydrographic surveys of the navigable areas within Boston Harbor, acquiring approximately 170 km^2 of sidescan-sonar and single-beam bathymetric data. In addition, multibeam echo sounder bathymetric data were acquired over 30% of the survey area (approximately 65 km^2) primarily for hydrographic mapping within the navigational channels between the Harbor Islands and areas of potential navigation hazards. NOAA-NOS provided CZM and the USGS with the 2000-2001 raw sidescan-sonar and processed bathymetric data.

Sidescan-sonar data were reprocessed on a line-by-line basis in order to account for various system configurations and acquisition parameters (e.g., different survey vessels, different sidescan-sonar systems, towed or hull-mounted sonar configuration, varied sonar ranges, gain modifications, and cable-out lengths). The sidescan-sonar data were slant-range corrected, tone-matched and mosaicked at 1 meter/pixel resolution. Minimal processing of the bathymetric data was necessary; data were "cleaned" and tide-corrected by NOAA-NOS. The multibeam echo sounder bathymetric grids were generated at 2 meters/pixel resolution. Single-beam and

multibeam soundings were merged and a composite grid was created at a reduced resolution (20-meters/pixel).

A 4-day ground-truth survey, used to validate the geophysical data was conducted by the USGS and CZM on the USGS R/V *Rafael* (September 14-17, 2004). This sampling survey included the acquisition of bottom video, high-resolution bottom photographs and sediment samples using the USGS mini-SEABOSS (SEABed Observation and Sampling System) system. These direct observations of the seafloor aid in the interpretation of the remotely-sensed sidescan-sonar data.

Integration of the sidescan-sonar, bathymetry and sample data begins to reveal the surficial seafloor character of Boston Harbor. Water depth in the surveyed area ranges from -1-32 meters and the seafloor landscape varies from gently sloping sub-tidal flats to regions of rugged elevated topography exhibiting as much as 7 meters of local relief. The Inner Harbor and sub-tidal flats of Hull, Quincy and Dorchester Bays are predominantly characterized by low backscatter intensity representing fine-grained sediments and a relatively "soft" seafloor. The finest sediments sampled in this survey, containing over 40% clay, occurred within the Inner Harbor at the mouth of the Mystic River. Sediments on the Governors Island and Deer Island Flats (east of Logan Airport) were predominantly silt-rich. Regions characterized by sand and silty-sand were typically found in the depressions and low-relief areas outside Boston Harbor proper, east of the Harbor Islands and in Broad Sound (south of Nahant).

The approaches to Boston Harbor and the dredged navigation channels around the Harbor Islands are generally characterized by high backscatter values with the sidescan-sonar imagery and relatively coarse surficial sediments. Two areas (each greater than 9 km^2), situated east of Nantasket Beach, exhibit algae-covered rock outcrops and large boulder- to cobble-sized sediment. These outcrop areas are separated by an approximately 700-m wide ribbon of well-sorted sand. Within Broad Sound, several isolated elevated features (each less than 1 km^2 in area) display similar acoustic characteristics to the features found offshore of Nantasket Beach, but have irregular extents and more gradual transition between areas of high to low backscatter intensity. The most striking geomorphic feature within the survey area is the approximately 10 km^2 area of outcropping ledges that lie east of the Brewster Islands. These ENE-WSW trending features exhibit the most extreme topographic variability in the survey area, 4-7 m of local relief (Figure 1). This area, characterized by mottled strong to moderate backscatter intensity, is bounded to the north and south by the Graves and the seaward extent of Nantasket Roads, respectively.

The geophysical mapping also revealed several anthropogenic features within Boston Harbor. NOAA-NOS conducted the Boston Harbor survey with the intention of updating nautical charts and depths surrounding features such as dredged channels, known wrecks and other navigational hazards. Other man-made features such as the Ted Williams Tunnel (Figure 2), deposits of dredged materials, pipelines/sewers and abandoned fish havens are clearly displayed within the sidescan-sonar and multibeam bathymetry data.

The integration of NOAA-NOS geophysical data and new ground-validation data provide a greater understanding of the seafloor morphology and distribution of surficial sediments within

the Boston Harbor study area. These geophysical datasets provide an excellent base for defining surficial sediment classification and visualizing seafloor topography in Boston Harbor.

For more information:
http://woodshole.er.usgs.gov/project-pages/coastal_mass/html/boston.html

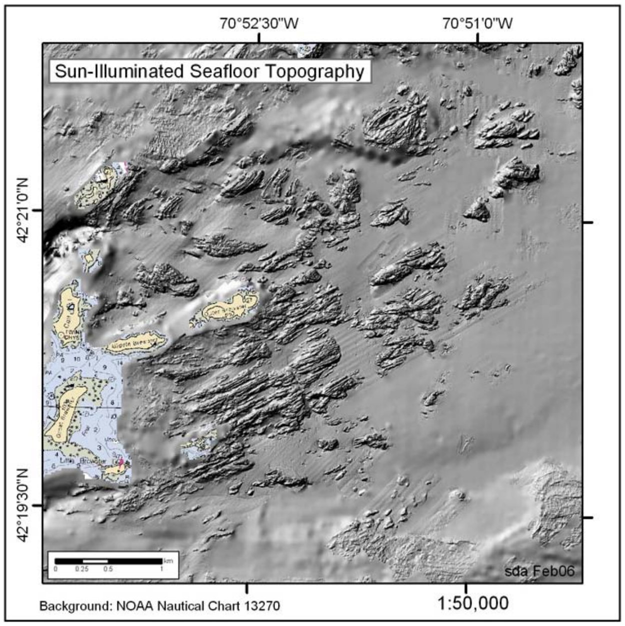

Figure 1 – Sun-illuminated seafloor topography east of the Brewster Islands in Boston Harbor. Note NE-SW trending outcrops of ledge.

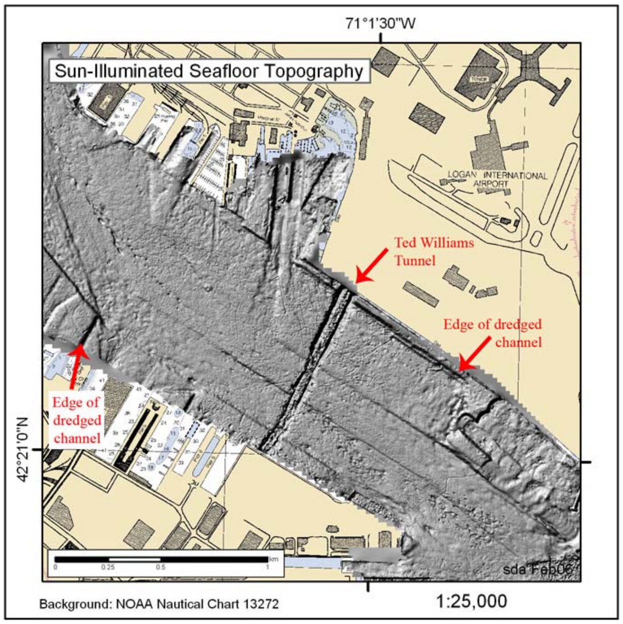

Figure 2 – Sun-illuminated seafloor topography delineates the Ted Williams Tunnel in Boston Inner Harbor.

INTEGRATED OCEAN MAPPING INITIATIVES USING NOAA IN-SITU RESOURCES TOWARD THE 'MULTI-USE' OF HYDROGRAPHIC SURVEYS

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ABSTRACT

Overview

The National Oceanic and Atmospheric Administration (NOAA) Navigation Response Teams (NRT's) are highly mobile field teams equipped to provide hydrographic surveys during normal and emergency situations. In the northeast, Navigation Response Team Five (NRT5) operate a thirty foot vessel equipped with single and multibeam echosounders, side scan sonar, differential global positioning systems (dGPS), a position orientation system (POS MV), and Conductivity/Temperature/Depth Sensors. The primary mission of the NRT's is to supply accurate and precise data for the purpose of nautical charting and/or reporting danger(s) to navigation.

Figure 1. National Network of NRT's and Operating Ranges.

Currently, with the advent of NOAA's Integrated Mapping Initiative,[1] data currently collected for nautical charting is underutilized due to the focus on bottom detection (water depth) and item detection (safety of marine navigation). Of particular

[1] Session 364 United States Senate. Feb 10^{th} 2005 Sec 4 titled: "NOAA INTEGRATED MAPPING INITIATIVE."

importance to nautical charting is the idea of "Shoal Biasing", where shoalest depths are preserved during data processing and subsequently reflected into a nautical chart. While this is standard practice for chart production, a portion of the data may also be lost in the process and may contain other significant morphological details of the seafloor. Furthermore, other data such as backscatter from a multibeam echosounder is deemed of no use to navigation and is subsequently overlooked and not used in charting.

Yet, a multitude of information can be derived from the data collected during hydrographic surveys such as Side Scan Sonar imagery toward seafloor characterization. Moreover, bathymetric data collected during hydrographic surveys are typically of high resolution and can be scaled in centimeters. This highly accurate bathymetric and geographic data can have a multitude of uses toward the fisheries community in determining benthic habitat, depth, slope, and rugosity. A brief inventory of integrated systems onboard the NRT's is depicted below:

Figure 2. Odom Echotrac CV Single Beam Echosouder

Figure 3. Innerspace 455c Single Beam EchoSounder

Figure 4. Klein 3000 Dual Frequency Side Scan Sonar

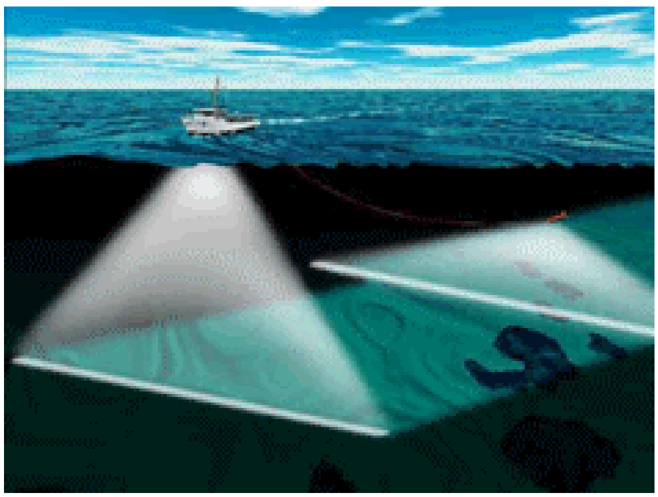

Figure 5. Multibeam Echnosouder Swath with towed Side Scan Sonar

Figure 6. Kongsberg Simrad EM3000 300 kHz Shallow Water MultiBeam System
(currently operational on two teams)

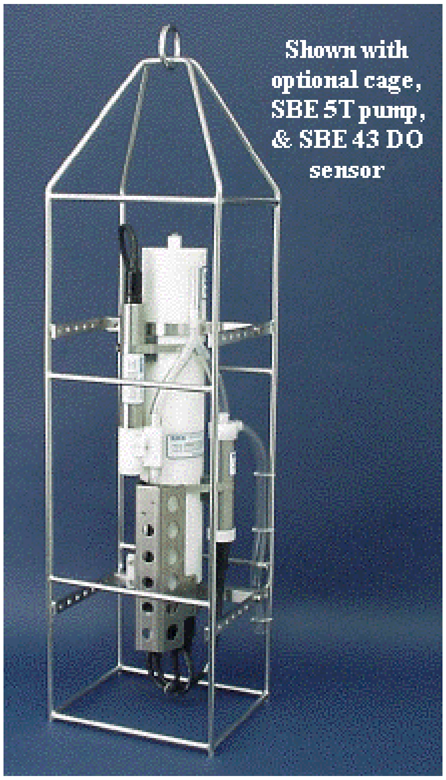

Figure 7. SeaBird CTD Profiler

Figure 8. Odom DigiBar Pro CTD Profiler used in beamforming

Conclusion

The use of an NRT can provide an excellent means of “filling in” data gaps in areas of particular concern to fisheries. More importantly, the same hydrographic data can be used in Geographic Information Systems for further modeling and analysis. The intent of this poster is to raise the awareness of the NRT’s and to foster potential collaborations among other agencies in order to facilitate the “multi-use” concept of hydrographic survey data.

SEAFLOOR MAPPING OPERATIONS AT THE USGS, WOODS HOLE SCIENCE CENTER

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ABSTRACT

The primary goal of the U.S. Geological Survey (USGS) Coastal and Marine Geology Program (CMGP) is to conduct research within the U.S. Exclusive Economic Zone (EEZ) in order to provide objective, unbiased geologic and oceanographic information to the science community, federal and state governments, and the public. Towards this end, systematic seafloor mapping programs are conducted in offshore, nearshore, and lake regions to gain an understanding of the geologic framework and active geologic processes shaping these areas. Critical to these studies is the development of interpretive geologic maps defining seafloor morphology, sediment distribution and the underlying geologic structure (Figure 1). These data have been used to establish mitigation strategies addressing erosion, contaminants, and natural hazards; to assess marine and coastal resources; to aid in marine and coastal resource management; and as baseline information for marine habitat and process-oriented investigations.

In the early 1990's, the research direction of the CMGP shifted from deep- to shallow-water to expand studies of pertinent coastal issues such as erosion, resource management, identification of benthic habitats, and sediment availability. Coupled with this shift in scientific direction were technological advances leading to the development of high-resolution seafloor mapping systems designed for the shallow water depths of estuaries and the inner-continental shelf (Hughes Clarke and others, 1996).

The USGS first began utilizing 'next-generation' systems, such as multibeam echo sounders (MBES), in 1994 to map benthic habitats within Stellwagen Bank National Marine Sanctuary (Valentine and others, 1995; 1998). This initial study was a cooperative program with the University of New Brunswick (UNB), the National Oceanic and Atmospheric Administration (NOAA), and the Canadian Hydrographic Service (CHS). The continued use of MBES in seafloor mapping studies (Butman, 1998; 2002; Butman and others, 1998; Gardner and others, 1998; Locat and Sanfaçon, 2002; Schwab and others, 1997; 2000), defined the complexity and heterogeneities of the seabed to scales previously unattainable, but also demonstrated the need to understand the shallow underlying stratigraphy.

Based on the early experience with MBES, the USGS looked to augment its mapping capabilities by incorporating swath bathymetry into a broader suite of seafloor

mapping and ground-truth, or sampling, tools (Figure 2). The USGS sought a high-resolution, swath bathymetric system that could achieve a wide-swath width in shallow water (depths 1 – 30 m), run concurrently with other geophysical systems, and be easily configured for use on various research vessels. Interferometric sonar systems met these needs, and have been utilized in USGS seafloor mapping activities since 1999 (Denny, and others, 2005).

This poster describes the seafloor mapping operations of the USGS, Woods Hole Science Center (WHSC). Sidescan-sonar, interferometric sonar, and sub-bottom profilers are run concurrently during seafloor mapping investigations, providing a fully-integrated suite of geophysical data. Comprehensive ground-truth studies are then integrated with the geophysics in order to develop a detailed understanding of the surficial and underlying geology. This information, in turn, is used to address a wide range of coastal and marine management issues, as well as providing the basis for future marine research.

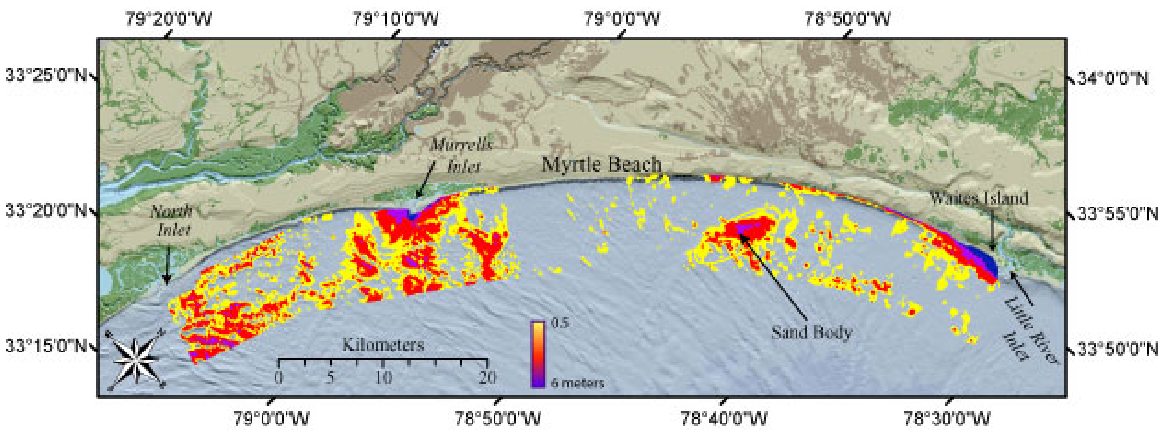

Figure 1: Map defining the thickness of modern sediment off the coast of South Carolina. This mapping effort was part of a cooperative USGS and South Carolina Sea Grant Consortium program designed to address shoreline change along the northern coast of South Carolina.

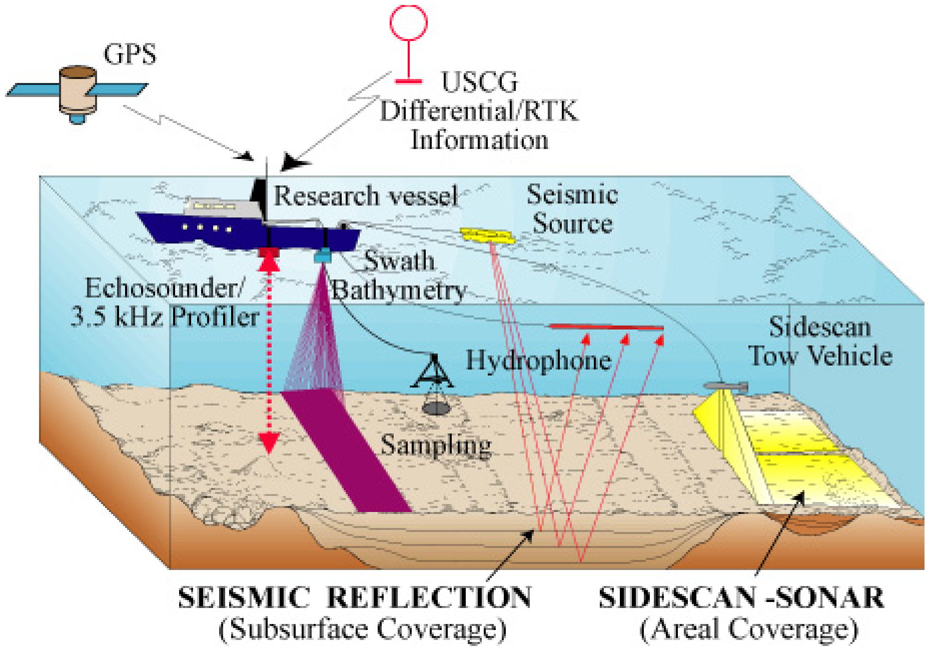

Figure 2: Figure depicting the suite of geophysical and sampling tools utilized by the USGS Woods Hole Science Center for seafloor mapping investigations.

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HIGH-RESOLUTION GEOLOGIC MAPPING OF THE INNER CONTINENTAL SHELF: NAHANT TO GLOUCESTER, MASSACHUSETTS (MAPSHEETS 10-5)

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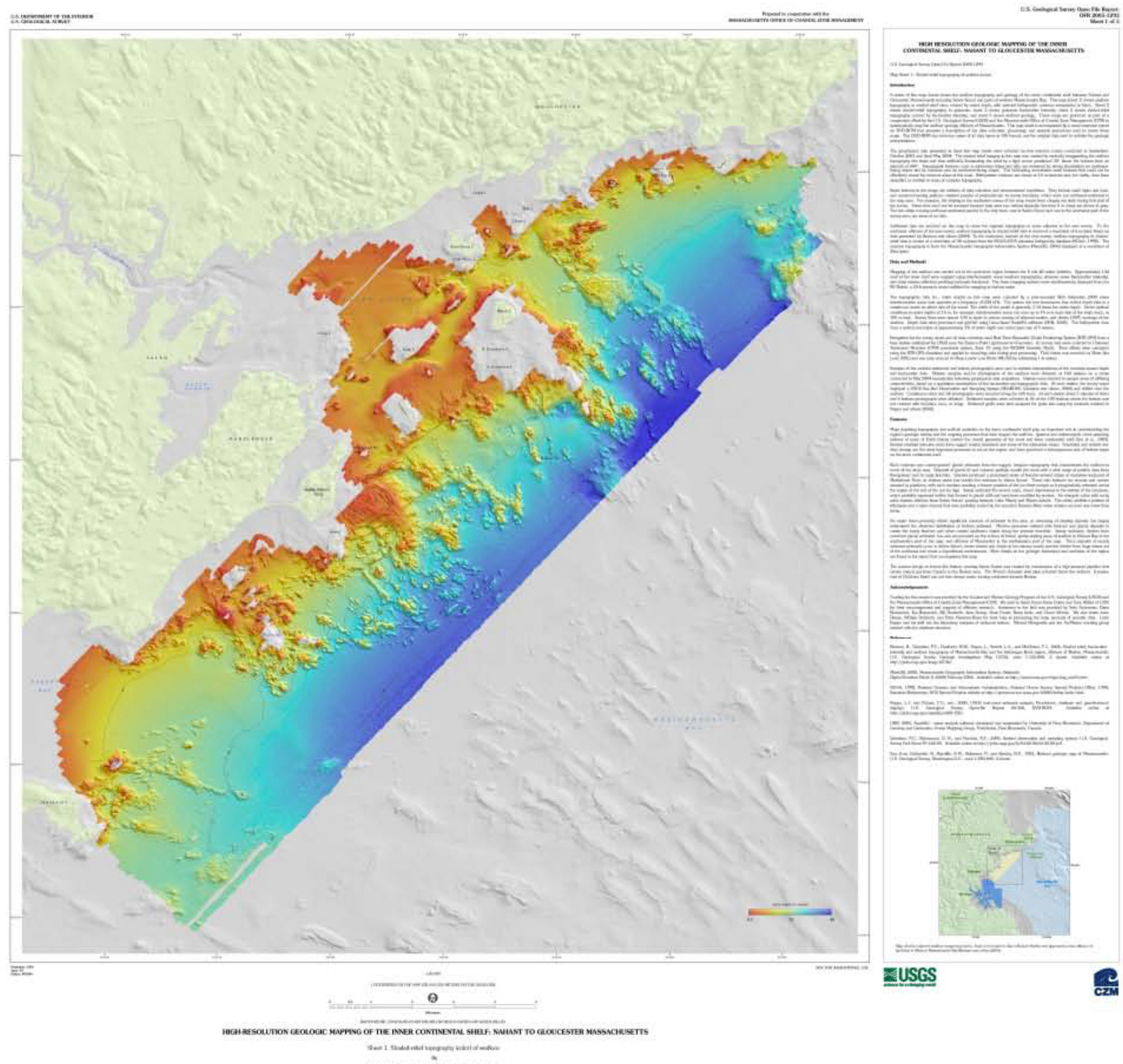
ABSTRACT

The U.S. Geological Survey (USGS) and the Massachusetts Office of Coastal Zone Management (CZM) began a cooperative program in 2003 to map the inner continental shelf offshore of the Massachusetts coast between Nahant and Gloucester. The primary objective of this program is to define the regional surficial sediment distribution, seafloor topography, and underlying geologic structure. This geologic framework information is presented as data layers and interpretative maps that are based on the results of two research cruises carried out in 2003 and 2004. Approximately 134 km^2 of the inner continental shelf were mapped with a focus on the nearshore region in water depths less than about 40 m. We used high-resolution geophysical equipment (swath bathymetry, sidescan sonar, and a subbottom profiler) to map the seafloor in three dimensions. The remotely sensed data were validated with sediment samples, bottom video, and photographs. The suite of data was compiled within a geographic information system (GIS) and integrated to define the physical character of the seafloor.

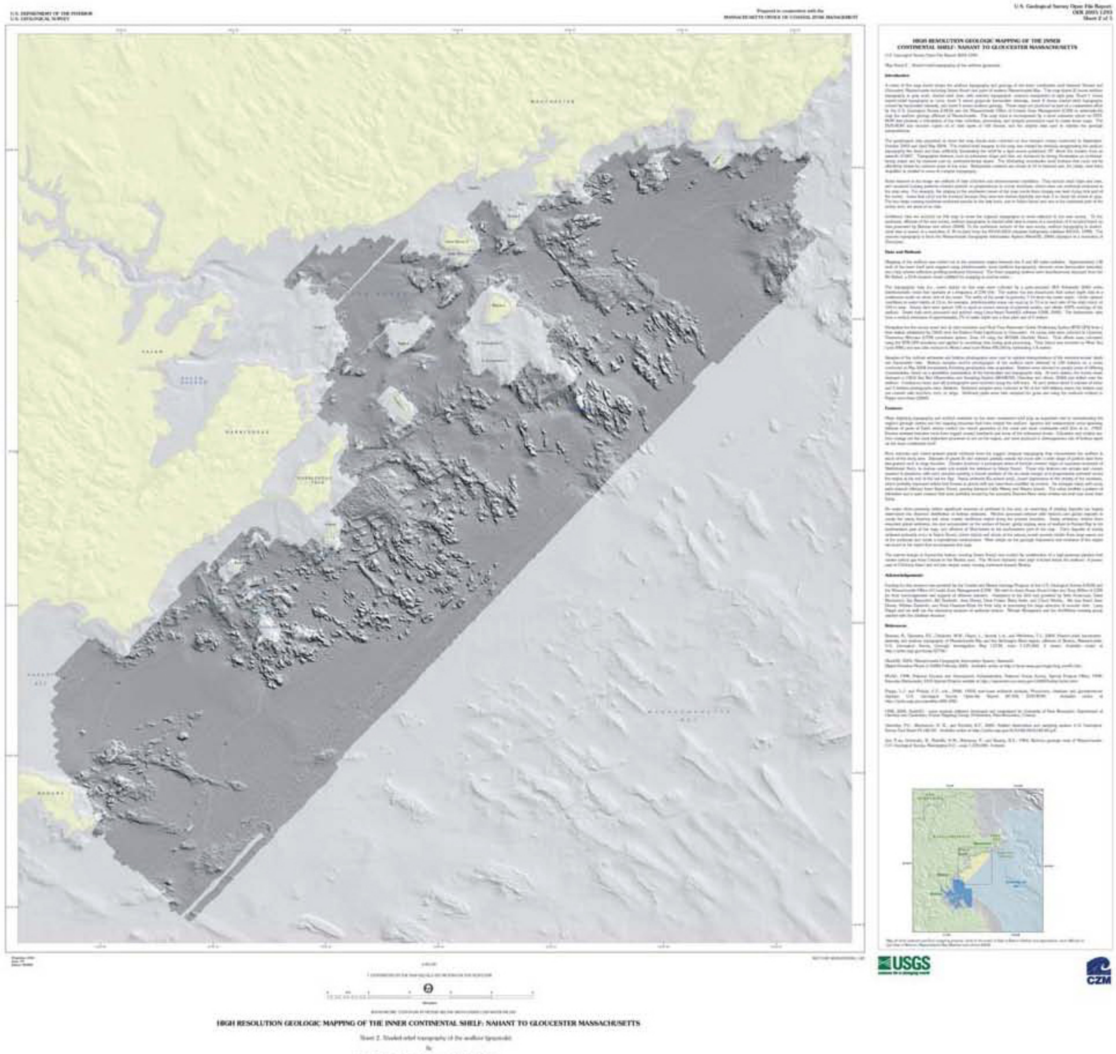
The glaciated, bedrock-framed seafloor of the Nahant-Gloucester region exhibits extreme changes in topographic relief and is covered with a wide variety of surficial materials. The seafloor topography and surficial geology are complex, due to widespread bedrock outcrops, as well as the influence of deglaciation and relative sea-level changes over the last 18,000 years. Quantitative, computer-generated mapping methods are being developed in this study to delineate the characteristics of geologic materials on the seafloor and test the validity of statistical approaches to mapping. Preliminary results of this multivariate analysis show potential for semi-automated classification of bottom types in the nearshore environment of this study. Using a different approach that relies on geologic interpretation, we also define five physiographic zones: *Nearshore Basins, Rocky Zones, Nearshore Ramps, Shelf Valleys,* and *Bay-Mouth Shoals*. The zones are delineated based on seafloor morphology (depth, slope, relief) and the dominant characteristics of surficial materials (bedrock, sediment grain size, thickness of sediment deposits). Although considerable variation exists within each zone, this method allows efficient mapping of large areas and presents geologic information in a readily useable format.

Generating accurate maps of seafloor geology is an important first step toward protecting fish habitat, delineating marine reserves, assessing environmental changes, and providing information for scientific research, industry, and the public. The USGS/CZM cooperative program represents a two-phase approach to mapping marine habitats. The first phase is to gain an understanding of the regional geologic framework of the study

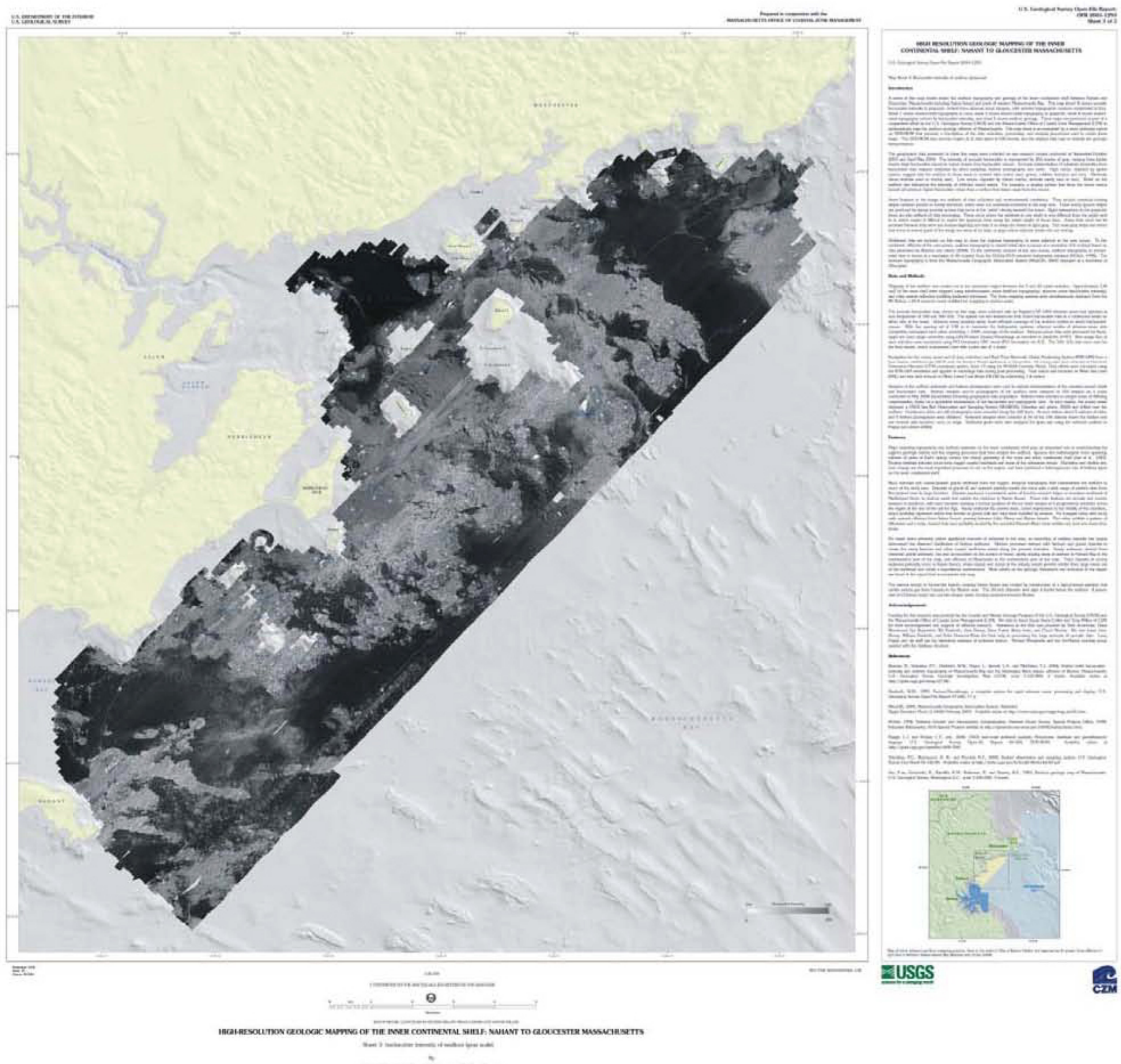
area. The five map sheets (below) summarize the results of this first phase. The second phase, which has not yet started, will use the defined geologic framework to guide biological sampling. The ultimate goal is to merge the regional geologic mapping with site-specific biological assessments to fully characterize benthic habitats.



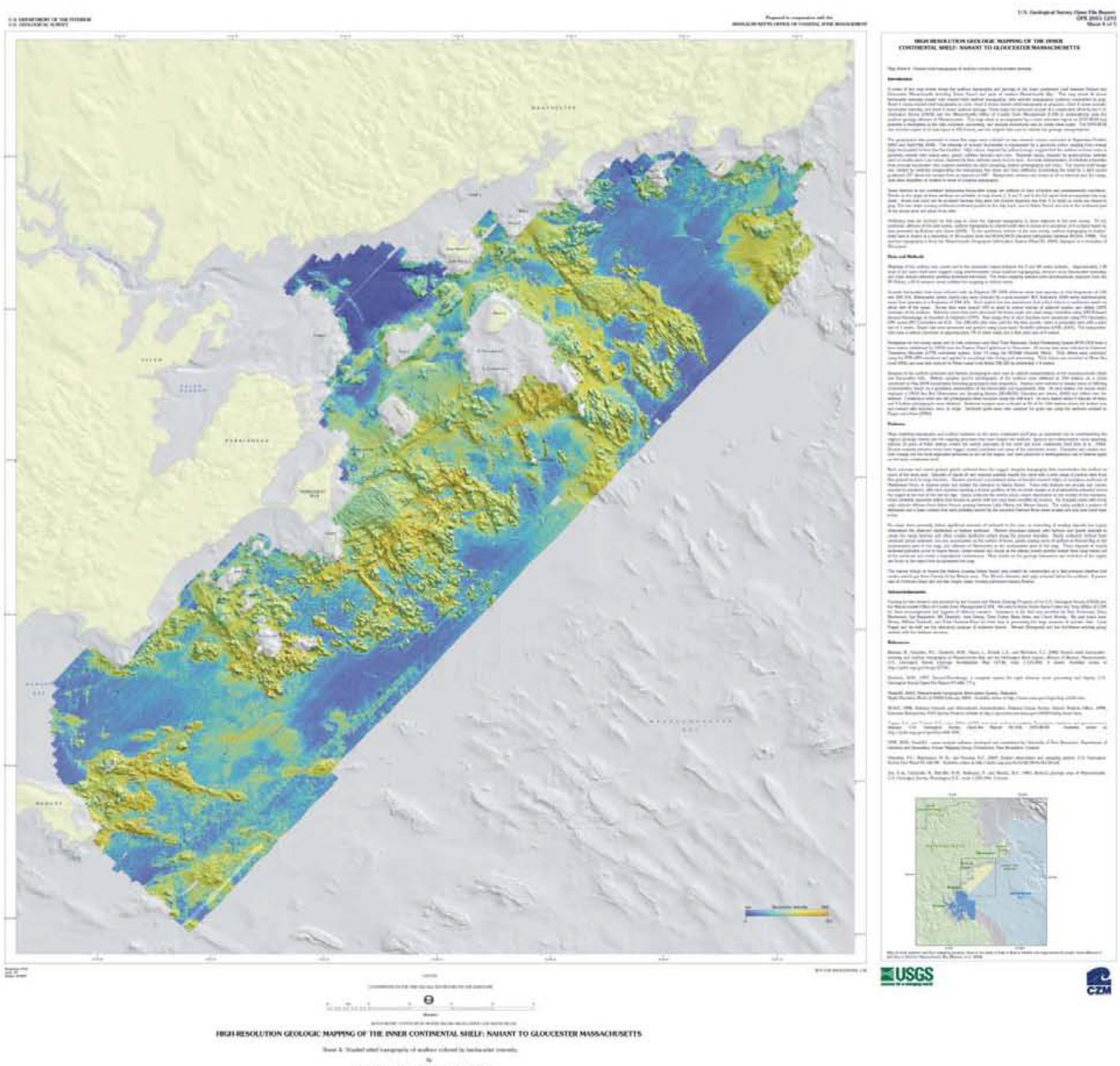
Map Sheet 1: Shaded-relief topography of the seafloor (color)



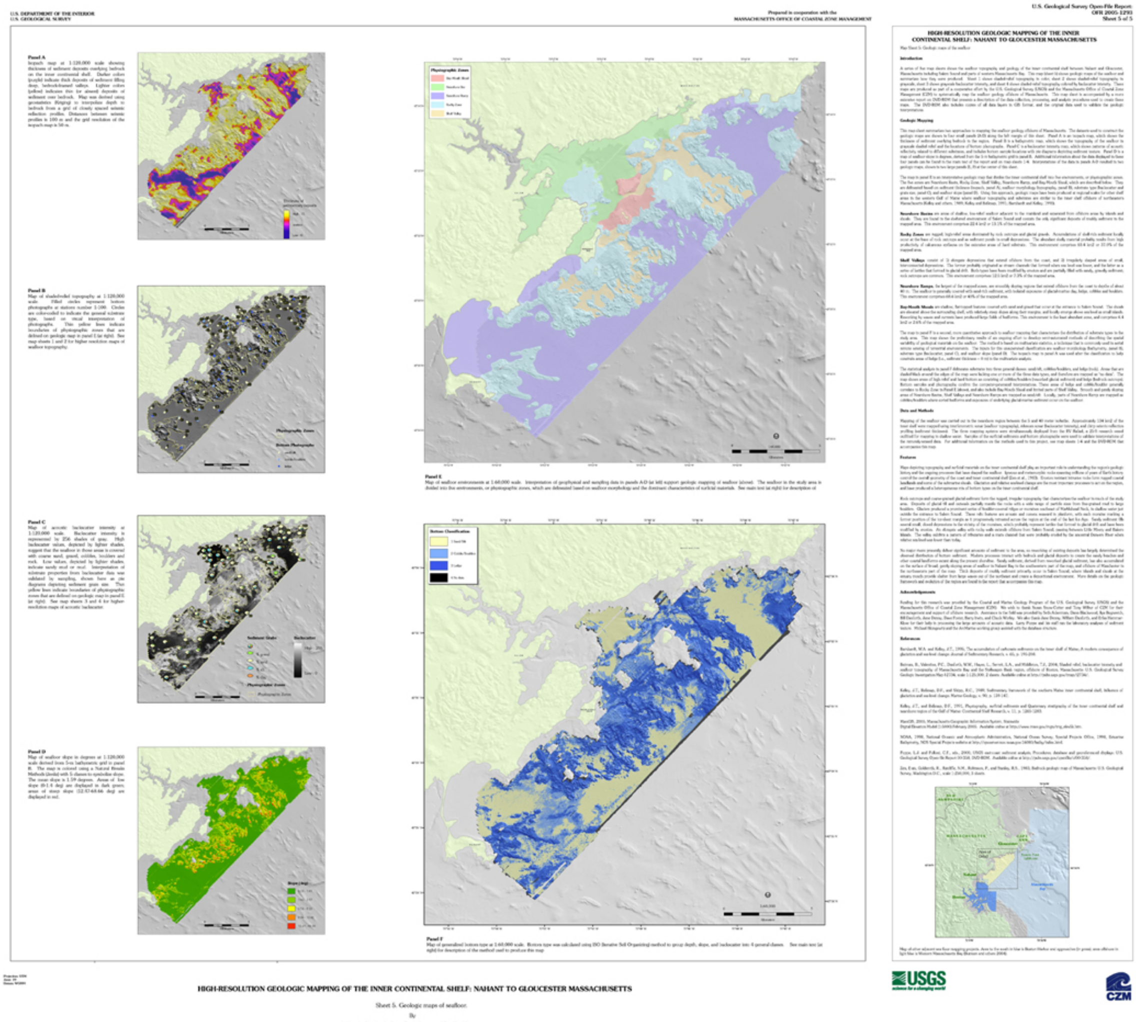
Map Sheet 2: Shaded-relief topography of the seafloor (grayscale)



Map Sheet 3: Backscatter intensity of the seafloor



Map Sheet 4: Shaded-relief topography of the seafloor colored by backscatter



Map Sheet 5: Geologic Map of the Seafloor

The text of this report (USGS Open-File Report 2005-1293), large-format map sheets, and all geospatial data from this project are available on DVD and for download at: http://woodshole.er.usgs.gov/project-pages/coastal_mass/

APPLICATIONS OF THE USGS usSEABED DATABASE FOR REGIONAL-SCALE UNDERSTANDING OF THE GEOLOGIC CHARACTER AND AGFREGATE RESOURCES OF THE ATLANTIC INNER CONTINENTAL SHELF, MAINE TO NORTH CAROLINA

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ABSTRACT

Explosive population growth (24 million increase from 1985 to 2005) and development in the coastal zone continues and demographic projections show that people will continue moving to the coast to live and recreate, placing more people and development at increasing risk. With the prospects of global climate change likely causing increased storminess and accelerating global sea-level rise in the near future, coastal regions will be more dynamic, experiencing even greater vulnerability to erosion, inundation, and storm-surge flooding.

Beach nourishment, a method of dredging sand from offshore areas and pumping it ashore to widen and elevate beaches and dunes to mitigate erosion has been in use since the 1920s when Coney Island was created. Nourishment is often viewed as a cost-effective and environmentally acceptable method for use on developed coasts to mitigate erosion, reduce storm and flooding risk, enhance recreation, and restore degraded ecosystems. Over the past 80 years about 650 million cubic meters of sand have been used throughout the U.S. coastal zone for beach nourishment. For beach nourishment to be viable, however, large volumes of high quality sand are necessary. Also, the sand deposits must be located reasonably close to the beaches being considered for nourishment and in water depths ranging typically from approximately 10 m, an approximate "close-out depth" for sediment transport, to 40 m, an approximate current limit of U.S. commercial dredging.

Continental shelf regions adjacent to the mainland are products of a complex geologic history and dynamic oceanographic processes, dominated by the Holocene marine transgression (>100 m sea-level rise) during the past 20,000 years. The area of the Exclusive Economic Zone, which extends 200 nautical miles seaward from the coast, is larger than the continental U.S. and contains submerged landforms that provide a variety of natural functions and societal benefits, such as: critical habitats for fisheries, ship navigation and home-land security, and engineering activities (i.e., oil and gas platforms, pipeline and cable routes, potential wind-energy-generation sites). Some parts of the continental margins also contain unconsolidated hard-mineral deposits such as sand and gravel that are regarded as potential aggregate resources to meet or augment needs not met by onshore deposits (Williams, 1992). As demonstrated recently by Hurricanes Katrina, Rita and Wilma, coastal erosion resulting from a combination of

natural processes (i.e., storms, sea-level rise, sediment starvation, land subsidence) and anthropogenic activities (i.e., dams, flood control, dredging, coastal engineering structures), is pervasive for all coastal regions.

Sand bodies on the inner continental shelf are often the most attractive sand sources for beach nourishment. Demand for offshore sand and gravel is likely to increase in the near future as accelerated sea-level rise and increased storminess increase coastal erosion and the vulnerability of coastal development to natural hazards. In addition, growing shortages of onshore supplies of aggregate in some parts of the country might be met using marine aggregates. However, for many regions offshore aggregates are sparse or unknown, and sand volumes needed to meet requirements (e.g. 50 yrs) and sustain long-term beach nourishment are uncertain.

Examples of the variety of marine sand bodies present on continental shelves are shown in the following figure.

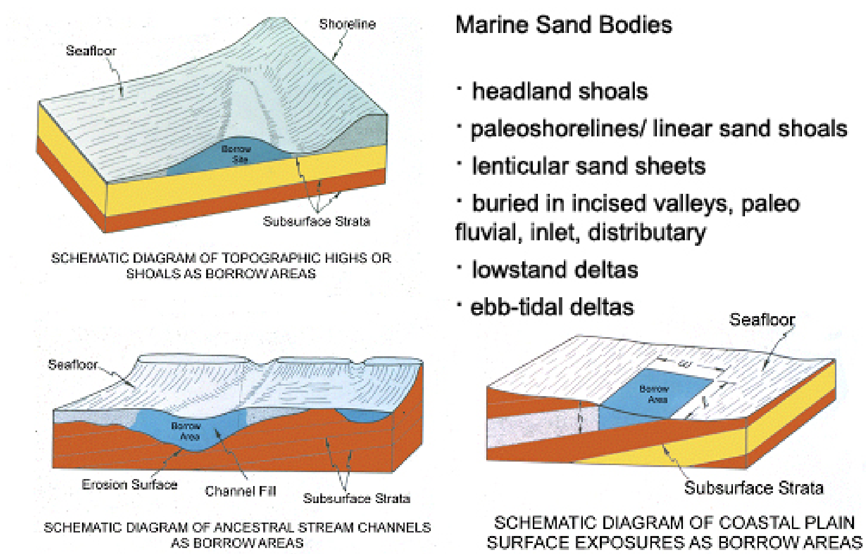

Figure 1. Marine sand bodies, having diverse geologic origins, are buried and exposed on continental shelves and often have been greatly modified by marine processes associated with sea-level rise over the past 20,000 years. Nearshore marine sand bodies of the types shown above offer the best potential sources for high quality sand for beach nourishment (Williams, et al., 2003).

Because offshore areas of the are increasingly important for a variety of purposes, knowledge of the framework geology and processes is critical and comprehensive, up-to-date and integrated computer databases are needed by a variety of users. Products of greatest value are GIS-compatible base maps displaying thematic information such as seafloor physiography, geology, sediment character and texture, seafloor roughness, and geotechnical engineering properties. Digital geologic maps, based on unified national datasets showing the sedimentary character of continental margins, are critical for scientists to better understand and interpret the geologic history and sedimentary processes that formed and continue to modify the sea floor. These map products are

useful to planners and managers for regulating, protecting, and managing coastal and offshore environments.

The U.S. Geological Survey in collaboration with other federal agencies (Navy/ONR, MMS, USACE, NOAA), coastal states, and universities, is leading a Nation-wide program to gather existing marine geologic data into the usSEABED system. This new data base is being used to conduct regional-scale assessments of offshore sand and gravel resources and for producing interpreted GIS maps that can serve a variety of needs (Poppe, et al., 2003; Poppe, et al., 2005; Williams, et al., 2004). Sand and gravel assessments are in-progress for offshore New York and New Jersey and similar assessments are planned for other regions. Figure 2, a gridded map of New York Bight depicting the seafloor sedimentary character, is one example a GIS map product resulting from the assessment study.

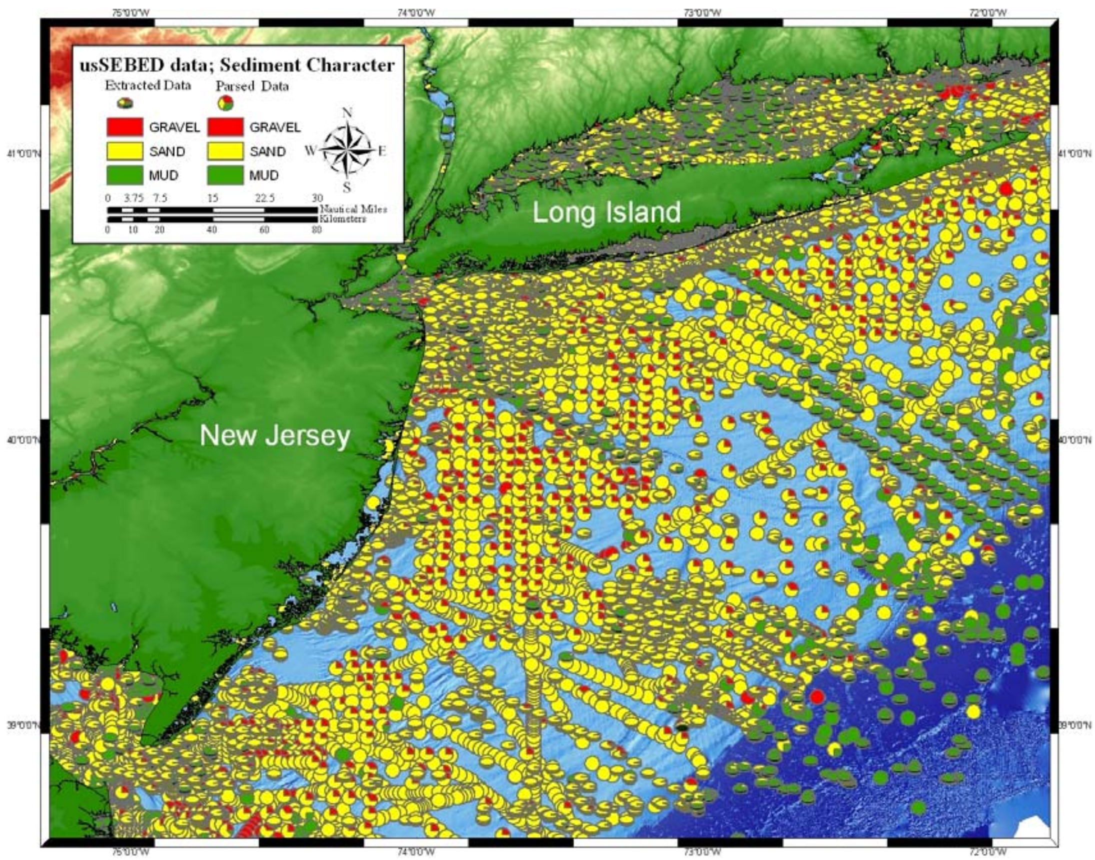

Figure 2. Sediment character map of the NY-NJ offshore region showing the distribution of three main sediment classes (red-gravel, yellow-sand, green-mud) comprising the seafloor. While sand predominates across the region, muddy sediments are associated with the Hudson shelf valley and deeper regions and gravels are patchy and common in erosional areas. The seabed character is the product of the framework geology underlying

the shelf and the Holocene marine transgression including modern oceanographic processes. A variety of such GIS maps are possible using the usSEABED database. This map is generated from the recently published Atlantic coast offshore sediment data release (Reid et al., 2005).

The GIS seafloor maps for New York Bight, scheduled to be completed in 2006, are providing fresh scientific insights into the geologic character and development of continental margins and the assessments are providing useful information about the potential availability and quality of offshore sand and gravel deposits. The GIS maps and the usSEABED data they are based on are likely also to provide useful information on benthic character and habitats useful for fisheries research and management.

Additional information is available at:

http://woodshole.er.usgs.gov/project-pages/aggregates/index.html
http://coastalmap.marine.usgs.gov/regional/contusa/eastcoast/atlanticcoast/data.html
http://walrus.wr.usgs.gov/usseabed/
http://marine.usgs.gov/
http://soundwaves.usgs.gov/
http://woodshole.er.usgs.gov/

Helpful comments and suggestions from peer reviews by C. Polloni and W. Barnhardt (both USGS) are appreciated.

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ECOLOGIC AND HYDROGEOLOGIC IMPORTANCE OF EXPOSED GLACIODELTAIC SEDIMENTS OFF OUTER CAPE COD, MASSACHUSETTS

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ABSTRACT

High-resolution seismic-reflection, multibeam echosounder bathymetry and backscatter, bottom photography, and sediment sampling surveys were conducted to examine the surficial geology and to map seafloor distributions of surficial sediment and sedimentary environments east of Cape Cod, Massachusetts. One result of this effort was the identification of irregular, somewhat discontinuous outcrops of glaciodeltaic sediments at four locations. These outcrops are readily distinguished from the mobile coarse sand and fine gravel that composes most of the sea floor off the outer Cape, and record 1) topset, 2) foreset, and 3) bottomset facies of deltas that prograded southwestward into pro-glacial lakes in Cape Cod Bay and Nantucket Sound from the South Channel lobe about 18 ka (Uchupi et al., 1996).

1) Topset Deposits: Ice-proximal glaciofluvial topset deposition is recorded by large bouldery areas at the eastern extent of the study area off Wellfleet and Eastham. Most of the finer sands and gravels that were originally present here have been winnowed away under modern high-energy sedimentary environments, leaving bouldery lag deposits. The extensive attached biota (e.g. hydrozoans, anemones, and seaweed) indicates that the boulders are not mobile even during high-energy storm events.

2) Foreset Deposits: Tabular blocks that show relief of more than 1 m above the surrounding sea floor and exceed 400 m across are located along the southern edge of the bouldery area off Eastham. These outcrops become smaller and more widely spaced both westward and northward. Although the surface of these blocks is characterized by fine, moderately well sorted sand and an undulating appearance, preservation of these blocks indicates that denser, more cohesive sediments (i.e. muddy sand and sandy mud) probably compose the interiors. Based on surface texture and relatively low backscatter intensity, we interpret these blocks to be the remnants of foreset beds of the delta that produced the Eastham outwash plain. As the sandy ice-distal topset beds were eroded away by the Holocene current regime, foreset beds over which they had prograded were exposed. The cohesive, muddier sands of the underlying foreset beds were more resistant and part of this facies is preserved as erosional outliers. Abundant skate suggest that the tabular blocks are an important habitat for these fish.

3) Bottomset Deposits: The glaciolacustrine bottomset sediments are gray to light bluish gray, cohesive, semi-consolidated and composed primarily of silty clay with some very fine sand. Ongoing degradation of the outcrops, which can exceed 1 m in relief, is mainly by wasting along varves, as evidenced by abundant slabs and blocky rip-up clasts present on the surrounding seafloor, and to a lesser extent by bioerosion. These strata, which record distal low-energy deposition within lakes in front of the deltaic systems, were found at three locations. The two southernmost exposures, which record deposition in the Eastham outwash plain and perhaps another older delta, are found about 1.5 km east of southeastern Wellfleet and about 5.7 km off Chatham, respectively. The northernmost outcrop, which occurs about 1.9 km off North Truro, probably represents distal deposition along the northern edge of the delta that built the Truro outwash plain.

Although exposed glaciodeltaic deposits constitute only a small portion of the sea floor east of Cape Cod, they are important for both ecological and hydrological reasons. Ecologically, these exposures provide benthic habitats of rough bottom and harder substrate in an area of the shelf dominated by mobile sand and fine-grained gravel. Bottom photography shows that lobsters construct burrows in outcrops of both the bouldery topset deposits and muddy cohesive bottomset deposits. Similarly, finfish shelter under the ledges, overhangs, and boulders; sessile fauna and flora attach themselves to the hard substrate provided by boulders. Most importantly, the exposed glaciodeltaic deposits add considerably to the overall benthic topographic and compositional complexity off the outer Cape, and influence the distribution and dynamics of the faunal populations and characteristics of the benthic communities.

Hydrologically, the impermeable glaciolacustrine units within the coarser grained unstratified drift can form aquicludes that restrict the flow of groundwater. Because these impermeable units can divide the aquifer, they may affect the position of the saltwater/freshwater interface in well fields on Cape Cod and limit recharge. Such stratigraphy can promote 1) saltwater intrusion and down-coning of the water table around wells drilled above the fine-grained units, 2) up-coning of saltwater in wells drilled to below these units, and 3) poor flow rates in wells drilled into these low-permeability sediments (Masterson, 2004). Therefore, information on the distribution and extent of these beds helps constrain hydrologic models, improves our understanding of the outer Cape's aquifer system, and facilitates better regional ground water management. Our multibeam data, sediment samples, and bottom photographs documented the glaciodeltaic deposits, and our subbottom profiles have traced them shoreward where they can be correlated with units in onshore boreholes (Gerhard and Phillips, 1989) .

Data and interpretations from this study are presently being assembled into a GIS that will be released as U.S. Geological Survey Open-File Report 2005-1048 on DVD and online.

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THE USE OF HIGH RESOLUTION BATHYMETRY AND TELEMETRY DATA TO DETERMINE HABITAT UTILIZATION CHARACTERISTICS OF AMERICAN LOBSTERS (*HOMARUS AMERICANUS*)

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ABSTRACT

The American lobster, (*Homarus americanus*), is one of the most well studied marine invertebrates in the world, as well as the basis of one of the most valuable fisheries in New England. Yet, despite the intense interest in this species, we still know little about its normal behavior in its natural habitat. Our research is focused on the factors that influence daily and seasonal lobster movements. While a great deal is known about temporal and spatial use of habitats by terrestrial species, our understanding of the movement patterns and home ranges of mobile marine species is very poor, especially with respect to invertebrates (Hooge *et al*., 2001; Pittman & McAlpine, 2003). This gap between what we know about terrestrial vs. aquatic species, in terms of habitat utilization, is primarily due to the challenges inherent in continuously observing aquatic species for long periods of time and the lack of accurate benthic habitat measurements.

To date, the majority of lobster movement studies have been conducted using tag and release methods that have a very coarse spatial and temporal resolution (Krouse 1980; Haakonsen and Anoruo 1994). Similarly, extensive high resolution maps of the coastal areas of the Gulf of Maine do not exist. Therefore, it has been extremely difficult to relate lobster movements and home ranges to habitat type or bathymetry.

In this study we combined two high-resolution systems to accurately track lobsters and map the habitats through which they moved. A total of 19 lobsters were fitted with ultrasonic transmitters and released near the mouth of the Piscataqua River in New Castle, NH. These animals were tracked using a triangulating, ultra-sonic telemetry buoy system (VEMCO Ltd.) that yielded approximately 312 positions/day for each lobster tracked. The spatial resolution of this system was ~2-4 meters when the lobsters were in the center of the buoy array. The daily movements of each lobster were analyzed using the Animal Movement Analysis Extension (AMAE) (Hooge *et al.*, 2001) written specifically for Arcview 3.3. The lobster positions were then merged onto high resolution multibeam maps of the ocean floor, that are part of the Portsmouth Shallow Water Survey Common Dataset of the UNH Center for Coastal and Ocean Mapping (see Mayer and Baldwin, 2001) (Fig. 1).

Typical multibeam maps yield information about depth and bottom structure, but only habitats that are drastically different, such as boulders vs. sand, can be resolved. We applied texture feature classification algorithms (Cutter, 2003; Cutter, 2005) to gridded bathymetry data from multibeam echosounders to further refine habitat types. Furthermore towed video and scuba surveys were used to ground truth the feature classification scheme. This combination of methods was used to create high resolution habitat maps for a large portion of the area in which lobsters were tracked. These habitat

classifications were developed on a per-cell basis for every 1-m by 1-m grid cell of the bathymetry datasets. In other words, every bathymetric grid cell was classified based upon the local texture, resulting in a habitat map with a predicted habitat class for every square meter of the seafloor in the study area (Fig. 1).

Visualizing the movements of individual lobsters with relation to bottom habitats provides insight into the impact of habitat type on lobster movement. This data will enable us to quantify habitat preferences and make inferences about how lobsters might use particular bottom features to guide their movements. This information may, in turn, serve as a basis for making informed decisions concerning lobster management; such as identifying essential habitats and delineating the size and boundaries of potential Marine Protected Areas or reserves.

The methods discussed in this abstract are in the process of being implemented and additional tracking studies are planned for the summer of 2006. Therefore, this poster will exhibit the results of the preliminary comparisons and analyses that have been conducted to date. Figures and topics to be presented will include: Home range size and homing events in relation to habitat type; variations in the temporal use of habitats; rates of movement, distance traveled and activity rhythms in relation to habitat type.

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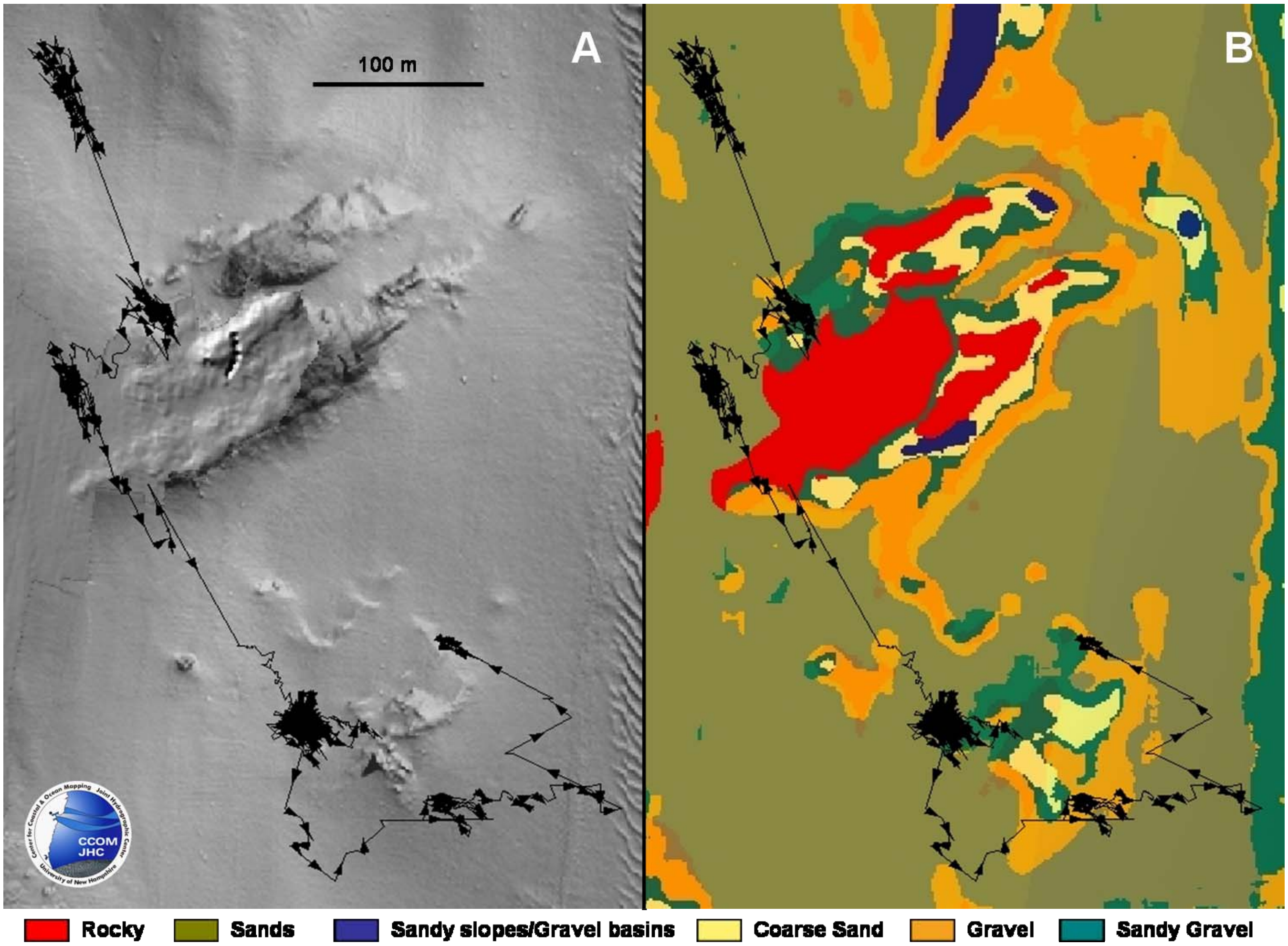

Figure 1. A. The movements of a 78 mm CL lobster obtained over a period of 6 days. The track is overlayed on a multibeam scan of the mouth of the Piscataqua River (NH) created by the UNH Center for Coastal and Ocean Mapping. **B.** This panel shows a texture feature classification of the scan in panel A. Six substrate classifications are identified along the bottom of the image. Classifying the scan in this manner allows lobster track to be associated with specific physical habitat types.

A THREE-DIMENSIONAL RECONSTRUCTION OF BIOLOGICAL INTERACTIONS ON PLATTS BANK

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ABSTRACT

In July 2005, we conducted a series of research cruises and aerial surveys to record the location and feeding activity of vertebrate predators, their prey, and oceanographic conditions on Platts Bank. The bank measures approximately 15 by 15 nautical miles and is located 55 km off Cape Elizabeth, Maine. We used acoustic data to map the distribution and abundance of plankton, micronekton, and herring. We used a USGS bathymetry layer of the Gulf of Maine to create a three-dimensional rendition of the area surrounding Platts Bank. We compiled the data layers in ESRI's ArcScene to analyze and visualize the spatial relationships between seafloor topography, currents, humpback whales and their prey. Hydrodynamic processes, including small scale fronts and internal waves, appear to be responsible for the concentration of zooplanktonic prey, leading to highly localized levels of predation. A three-dimensional GIS model allows researchers to view multiple data sets simultaneously from a new perspective, thus enhancing the potential to identify the diverse physical and biological forces interacting on Platts Bank.

SINGLE BEAM SONAR MAPPING FOR DEEPWATER HABITATS IN HUDSON CANYON

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ABSTRACT

Hudson Canyon (Fig. 1A, B) is the largest and most heavily fished submarine canyon in the eastern United States, yet little is known about the fisheries habitats that this large feature supports. Ecosystem-based fisheries management decisions in this region are therefore problematic. Indeed, the details of topography that underlie habitat structure in Hudson Canyon are only partially known; no modern multibeam survey has mapped the topography completely. Visual exploration of other canyons in the mid-Atlantic and New England regions has shown that canyons support extensive deepwater coral habitats (reviewed by Packer *et al*. in review). As a result, Oceanographer and Lydonia Canyons have been closed to some fishing. To date there have been few reports of deepwater coral, sponge or other hard substrate communities in Hudson Canyon other than tilefish "pueblo villages" (Able *et al.* 1982), but it is strongly suspected that this is a result of looking in the wrong places based on poor topographic information, rather than actual absence. Indeed, the coarse scale of current topographic data for much of Hudson Canyon itself discourages exploratory investigations; loss of sampling gear in poorly-characterized, irregular terrain is a constant hazard.

A systematic search for likely areas with hard substrate was undertaken by identifying areas of steep (>30º) slopes based on existing NOAA National Geographic Data Center GEODAS data along the walls of Hudson Canyon. Since multibeam sonar was not available, rectangles of 2 to 4 km^2 that could be covered using single beam sonar system in 6 to 10 hours each at 5 kt. were drawn around steep areas (Fig. 1C). Fourteen such rectangles were swept in November, 2005 by F/V *Delaware II*, collecting bathymetric data with a single beam Simrad EK-500 Scientific Sounder. Raw data values, processed to remove gaps, glitches, and the ship's vertical motions, were interpolated to 15m X 15m grids for plotting. Comparison was made of these plots against the highest resolution GEODAS bathymetry available (0.05 minute grid). Features, including steep slopes, appeared in the single beam bathymetry that were not evident in the GEODAS plots, as well as features that appeared displaced or changed (Fig. 2). In the absence of multibeam data for much of Hudson Canyon, single beam data promises to provides a more detailed and accurate guide in limited areas for subsequent targeted habitat investigations via videographic, photographic, and other sampling methods. A rigorous test of accuracy awaits a new cruise season.

Fisheries management measures necessary to protect sensitive deepwater habitats demand that their location and extent are documented. This mapping effort is a first step toward achieving that goal, should this become a priority in Hudson Canyon.

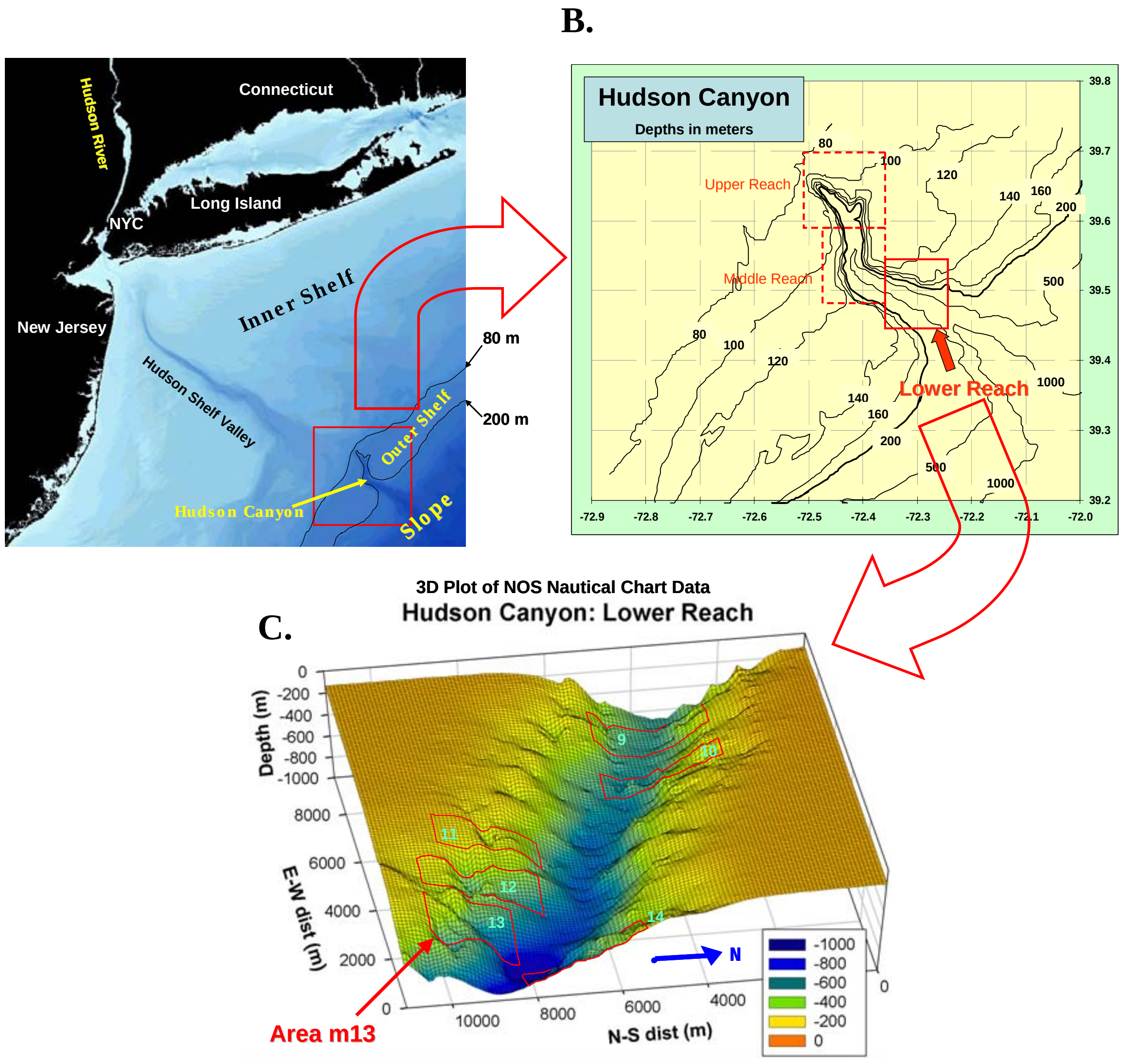

Figure 1. Hudson Canyon: A. Location, B. Rough bathymetry, C. Lower reach topography with mapping rectangles.

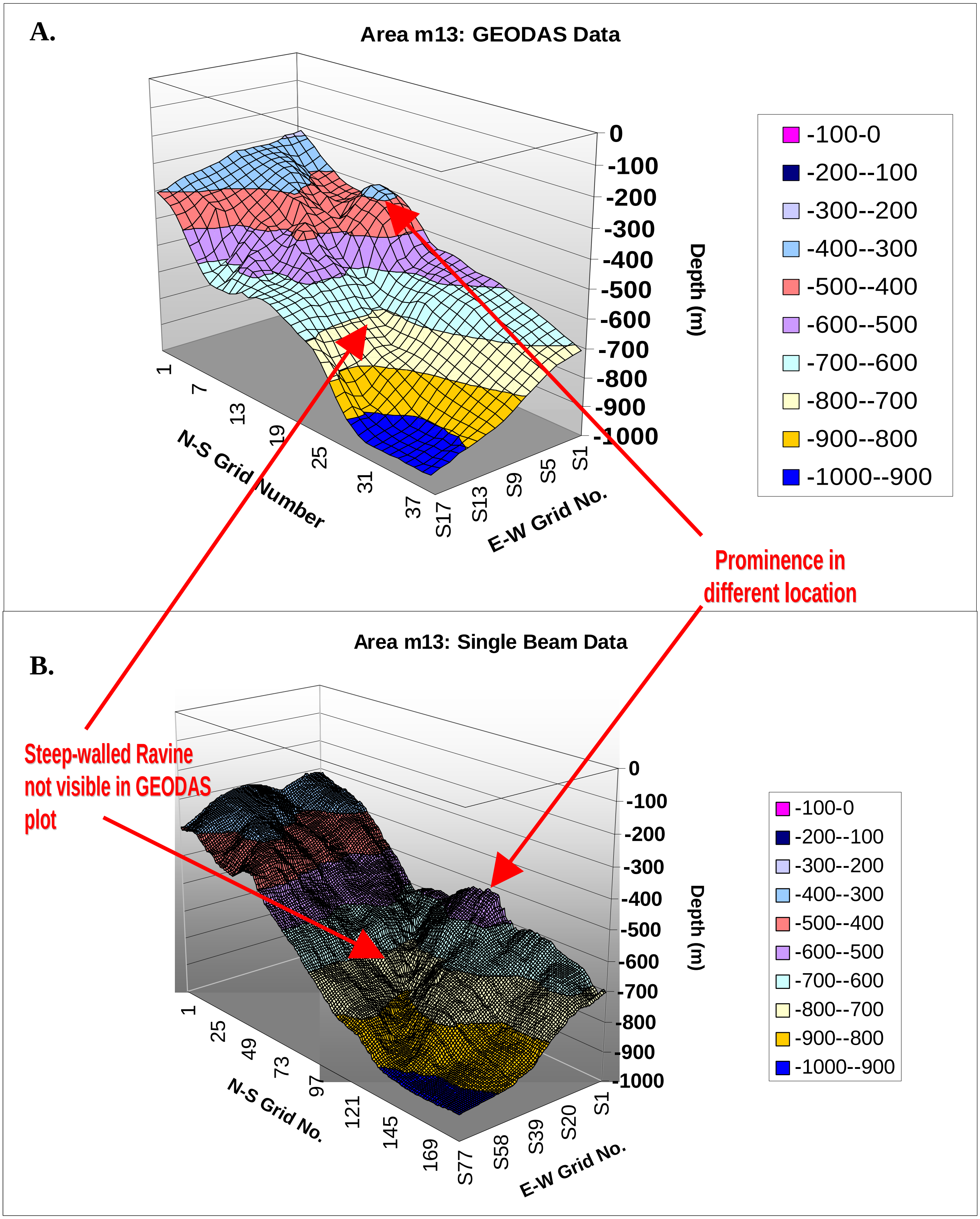

Figure 2. Comparison of GEODAS 71 m grid topography with *Delaware II* 15 m grid topography for mapping area m13.

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CHARACTERIZATION OF SCALLOP ABUNDANCE AND BENTHIC HABITAT USING OPTICAL IMAGING TECHNOLOGY

Scallop Research Setaside Project 2004-SCA-007

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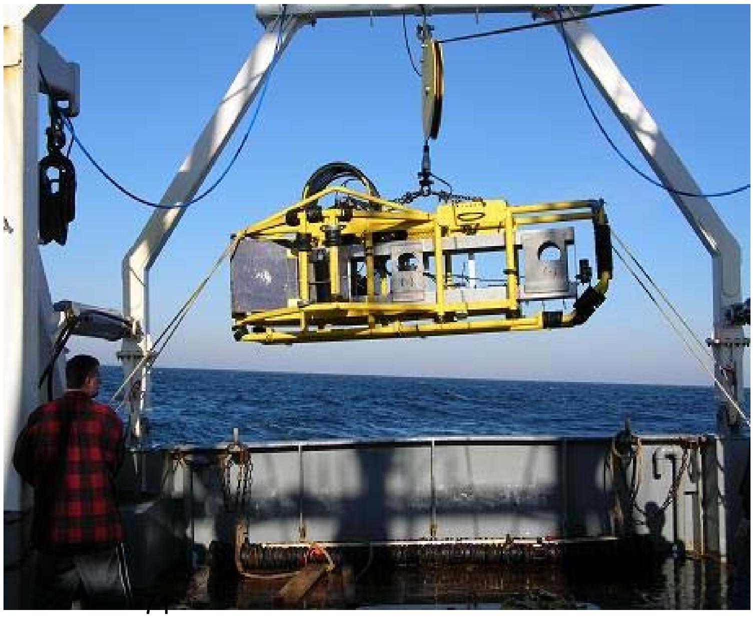
ABSTRACT

Overview

The development of accurate fine scale monitoring tools has become increasingly critical to fisheries management as we begin to manage on spatial scales smaller than current survey methods were designed to resolve. Recent evolution toward discreet area management and individual vessel catch quotas for small areas of the shelf result in relatively small differences in biomass assessment having monetary results worth millions to the scallop fishery. Additionally, the Sustainable Fisheries Act (1996) requires us to consider the impacts of fishing gears on habitats considered important for the growth and survival of non-target species, and yet we have relatively sparse information concerning both the biota and associated substrates. Accordingly the Atlantic sea scallop industry has generated the funding for this effort using the Scallop Research Set Aside program with the administrative oversight provided by NOAA Fisheries.

In this project we develop a digital imaging system to be towed by a commercial scallop fishing vessel that delivers high resolution still images (1280 x 1024) to the vessel bridge for immediate viewing, for onboard image processing, and offline segmentation, useful for both scallop biomass assessment and habitat classification. The vehicle, HabCam, is towed from the vessel using high strength steel towing cable containing power down via copper and the data up via the internal fiber using a hydraulic winch equipped with combination fiber and power slipring. Data from all vehicle instruments (compass, altimeter, CTD, etc) is



packetized and multiplexed onto the Gigabit Ether network, with all data streams including shipboard GPS position, course over ground, logged to topside drives. The vehicle is flown at an altitude of two meters and controlled by the winch operator using both the altimeter and every fifth image for visual feedback. Current operational speed over ground is 4 to 6 knots, with the camera operating at 4 to 6 frames per second (14,000 to 20,000 images per hour) in order to achieve overlap adequate for continuous mosaicing. Data volumes approach 1 terabyte/day.

Methods and Progress to date

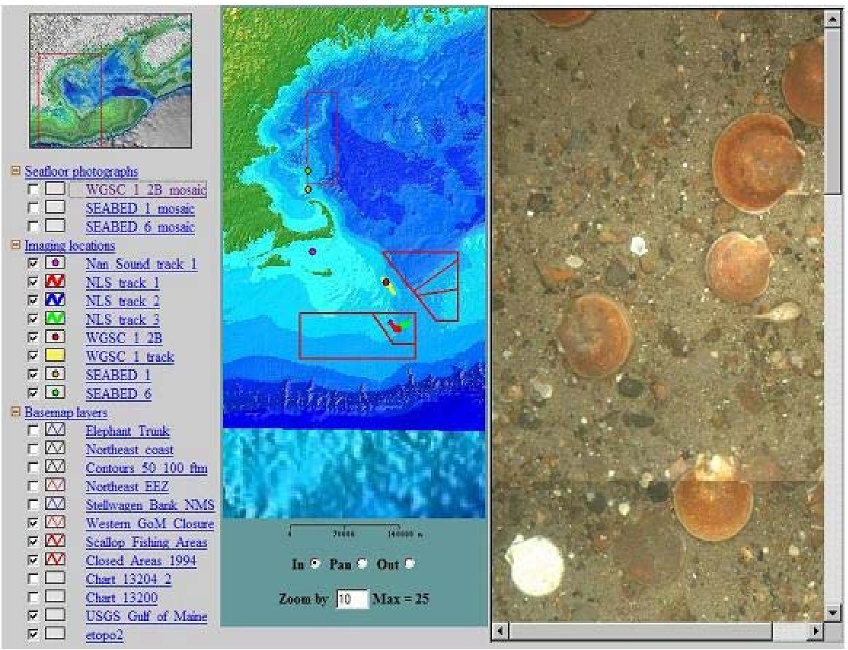
1. Data collection

Four separate data collection trips have been taken including the first 12 hour sea trials in Nantucket Sound, October 2005, where ~30,000 images were obtained. Trip two, November 2005, was made in the Nantucket Lightship Closed Area and served as a very positive proof of concept that it not only was possible but beneficial to operate in both fishing and survey modes during the same voyage given the distance from shore. Several hundred thousand images were obtained. Several changes to both lighting and camera were necessary. Our third trip was to the Western Great South Channel, in January 2006, this time while fishing under a Research Set Aside compensation trip Day At Sea (RSA DAS). Image processing routines for color balancing, warping, and registration for mosaicing were significantly advanced. A fourth trip consisting of a preplanned 65 mile long serpentine transect was made to the Elephant Trunk scallop grow out area off Cape May, New Jersey in February 2006. Transect route planning using the results from the last two years data of the Albatross survey was the central consideration of this effort. Over 200,000 images were obtained in 13 hours. However the significant steam each way further emphasized the utility of integrating distant survey such as this into simultaneous fishing or compensation collection activities. Total images to date: approximately 700,000 with an estimated 90% usable for further focused studies. This percentage has increased as vehicle flying techniques are becoming more familiar and routine, and more advanced software developed.

2. Image processing and analysis

Three image processing elements are central to this project, particularly critical as data volumes are large. The first two require development/refinement of an automated segmentation algorithm to be used for: 1) counting (and rudimentary sizing) of scallop within each image frame, and 2) segmentation and classification of all other foreground targets and background substrate. This substantial task begins with frame by frame human identification of targets to build a training set for the Support Vector Machine (SVM), with repeated iterations to refine the segmentation process and results. The third element in this processing subtask is the

development/refinement of semiautomated mosaicing softwares adequate for warping, registration, and color balancing of sequential frames. Testing of several current softwares are underway, with operational applications in use, however no off-the-shelf solution has proven capable of meeting all of our requirements in a timely manner given the computationally intensive nature of the solution.



3. Development of web-based data access and presentation of results

The fifth element of our bottom imaging effort is making the data, images, scallop counts, and classification available to all via the internet.

Full accomplishment of this aspect involves establishing a database of imagery, archiving and serving all imagery and mosaics, and an html based display engine. Several methods have been tried with current efforts using an open source MapServer application for internet access. Primary challenge is making the access and display scalable, meaning that as we continue to collect more imagery that the system can rapidly respond to requests for imagery at any and all scales. Currently many of the early mosaics are available via www.seascallop.com.

The final objective is to make these data collection and analysis efforts available to managers via presentation of results at Fishery Council scallop related meetings including the Plan Development Team and Committee, describing results and methods of accessing the data, mosaics and other output. These latter aspects are awaiting completion of earlier elements.

Acknowledgements

This project has been funded by the Atlantic scallop industry using the Scallop Research Set Aside with administrative oversight provided by NOAA Fisheries. Considerable contribution has been made by the outstanding efforts of individuals from the Woods Hole Oceanographic Institution, including Andy Girard, Lane Abrahms, Chris Griner, Emily Miller, and the gang in the machine shop.

PRELIMINARY INVESTIGATION OF MARINE BIOTOXINS ALONG THE NORTHWEST ATLANTIC SHELF INCREASING THE ECONOMIC RETURN FROM THE US ATLANTIC SCALLOP RESOURCE

Scallop Research Setaside Project 2004-SCA-008

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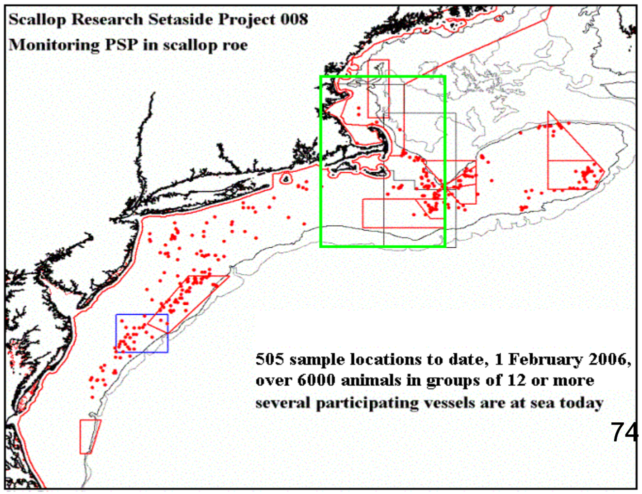
ABSTRACT

Overview

The Atlantic sea scallop (*Placopecten magellanicus*) fishery currently discards more than half of the edible portion of the animal, in great part due to the potential uptake of marine biotoxins occasionally retained in the gonad, viscera, mantle and gill. Occasional blooms of the dinoflagellate causative of these toxins can create high concentrations of toxins in shellfish viscera which, when consumed in sufficient quantity, are toxic to humans. Worldwide, safe harvest of these supplemental soft tissues is controlled by public health officials through screening of tissue, water testing and closures.

Scallop gonads marketed in Europe as roe-on scallops would increase the saleable poundage by up to 50%. Marketing of scallop eye-rings (mantle) could add another 10-15%. Whole scallops, of interest to Asian markets, can increase saleable poundage up to 100%. US fisheries currently do not commonly harvest and market these forms of scallop products as there is no comprehensive testing program to determine the presence or absence of marine biotoxins harmful to humans.



In this study, we collect and test over 6000 animals from over 500 sample locations across the US range of the species, from the waters off Virginia to the International Court of Justice line on Georges Bank. Testing of the sample groups was accomplished using two newly developed methods, Jellett Rapid Test and Receptor Binding Assay, with a

portion crosschecked with both High Performance Liquid Chromatography (HPLC) and the ISSC approved Mouse BioAssay.

Methods

1. Sample Collection

In the fall of 2004 ten commercial scallop fishing vessel Captains were engaged to bring in multiple samples from all fishing operations conducted during the course of the year with the incentive provided by participation in the Scallop Research Setaside program (RSA). Additional samples were collected by the NOAA Fisheries R/V Albatross IV during the annual scallop survey cruises conducted each summer, providing an opportunity to obtain samples from areas that were not necessarily open to the commercial vessels. Albatross samples obtained in summer of 2004 exhibited saxitoxin levels in the viscera between 5 and 10 times the federal standard and gonadal toxins approximately 1.5 times federal levels in the Nantucket Lightship Closed Area, an area previously considered free of toxins. These observations served to increase sample collection and testing over time both there and in the surrounding areas.

Subsequently, in the spring of 2005, an unusually large bloom of *Alexandrium fundyense*, a major source of saxitoxin, the marine biotoxin responsible for paralytic shellfish poisoning, formed in the western Gulf of Maine and dispersed southward toward the Closed Areas in the Great South Channel. This event resulted in the closure of a large area (41-43N, 69-71W, green boundary above) to whole molluscan shellfish harvesting by the Massachusetts Division of Marine Fisheries in conjunction with the FDA Seafood Safety Program. Toxins in the viscera exceeded 40 times federal standards in 1 sample in that area at peak time with gonadal toxins for the same samples exceeding standards by a factor of 4. `

Preliminary indications are that toxins found in the gonads of almost all samples both before and after the peak of the bloom were well within safety standards, yet toxin levels in the remaining viscera were potentially toxic to humans. While portions of the emergency closure area were later reopened for harvest of clams and quahogs, the entire area remains closed to the harvest of whole scallops at this time almost one year later.

Many of the smaller vessels in these more inshore waters land the whole scallop, thus this closure has had a particularly strong impact on that fishery. As an unplanned result these vessels have contributed thousands of additional sample animals to this study in an effort to provide data sufficient to reopen the Great South Channel area, the area of highest toxicity.

2. Sample handling and processing

All samples were fresh frozen at sea aboard participating vessels or delivered directly to the freezer for storage. As the vessels had highly variable schedules groups of samples were held at a central location, Bergies Seafood, New Bedford, until sufficient samples were on hand to provide a full days processing. Samples were then processed at the Shellfin facility, including dissection into meats, gonad, and

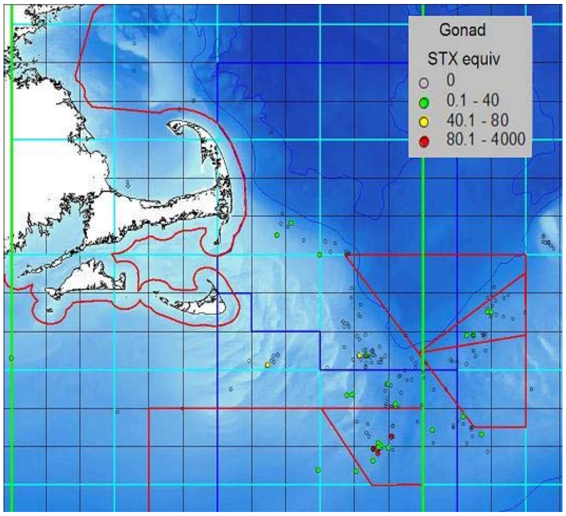
remaining viscera, weighing of all parts, and shells measured to the nearest mm. Soft parts were separated, rinsed, mascerated into a thick paste consistency, labeled and refrozen in small replicate sample tubs for local testing, shipping to project partners, and archiving.

3. Marine biotoxin testing

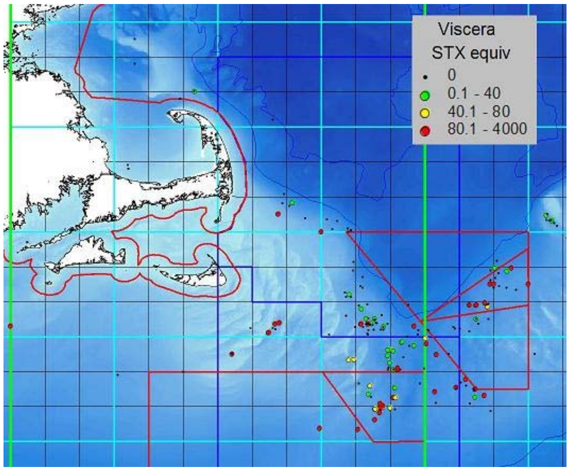
Initial tests for PSP were conducted using the Jellett Rapid Test aboard F/V Westport, with ease of use aboard a fishing commercial vessel the key attribute. These test kits are set to read positive at 40um/100 grams tissue STX equivalent, one half the current federal standard. All further Jellett testing was conducted at the Shellfin plant in Falmouth as a method of achieving more time efficient centralized processing. In most cases both tissue compartments, roes and remaining viscera (rings and hepatopancreas), were tested separately. Replicates of samples were shipped to the CCHEBR facility in Charleston for Receptor Binding Assay (RBA) tests. Additional testing was conducted using HPLC at the Woods Hole Oceanographic Institution, with a subsample from the Emergency Closure Area used for Mouse BioAssay (MBA) at the Massachusetts Division of Marine Fisheries Lab in Gloucester.

Results

These data along with sample location, the various test method results, gonad fraction (GSI), and meat to roe ratio, were entered into a comprehensive (now 25,000 cell) flat file and plotted for all sample groups using both the ArcView and MapServer applications, the latter for web access to project data.



Although the strong bloom in Spring 2005 reached extremely high cell counts and rapidly spread south to Martha's Vineyard, it dissipated rapidly as well, giving this project an unexpected chance to monitor a "worse case to date" event. All data has not been completely analyzed as the project is several months from completion.



A preliminary "First Look" assessment is that while the amount of toxin in the viscera is many times a multiple of the federal standard, uptake into the roe is more moderate, and most often well below the 80ug/100grams STX equivalent standard. The amount of time it takes the scallop to clear the toxins remains an area of special interest. Additionally, as this was the first year of testing, the amount and frequency of "normal" spring bloom toxicity remains unclear. This project has been funded for a second year via the same Scallop Research Set Aside program.

One day workshop

A one-day meeting with overviews of the Harmful Algal blooms (HABs) in the Gulf of Maine region, and summarizing results to date was conducted on 4 November 2005. There were approximately 50 people in attendance, with good representation from industry, state and federal public health administrators, and from the science community.

Identified Problem Areas

Several areas needing improvement were discovered during the course of this first year, including streamlining of sample collection, storage, and processing, timeliness of data plotting and dissemination to partnering test centers. These were for the most part normal startup level issues with procedures modified on the fly as the project progressed. Of more major concern is the lack of samples from the more northern portions of the Gulf of Maine, historically a significant part of the scallop fishery. However many of the areas where scallop were fished are currently off limits due to closures in the multispecies fishery.

Acknowledgements

This research was supported by funds generated by the scallop industry via the Scallop Research Set Aside program within the New England Fishery Management Council and administered by NOAA Fisheries, project 2004-SCA-008. This project would not have been possible without the initial interest and continuing participation of Captain Paul Rosonina, F/V Kathy Marie, for five years of sample collection before this project was begun.

Particular thanks is due the offshore Limited Access vessels include F/Vs Kayla Rose, Westport, Christian and Alexa, Guidance, Atlantic, Kathy and Jackie, Elizabeth and Niki, and Silver Sea, the General Category vessels who contributed greatly without compensation, including F/Vs Alison Lee, Three Graces, Betsy Gals II, Equinox, NoName, Beggar’s Banquet, Donna Marie, Pat Sea, Venture and many others. Workspace made available by New England Shellfin, Falmouth, and Bergies Seafood, New Bedford.

Special mention for extra effort goes to Catherine Tadema-Weilandt and Susan Olsen of NOAA Fisheries State and Federal Programs for making it all happen smoothly at that level.

SIDESCAN SONAR, MULTIBEAM BATHYMETRY AND ROV OBSERVATIONS: DEALING WITH CONCORDANT AND DISCORDANT SCALES

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ABSTRACT

Coupling geophysical observations with direct observations of the seafloor is nothing new. Scientists have been using these tools in tandem for years for fisheries management, marine archeology, geological investigations and marine resource management. With the advent of greater resolution geophysical equipment, high-power submersible lights and high-definition video, objects on the seafloor and seafloor geology are much easier to resolve.

We will discuss two projects where geophysical observations were coupled with direct observations to conduct essential fish habitat mapping for lobsters and deep-water coral. Project 1, essential habitat of the American lobster (*Homarus americanus*), coupled sidescan sonar and ROV observations on a nearly concordant scale. Conversely, Project 2, the biology, ecology, habitat and speciation of deep-water corals, coupled multibeam bathymetry and ROV observations on discordant scales.

Project 1, lobster habitat, (sponsored by NURC; PI's: Wahle, Belknap, and Hovel) was conducted in shallow (<50 m) water. The goal of this project was to investigate the potential movement of lobsters between areas with varying surficial geology. It was imperative for us to be able to delineate and subsequently observe boundaries between coarse (gravel) and fine (mud/sand) seafloors. The geophysical tool of choice was an EdgeTech DF 1000 dual frequency sidescan sonar. Direct observations were conducted with the NURC *ROV Hela*. Both systems were deployed from the *RV Connecticut*. The study selected approximately 30 nm of geophysical survey orientated along a set depth contour. Three dive sites were selected during geophysical data acquisition. Sidescan imagery of the site were post-processed during transit to dive site locations. The geo-referenced, post-processed imagery were used as a "map" in Winfrog to locate the ROV with respect to surficial geology. The post-processed sidescan imagery was accurate to approximately 2 m, and could resolve individual boulders less than 1 m in diameter with pixel sizes of 10 cm.

Project 2, deep-water corals, (multiple projects sponsored by NOAA Ocean Explorer & NURC; PI's Watling, Auster, France and others) was conducted in deep (>1500 m) water. The goal of this project was to assess the biology, ecology, habitat and speciation of deep-water corals and associated invertebrates and fishes on a transect of seamounts from the Corner Rise Seamount Complex along the New England Seamount Chain to the canyons on the northern US continental slope. The geophysical tool of choice was the hull-mounted SeaBeam 2120 system of the *NOAA Ship Ronald H Brown*. Direct seafloor observations were made with the tandem *ROV Hercules* and *Argus* system. The project mapped individual seamounts in detail based on locations from other reconnaissance surveys or satellite altimetry to select dive sites. Specific attention was paid to ensure 100% ensonification of areas shallower than 3000 m. The multibeam imagery was post-processed and the geo-referenced imagery imported into HyPack as a map for ROV navigation. This imagery, at 200 m of water depth, had pixel sizes that ranged from 25 to ~75 m, depending on the proximity to the center beam. A typical ROV dive covered between 1 and 1.75 km or between 40 and 70 25-m pixels.

The shallow water, sidescan imagery used for the lobster project was concordant with the scale of video imagery produced by the direct ROV observations. Individual boulders, small topographic changes and detailed seafloor surficial geology could be determined that related well to the scale of the sidescan and video imagery. This allowed for easy dive site location selection, ROV navigation over targeted topography and seafloor geology as well as extrapolation to areas imaged with sidescan sonar but not directly observed with the ROV.

The geophysical imagery collected during the deep-water coral project was discordant with the scale of video imagery. The deep water and large pixel size of the multibeam bathymetry provided a large-scale landscape overview of the topography, while the lights of the ROV rarely illuminated more than a portion of a single pixel at any time. Based on the observations and scale discordance, it was difficult to correlate the geophysical data with different habitats.

The two projects show geophysical imagery that is concordant and discordant with the scale of ROV observation. During planning of geophysical surveys for habitat delineation, it is imperative to consider the resolution of the geophysical data and not over interpret the resolution and create data out of noise by stretching the resolution beyond the physical limitations of the system employed. There is generally a trade off between resolution, coverage, available survey time and other project limitations. All factors must be considered during the early planning phases of each project to ensure adequate geophysical data at the desired scale. Even in very deep water, systems exist to collect high-resolution imagery that are concordant with the scale of ROV video observations. An example of such a system includes the Autonomous Benthic Explorer (ABE), which is outfitted with an EM 3000 multibeam system and can operate within meters to 10's of meters above the seafloor.

HABITAT CHARACTERIZATION AND MAPPING IN SUPPORT OF ECOSYSTEMS-BASED FISHERIES MANAGEMENT FOR CHESAPEAKE BAY

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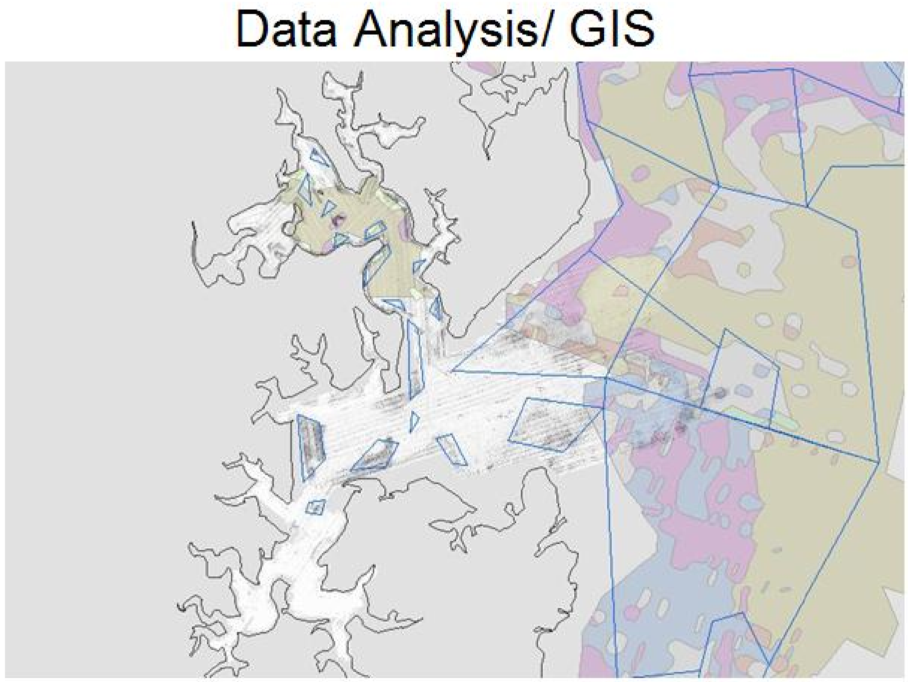
ABSTRACT

The Chesapeake Bay and its tributaries comprise a biodiverse ecosystem sustaining more than 3,600 species of plants and animals. Among them are 348 species of finfish and 173 species of shellfish, which have for centuries supported major fisheries and a rich aquatic heritage. Shallow (<20m) marine benthic habitat provides essential ecological support for key biota within the Chesapeake Bay ecosystem. Integrating acoustic mapping technologies with direct sampling techniques allows the construction of high-resolution spatial and temporal data sets of the bay bottom. Analysis of the image-rich database aids the understanding of complex ecosystems and supports biogeographic assessment of multiple fisheries in Chesapeake Bay. The NOAA Chesapeake Bay Office Habitat Characterization and Mapping Program is focused on identifying the framework of surficial sediments, bay floor rugosity, sub-bottom structure, and other bathymetric trends that make up habitats integral to the Bay's food web.

Two small vessels (13 & 8m) have been configured to acquire bathymetry, side scan sonar, acoustic seafloor class data, and sub-seafloor, stratigraphic, information. Acoustic classifications are derived from this imagery and then verified with video, profiling cameras, divers, and sediment sampling. The combined acoustic and physical data are organized into a growing GIS-based framework that defines the extent and character of multiple bottom types and defines the transition between them.

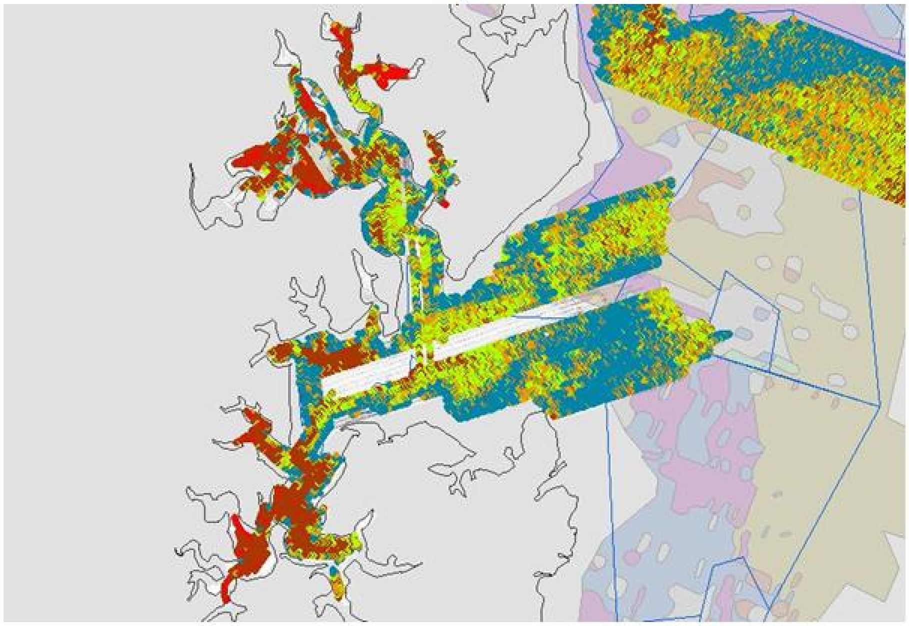
Habitat characterization provides the baseline for stratifying the ecosystems by habitat type and a foundation for the design of intensive random sampling of water quality, plankton, benthic, and fish community structure. Analysts will use the robust, cross-referenced, GIS data layers to define criteria for fisheries habitat evaluation and generate large-scale integrated assessments at the sub-watershed level. By ascertaining species affinities for specific habitats, resource managers will be better able to make informed decisions that will enhance the Bay's ecosystem by providing input into ecosystem-based fisheries management models. For example, it may be used to identify benthic areas with the highest probability for successful restoration of Submerged Aquatic Vegetation or investigate the 3-D structure and optimum hydrodynamic

conditions that would advance oyster reef restoration techniques. Other, value added, products created through this program include; formal and informal educational modules, the location of shell resources that may aid oyster reef construction success, further understanding of the geologic history of the bay, revealing submerged cultural resources, and support of a pilot project that involves the mapping and cataloguing of marine debris, including derelict fishing gear that is ghost fishing and littering the Bay floor.



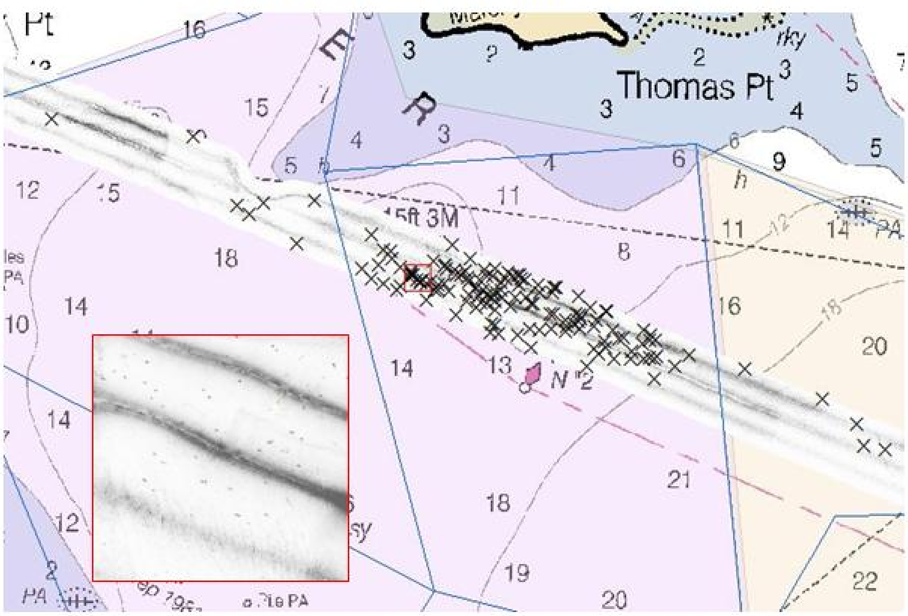
Side scan sonar imagery referenced to a historic (30 year old) acoustic interpolation of bay bottom classes. The blue polylines represent historic (100 year old) oyster habitat.

Data Analysis/ GIS



The next step in characterizing bay bottom habitat is to integrate higher resolution acoustic seafloor point data to the side scan imagery for interpolation through a spatial analyst.

Pilot Studies- Marine Debris



Positions of suspected derelict fishing gear are shown above with the inset providing the details from side scan sonar imagery.

Survey Vessels

R/V Bay Commitment

- •41' UTB is the perfect CB runabout for all weather and all types of sampling

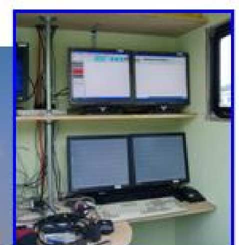
R/V In Situ

- •27' Whaler redesigned for Shallow-water surveying in calm conditions
- •Trailerable

Science, Service, & Stewardship NOAA Chesapeake Bay Office

Survey Equipment

- •DGPS Positioning- MX-Marine
- •Side Scan Sonar- Edgetech DF1000
- •Seabed Classification- QTC View 5
- •Echosounder- Knudsen 320BP w/ KEL771 Dual Frequency Transducer
- •Sub-bottom Profiler- Edgetech SB216
- •Sound Velocity Probe- Odom Digibar Pro
- •Hypack and Chesapeake Technology acquisition software



Science, Service, & Stewardship NOAA Chesapeake Bay Office

NEW MULTIBEAM MAPPING IN THE GULF OF MAINE

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ABSTRACT

In the spring and summer of 2005, the National Oceanic and Atmospheric Administration (NOAA) funded a multibeam survey of portions of the Gulf of Maine in support of the Gulf of Maine Mapping Initiative. The project was managed by the NOAA/University of New Hampshire (UNH) Joint Hydrographic Center (JHC) and UNH Center for Coastal and Ocean Mapping (CCOM). The multibeam data were acquired by SAIC of Newport, Rhode Island operating under contract to NOAA. We present here preliminary images created from excerpts of the data set, and describe plans for advanced data processing and seafloor mapping product creation.

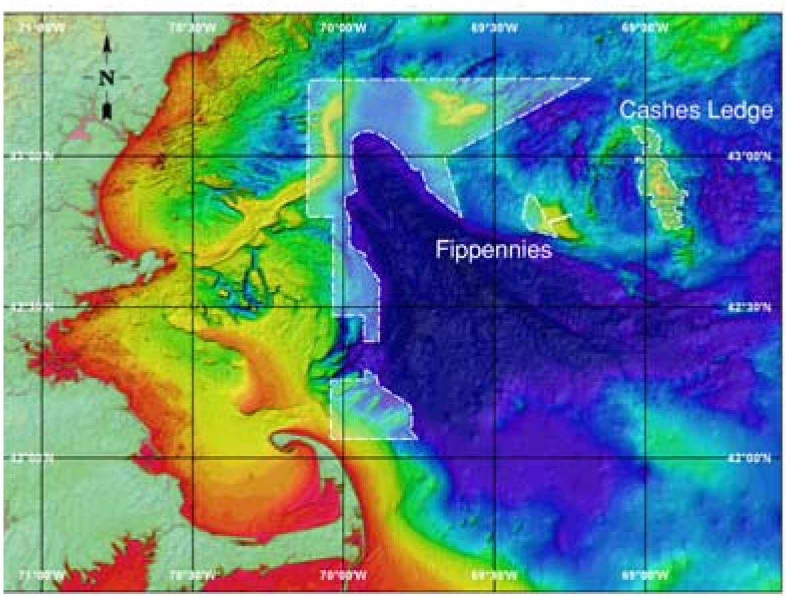

Figure 1. Shaded area delineates recent Gulf of Maine survey area

This Gulf of Maine seafloor project was conducted on a vessel-time-available basis using a survey vessel already mobilized for NOAA surveys in support of nautical charting. This significantly reduced the cost for this project, but required that the survey area be selected considering the capabilities of the mobilized vessel. The survey limits for this project were defined based on the efficient range capabilities of the installed Reson 8101 multibeam, generally restricting the survey to areas inside the 200 m depth contour. A portion of Wildcat Knoll was left undone in anticipation that this area would be surveyed by the *NOAA Ship Thomas Jefferson.* The completed survey area is shown in Figure 1.

The Reson 8101 multibeam sonar was installed on the *M/V Atlantic Surveyor* (length 33.5 m, beam 7.9 m, draft 2.7 m) and operated by SAIC. A complete listing of the survey system is provided in Table 1. Data acquisition was controlled by SAIC's Integrated Survey System (ISS 2000). Survey line planning, data processing, and preliminary analysis were performed using SAIC's SABER software (SAIC, 2005).

System	Manufacturer/Model Number	Subsystem
Multibeam Sonar	RESON SeaBat 8101	Transducer
		8101 Processor
Vessel Attitude	TSS POS/MV Inertial Navigation System	
Positioning	TSS POS/MV	
	Trimble 7400 GPS Receiver	
	Trimble ProBeacon Differential Beacon Receiver	
Sound Speed Profiling	Brooke Ocean Technology Ltd. Moving Vessel Profiler-30	Applied Microsystems, Ltd. Smart SV and Pressure Sensor

Table 1. Acquisition systems for Gulf of Maine survey

Seafloor mapping on this project was conducted with strict attention to accuracy and quality for both bathymetry and backscatter. Corrections for static and dynamic draft, heave, vessel attitude, sound speed profile, and tide were applied, as were bias corrections for timing, roll, pitch, and yaw. Cross swaths were obtained and compared to main scheme swaths. While not conducted nor intended specifically for charting purposes, the results of this survey are generally consistent with International Hydrographic Organization (IHO) Order 1 standards as described in IHO Special Publication 44, 4th edition, 1998. Additional data processing and quality assurance at JHC/CCOM will establish the degree to which these surveys can be applied to nautical charts.

As these surveys are intended to support fisheries and habitat applications, survey operations were tailored to that end. Changes to gain and power settings were minimized

and tracked carefully to allow post-survey backscatter processing. This advanced processing will be done at JHC/CCOM using the Geocoder software package. (Fonseca and Calder, 2005). In Geocoder, the raw backscatter data acquired during the survey will be corrected for radiometric and geometric distortions, including among others, power and gain levels, water column attenuation, bottom bathymetry, and sonar angle of incidence.

Bathymetry and backscatter from Cashes Ledge are shown in Figures 2a. and 2b. The bathymetry is depicted in a color-mapped shaded digital terrain model and the backscatter before Geocoder processing is shown in a mosaic draped over the bathymetry.

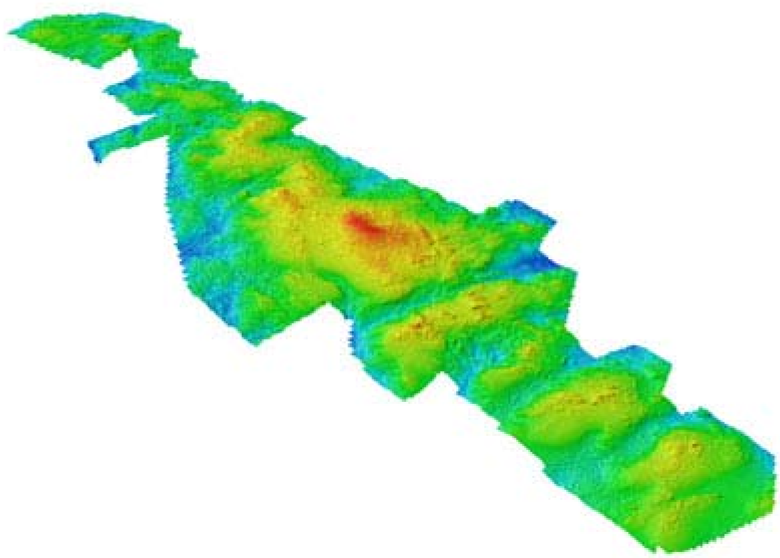

Figure 2a. Cashes Ledge bathymetry

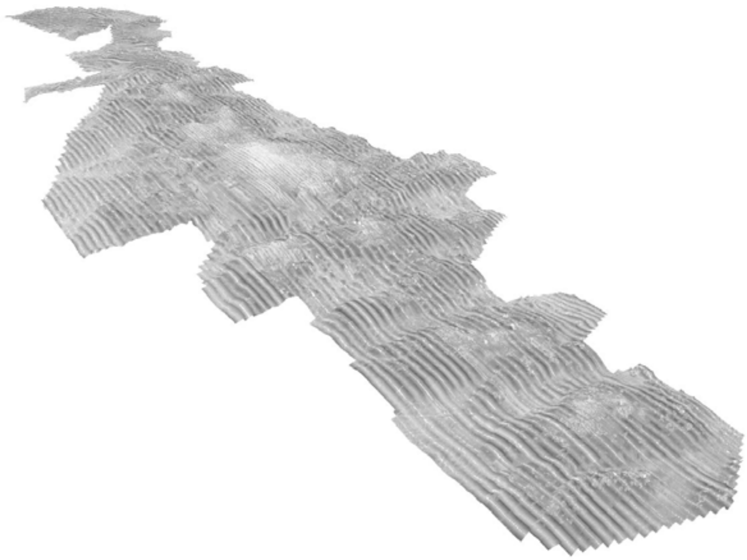

Figure 2b. Preliminary Cashes Ledge backscatter mosaic (before Geocoder processing)

These new, high resolution bathymetric and backscatter data sets will be available on the JHC/CCOM website once final processing is complete. Following data processing, JHC/CCOM will begin to use these data sets in the development of a suite of new prototype seafloor mapping techniques and products for both resource management and nautical charting. Among the new technologies being explored are approaches to remote determination of seafloor character and segmentation of the seafloor into meaningful habitat maps. In this regard, the Center hopes to work with fisheries experts and other marine biologists in the correlation of measurable physical seafloor characteristics with supportable habitat definitions.

(Note: additional views of important regions in the survey project, and examples of fully processed backscatter mosaics will be included on the poster.)

References

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Science Applications International Corporation, “Gulf of Maine Mapping Initiative Priority 1 Area Survey Report” (Prepared for National Oceanic and Atmospheric Administration), November 18, 2005.

BayMap: MAPPING THE GEOLOGICAL, BIOLOGICAL AND ARCHAEOLOGICAL RESOURCES OF NARRAGANSETT BAY, RHODE ISLAND

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ABSTRACT

Narragansett Bay and the south-shore coastal lagoons in Rhode Island lack a comprehensive inventory of their geology, habitats, biological communities, and archeology. For the last two years, the Rhode Island Sea Grant funded BayMap project has been underway, addressing these needs. The research is based on methods of seafloor imagery that integrate multibeam and sidescan sonar imagery with other surveys (e.g., underwater video, sediment profile camera images) and sampling methods (for ground-truthing biological communities and sediment types) to produce a comprehensive, three-dimensional image of seafloor habitat, contamination sites, and other human-derived disturbances (e.g., fish trawls, dredge sites, and wrecks).

Details

In addition to mapping, we are formulating testable hypotheses about temporal changes in habitat types and biota. We are actively testing the following hypotheses:

1. Acoustic signatures of underwater habitats are distinctly different, and can be used to differentiate between seagrass, algae, shellfish, and other habitats.
2. Disturbance (dredging/fishing gear) creates an opportunity for recolonization and increased biodiversity on a broad scale.
3. Differences in biological community can be predicted by depth, slope, and sediment type.
4. Availability of Essential Fish Habitat (such as submerged aquatic vegetation) is an effective indicator for declining or improving benthic habitat conditions.
5. Changes in land use have measurable effects on benthic marine resources.

The first two years of BayMap have produced sidescan sonar maps of Ninigret and Quonochontaug Ponds (coastal lagoons on the south-shore of RI), Greenwich Bay, the Providence and Seekonk Rivers, 75% of coastal Jamestown, and other smaller-scale surveys (Figure 1). Habitat maps have been completed for both Ninigret and Quonochontaug (Figures 2, 3), while ground-truthing is continuing at the other sites (Figure 4).

The goals for BayMap in 2006 include mapping the most dense eelgrass beds in Narragansett Bay, surrounding Prudence Island and Jamestown. Eelgrass beds (*Zostera marina*) in Narragansett Bay are known to serve as nursery grounds for many

commercially important species, such as winter flounder (*Pseudopleuronectes americanus*). Eelgrass maps produced by this project will be utilized by several organizations for ongoing research, such as USDA Natural Resource Conservation Service, Save the Bay, and RI Department of Environmental Management.

Most recently, BayMap has been conducting research with local mussel fishermen to map mussel beds (*Mytilus edulis*, *Geukensia demissa*), determine the extent of pea crab (*Pinnixia* sp.) infestation, and study the mussel-pea crab association in Narragansett Bay (figure 5). This work is aimed at developing a viable bottom aquaculture industry for *Mytilus edulis*.

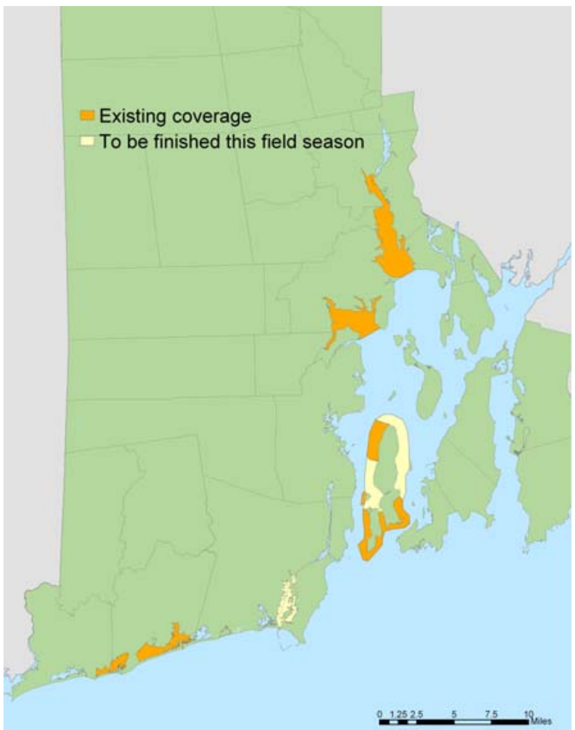


Figure 1

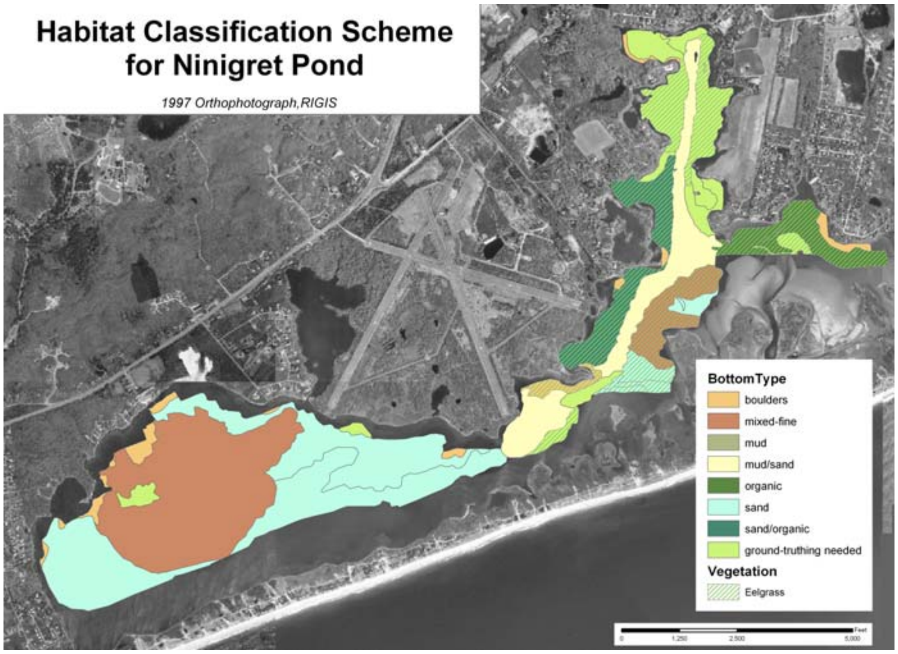


Figure 2

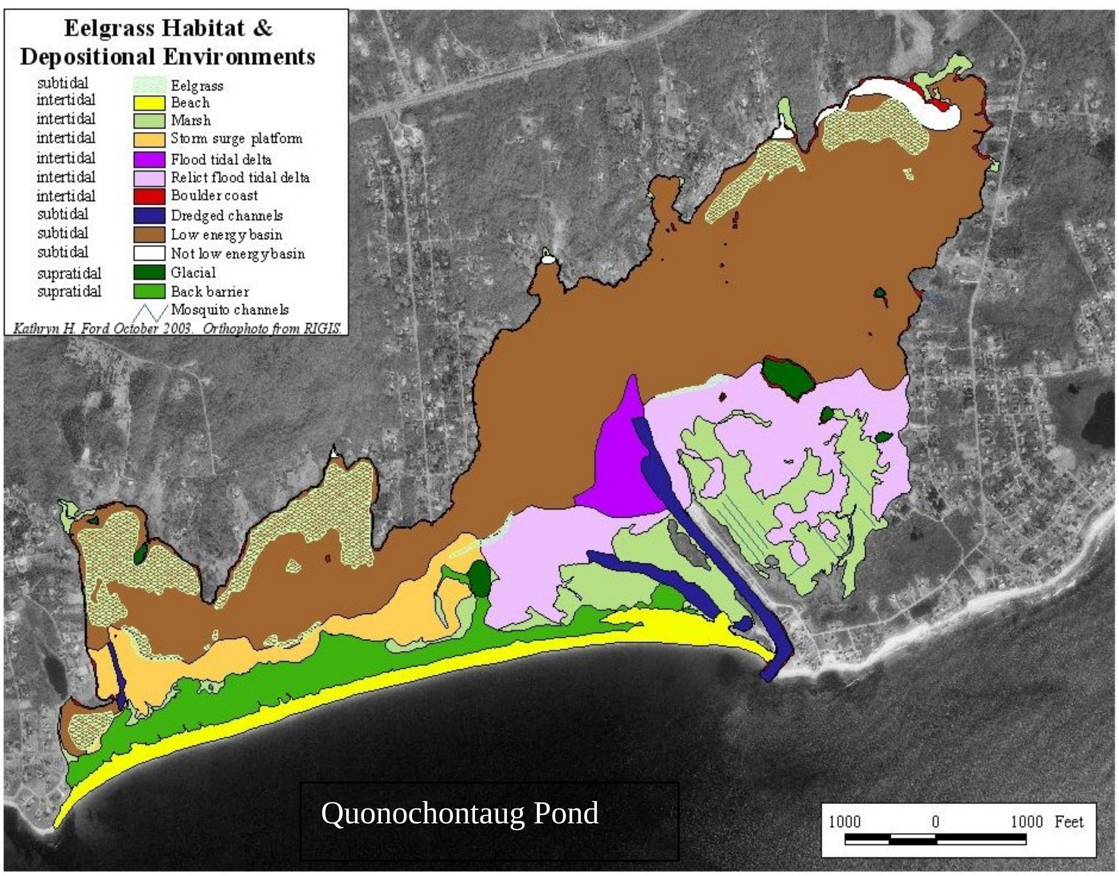
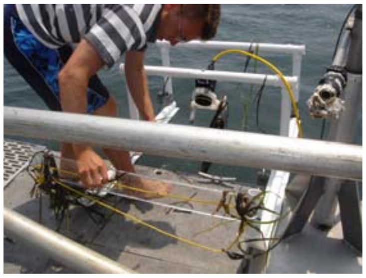
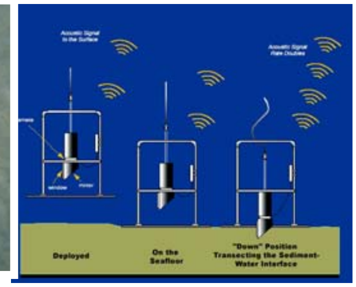


Figure 3



Underwater video

Grab samples



Sediment profile imagery

Figure 4

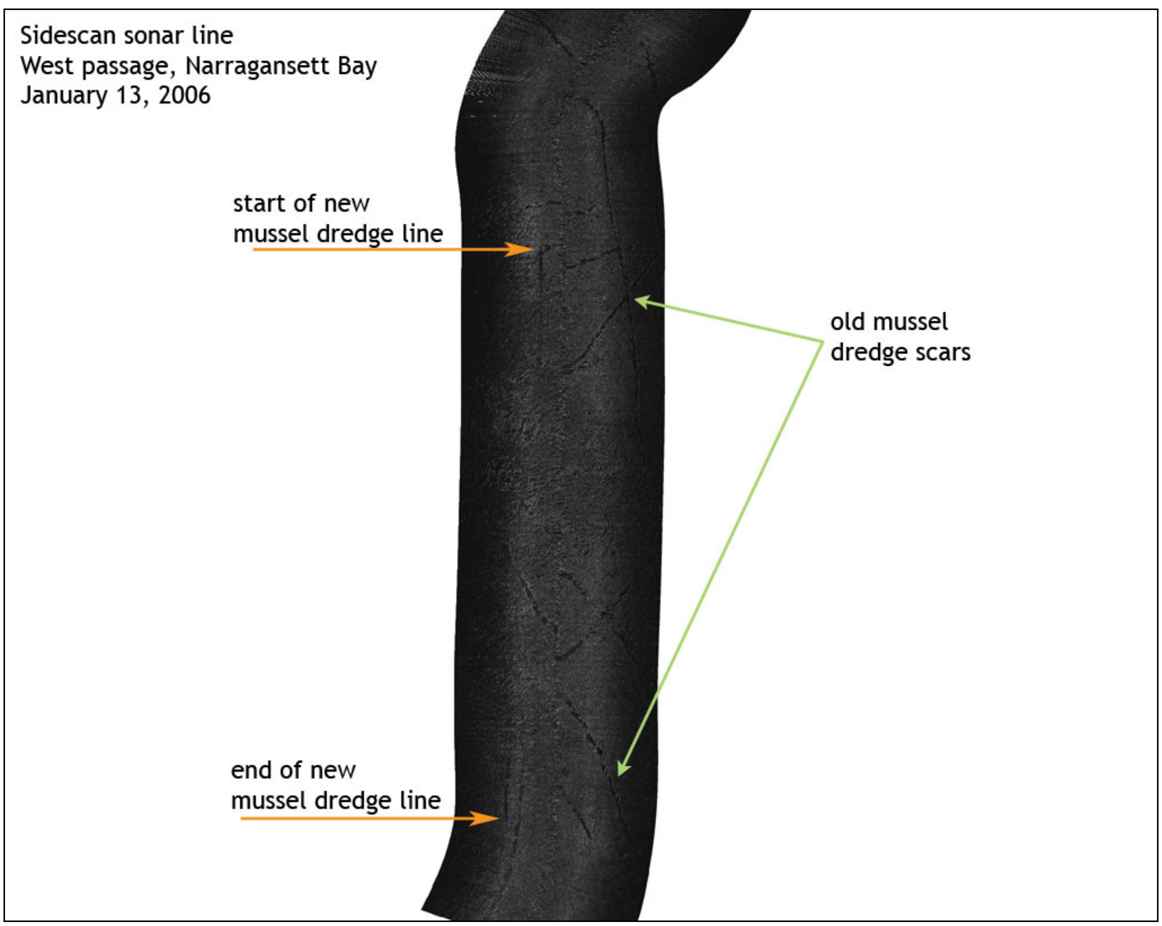


Figure 5

ATLANTIC COD AND AMERICAN PLAICE CATCH IN THE WINTER HADDOCK FISHERY OF GEORGES BANK

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ABSTRACT

Marine species of fish do not live isolated in a vacuum. Different species feed upon each other and compete for food and space. This phenomenon is called biological interactions which, together with the fact that an ideal net of 100% selectivity is a utopian assumption, will always lead to a mix of species in the catch and net, respectively. Thus, biological interactions produce technological interactions and hence create the issues of bycatch and discarding – even if the fishery targets just one species such as haddock on Georges Bank.

These two issues are the major reasons why the School for Marine Science and Technology (SMAST - University of Massachusetts, Dartmouth) began a co-operative industry based fishery research program with the New Bedford fishing fleet in November 2000. Since its inception the program has completed two years of field observations with catch and discard data collected during normal fishing operations. A total of 5,986 trawl tows from 169 fishing trips, primarily on the northern flank of Georges Bank, were reported from November 2000 through October 2001 and continuing from August 2002 through July 2003. Fishermen recorded the target species for each tow. Haddock were the target species in 597 tows and averaged 767 lbs/tow. On the tows targeting haddock, Atlantic cod and American plaice were a component of the catch averaging 113 lbs/tow and 17 lbs/tow, respectively. The peak by-catch of Atlantic cod occurred in March (250 lbs/tow), coinciding with the highest haddock catches in March and April.

Most of the haddock targeted tows (344 out of the 597) occurred in the winter fishery (January - March) located north and west of Closed Area I with an average catch of Atlantic cod of 120 lbs/tow during this time. Similar to patterns for the entire Georges Bank, by-catch of cod was greatest in March, when haddock catches peaked. The catch of American plaice in tows targeting haddock was negligible during the winter fishery, averaging only 12 lbs/tow. The area northeast of the Closed Area I had the highest average catch of American plaice but was still less than 45 lbs/tow. This data suggests that fishermen can successfully target haddock and realize low catches of Atlantic cod and American plaice, especially considering that during normal fishing operations fishermen were not trying to reduce catches of cod or plaice. However, it should be pointed out that these findings reflect specific results in space and time.

STATIC DISPLAY OF DYNAMIC OCEAN CIRCULATION

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ABSTRACT

The Nature Conservancy is mapping pelagic circulation to find the distribution of elements of biodiversity, or threats like pollution borne in river plumes. Predicting where these features overlap helps prioritize our conservation work.

Circulation data from the University of Miami's Hybrid Coordinate Ocean Model (HYCOM), delivered as cell-assigned eastward and northward velocity, are used as the legs of a right triangle to calculate the hypotenuse distance as flow in cm/second. An input raster is sampled at each arc's fixed end, and its value transferred to the arc's free end. These output points are interpolated into a new surface representing the concentration of the variable to be measured after each unit of time.

Dynamic systems like ocean circulation are difficult to portray in static media. Effective presentation has relied on the subtle use of color and symbols to maximize the flat map. Adding a third dimension using multiple sheets produces a time series flip-book, a portable communication tool with no batteries.

MOVING FROM TRADITIONAL FISHERIES MANAGEMENT TO SPATIALLY-EXPLICIT, HABITAT-BASED FISHERIES MANAGEMENT: A CASE STUDY FROM THE ESSENTIAL FISH HABITAT PROCESS ON THE WEST COAST

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ABSTRACT

The Essential Fish Habitat (EFH) amendment to the Magnuson Stevens Fishery Conservation and Management Act (MSA) has provided regional fishery management councils with an opportunity to explicitly incorporate fish habitat requirements into the management process. Although the importance of habitat for healthy fish stocks was acknowledged prior to the 1996 EFH amendment to the MSA, there was no mandate to consider habitat function for the wide variety of species (e.g., over 80 species in the West Coast groundfish fishery management plan (FMP)) over the range of their distribution within U.S. waters. Due to its relative newness, consideration of fish habitat and ecosystem requirements within the fishery management process presents many technical and policy challenges. Many of these challenges are caused by the lack of existing infrastructure to support spatially-explicit, habitat-based fishery management.

The foundation of traditional fishery management is single-species stock assessment, whereby catch, abundance, and life-history data are interpreted through population dynamics modeling. The results of these stock assessments flow into an established management process to set allowable harvest quotas:

Data -> Stock Assessment -> Harvest Policy

In contrast to habitat-based assessment, statistical methodologies for the assessment of fish stocks have been in place since the 1940's (Ricker 1975). Much infrastructure, such as data collection programs and scientific methods, has been developed to provide focused and specific input to the traditional stock-assessment model and support the decision framework via a policy/science feedback loop.

Because of its maturity and acceptance within the fisheries management community, the traditional stock assessment model provides a good starting point and conceptual framework for EFH or ecosystem management. For the West Coast EFH process, we developed a decision framework that is similar to the stock assessment process and consists of three distinct but interconnected components:

Data Consolidation -> Data Synthesis & Modeling -> Policy & Spatial Management Measures

Unlike traditional stock assessment, habitat-based management is inherently spatial. Therefore, incorporation of Geographic Information Systems (GIS) data and spatial analyses is essential to its success. To designate EFH for West Coast groundfish, we developed a Bayesian Network model, (the EFH model), integrated with GIS input and output, to characterize the probability that particular habitats are suitable for groundfish species. Our approach uses habitat suitability modeling based on presence/absence and habitat associations of groundfish to provide a quantitative framework for decision making. The GIS output of the EFH model is depicted as a contour map of Habitat Suitability Probability (HSP), which indicates the likelihood of each habitat being suitable for a particular groundfish species and lifestage.

GIS also provided a context and framework for public participation in the West Coast EFH process. Due to the complexity of modeling habitat associations of more than 80 groundfish species and their lifestages within the 80 million hectares of the West Coast Exclusive Economic Zone (EEZ), we incorporated data and technical reviews from a large number of collaborators. The mapped outputs from the EFH model, as well as other components of the EFH process, were reviewed and validated by a technical committee that included fishery scientists and fishermen.

All phases of the EFH process (data consolidation, data synthesis and modeling, and policy) incorporated technical review. This transparent process encouraged scientific and constituent participation and support for the final outcome. The data consolidation component resulted in an accurate and precise description of data gaps. Acknowledging what we do not know, as well as what we do know, is important for scientific credibility.

For the U.S. West Coast, habitat data have been applied in a geographically comprehensive assessment that was tailored specifically to support management decisions. The assessment was designed to be "user-friendly", thereby influencing the design of the model and output. The spatially-explicit probability profiles of habitat suitability that have resulted from this assessment have been used by managers to identify EFH. Just as important however, we

now have experience on the West Coast in organizing ecosystem data specifically for management decisions, the results of which can feed back into tailored data collection programs.

At the scale of the West Coast EEZ, it is perhaps surprising to realize how little we know about habitat and its function for fishes and the ecosystem. While a coastwide assessment of probable habitat suitability for groundfish is an impressive achievement, it is informative primarily at the most basic level. That is, it provides managers and researchers with the likely locations of suitable habitat, but does not predict the results of policy decisions in terms of fishery or ecosystem response. This limitation in knowledge results in our use of precautionary management principles to regulate human activities when we do not fully understand both the risk of non-action and the effects of the regulations.

Researchers who will be implementing future habitat-related data collection programs can benefit from feedback provided by managers. Habitat data can be expensive to collect, particularly in deep offshore environments where ship time and sophisticated instrumentation are necessary. To justify such expenditures, it is useful to think of traditional stock assessments and their supporting data programs as a model that is compatible with and exportable to EFH and ecosystem management. In stock assessment processes, data collection programs have been developed specifically to function in the assessment and policy process. The developing discipline of habitat studies can now take advantage of a similar approach, whereby data collection is cast in terms of EFH assessment and habitat- and ecosystem-based management.

References

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DEVELOPING A GIS-BASED DECISION SUPPORT TOOL FROM AN ATLAS OF HUMAN ACTIVITIES FOR THE SCOTIAN SHELF

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ABSTRACT

Background

Integrated ocean management is one of the cornerstones of Canada's Ocean Act, which came into effect in 1997. The position of the government of Canada is that ocean management must be a collaborative effort among stakeholders. The Oceans Management Strategy aims to develop and implement an integrated management framework nationally (Oceans Directorate, 2002). Announced in December 1998, the Eastern Scotian Shelf Integrated Management (ESSIM) project is one of the first integrated management initiatives in Canada.

The eastern Scotian Shelf was selected as a pilot project because of the important marine resources, multiple human use activities with potential user conflicts, high biological diversity and productivity and areas of sensitive marine habitat (including one of only five designated marine protected areas currently in Canada).

An Atlas in Support of Ocean Management

A key component of the ESSIM Plan is dedicated to management strategies divided into three categories: 1) multiple human use; 2) marine ecosystem management and conservation, and; 3) collaborative planning and management coordination (Oceans and Coastal Management Division, 2005a). Developing each of these strategies requires effective communication of the spatial and temporal patterns of human activities, management/jurisdictional boundaries, in addition to ecological and biological characteristics. To that end, the ESSIM Planning Office (Fisheries and Oceans Canada) has developed an atlas of human activities (Figure 1) for the Maritimes Region (Scotian Shelf, slope, Georges Bank and Bay of Fundy areas) entitled: *The Scotian Shelf: An Atlas of Human Activities* (Oceans and Coastal Management Division, 2005b).

Since the development of geographic information systems Fisheries and Oceans Canada (DFO) and many other ocean sector agencies have collected and/or developed spatial data relating to the Scotian Shelf. Often these data were at different scales, different map projections, not digitally available and represented various incongruent time periods.

The atlas represents the development and compilation of 54 maps to describe a wide variety of human activities for the five year time period from 1999-2003. Fishing related activities are a major source of direct and indirect income in the region and therefore 25 of the maps in the atlas examine fishing related activities. The remainder of the maps illustrate coast guard and military activities, offshore oil and gas exploration

and development, shipping, research and monitoring, tourism, pollution incidents, marine environmental quality and political/jurisdictional boundaries. The result is a reasonably current and complete picture of human use on the Scotian Shelf that can be used by stakeholders and ESSIM planners.

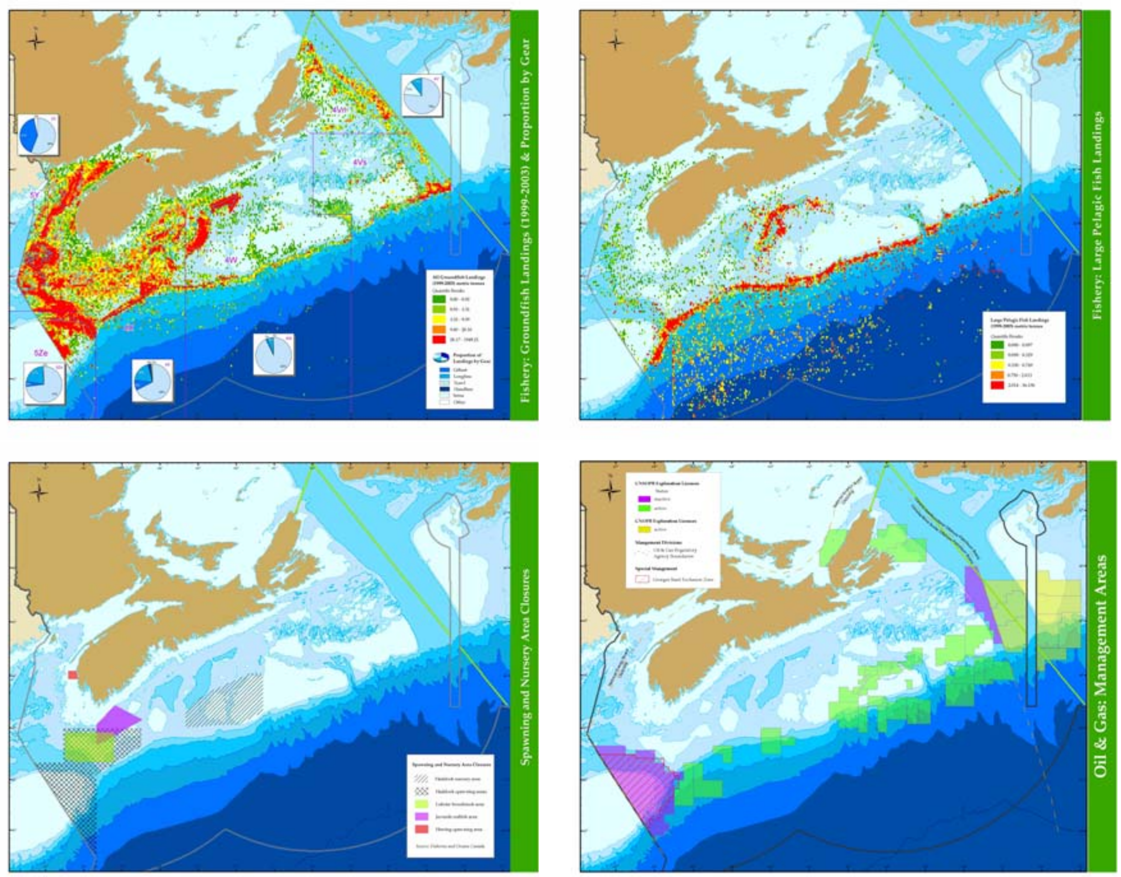

Figure 1. Examples of maps in *The Scotian Shelf: An Atlas of Human Activities*

The atlas is available both in print and via a public web map service (in progress) in either web map service (WMS) or web feature service (WFS) format, depending on the data.

A GIS-Based Decision Support Tool

Beyond the atlas, data collected for its creation are being used to develop planning tools to assist decision makers in ocean management. Ocean management requires relevant information for multiple use management and conservation planning in support of use-use conflict avoidance and problem solving, interaction between human use and ecosystem elements, and the evaluation of sensitivity of ecosystem elements to human activities and the levels of impact.

A prototype GIS-based decision support tool has been developed in a geodatabase with Environmental Systems Research Institute's (ESRI) ArcGIS software. The geodatabase allows users to quickly access the spatial and attribute information available about human uses and ecological/biological areas for any area in the region (Figure 2).

The prototype is based on a two-minute grid cell aggregation of spatial information. Each grid cell is uniquely identified. The cells are represented as polygons across the area of interest. All other spatial information (human uses, ecological features, etc) is spatially overlaid with the grid cell layer and summarized by the grid cell identification number using either zonal statistics or intersection operations. Any resulting spatial dataset is discarded but the attribute information is preserved and linked to the primary key in the grid cell layer. This eliminates data redundancy and results in much smaller map document files, which has the benefit of saving disk space and speeding access to the information. Additionally, each activity or feature table has a common field that contain an identification value for the source information. This field is linked in the relational database to a table that contains information about the source of information (i.e. original file name, contact information, date acquired, time period the information describes, etc.). Using this field, it is possible to quickly determine the source of information and revisit the original data layer(s) for further detail or fine-scale analysis, if necessary. Another benefit of structuring this information in a geodatabase is that users without GIS software can query the information using Microsoft's Access software.

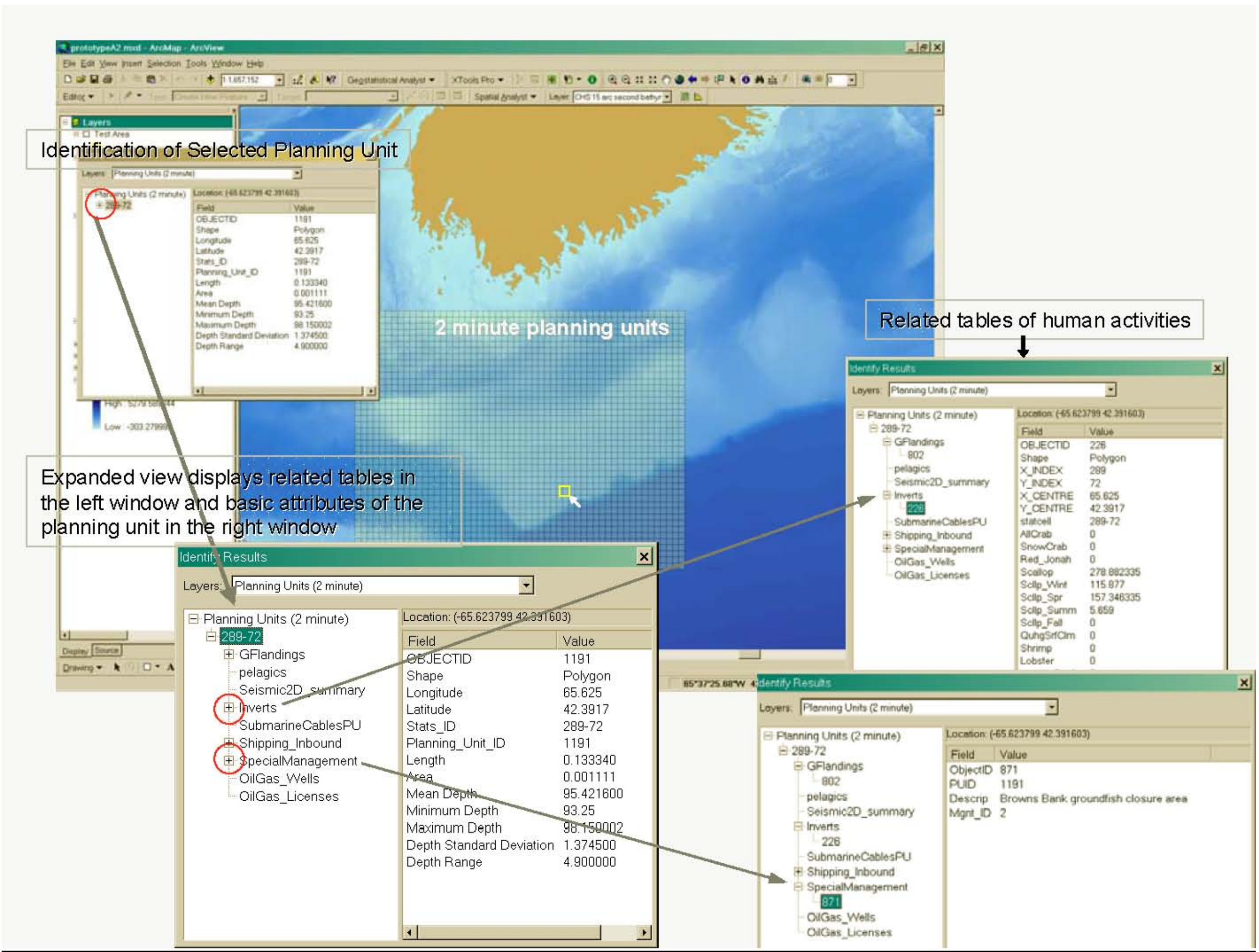

Figure 2. This screen shot illustrates one of the many ways a user can access information with the prototype geodatabase.

Next Steps

DFO plans to continue the development of a GIS-based decision support tool for integrated management of the ocean by incorporating more data on biological and ecological features as they become available. Future plans include: developing a similar database for coastal and inland waters; making modifications based on user feedback; investigating methods to make a similar tool available to stakeholders and the public, and; developing predefined queries on the database to facilitate the execution of repetitive tasks by ocean managers.

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BENTHIC HABITAT MAPPING AT MASS DMF: FOCUSING ON BETTER FISHERIES SCIENCE AND MANAGEMENT

Kathryn Ford

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ABSTRACT

This poster will introduce the Benthic Mapping Group at the Massachusetts Division of Marine Fisheries (*MarineFisheries*). It will cover partnerships that *MarineFisheries* has developed with Coastal Zone Management and the University of Massachusetts to further habitat mapping efforts in state waters. It will also define specific mapping products available from *MarineFisheries* and delineate our specific mapping needs.

Congress mandated the identification of habitats essential to managed species and measures to conserve and enhance this habitat. Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (Magnuson-Stevens 1996). Toward the end of bettering the definition of EFH, the Massachusetts Division of Marine Fisheries (*MarineFisheries*) has put significant focus on the development of fisheries habitat-related investigations. Among these investigations include several projects that either specifically focus on benthic mapping or require as a component an assessment of benthic habitat. As the benthic habitat and mapping needs of the division have grown, the Benthic Habitat Mapping Group was formed. The specific objectives of this group include 1) to address habitat mapping needs of the division, 2) to develop and encourage linkages between state, federal, academic, and industry partners, and 3) to provide educational opportunities at SMAST through the Marine Fisheries Institute. This poster will address the first two objectives of the group, and describe key datasets and infrastructure available to other agencies and research groups as well as cooperative research with other organizations.

Application to fishery research and management:

The work described has very clear and direct relevance to fisheries management. Included among the many responsibilities of *Marine Fisheries* is the obligation to enact fisheries management strategies affecting the marine fisheries of the Commonwealth of Massachusetts. In order to meet these responsibilities, *MarineFisheries* conducts research to evaluate and improve the effectiveness of the management strategies. Many of the projects conducted by *MarineFisheries* scientists address the increasing need for better habitat-based research and management.

References:

Magnuson-Stevens Fishery Conservation and Management Act As amended through October 11, 1996 § 94-265 U.S.C. § Section 3, 104-297(10).

BENTHIC HABITAT MAPPING PROJECTS AT MASS DMF

Bruce Estrella, Bob Glenn, Julie Barber, Ross Kessler, Alison Leschen

Massachusetts Division of Marine Fisheries

ABSTRACT

There are three MarineFisheries research projects that incorporate benthic mapping in a significant way. The three described below will be presented on a single poster.

Ventless Lobster Traps

Fishery dependent trap sampling has long been used to characterize commercially important crustacean populations. However, CPUE estimates and trawl survey data can be biased and are potentially non-reflective of relative abundance. We have developed a random stratified ventless trap survey in order to effectively sample lobster relative abundance and to address the variables of depth, and substrate. We used ArcGIS 9.0 as a tool to stratify the survey by sediment type and bathymetry. The study area, Massachusetts Bay, was partitioned into 15 second latitude/longitude cells, each characterized by substrate and depth. The combinations of substrate and depth in the bay yielded a total of 11 strata types from which an equal number of sampling stations were randomly drawn. Each station was sampled bimonthly using a six pot trawl, alternating vented and ventless lobster traps. Preliminary data suggest that lobster size and abundance varies by sediment type and depth. These results justify the need for our stratification scheme, and demonstrate the importance of accounting for habitat in population surveys. For this reason we will be conducting a sediment verification survey at our sampling sites in 2006 in order enhance the resolution of the sediment data used to stratify the survey. This work will ensure that the resolution of our habitat description matches the spatial scale of our sampling design. This approach presents a mechanism to improve the manner in which we monitor lobster stocks in the Northeast.

Bottom Sediment Enhancement Program (Artificial Reef Program)

The installation of an artificial reef in Massachusetts Bay has been planned as part of a mitigation effort to enhance habitat for lobsters and finfish in an area adjacent to a recently established natural gas pipeline. A model was developed to select potential sites for a 2400 m^2 cobble/boulder reef using ArcGIS 9.0. We chose three parameters for use in our model: substrate, bathymetry, and proximity to the pipeline. These data layers were coded to represent prime, potential, and unsuitable areas for the artificial reef and multiplied together to create a single layer map. The results of this model allowed us to identify four prime locations for potential reef sites (0.12 km^2 total); within these areas we selected 24 sites near naturally occurring bedrock. Through the use of GIS, we were able to eliminate 80% of potential reef area prior to field assessments. Underwater transect surveys were then conducted to determine the stability of the substrate at each

site, as well as to classify and quantify the substrate at a smaller scale. Additional biological and physical data were collected including: larval supply, species abundance and diversity, current speed and direction, and sedimentation rate. These data allowed us to select a site with high larval recruitment potential and avoid placing the reef on pre-existing productive habitat. Upon the completion of our data collection, we conducted multiple analyses including species abundance and diversity indices and a site ranking analysis. Site 29 in Boston Harbor, located near Lovell and Calf Island, ranked higher than all other sites considered for the reef. Therefore, we have selected this site for the installation of the habitat enhancement project. Construction of the reef is scheduled for March 2006. Final reef design includes a control area with naturally occurring cobble/boulder habitat, a second control area with open plots in the area of the artificial reef, and the artificial reef.

Boston Harbor Eelgrass Restoration

MarineFisheries is conducting an eelgrass restoration effort in Boston Harbor as partial mitigation for assumed impacts to the environment from the construction of the "HubLine" natural gas pipeline across Massachusetts Bay during 2002-2003. In order to select suitable sites for transplanting eelgrass, the site selection analysis used by Short et al. (2002) was modified and adapted to a GIS model based on a grid of 100 m^2 cells. A review of available water quality databases for Boston Harbor was augmented by on-site monitoring of pertinent environmental parameters. Seven parameters were estimated at each cell: depth, exposure, historical SAV distribution, current SAV distribution, water quality, bioturbation, and sediment type. Parameters were assigned scores based on their suitability for eelgrass and each cell was color-coded to reflect the total, multiplicative scores. Because the index was multiplicative, any cell receiving a score of zero on any of the parameters was eliminated. The USGS sonar-generated sediment data layer (Knebel 1993) was originally used. However, our sediment groundtruth sampling revealed a number of areas that yielded unsuitable substrate despite an acceptable score. We therefore substituted information obtained through groundtruthing for the USGS sediment layer, which was not accurate enough in shallow water. An Atlantis underwater camera, Ponar grab samples, and core samples analyzed for grain size composition, TOC, and sulfides were used to refine the sediment layer scores in shallow areas. These scores were then incorporated into the model. Twelve test transplant sites were selected for 2005 based on their total score. Each site was planted using four weighted, wire mesh frames arranged in a square, each with 50 eelgrass shoots attached. Mid-scale test transplants were conducted later in the season at four of the twelve sites which yielded the best results. Three of these were then planted at a larger scale in late summer. Further test transplants and large-scale plantings will occur in 2006/7. The GIS model using a multiplicative index of relevant parameters proved an efficient method of focusing effort on potentially suitable benthic habitat for eelgrass restoration.

Application to fishery research and management:

The projects described have very clear and direct relevance to fisheries management. Included among the many responsibilities of *Marine Fisheries* is the obligation to enact fisheries management strategies affecting the marine fisheries of the Commonwealth of Massachusetts. In order to meet these responsibilities,

MarineFisheries conducts research to evaluate and improve the effectiveness of the management strategies. Many of the projects conducted by *MarineFisheries* scientists address the increasing need for better habitat-based research and management.

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GULF OF MAINE MAPPING INITIATIVE: A FRAMEWORK FOR REGIONAL FISHERIES RESEARCH AND MANAGEMENT

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ABSTRACT

The Gulf of Maine is one of the world's most dynamic, productive, and important ocean systems, often called "a sea within a sea." This ecosystem is facing a range of human uses including commercial and recreational fishing, whale watching, transportation, aquaculture, military operations, pipeline and cable construction, wind and wave energy production, offshore oil and gas development, and mining of sand and gravel. To pursue these activities and evaluate their effects on the environment requires information about seafloor topography, geology, and habitat.

The Gulf of Maine Mapping Initiative (GOMMI) is a United States-Canadian partnership of government and non-government organizations, which aims to conduct comprehensive seafloor imaging and mapping. GOMMI's goal is to produce four map products: seafloor topography and backscatter maps based on acoustic surveys, and surficial geology and benthic habitat maps that incorporate biological and geological groundtruth information. Our goal is to map the seafloor from the intertidal zone to the upper continental slope to provide a geospatial framework for managing the marine resources of this 63,778 square mile (165,185 square kilometer) region. GOMMI's intent is to mobilize the best technical approach to seafloor data acquisition and processing and to develop map products in a coordinated and efficient way. GOMMI will pursue an approach to mapping the Gulf of Maine that will:

- Address the interests of stakeholders
- Prioritize areas to be mapped based on the needs of stakeholders
- Operate using a multiyear strategy

- Include fieldwork to collect seafloor imagery and groundtruth information, data interpretation and management, and release of map products
- Encourage the collaboration of government agencies and academia for the planning and management of mapping activities under the administrative management of the Gulf of Maine Council on the Marine Environment (GOMC)
- Seek a stable annual source of funding over the life span of the project

The emergence of remote acoustic technologies coupled with groundtruthing (video and photographic imagery, geological and biological sampling) now allows researchers to survey large areas of the seafloor and produce high-resolution maps of seafloor topography, surficial geology, and habitats. These types of maps are currently available for only about 20% of the Gulf of Maine, but they have already proven to be valuable to the fisheries research and management. For example, they have been used to improve fishing efficiency of scalloping on Browns Bank, and to facilitate management decisions such as choosing sites for salmon aquaculture pens that will minimize build up of pollutants (Taylor, 2003). Maps of seafloor topography, surficial geology, and habitat will help implement ecosystem-based resource management in the Gulf of Maine.

Comprehensive seafloor mapping is an ambitious undertaking. GOMMI's mapping strategy is to simultaneously address the needs of coastal and offshore stakeholders by mapping prioritized areas of the coastal and offshore seafloor. GOMMI intends to request support from federal, state and provincial governments and the private sector to fund data acquisition and processing. For GOMMI to succeed, partnerships between government, academia, and the private sector; between researchers and managers; and between state/provincial and federal governments are essential.

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INTEGRATING GIS AND QUALITATIVE RESEARCH METHODS TO MAP FISHING COMMUNITIES AT SEA

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ABSTRACT

Almost a decade after the Magnuson-Stevens Fishery Conservation and Management Act was amended by the Sustainable Fisheries Act in 1996, Fishery Management Councils, fishermen, communities, and others still struggle with the requirement to consider socio-economic impacts of regulatory change on fishing communities. Interpretations of the Act hold that communities are place-based entities with significant harvesting and/or processing operations. However, the results of a collaborative mapping project with fishing industry members illustrate that fishing communities are not restricted to ports of residence but are integral to and inhabit specific resource areas at sea. Linking newly recognized communities to locations at sea suggests that they are more than just sites of impact but actors in the maintenance and, potentially, management of specific resource areas.

Vessel trip report (VTR) data, based on logbooks required by the Multispecies Fishery Management Plan, was used to develop charts of probable communities on the water. The VTR-based charts were vetted, amended and ultimately, the patterns were explained by fishermen from Maine, New Hampshire, and Massachusetts working with interviewers who were also local industry members. VTR data, once aggregated and processed via a GIS, was a good predictor of broad categories of fishermen and locales at sea where they fished. In addition, the participatory interview approach has lead to a wealth of information as to how fishing communities inhabit those locales, what environmental information they produce about those locales, and their willingness to be part of scientific and management efforts focused on those locales. The project is driven by the hope that mapping the resources upon which particular fishing communities depend would contribute to social impact assessments of regulations and, importantly, would suggest ways that communities might be more than just sites of impact but participants in the future of a more local fisheries science and management.

STELLWAGEN BANK FISHERIES, 1984-2004

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ABSTRACT

Increasingly strict regulations restricting fishing in New England and the anticipation of the development of a new management plan for Stellwagen Bank Marine Sanctuary led commercial fishermen, including charter boat captains, who use the Bank to seek ways to document current and traditional use of each gear type. They recognized that management requires accurate, area-based information about fishing practices and how these have changed over time.

A lack of spatial data at a fine scale of resolution, including details about the use of available resources, and the absence of information about the social and economic impacts of changes to such uses, constrains the potential for equitable management. With the help of Massachusetts Fishermen's Partnership, almost 150 interviews of fishermen were conducted in 2005 by seven fishermen using a short list of questions and separate charts to mark fishing patterns in 1984, 1994, and 2004. Data on current and historical information about fishing locations (according to season and year), species targeted, landings (quantity and value), species life cycles, ports of landing and home ports, gear type, and bottom type was gathered. The charts were digitized for use in Geographic Information Systems (GIS).

GIS allows selection and viewing of data by any field in the database. In addition, GIS facilitates viewing data on top of multiple map layers, such as maps of underwater terrain, bottom conditions, temperature, regulatory boundaries or scientists' information on habitat features and extent. Because everything has a location reference, databases can be linked through space and analyzed statistically.

The digital charts depict what has changed over time and space in Stellwagen. By summarizing the data spatially, 3-dimensional figures emerge that depict the intensity of fishing in each time period. From these changes and the links to responses to interview questions, inferences about the resulting social and economic changes can be drawn. Additionally, GIS enables the fishermen's documentation of aspects of bottom type and habitat to also inform management choices. Furthermore, the data will allow managers at the Stellwagen Bank National Marine Sanctuary and the New England Fishery Management Council to analyze how regulations have already altered fishing behaviors and impacts, information essential to assess as new measures are considered.

EcoGIS – GIS TOOLS FOR ECOSYSTEMS APPROACHES TO FISHERIES MANAGEMENT

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ABSTRACT

The EcoGIS project is developing a set of GIS tools to better enable both fisheries scientists and managers to adopt ecosystem approaches to fisheries management. EcoGIS is a collaborative effort between NOS, NMFS, and four regional Fishery Management Councils. The need for these types of tools was highlighted in a September 2004 workshop in Charleston, SC, with fishery scientists and managers from NOAA, Fishery Management Councils, academia, and NGOs. Based on the issues identified by the Workshop, four topic areas to guide the development of prototype GIS tools are:

Area Characterization – Within a selected area, what are the physical parameters (e.g. sediment type), and biological parameters (e.g. species abundance), and regulatory framework?

Fishing Effort Analysis – Where, when, and how do fisheries operate within a given area? How have fisheries been impacted as a result of regulatory changes?

Habitat Interactions – What types and amount of habitats have been fished using bottom-tending gear?

Bycatch Analysis – What are the trends in bycatch among different fisheries, geographic areas, time periods, depth ranges, and habitat types?

GIS needs of the end users range from simple map-based queries to complex ecosystem modeling. These tools are developed as an extension for ArcGIS 9.x, and generate spatial and temporal analyses using specified criteria from a variety of data sources, including base map layers, commercial fishery observations and vessel trip reports. The end product will enable a simplified means to query data and create models of complex multi-dimensional datasets and a visualization of results that will help communicate information to support decision makers.

This poster will present the rationale and objectives of the EcoGIS project, illustrate the steps to develop tools and analyze the source data, and display maps of example analyses.

USING GIS TO ILLUSTRATE SOCIAL AND ECOLOGICAL CONNECTIONS IN COMMERCIAL FISHERIES OFF THE NORTHEAST COAST OF THE UNITED STATES

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ABSTRACT

Background

The social (and ecological) interactions inherent to marine fisheries are a mystery for many who are not fishermen or members of fishing families. In areas where fishing takes place near the coast, there may be a general awareness and understanding of these interactions as fishing activities become part of the economic, social and cultural landscape of the community. Understanding offshore commercial fisheries, however, can be challenging for coastal and non-coastal residents alike. Vessels come and go along with trucks hauling catch away from ports (in many cases already processed, bagged or packaged). Additionally, while nearshore fisheries often supply local markets, larger scale commercial fisheries (commonly fishing offshore) often cater to markets outside local and even regional boundaries. Fishing distance offshore as well as increased vessel size and mobility present challenges for understanding the interactions between fishers, other fishery participants and fishing grounds. Given the increased specialization of the fishing industry, while one might have a general understanding of one fishery, the social, economic and ecological connections in another may not be obvious.

Mapping social and ecological marine connections

Analysis of economic and social impacts of fishery regulations is required by the National Environmental Policy Act and by the Magnuson-Stevens Fishery Conservation and Management Act, with the latter emphasizing the need to understand the history of the fishery and impacts on fishing communities (National Standard 8). Each fishery management plan (FMP) or amendment to a plan must include a description of the potentially 'affected human environment'. Ideally, this information is used as a baseline against which socio-cultural and economic changes experienced by stakeholder groups and relevant communities can be measured over time. A common criticism of the FMPs and FMP amendments is that they are too long, complicated, and inaccessible to most fishery stakeholders. A recent Federal court decision in a challenge to Amendment 13 of the Northeast Multispecies Fishery Management Plan found that the content of the Amendment document met legal requirements, but was less successful at 'disclosing information in terms intelligible to interested members of the public, public servants, and legislators'. (*Oceana* v. *Evans* (Civil Action No. 04–0811 (D.D.C. March 9, 2005), p.42). The total length of the Amendment 13 document was over 1,500 pages with the 'affected human environment' section of the document comprising over 350 pages (NEFMC, 2003).

Formal analysis of fishing activities is generally limited to either at-sea activities or the economic impacts of regulatory changes on fishing *businesses*. Only recently have research efforts focused on the social and cultural impacts on fishermen (including crew), their families, and on other fisheries stakeholders such as coastal communities. Traditionally, the data

collected about fishery participants focused on vessels and landings. Socio-cultural data are only now being acquired. One example of this is the baseline demographic data on coastal communities that are now collected to better document and understand social change over time (50 CFR part 600, 1998). However, rarely, is a connection drawn between the marine resource and coastal stakeholders to evaluate how environmental or regulatory changes might impact a region. One notable initiative to address this gap is the development of an economic impact model that is capable of predicting multiplier effects of proposed fishery management actions on subregions in the Northeast (Steinback & Thunberg, in press).

Mapping the Herring Fishery

The impetus for the current GIS work was the development of the Affected Human Environment Statement for Amendment 1 to the Atlantic Herring Fishery Management Plan developed by the New England Fishery Management Council. Currently, the herring fishery is an open access fishery managed by quotas and divided into four separate areas (1A, 1B, 2, 3), each with a separate TAC. Key measures in this Amendment involve limiting fishery access, as well as creation of a seasonal purse seine/fixed gear only area in the northern part of Area IA. Implementation of these measures will impact current and future access to the fishery as affect the distribution of potential catch among different stakeholders. Given this, the primary purpose of our GIS efforts was to identify and illustrate the linkages between the herring resource in Management Area 1A and coastal communities and other fishery stakeholders in New England. This information will be used to predict changes and impacts to fishery stakeholders and to analyze future changes in the fishery. Management Area 1A encompasses the primary fishing grounds of the summer herring fishery, which supplies the bait markets for the American lobster fishery and also the Region's only sardine cannery[1]. The Area 1A is the only herring management area where the annual total allowable catch (TAC) is consistently attained.

Figures 1 and 2 illustrate the herring fishery in Management Area 1A, in terms of seasonal activity, geographic distribution, gear type, processing capabilities, and key ports. Herring landings data in these maps were provided by the State of Maine, while vessel trip reports, catch, gear type and location data were obtained from NMFS databases. The number of lobster permits in each town in Maine, New Hampshire and Massachusetts was provided by the respective states, and was included to identify the harvesting sectors which might be most impacted by changes in the availability of herring. Major roads were included to indicate possible trucking routes for the distribution of herring to more remote coastal areas. The locations of primary herring ports and support facilities (pumping stations, freezer plants, canneries, and bait dealers) near these ports are also depicted on the maps.

The maps were created using the ArcView 8.3 GIS system. Separate maps were generated for the Winter/Spring (December-May) and Summer/Fall (June-November) seasons because the fishery exhibits seasonal differences. Total landings for each vessel were summed over the 2000-2003 period to identify the most active vessels (in terms of herring catches) in the fishery; 34 vessels accounted for 99.5% of the landings during this period. To ensure that these vessels actually represented regular participants in the fishery, an additional requirement was that a vessel had to have made at least 20 trips within the combined management areas during the four year period. For each of the 34 vessels, the primary gear used during each season in each management area was identified, as well as the port where the vessel unloaded the largest percentage of its catch during the winter/spring and summer/fall seasons.

Ideally, these maps provide the reader with a one-page snapshot of the land-sea connections of the herring harvested from Management Area 1A. Key communities associated with the fishery are

[1] Currently the Connors Brothers facility in Prospect Harbor Maine is the only operative cannery in the region.

mapped, and are shown with icons next to them indicating what herring-related infrastructure exists there. For example, the figures show that Gloucester, MA, Newington, NH and Rockland, ME all have pumping stations, bait dealers and freezer plants. Red dots show concentrations of lobster permit holders in all New England states, with Maine having the greatest number (and consequently) the greatest dependency on herring as a source of bait. The maps identify three main destinations for herring from Area 1A – lobster dealers/bait dealers, sardine canneries, and freezer plants.

The maps also indicate the connection between vessels and ports, and depict the distribution of gear types used in different regions. For example, purse seine vessels are largely linked to more northerly ports (such as Rockland and Prospect Harbor, ME) and associated bait markets, while pair and mid water trawlers are concentrated in southern ports possessing processing and freezing facilities. The maps also illustrate the connections between vessels and processing plants.

The maps are clearly an oversimplification of the herring fishery - but provide the reader with a point of departure to explore social economic and ecological aspects of the fishery. Coupling maps with descriptions of the ports, communities, businesses, and other stakeholders should help to contextualize these aspects. Future web-based improvements are aimed at presenting this information in a more user-friendly way allowing users to explore the maps by clicking on icons of particular interest to them.

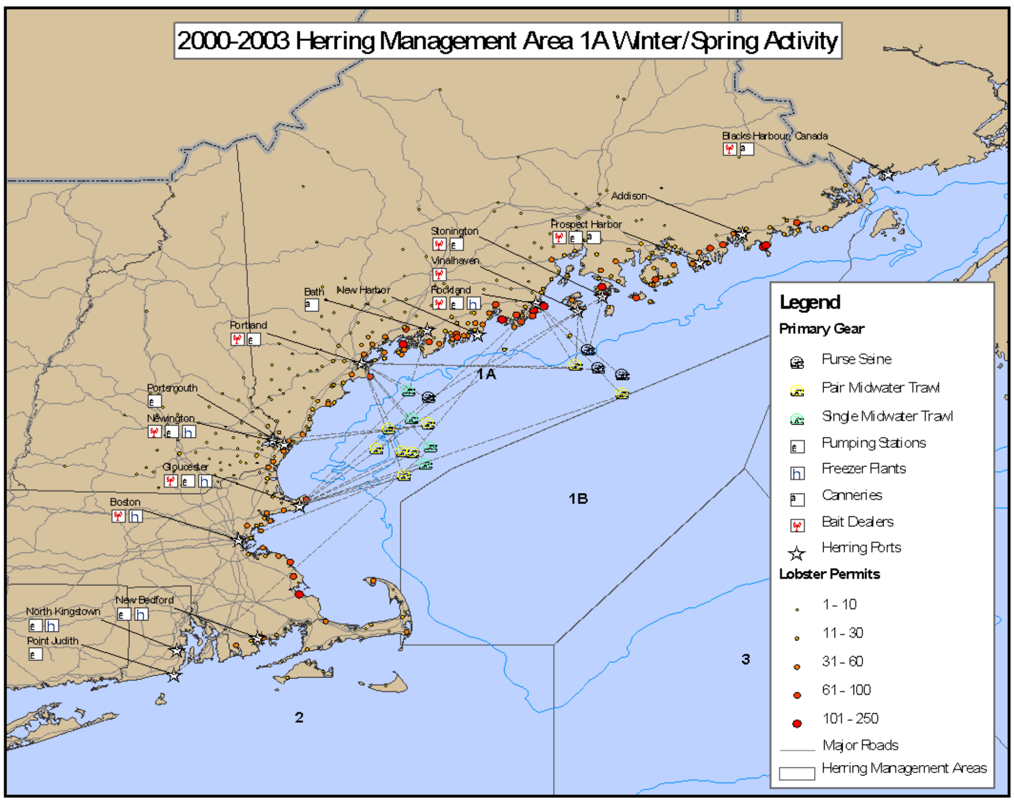

Figure 1a. 2000-2003 Herring Management Area 1A Winter/Spring Activity

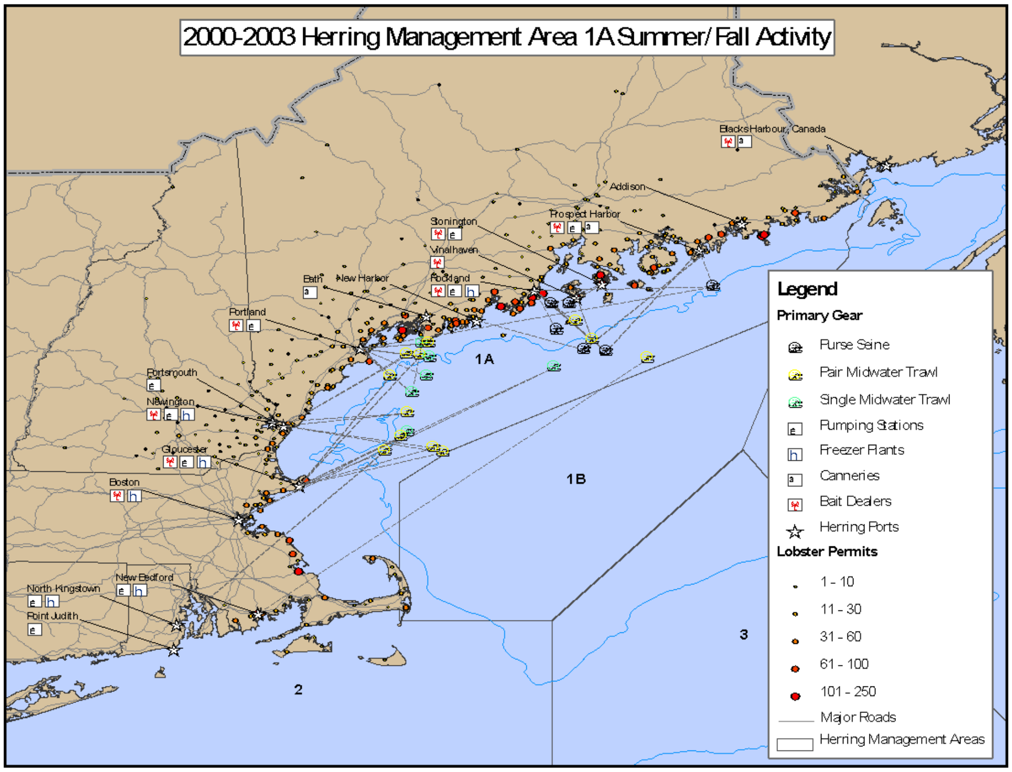

Figure 1b. 2000-2003 Herring Management Area 1A Summer/Fall Activity

Mapping the Tilefish Fishery

The maps in this section were created to better understand the land sea linkages in the Atlantic Tilefish fishery for a study on trust and cooperative behavior in this fishery (Kitts, Pinto da Silva & Rountree, forthcoming). Figure 2 illustrates the geographic distribution in 2005 in terms of the land-sea connections for all active vessels possessing limited access permits. Each of the three different fishing permit categories defined within the FMP are differentiated by their association to a port or series of ports (See Figure 2). The figure shows that all Category A Tilefish vessels land their catch in the same location – a characteristic that has fostered cooperation among the Category A fishermen. The maps also show that Category B vessels fish from Shinnecock and Hampton Bays, NY and out of Barnegat Light, NJ, while Category C vessels fish from Barnegat Light, NJ and Pt Judith, RI. For each permit category, the maps illustrate the areas fished and connections to landing ports. Each fishing trip is depicted, and solid lines represent multiple trips. The total number of trips taken by all vessels in each permit category is also noted on the map. Although Figure 2 is for the 2005 fishing year (from November 1, 2004 to October 31, 2005), all of the tilefish vessels have historically fished in the same geographic areas along the 50-fathom line. New York City's Fulton Fish Market is shown on the map as this is where virtually all of the tilefish catch is sold.

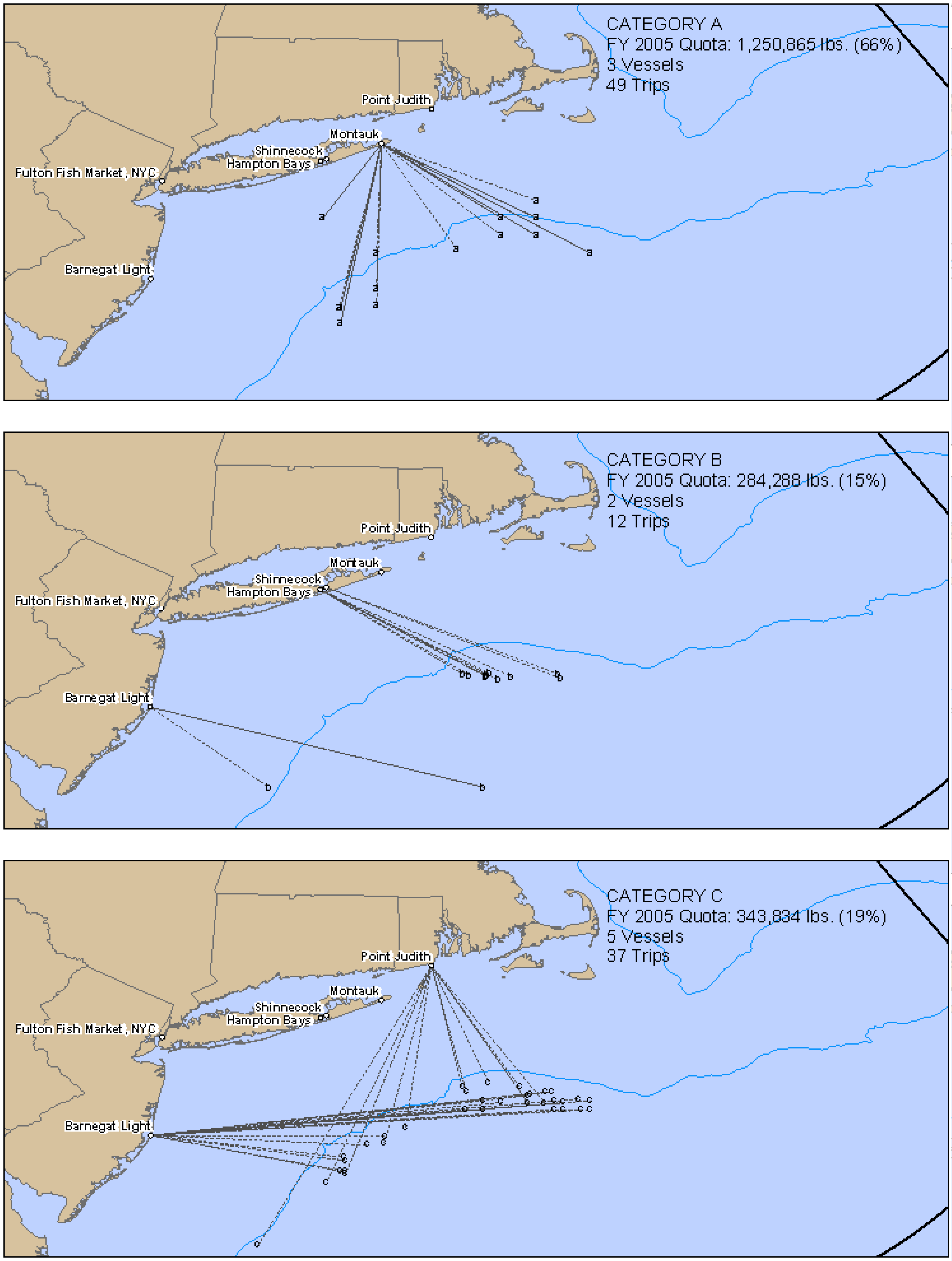

Figure 2. Geographic Distribution of the Atlantic Tilefish Fishery During the 2005 Fishing Year.

Application to fishery research and management

Research and analysis for fishery management plans are usually provided in three areas: biological, social, and economic. Typically, information in each area is independently analyzed, thereby presenting an artificial disaggregation of related information (Degnbol et al., 2005). Improving our understanding of social, economic and ecological connections is critical to linking people to the marine environment and understanding the role of humans and human communities in an ecosystem-based framework. Fisheries management will benefit from an improved ability to visualize these connections, as social and economic impacts of regulatory changes can be more quickly analyzed and also made accessible to a wider audience. GIS maps can depict information that would otherwise be inaccessible, along with layers of information illuminating social and ecological networks that are typically very poorly understood. Interactive web-based tools should increase the usefulness of this approach and allow for increased layering, options, and better integration of qualitative and quantitative data.

GIS maps like those presented here could also be used as 'visual baselines' to measure changes in a fishery over time. Much can be gleaned by simply comparing or overlaying maps from two different time periods. By making such maps web-based and interactive, quantitative information could be accessed alongside qualitative data. For example, clicking on a key port icon could link the viewer to the community profile for that port, which would include socio-cultural and economic information for that port. Text-based information related to the Affected Human Environment of the fishery could also be linked to each icon. This information might include site visits, structured and unstructured interviews with fishery participants, existing literature, census data, and web links. Over time, even photos and video could be incorporated into these interactive documents.

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THE NORTHEAST REGIONAL COD TAGGING PROGRAM: USE OF GIS AND AN IMS INTERFACE TO DISPLAY INTERACTIVE DATA FOR ATLANTIC COD (*GADUS MORHUA*) THROUGHOUT THE GULF OF MAINE

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ABSTRACT

Atlantic cod, *Gadus morhua*, total stock biomass estimates have shown a steady decline since the 1960s (NEFSC 2001), resulting in dramatic effects on the groundfish industry. Despite the recent stock biomass increases seen in some New England fishing grounds, a greater understanding of cod distribution, migration patterns and growth in the Gulf of Maine and neighboring waters is needed before management efforts to rebuild cod stocks will succeed; this tagging study provides insight into the movements, mixing and growth of three trans-boundary Atlantic cod stocks.

The Northeast Regional Cod Tagging Program represents a partnership of eight different research organizations and >250 fishermen along the Northeast seaboard, and has been coordinated out of Portland, Maine, by the Gulf of Maine Research Institute (GMRI). This large, internationally collaborative Program was launched January in 2003 with the following key objectives: (1) develop a collaborative cod tagging program between scientists and fishermen in the Gulf of Maine region, including Canada; (2) obtain and analyze data from tag recaptures to improve our understanding of cod distribution, movement and growth; (3) make the tagging data available to the public via an online GIS mapping interface; and (4) establish a preliminary understanding of cod movements and stock structure that will enable us to develop testable hypothesis for continuing tagging studies.

Between April 2003 and July 2005 >114,000 cod were T-bar tagged on >100 commercial and recreational vessels, during dedicated tagging trips in both US and Canadian waters. Approximately 5% of the tagged cod releases have been reported with recapture information to date; this recapture information will be used to determine migration patterns and will provide preliminary estimates of mixing rates between the trans-boundary cod stocks. In turn, these findings will help stock assessment scientists determine the most appropriate definition of cod stocks, based on their movements. The recapture data will also providing new, in situ growth information for comparison with the growth estimates currently used in cod stock assessments.

Fisheries has traditionally been an arena for mistrust between different stakeholder groups, with one common complaint being that the scientific data is rarely made available to the industry, and that the period between data collection and presentation is unacceptably long. GIS mapping technology was seen as a useful and efficient tool for providing the general public with a near real-time visualization of the tagging data. GMRI has worked, in collaboration with Northern Geomantics Inc, to develop a complex, online, GIS-enabled database, capable of supporting remote data entry by multiple tagging organizations. The data are quality controlled and approved by GMRI and upon approval, the tagging data becomes publicly accessible for

viewing and filtering via the Program's online GIS mapping interface (www.gmamapping.org/codmapping). This GIS mapping interface has provided a powerful means of ensuring that fishermen and non-partner scientists can see and interact with the tagging data as soon as it has been audited. This tool also enables the generation of sophisticated recapture reports for tagged cod recaptures which can be emailed or mailed to the tag reporter, but also to the original release vessel. This type of feedback is crucial to the success of collaborative fisheries research and the Program's use of this tool has set a precedent for future tagging projects worldwide.

Funded by NOAA Fisheries (NE Region), Cooperative Research Partners Program.

COLLECTING AND MAPPING FISHING GEAR AREAS IN THE NORTHEAST

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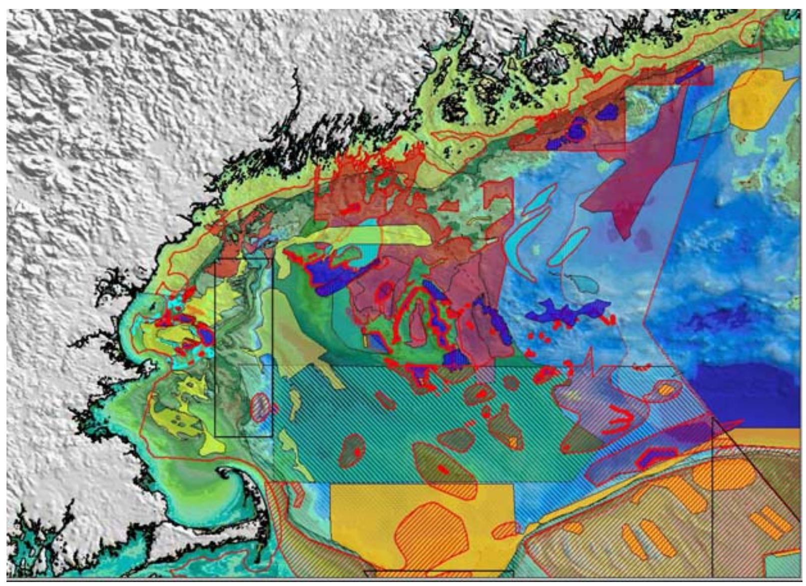
ABSTRACT

The assertion that coastal and offshore habitats are being ravaged by commercial fishing activity, particularly mobile gear, is a common one. Yet even a casual knowledge of commercial fishing practices reveals otherwise. A combination of factors, including fishing regulations, fish distribution, and un-fishable bottom, greatly restrict the actual areas impacted. However, fixed gear areas that have effectively been claimed for lobster, gill net, and hook fisheries are a major factor in where trawling and dredging occurs. Data on the boundaries of these areas has been sparse and knowledge on who is fishing where is not available to policy makers and others concerned with the sustainability of our region's marine resources.

Lead by the MIT Sea Grant College Program, the Sea Grant programs of the Northeast have helped fill that informational void using data gathering techniques that depend on the locale and nature of the data. In some cases, groups of fishermen, aided by the graphical presentation of existing public data, have developed a consensus on how areas are being used (or not used) within their combined operating areas. In other cases, fisherman interviews and paper charts were used to define individual fishing locations. Some willing fishermen have even shared their plotter files of current and historical tows and gear sets.



Fishing area data for the Gulf of Maine

In all cases, the proprietary aspects of any data (specific tow or set locations) have been maintained. Instead, electronic data has been combined and generalized to provide sector boundaries rather than levels of effort or individual hot spots. The data from all sources have been combined into a GIS database.

Using appropriate overlays, we are able to compare the data with depth, substrate, and resource abundance information to help decipher the relationship between fishing areas and physical and biological factors. Most important is the fact that this data was collected from fishermen who are participating in the project voluntarily and has avoided the common concerns about inaccuracies and obfuscation that are currently associated with mandated trip reports.

Data from the project is available at: http://web.mit.edu/seagrant/northeast/index.html where fishing areas by location and gear type can be displayed with a variety of geo-spatial layers and political boundaries.

DEVELOPMENT AND USE OF GEOGRAPHIC INFORMATION SYSTEMS AND THE ESRI/SAS BRIDGE AS A TOOL TO AUDIT VESSEL TRIP REPORTS

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ABSTRACT

A significant development in geospatial statistical analysis has been the development of the SAS/ArcGIS Bridge. The combination of a powerful statistical program with a GIS application affords a robust tool for analysis of fishery dependant data. Implementing the SAS/ArcGIS GIS Bridge has enabled us to better audit outlier data by accounting for geographic variances in fishing practices.

In the Northeast, fishing vessels permitted by NMFS are required to submit Fishing Vessel Trip Reports (FVTR) describing each trip they make. These reports record the catch, effort and fishing area, as well as descriptors of the gear used. Each week an auditing program combs through data entered the previous week. This program was devised as a way to detect, track, correct, report and reduce errors in the database. The SAS/ESRI GIS Bridge has been added to the audit process to verify the spatial information reported by vessel operators and exclude records within regions where fishing methods are valid, yet remain as outliers. To date, the use of the GIS/SAS Bridge as a tool for excluding false positives in the weekly audit has reduced the numbers of FVTR's which require inspection allowing resources to be dedicated to other audits.

USE OF A WEIGHTED GIS RASTER MODEL TO COMPARE BIOLOGICALLY SIGNIFICANT REGIONS WITH IMPORTANT COMMERCIAL FISHING GROUNDS ON GEORGES BANK AND IN THE GULF OF MAINE

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ABSTRACT

Effective fisheries management depends on the integration of basic biological information with the needs of stakeholders. A multi-species weighted raster model was developed to compare biologically significant regions to important commercial fishing grounds in the Gulf of Maine and on Georges Bank. Fishery-independent data collected in NMFS spring and autumn bottom trawl surveys conducted during 1994-2003 were used to define biologically significant regions of biodiversity, spawning areas, and juvenile habitats for 14 fish species (Figures 1 & 2). Important commercial fishing grounds were identified using Vessel Trip Reports (VTR) landings data collected during 1994-2002 (Figure 3). The biological and commercial fishing attributes of each spatial cell in the raster model were assigned a relative but opposing score to illustrate tradeoffs in cell utilization. The sum of these opposing scores defined the overall weighted value of each spatial cell.

The model was constrained to regions with congruent biological and commercial fishing datasets, therefore eliminating results from existing closed areas and Canadian waters. Results can be viewed in simple categorical form, (-1, 0, +1) or as a spectrum of negative to positive values. The level of resolution used to represent the weighted raster values can vary with management objectives. The summed relative scores may be used to identify contiguous regions associated with their utility.

The weighted model can be designed for multi-species management, ecosystem management by incorporating numerous environmental and social constraints, or to address specifically targeted species of particular concern (such as endangered or threatened species). The model can be tuned by adjusting the weighting scenarios for the input variables, and the results used to simultaneously consider the condition of biological resources and the needs of fishing communities.

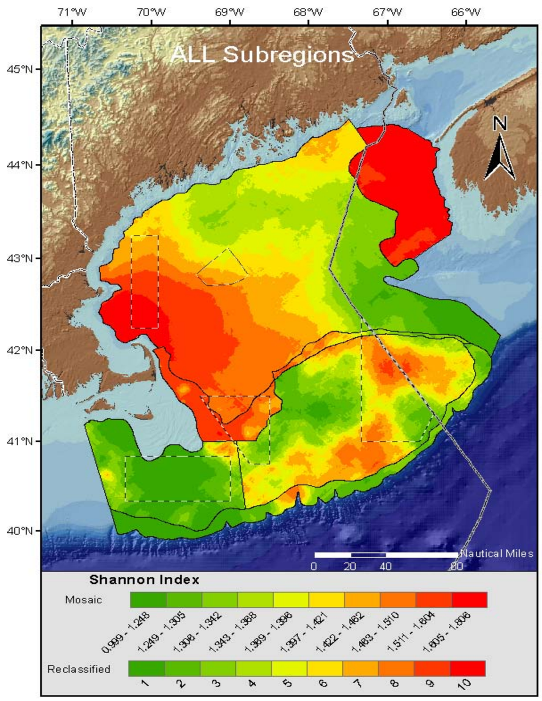

Figure 1. Interpolated Shannon index of diversity values based on spring and fall NMFS data, 1994 -
2003.

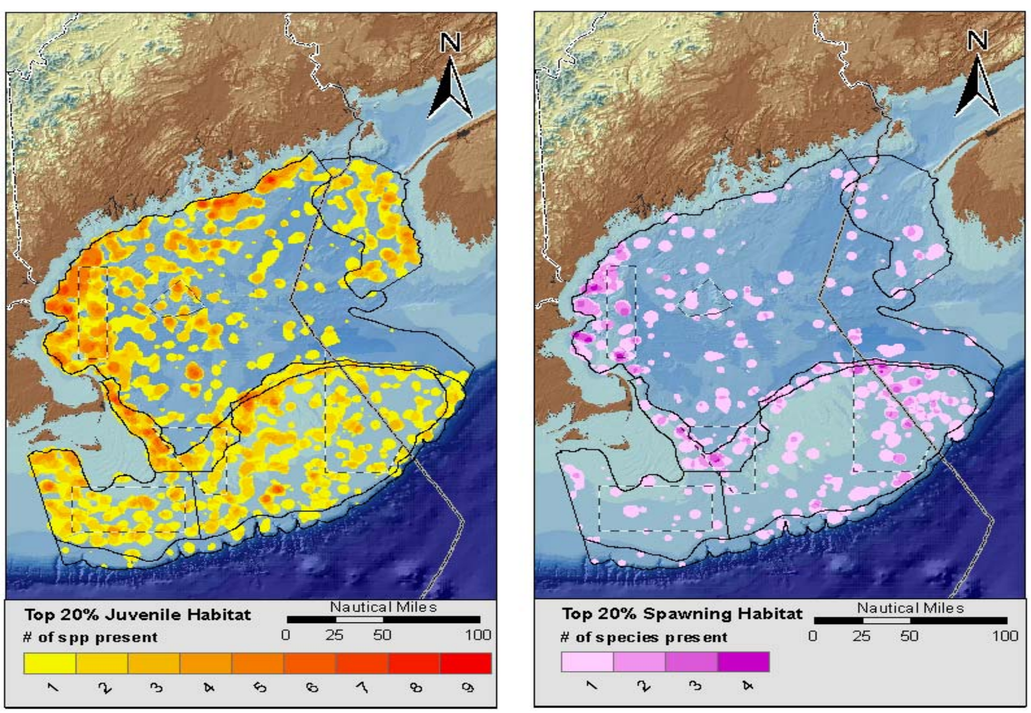

Figure 2. Juvenile and spawning habitats for select commercial fish species from spring and fall NMFS data, 1994 - 2003.

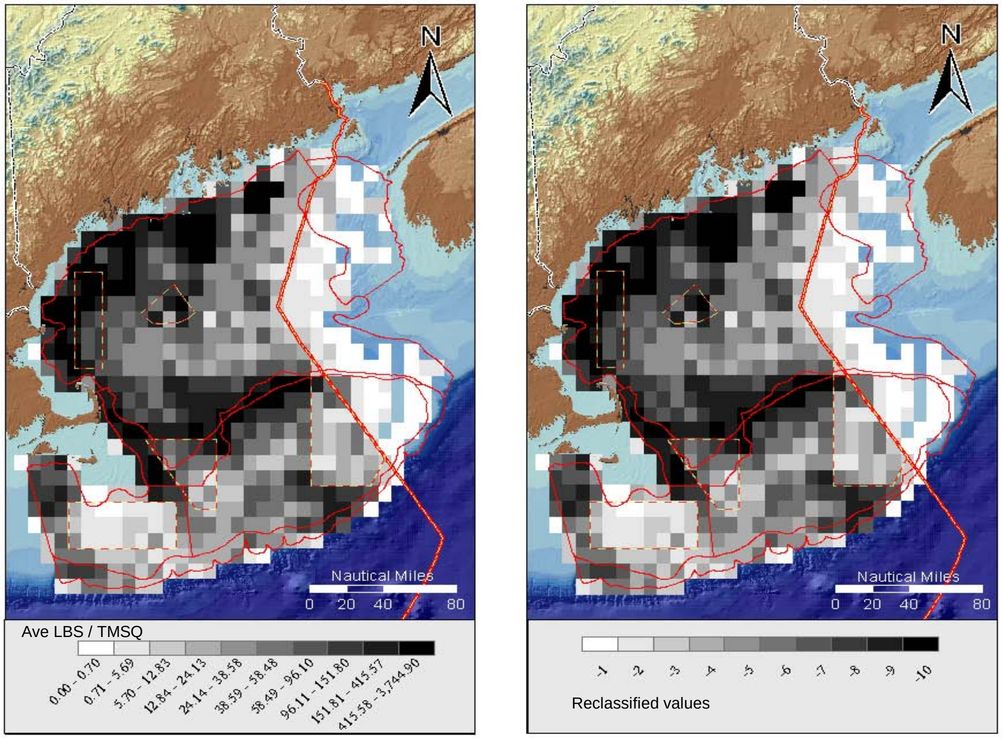

Figure 3. Important commercial fishing grounds for selected fish species derived from VTR data, 1994 - 2002.

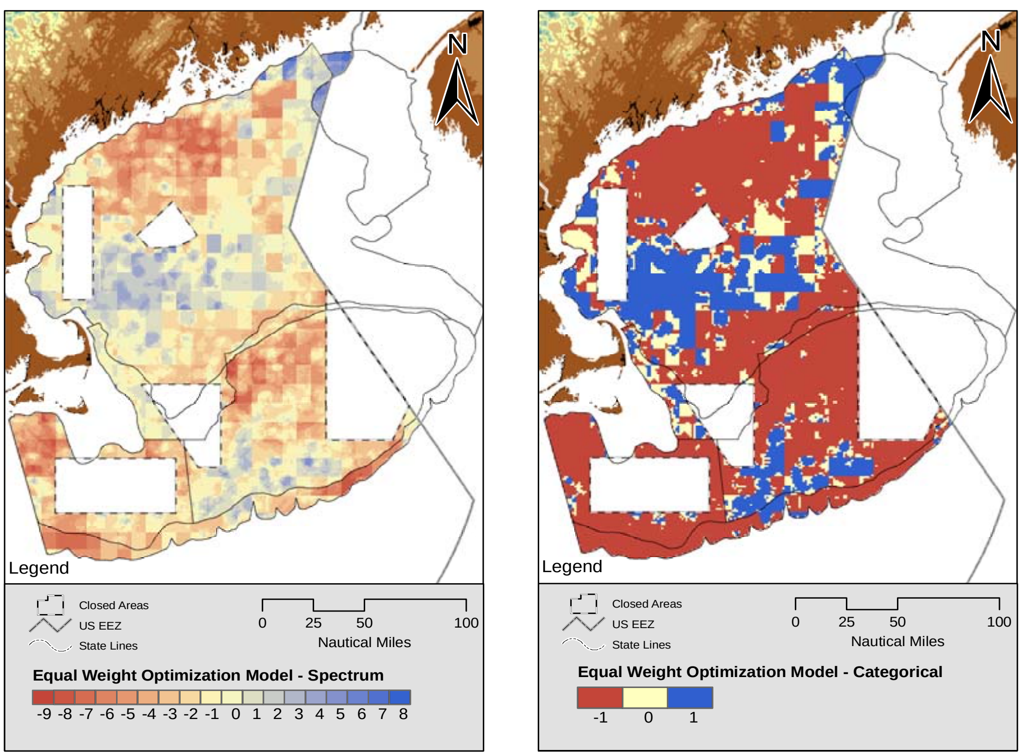

Figure 4. An example of a weighted raster model output illustrating values in both the spectrum and categorical form.

DEVELOPMENT AND USE OF OCEANOGRAPHIC GIS DATA TO IMPROVE MANAGEMENT OF PROTECTED SPECIES

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ABSTRACT

GIS raster databases have been developed by NEFSC staff for use in bycatch and habitat analyses of protected species (marine mammals and sea turtles) occurring in the Northwest Atlantic Ocean. These databases include multiple rosters of bottom depth, and time series of satellite-derived SST, chlorophyll, and oceanographic fronts (SST gradient). Each time series contains a 5-day composite of the available daily data. The SST and frontal time series extends back to 1993, and the chlorophyll time series extends back to 1997. Included within these databases is a suite of programs used to extract oceanographic data based on either point locations or fishing areas. To date, the GIS raster databases have been used to estimate total bycatches of protected species, to assess movement patterns of leatherback turtles, and to describe preferred habitats of marine mammals using sightings survey data.

DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM AS A MANAGEMENT TOOL TO REDUCE BYCATCH OF SEA TURTLES IN U.S. ATLANTIC OCEAN AND GULF OF MEXICO FISHERIES

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ABSTRACT

Incidental capture (bycatch) of sea turtles in commercial fishing gear is a major factor affecting recovery of sea turtle populations in the Atlantic Ocean and Gulf of Mexico. All species of sea turtles inhabiting these waters are listed as either endangered or threatened under the Endangered Species Act (ESA). To help meet ESA recovery goals for sea turtles, NOAA Fisheries implemented the Strategy for Sea Turtle Conservation and Recovery in Relation to Atlantic Ocean and Gulf of Mexico Fisheries (Strategy). The Strategy's goal is to reduce incidental capture of sea turtles in U.S. commercial fisheries by evaluating sea turtle bycatch and developing and implementing solutions to reduce bycatch by gear type. NOAA National Ocean Service's Biogeography Team has been partnering with NOAA Fisheries to develop a geographic information system (GIS) as a management tool in support of the Strategy. The GIS greatly facilitates spatial analyses and the dissemination of information regarding sea turtle and fisheries interactions by integrating commercial fishing effort, known sea turtle distribution, observed sea turtle bycatch, existing regulations relevant to sea turtle bycatch, and oceanographic features that likely influence sea turtle behavior. This is the first comprehensive GIS management tool dedicated to addressing the problem of sea turtle bycatch across gears in the Atlantic and Gulf of Mexico regions.

MARINE WILDLIFE BEHAVIOR DATABASE FOR PREDICTING AND MINIMIZING ENVIRONMENTAL IMPACTS

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ABSTRACT

Project Background

Assessing the potential effects of underwater sound on the environment is an increasing concern for many activities. The heightened awareness of the environmental impact of noise on marine wildlife has dramatically affected the ability of governmental, institutional, and commercial groups to conduct research and routine operations with any device that makes sound underwater. Noise-producing operations must comply with various environmental regulations that provide varying levels of protection to the environment and wildlife. Although a number of tools to assess environmental impacts have been developed in recent years, they all require a forecast of the species present at the time of the operation, their abundance and distribution, as well as their diving, general movement, and acoustic behavior. A national database of the seasonal distribution, abundance, and behavior of marine wildlife is needed to consistently assess the impact of noise activities and to identify areas requiring further research.

The University of Rhode Island, in partnership with Marine Acoustics, Inc., is developing a Marine Wildlife Behavior Database that will include geo-referenced baseline data on marine wildlife behaviors, namely diving, movement, and acoustic characteristics of fishes, marine mammals, and sea turtles. During the first phase of this project, a prototype structure is being developed for a select number of species in the Gulf of Maine. The second phase of this project will expand the geographic extent of the prototype database to include species known to occur in the North Atlantic Ocean. A scientific advisory council is being created to establish standards and guidelines for the data and identify new data or partnerships for inclusion into the system. The council will consist of expert scientists from the University of Rhode Island and Marine Acoustics, Inc., along with other academic and research institutions in the fields of marine acoustics, marine mammals, marine reptiles, fisheries, physical and biological oceanography, sea and land remote sensing, coastal ecosystems, GIS, and meta-databasing and dissemination systems. The Marine Wildlife Behavior Database will be made available over the Internet through a registered node on the National Spatial Data Infrastructure (NSDI).

Project Details

In order to accurately predict environmental impacts in the marine world, it is necessary to operate in at least three dimensions (in fact, four dimensions when time is considered). For noise-producing activities, the location and depth of an animal significantly affects the amount of acoustic energy to which it is exposed. As an animal moves through the environment, it is exposed to varying levels of sound as a function of its range from the source and depth in the water column. Coupled with the varying location and depth of an acoustic source, predicting an animal's exposure can become complex. Assessment tools that attempt to predict and minimize acoustic exposure require detailed data on the species most likely to be present at the time of the operation, their abundance and distribution, as well as their diving, general movement, and acoustic behavior. These behavioral data are being collated and geo-referenced as part of the Marine Wildlife Behavior Database and will be made available via the Internet.

The prototype structure will include available behavioral data from six species critical to the Gulf of Maine ecosystem. The primary species being considered are Atlantic cod (*Gadus morhua*), North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), harbor porpoise (*Phocoena phocoena*), harbor seal (*Phoca vitulina*), and leatherback sea turtle (*Dermochelys coriacea*). Each species' behavioral profile will include information on distribution in the water column, duration at given water depths, swim speed and direction, and propensity for directional changes. Preliminary analyses of the data available for North Atlantic right whales yielded one study that provided time-depth recorder data in a very comprehensive format (Table 1 from Baumgartner and Mate, 2003). These data can be used to create Monte Carlo simulations of North Atlantic right whale diving behavior (Figure 1) that could then be coupled with acoustic energy levels. By examining the original literature for the selected species and contacting researchers regarding their results when necessary, a consistent database of behavioral parameters will be suggested. One of the first tasks of the scientific advisory council is to develop consensus on the behavioral data required for environmental assessments and a consistent reporting format.

The scientific advisory council will also focus on linking with parallel or supporting data or information dissemination systems that are necessary for a full environmental analysis. Data on animal distribution and abundance are needed, as well as other environmental data such as sea surface and water column temperature, ocean currents, and surface winds. The Marine Wildlife Behavior Database will either provide links to other oceanographic database web sites or will work with other research groups to create independent data themes or channels on the Marine Wildlife Behavior web site. The Marine Wildlife Behavior Database will utilize portal technology styled after the Geospatial One-Stop, allowing individual research groups to remotely administer their channels and providing one coherent web site for Internet users.

Table 1. *Eubalaena glacialis* and *Calanus finmarchicus*. Summary of feeding dive characteristics for whales that engaged in at least 1 feeding dive while tagged. Dive characteristics were initially averaged to provide a single observation for each whale. Distance and minimum speed were computed from the consecutive diving and resurfacing positions obtained in 2001 only. Prey abundance refers to the peak abundance of *C. finmarchicus* C5 in the water column

Dive characteristics	n	Median	Mean	SD	95% CI	Range
Dive duration (min)	34	12.65	12.17	2.22	11.39–12.94	7.83–16.32
Duration at depth (min)	34	9.50	9.39	2.29	8.59–10.18	4.72–13.55
Descent speed (m s^{-1})	34	1.38	1.40	0.30	1.29–1.50	0.81–2.00
Ascent speed (m s^{-1})	34	1.54	1.47	0.26	1.38–1.56	0.93–2.05
Dive depth (m)	34	119.9	121.2	24.2	112.8–129.7	78.7–174.0
Distance (km)	18	0.59	0.59	0.20	0.49–0.70	0.21–0.94
Minimum speed (km h^{-1})	18	0.85	0.93	0.44	0.71–1.15	0.38–1.94
Prey abundance (copepods m^{-3})	31	6219	7481	4581	5800–9161	2059–20610

Source: Baumgartner and Mate, 2003

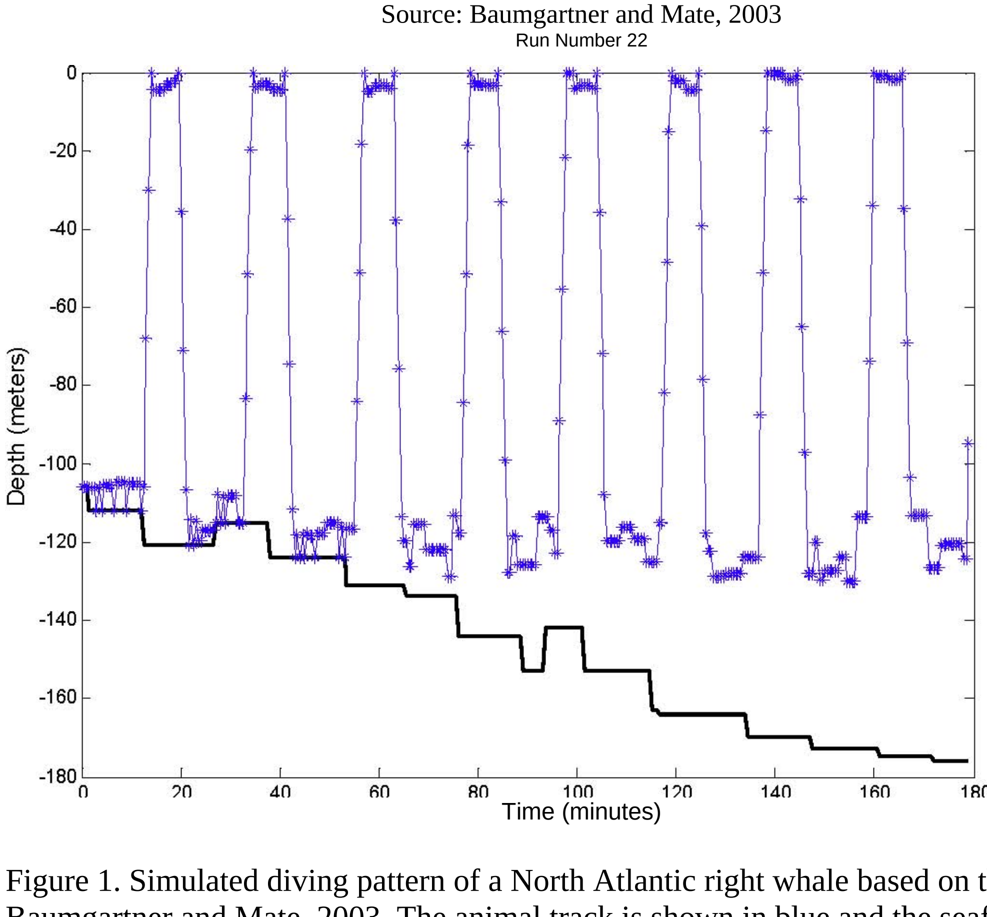

Figure 1. Simulated diving pattern of a North Atlantic right whale based on the data of Baumgartner and Mate, 2003. The animal track is shown in blue and the seafloor is the thick black line.

Application to Fisheries Research and Management

The Marine Wildlife Behavior Database will provide a three-dimensional component to animal behavior that has not been captured by existing Internet databases. Current efforts to georeference marine animal data, such as the Census of Marine Life's Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBISSEAMAP) project, have focused on the two-dimensional components of distribution and abundance. However, since acoustic energy levels can vary greatly with depth at a given location, the three-dimensional behavior of animals must be characterized in order to accurately calculate acoustic exposures. The Census of Marine Life's Tagging of Pacific Pelagics (TOPP) program provides movement maps derived from tagging experiments, but no detailed diving or movement data are being distributed publicly. The Marine Wildlife Behavior Database will distribute three-dimensional behavior data on fishes, marine mammals, and sea turtles over the Internet through a registered node on the National Spatial Data Infrastructure.

The Marine Wildlife Behavior Database will also create a consistent format for behavior data to be reported. Currently, the format of behavior data depends on the researcher's preference, the type of tag or method for collecting data, and/or the analytical software used for post-processing. This has produced a discontinuity between parallel studies that makes a coherent assessment of a species' behavior very difficult. By examining the original literature and contacting researchers regarding their results when necessary, a more consistent database of behavioral parameters will be created.

Marine Acoustics, Inc. is also currently working with other U.S. and international research groups to develop and establish a database standard. This standard would allow other research organizations to directly contribute data to or couple their existing databases with the Marine Wildlife Behavior Database. By utilizing portal technology styled after the Geospatial One-Stop, distinct data themes or channels could be created that would be administered by distributed research groups. This will allow, for example, the University of Rhode Island to administer the marine wildlife behavior channel, whereas Marine Acoustics, Inc. will administer the components dealing with marine sounds and sound propagation modeling tools. Therefore, one Internet site would network separate channels that together would provide the necessary data for a complete environmental impact assessment.

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DETECTION OF BOTTOM FISHING IMPACTS ON BENTHIC STRUCTURE USING MULTIBEAM SONAR, SIDESCAN SONAR, VIDEO AND AN INTERACTIVE 3-D GIS

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ABSTRACT

Bottom fishing gear is known to alter benthic structure, however the resulting changes in the shape of the seafloor are often too subtle to be detected by acoustic remote sensing. Nonetheless, long linear features were observed during a recent high-resolution multibeam sonar survey of Jeffreys Ledge, a prominent fishing ground in the Western Gulf of Maine (WGOM) (1), located about 55 km from Portsmouth, NH. These marks have a relief of only few centimeters, widths of 3-5 meters and lengths up to 4-5 km. The pattern, shape and size of these marks mimic closely the known fishing gear impacts of bottom dredges (2,3). The other possible explanations of the bottom marks (e.g. anchor drags) were studied as well, but ruled out (e.g. no anchorage in the area, too deep to anchor). Analysis of results from multibeam sonar and sidescan sonar show that several bottom dredge marks are also present in the area closed to fishing (WGOM closure area since 1996), and, are presumed to be caused by bottom dredging gear used in the area for scallop and clam fisheries. Detailed maps of bottom marks were constructed which can be used during future studies to enhance our understanding of the persistence of bottom fishing marks or to identify possible illegal bottom fishing activity. To enhance the detection and identification of these features, data artifacts were identified and removed selectively using frequency filtering. Verification was attempted with sidescan sonar and video surveys. While clearly visible on the sidescan sonar records, the bottom marks were not discernable in the video survey data which may imply that the marks are old enough to have lost textural contrast. The inability to use video to see features that are clearly visible in the sonar record also has important ramifications about appropriate methodologies for quantifying fishing gear impacts.

Integration of these complex data sets, comprising of processed multibeam sonar, side scan sonar, still images, streaming video and mosaics developed from video, was done using an interactive 3-dimensional Geographical Information System (GIS). Subtle signatures of bottom marks as observed in sonar data were greatly enhanced by interactively examining data from many perspectives. Sonar contacts were linked with photos, side scan sonar data, and video mosaics. The ability to mine/examine several different types of data in a single application greatly reduced the effort needed to examine areas of interests while increasing confidence in the analysis.

Note: A laptop demonstration of data exploration and fusion using the IVS-Fledermaus interactive 3-D visualization package will be presented.

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1. Baird, S.F., G. W. Goode (1887). “The fishing grounds of north America.” United States Commission of Fish and Fisheries.
2. Auster, Peter J. (1998). “A Conceptual model of the impacts of Fishing Gear on the integrity of Fish Habitats.” Conservation of Biology , Vol. 12 , No. 6 , December, 1198-1203.
3. Collie, J.S, G.A. Escanero and P. C. Valentine (1997). “Effects of bottom fishing on the benthic megafauna of Georges Bank.” Marine Ecology Progress Series, 155: 159-172.

Figures

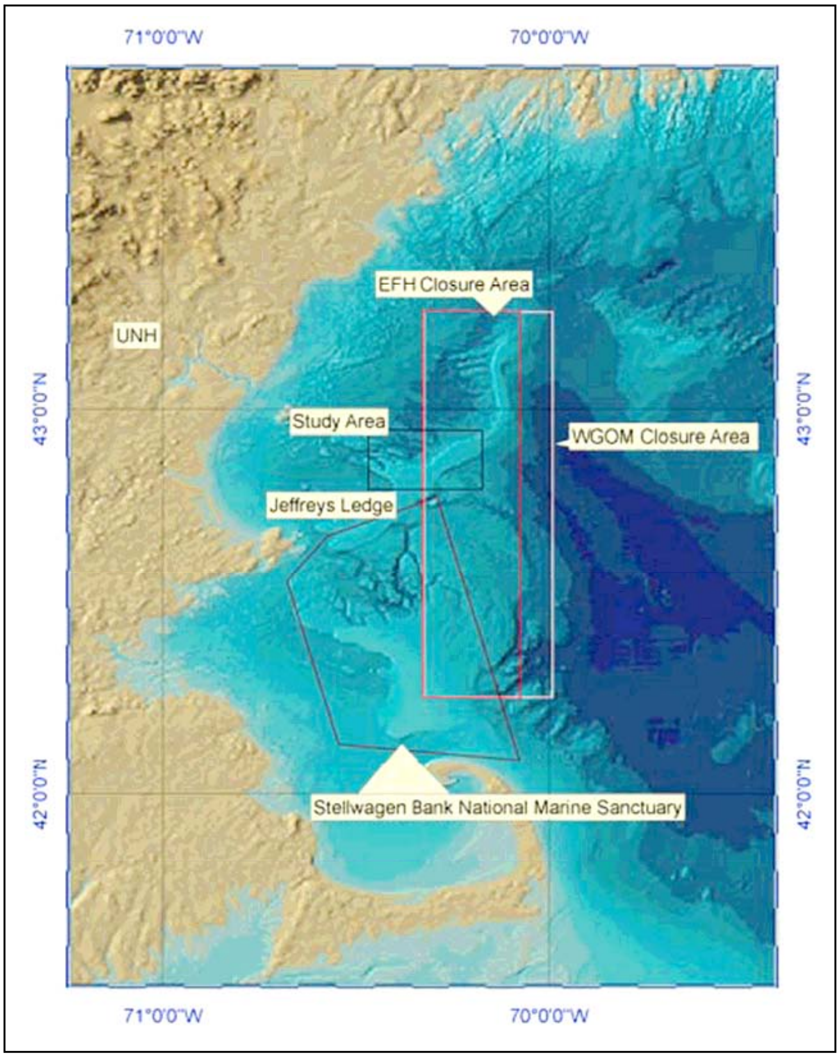


Figure 1: Location of Study Area, WGOM closure and EFH closure. Study area located about 55 km from Portsmouth, NH USA.

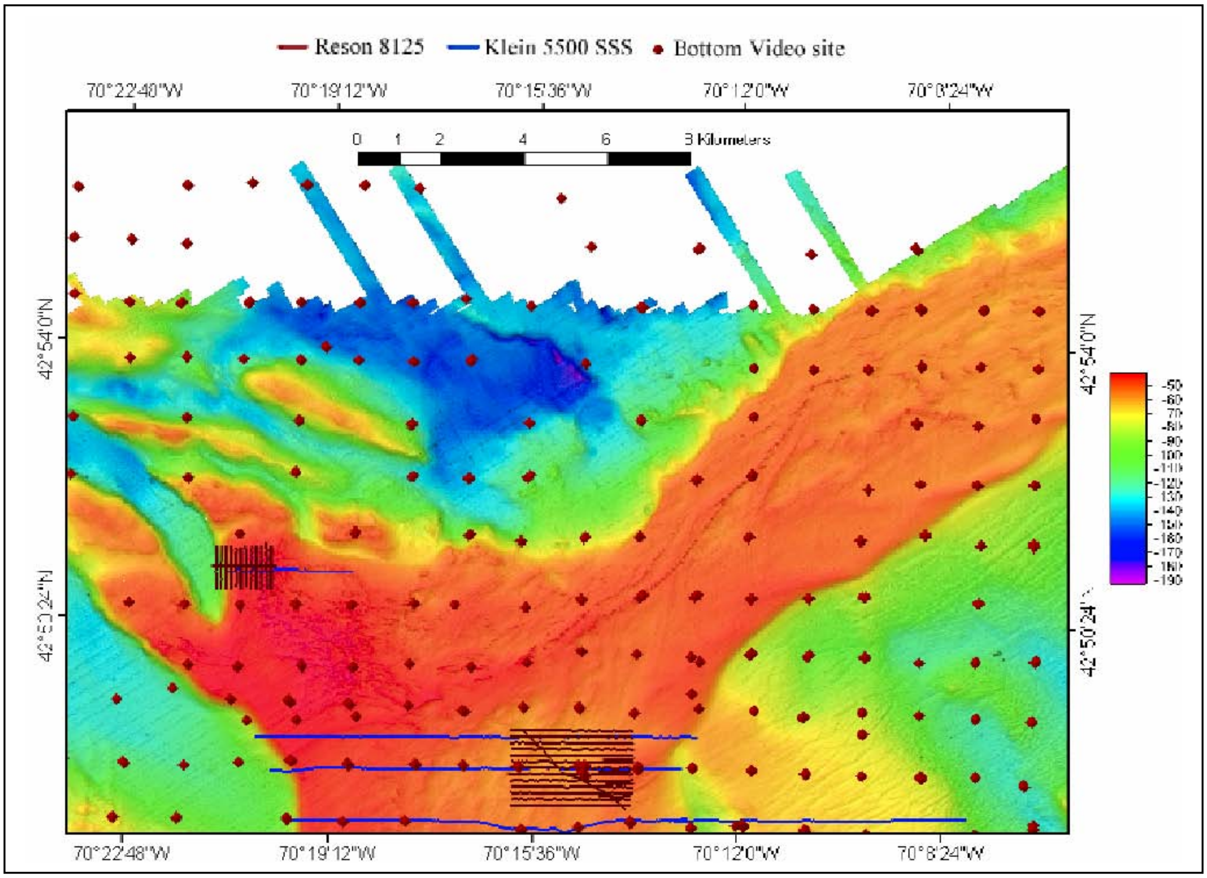


Figure 2: Data collected for the study: Reson 8101, Reson 8125, Klein 5500 and bottom video.

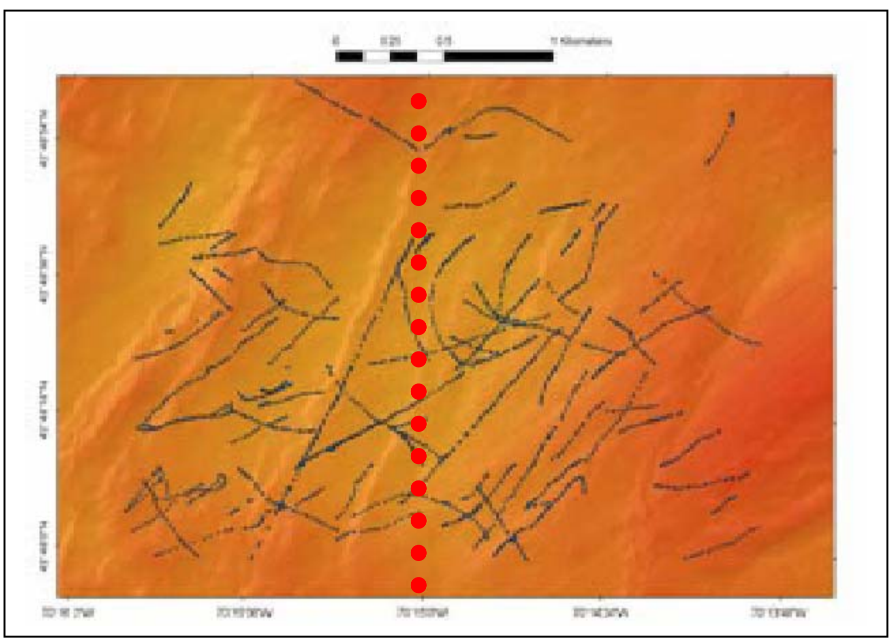


Figure 3: Inferred bottom marks from MBES data. Red line marks boundary of fishing closure.

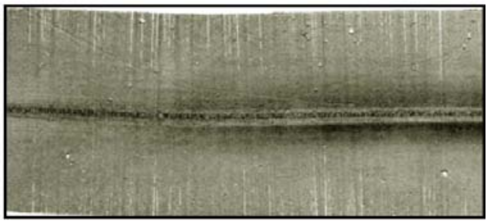


Figure 4: An example of bottom marks detected in Klein 5500 sidescan sonar survey.

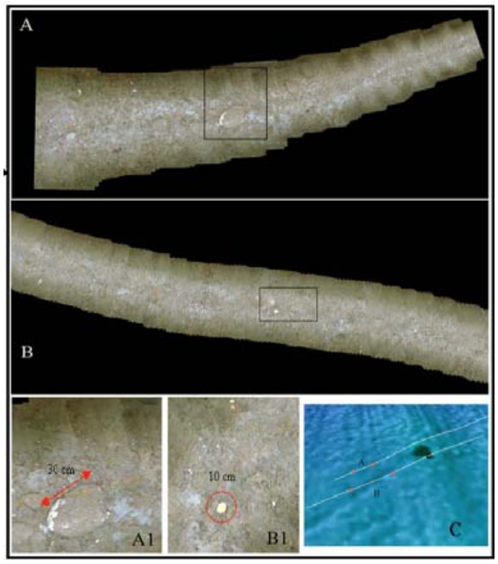
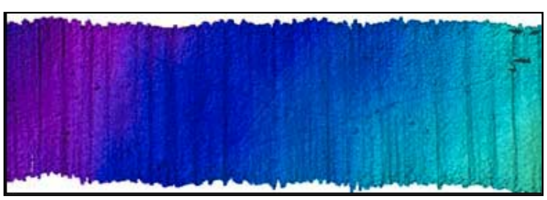
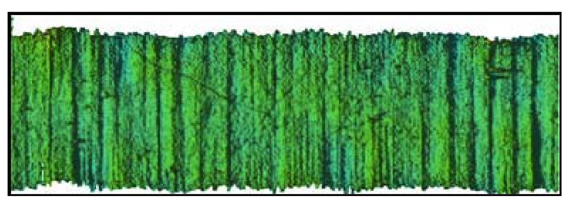


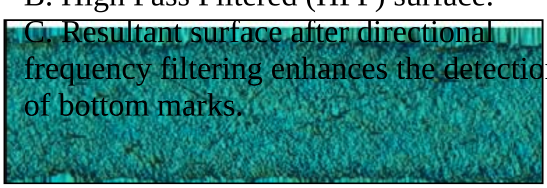
Figure 5: Investigation of bottom marks using video. A and B show mosaics built from video collected in vicinity of bottom marks, location shown in C. A1 and B1 are zoomed in views of mosaics in A and B.





A B

Figure 6: Extraction of bottom marks from a track line of MBES data.
A. Original DTM from Reson 8125 MBES.
B. High Pass Filtered (HPF) surface.
C. Resultant surface after directional frequency filtering enhances the detection of bottom marks.



C

EFFECTS OF THE WESTERN FUL OF MAINE CLOSURE AREA ON BOTTOM HABITATS: A PRELIMINARY GIS-BASED ASSESSMENT

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ABSTRACT

Overview

In 1997, the Western Gulf of Maine (WGOM) closure area was established as part of the overall effort to re-build depleted groundfish stocks. Although some commercial gear types (e.g. lobster traps) are permitted, those capable of retaining groundfish (mainly otter trawls and gillnets) are prohibited year-round. The WGOM closure area, which is approximately 32 km (20 mi) wide (east-west) and 113 km (70 mi) long (north-south), is located off the northern New England, USA coast. The general area has been a primary fishing ground for cod, other gadids, and flatfish for centuries. The present project involved acquisition of new multibeam imagery (in 2002/03) and sampling of the seabed (during 2002 to 2005) at about 190 sites in a 400 km^2 (150 mi^2) study area (half inside the closed area and half outside) located along the western boundary of the closure area. A combination of towed video, box coring, and Shipek grab sampling was used to characterize the bottom. Some preliminary fish sampling at paired sites inside and outside the closed area was also conducted in October 2005.

GIS has been used to produce a variety of maps of bottom habitats, with emphasis on characteristics of benthic communities. All data have not been analyzed, but preliminary results indicate four major conclusions can be drawn at this time:

(1) Habitat types in the study area range from highly organic mud bottoms in deep water (>100 m) dominated by deposit-feeding infauna to hard bottoms (gravel and boulders) in water <80 m dominated by epifaunal organisms (see Fig. 1 below for example stills). This range of bottom habitat types spans much of the spectrum for the entire Gulf of Maine. In addition, most of the habitat types were found both inside and outside the closure area. This probably will allow

extensive "in vs. out" assessments to determine how the major bottom habitat types have been affected by the closure.

(2) A variety of bottom physical characteristics and benthic community characteristics correlated strongly with water depth, suggesting that the new multibeam bathymetry map (Fig. 2) can be used to construct high-resolution (5-m pixels) maps of bottom sediment and habitat types. Seabed sampling with video and grabs was conducted at a maximum of ~1.6 km (1 nautical mile) intervals, which is a very high intensity compared to previous studies in the region. However, for bottom habitat mapping this resolution probably can be increased substantially by utilizing the multibeam map to determine habitat boundaries. This component of the study is in the initial stages.

(3) Distribution and abundance patterns of some benthic taxa and community characteristics showed substantial differences when comparing sites inside to similar sites outside the WGOM closure area (Fig. 3). These data suggest that there has been substantial recovery of some habitat types—particularly epibenthic communities dominated by ascidians and/or sponges—since establishment of the closure.

(4) Gillnet sampling over five days at paired (inside vs. outside) hard-bottom sites in October 2005 showed an average 3-fold higher biomass of groundfish (cod, haddock, pollock and hake combined) at sites inside the closed area compared to outside. Nearly all fish captured were large juveniles or adults, and the largest fish (up to ~22 kg) were caught inside. These data suggest that rocky bottoms in the closed area provide enhanced habitat for groundfish, but more intensive sampling of these habitats is needed.

Application to Fishery Research and Management:

Previous research on the WGOM closure area includes analyses of commercial trawl data and groundfish tagging studies. None of this research demonstrated an appreciable effect of the WGOM closure on stock re-building in the region, although there has been substantial recovery of some groundfish stocks since the closure was established. Based on studies of other fishing closures, including some in New England, it seems reasonable to presume that a closure of the magnitude of the WGOM area would have a measurable impact on fish stock recovery. Its role in this respect, however, remains to be demonstrated. Our study provides evidence that the closure has resulted in substantial recovery of some bottom habitat types since its establishment, and some fish populations may also have been affected.

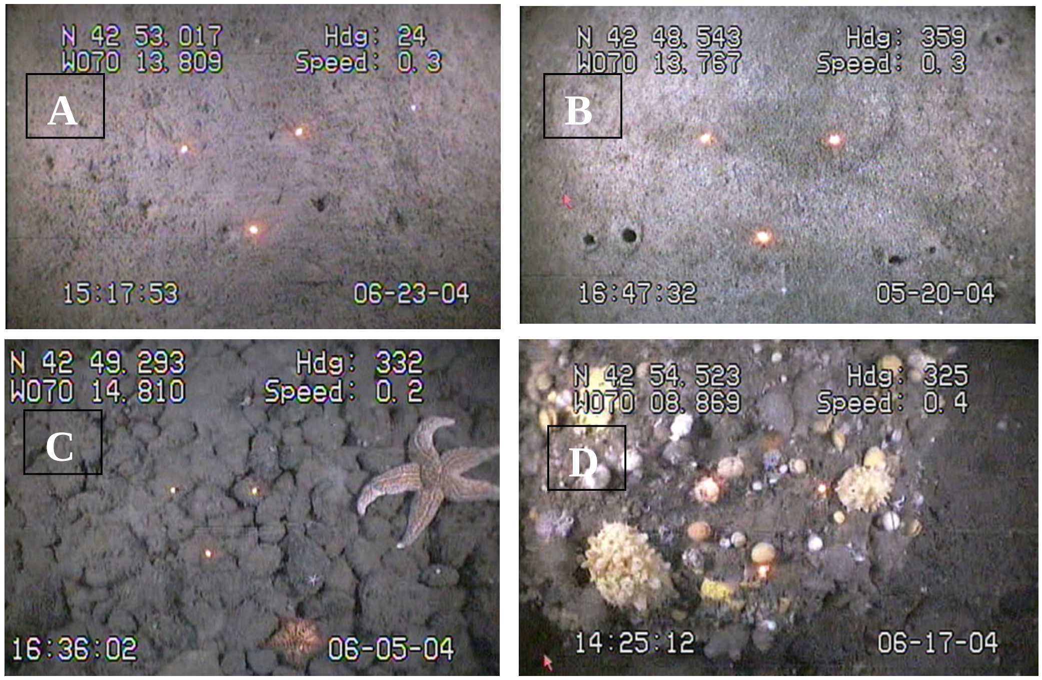

Fig. 1. Video stills showing examples of major bottom habitat types (preliminarily defined by water depth/bottom type/dominant macrofauna) within the overall study area (Fig. 2). A) 135 m/muddy sand/deposit-feeding infauna. B) 60 m/sand/infauna. C) 62 m/gravel/epifauna. D) 57 m/boulders/epifauna.

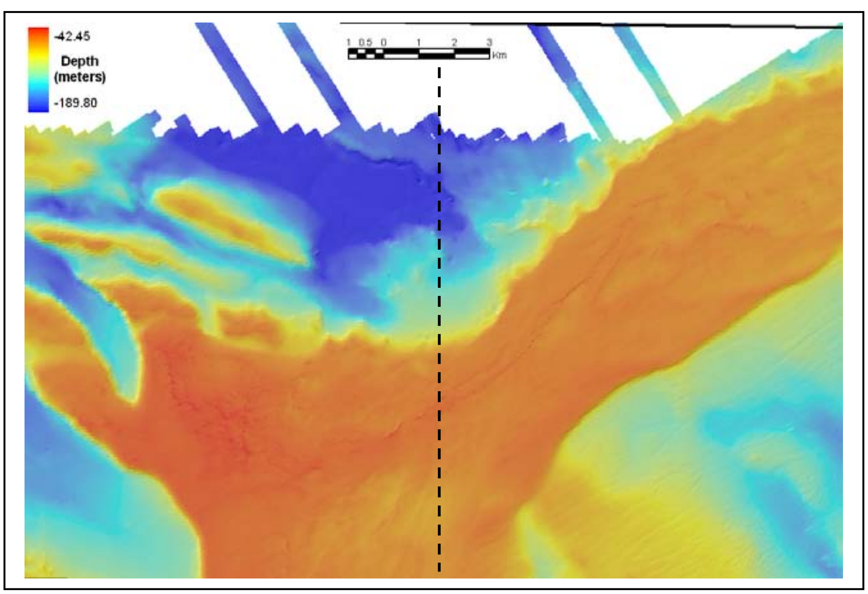

Fig. 2. Bathymetric map at 5-m pixel resolution of the 400 km^2 study area. Vertical dashed line is the western boundary of the WGOM closure area.

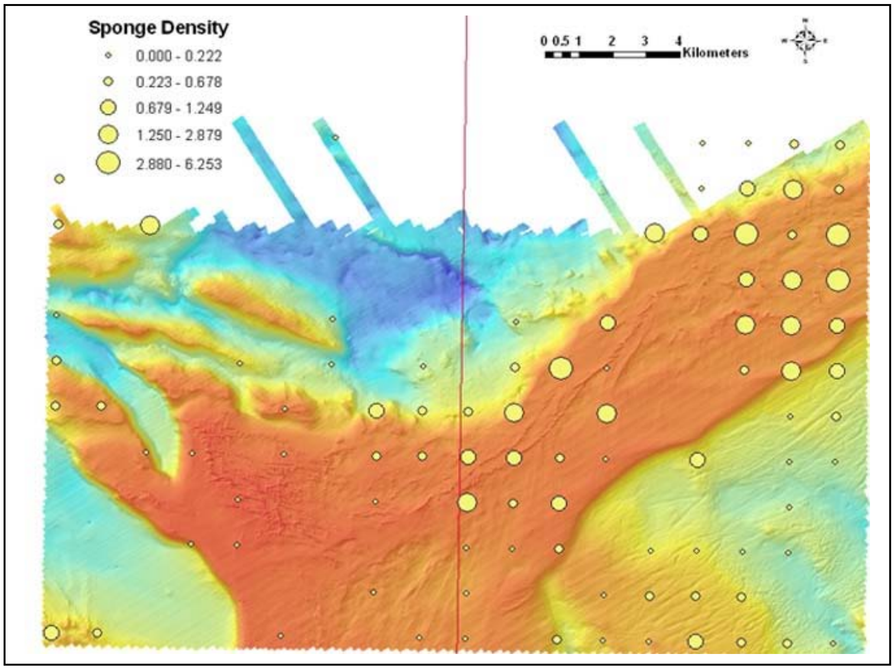

Fig. 3. Densities (#/m^2) of sponges based on video data. Vertical dashed line is the western boundary of the WGOM closure area.

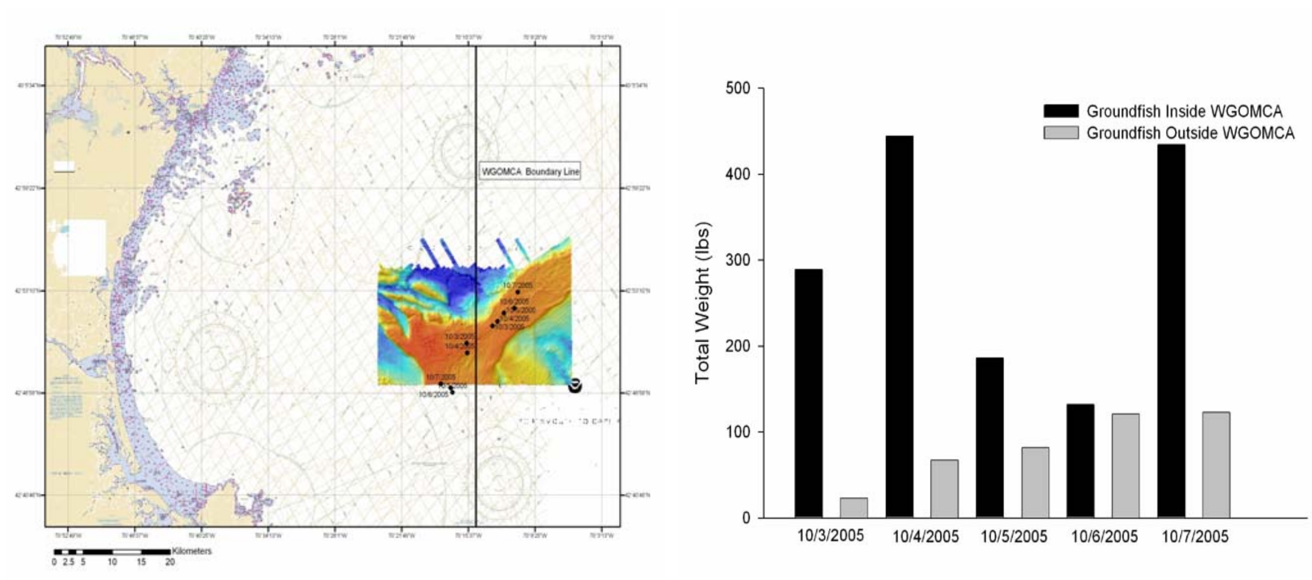

Fig. 4. Locations and groundfish catches for 5 days of paired (one site inside the WGOM closure area, one outside) identical 24-hr gillnet sets on hard bottom sites along Jeffreys Ledge.

DESIGNATING HABITAT AREAS OF PARTICULAR CONCERN FOR THE GULF OF MEXICO USING GIS

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ABSTRACT

The Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act encourage the National Marine Fisheries Service (NMFS) and regional Fishery Management Councils to designate Habitat Areas of Particular Concern (HAPC) within areas identified as EFH to focus conservation priorities on specific areas that play a particularly important role in the life cycles of federally managed fish species. Identifying a few most important habitat areas as HAPC on the basis of their habitat attributes encourages a higher level of scrutiny for conservation, and gives the managed species that occur there an extra buffer against adverse impacts. HAPCs are intended to be very specific, mappable, and definable areas, and not broad areas of the Gulf or all areas of a particular habitat. HAPCs may be designated for purposes other than mitigating adverse fishing impacts. Identification of HAPCs gives the Gulf of Mexico Fishery Management Council (Council) and NMFS added opportunity to influence non-fishing activities that may adversely affect habitat. All mapping of the HAPC sites was conducted using a GIS developed exclusively for this analysis.

Whereas EFH must be described and identified as for each species and life stage in the fishery management units (FMUs), HAPCs are identified on the basis of habitat level considerations. The Final Rule lists the following considerations that guide the designation of HAPCs:

- The importance of the ecological function provided by the habitat;
- The extent to which the habitat is sensitive to human-induced environmental degradation;
- Whether and to what extent development activities are or will be stressing the habitat;
- The rarity of the habitat type.

The designation of HAPCs is intended to identify to anyone considering actions that might be potentially threatening to habitat those areas of EFH considered to be of the highest importance in the life cycles of managed species and most in need of protection. An HAPC is expected to be a localized area of EFH that is especially ecologically important, sensitive, stressed, or rare when compared to the rest of a species EFH geographic range.

The ecological importance of a habitat stems from the function that it provides to the managed species. An important aspect of measuring ecological importance for the purpose of identifying HAPCs is that the metric used provides sufficient contrast to enable local areas to be distinguished from one another. A habitat use database was used to run queries for the suite of species in each fishery management plan (FMP). The tally results or scores were used to rank habitats in order of importance for each FMP and ecological function within each eco-region. Maps were produced depicting the habitat use rankings of mapped habitat types. The maps were used to show locations of potential HAPCs for the purpose of developing HAPC alternatives under each FMP. In addition to the rankings under each FMP, a composite ranking of overall use of habitat across all FMPs was also developed. This was intended to show areas of habitat that are important for all FMPs to provide additional options for identifying HAPCs.

Human induced environmental degradation can result from both fishing activities and non-fishing activities such as coastal development and pollution. Certain habitat structures such as reefs, hard/live bottom, mangroves, seagrasses, and marshes are particularly sensitive to human-induced environmental degradation. They are sensitive to fishing gears and other activities such as dredging, mining, pipeline construction, coastal development, shipping, contaminants, and disposal. In developing metrics for sensitivity, the inherent susceptibility of habitats to fishing and non-fishing impacts that are likely to result in impairment of the function of the habitat for fish species was considered. It is a measure of the potential for impairment given the types of activities that could affect the habitat, and the natural characteristics and situation of the habitats themselves. A sensitivity index was developed as a tabular matrix for both fishing and non-fishing activities. Sensitivity index scores were assigned based upon the effect's direct influence on a specific habitat type. Data from the sensitivity indices were mapped on a grid consisting of the 21 NOAA Fisheries Statistical Zones with bathymetry. Sediment and habitat types were assigned their respective relative sensitivity index values and mapped throughout the Gulf of Mexico.

Assessing the extent to which development activities are stressing or will stress areas of habitat requires knowledge of the spatial distribution of those activities in the past, present, and possible future in relation to local habitats. To obtain a measure of the risk that an area is or will be stressed by development activities, data on the spatial intensity of these non-fishing activities must be combined with the sensitivity of habitats to impacts that they might cause. To quantify the effects of non-fishing activities, geographic information system (GIS) data that represented these activities were gathered from various sources throughout the Gulf of Mexico region and used in the analysis. These sources included the USGS, NOAA, USACE, MMS, EPA, and various local government agencies.

alculation of habitat rarity requires subdivision of the total area into parcels of contiguous patches of single habitat type, characterized, for example, by substrate/biogenic structure type, depth, temperature, and possibly some geographic range such as a predefined ecological sub-region. Ideally, the parcels should be of the

same sort of local scale as that envisioned in the EFH Final Rule, so that the analysis can be used to identify viable candidate areas for HAPCs. The rarity of the habitat parcel was measured in terms of the mapped area of the habitat type relative to the total area of all mapped habitat types multiplied by the distance to the nearest neighboring parcel(s). Calculations of this type can be implemented relatively easy in a GIS that maps all the habitats. For the analysis, a habitat rarity index was calculated as follows:

$$\textit{Rarity Index Score for habitat type within Unit} = \frac{\textit{Total Area of Unit}}{\textit{Total area of habitat type within the Unit}} \; X \; \textit{Average of the nearest neighbor distance for the parcels of habitat type within the Unit}$$

A habitat type was defined by its standard substrate/biogenic structure type (as mapped) and its depth (split into estuarine, and nearshore/offshore). The analysis was done separately for each eco-region in an effort to represent rarity on a reasonable basis. It gives scores on a scale from high rarity to low rarity. The results were difficult to interpret. This is in part because the analysis is looking across the entire Gulf of Mexico for parcels of habitat that might be only a few miles or less in scale. The total number of individual habitat parcels in the analysis was about 31,500. Of these about 30,300 (96%) had rarity that are less than 0.02% of the values of the parcels in the most rare category. The statistical properties of this index needed to be carefully considered in terms of its utility as a metric for identifying HAPCs on the basis of rarity. The analysis could have been enhanced. However, due to the large number of habitat parcels there was insufficient time to refine the analysis.

The Council designated HAPC as discrete areas and sites selected to meet one or more of the four criteria. These HAPC sites predominantly contain living coral reefs or hard bottom areas with known coral colonies. They include the following areas: the Florida Middle Grounds; Tortugas North and South Ecological Reserves; Pulley Ridge; and the individual reefs and banks of the Northwestern Gulf of Mexico (East and West Flower Garden Banks, Stetson Bank, MacNeil Bank, 29 Fathom, Rankin Bright Bank, Rezak Sidner Bank, Geyer Bank, McGrail Bank, Bouma Bank, Sonnier Bank, Alderice Bank, and Jakkula Bank). Additionally, the Madison-Swanson Marine Reserve is very important as a known spawning aggregation site primarily for gag and scamp, though other reef fish species also spawn there. Living coral reefs (on patch reefs or as outer bank reefs) are rare in the Gulf of Mexico. They are highly sensitive to human induced degradation (from direct physical impact and degradation of water quality); are currently being stressed in many regions; and are important habitat to numerous species of reef fish and shellfish.

The following fishing restrictions were established for the Gulf of Mexico: 1) prohibit bottom anchoring over coral reefs in HAPCs (East and West Flower Garden Banks, McGrail Bank, Pulley Ridge, and North and South Tortugas Ecological Reserves) and on the significant coral resources on Stetson Bank; 2) prohibit the use of trawling gear, bottom longlines, buoy gear, and all traps/pots on coral reefs in the East and West Flower Garden Banks, McGrail Bank, Pulley Ridge, and North and South Tortugas

Ecological Reserves HAPCs and on the significant coral communities on Stetson Bank; 3) require a weak link in the tickler chain of bottom trawls on all habitats throughout the Gulf of Mexico exclusive economic zone.

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TWO EXAMPLES OF THE PROCESS USED TO ASSESS THE EFFICACY OF MPAs: THE WEST FLORIDA SHELF AND THE SOUTH ATLANTIC BIGHT

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ABSTRACT

Introduction

For the past five years the NOAA Fisheries laboratory in Panama City, FL, concretely its Marine Reserves group, has been working on the evaluation of Marine Protected Areas (MPAs) and its effectiveness as a management tool. The areas being examined include: the reserves in the Gulf of Mexico along the West Florida shelf and proposed MPAs in the South Atlantic area.

Both projects are ongoing at this point, although in different stages of the evaluation process. The West Florida study began in 2000 after the closure had already been implemented, data from 2001 and 2002 has already been processed and data from 2003 and 2005 is presently being analyzed. The South Atlantic reserves are not closed to fishing yet, which presents a unique opportunity to examine these areas before fishing restrictions are implemented. To data, only one cruise has taken place, so data at this point is limited.

Both projects follow the same methodology, a stratified random survey to estimate fish abundances associated with bathymetric features. A remotely operated vehicle (ROV), a camera array, and chevron fish traps are used to examine habitat and fish populations of the MPAs. High resolution bathymetric maps, when available, are used for site selection and habitat stratification.

Although they are not completed, these two projects represent a good example of the process followed to assess the effectiveness of MPAs for increasing populations of economically valuable fish and will in the future show the weaknesses and strengths of this management tool.

Background Information

West Florida Reserves

In July 1999, the Gulf of Mexico Fishery Management Council established two marine MPAs closed to fishing of all species with the primary purpose of protecting spawning aggregations of gag grouper (*Mycteroperca microlepis*). These MPAs, Madison Swanson and Steamboat Lumps, are located between 28 and 30 degrees latitude in the northeastern Gulf of Mexico, approximately 80 and 160 km SSE of Panama City, FL.

The life history strategy for gag makes them particularly vulnerable to fishing during their spawning season. Gag are protogynous hermaphrodites, that is, all gag are born as females and a small percentage switch sex to males once they reach a certain size and if no other males are

nearby. During the spawning season, December - April, female gag gather in large breeding harems of up to 50 fish, all guarded by a single male. This male becomes very territorial and loses his natural wariness of baited hooks. The practice of fishing on gag spawning aggregations increases the focus of the fishery on large breeders, decreases the proportion of males in the population, disrupts the social structure of the spawning groups, and can even cause complete loss of spawning groups. Therefore, it was recommended that a representative area of known gag spawning habitat be closed to fishing.

In 2000, the NOAA Fisheries Laboratory in Panama City, FL, proceeded to evaluate the effectiveness of the marine reserve concept in this application, choosing Madison-Swanson and Steamboat Lumps areas as study sites. Both are approximately the same size (roughly 100 square miles), contain similar depths (200-400 ft.), and have similar habitat (rocky ledges on sandy plains). The differences between the reserves include the geographic locations and the scale of the rocky habitat; Madison-Swanson is characterized as high relief and Steamboat Lumps is characterized as low relief. Another area of similar depth and habitat, known as the Twin Ridges, is adjacent to Madison-Swanson and will be studied as a control site as it remains open to fishing.

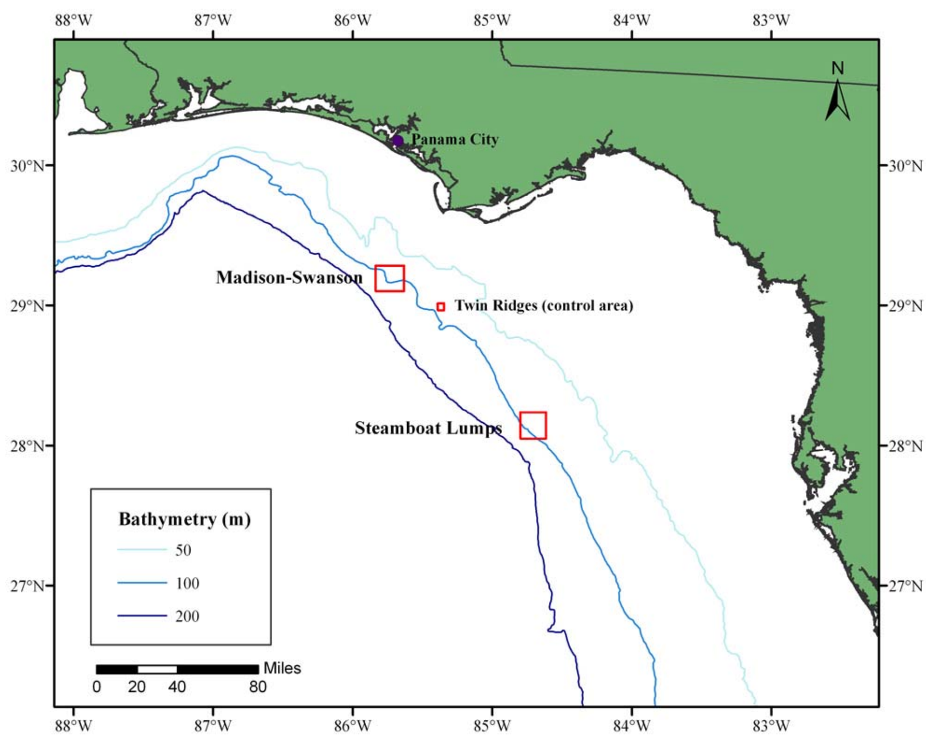

Fig. 1.- Map of the West Florida MPAs, Madison-Swanson and Steamboat Lumps, and the control area, Twin Ridges.

The specific objectives for this study are:

- Obtain baseline estimates of fish abundance
- Map and describe habitat features

- Track changes in reef fish distribution and abundance through closure period
- Locate spawning aggregations of groupers and snappers
- Compare MPAs with open to fishing areas

The reserves have been sampled during two time periods, corresponding to spawning of the target species, between 2001 and 2005 thus far. Sampling in February/March corresponds to gag and scamp spawning and sampling in the summer corresponds to snapper spawning. Moreover, the area was mapped in 2001 and 2002 obtaining multibeam and backscatter maps of both the sampling sites and the control area, which were used to stratify the areas and choose sites to be evaluated.

South Atlantic Reserves

The South Atlantic Fishery Management Council (SAFMC) is considering the implementation of nine MPAs between Cape Hatteras, NC, and the Florida Keys to protect seven species of the deepwater snapper-grouper complex. These consist of five species of grouper including snowy grouper (*Epinephelus niveatus*), yellowedge grouper (*E. flavolimbatus*), warsaw grouper (*E. nigritus*), speckled hind (*E. drummondhayi*), and misty grouper (*E. mystacinus*) and two species of tilefish including tilefish (*Lopholatilus chamaeleonticeps*) and blueline tilefish (*Caulolatilus microps*). These species are considered to be at risk due to currently low stocks and their life history characteristics. All of them are slow growing, long-lived species, most of which are considered to be overfished based on recent stock assessments. In addition, as explained in the case of gag grouper, most of the grouper species are protogynous hermaphrodites attracted to high-relief sites where they aggregate to spawn and are thus susceptible to targeted fishing operations which may selectively remove males (Coleman et al, 1996). The proposed areas are known to contain habitat which supports populations of economically valuable reef fish including the seven targeted species and other reef fish.

The NOAA Fisheries Laboratory in Panama City volunteered to conduct preliminary investigations of the proposed MPAs and then to evaluate the efficacy of the closures once they have been made. Our goal was to conduct preliminary examinations of five of the proposed MPAs including Snowy Wreck, NC, two sites in South Carolina (denoted as “A” and “B”), Georgia and North Florida, each containing two or more options.

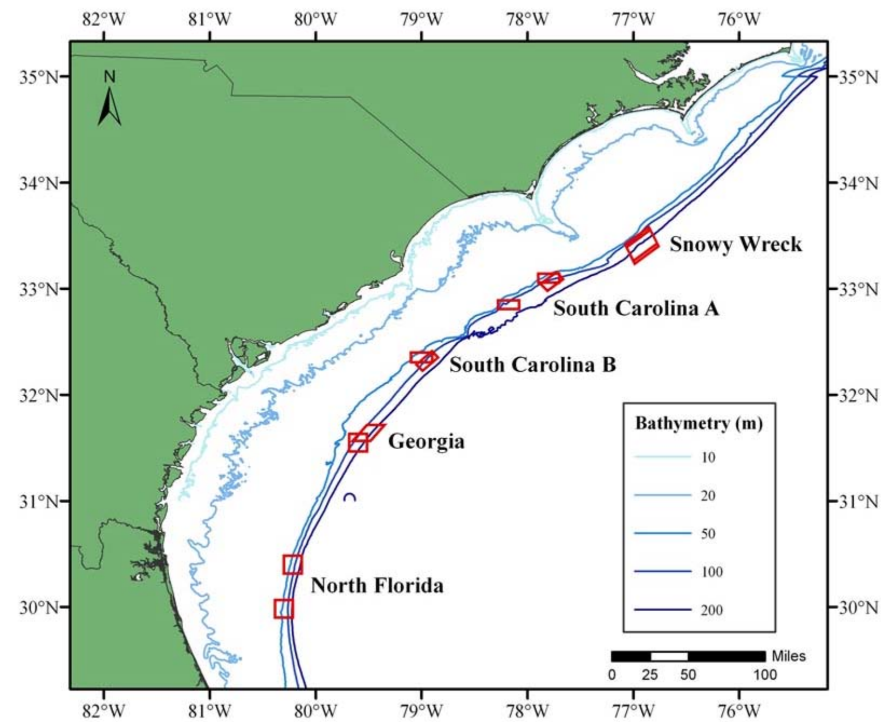

Fig. 2.- Map of the 5 proposed MPAs studied by the NOAA Fisheries Laboratory, in Panama City, FL. Each MPA has two options, except South Carolina A which has three.

The objectives of the pre-closure study include:

- Establish baseline estimates of reef fish density and species composition associated with bottom features within and outside the MPAs
- Map and describe habitat features
- Document the relationship between habitat and species assemblages

The proposed MPAs were sampled on a cruise in April-May 2004, and another is planned for April-May 2006. High resolution bathymetric maps didn't exist before the first cruise. However, in June-July 2005, a mapping cruise was funded for the areas of South Carolina A and Georgia, completing only 35% of the South Carolina MPA and 10% of the Georgia MPA.

Methodology

Both areas are studied following the same methodology, with the use of underwater videography, which is an effective, non-destructive and data-rich method for surveying benthic communities over relatively large areas (Stevens and Connolly, 2005).

The primary gear used is a remotely operated vehicle (ROV). A down-weight of about 145 kg was tethered to an umbilical to allow the ROV to drift just above the bottom at approximately one knot. The ROV provides continuous video data as well as high resolution digital still images

of fish and habitat within the study areas. The video footage is then used to delineate and quantify habitat type as well as fish species presence and density within each habitat type.

We also used a stationary video camera array to determine relative abundance of fish and percent cover of habitat within each proposed MPA. The array is comprised of four cameras mounted at 90° angles to each other in the horizontal plane at a height of 30 cm above the bottom of the array.

A chevron fish trap baited with mackerel was also deployed at the study sites. All fish captured were measured and, in addition, the targeted species were weighted and their otoliths and gonads removed for age, growth and reproductive studies back at the laboratory.

Fig 3.- Gear used during the monitoring programs. From left to right: ROV, Fish trap and Camera array

Ideally, the assessment of the efficacy of MPAs would require a sequential approach of mapping, habitat delineation and fishery surveys. High resolution maps are extremely crucial in site selection for this type of study. However, maps are not always available before a cruise starts. This was the case of the South Atlantic study, where site selection was based on local knowledge and split beam bathymetry collected during the cruise.

Multibeam maps and all fishery data are included in a GIS project for its future geospatial analysis.

Discussion and future work

Conclusions at this point are limited, but there are some statements that can be made from the data obtained during the last five years.

For the West Florida MPAs, the data from 2001 and 2002 showed that in general abundances were greater within the reserves. Moreover, some changes in abundance estimates between years were noted. Within Madison-Swanson, the abundance of red grouper, gag, and scamp increased. Within Steamboat Lumps, an increase in abundance was noted for red grouper and scamp.

Although the numbers show an improvement since the implementation of the MPAs, fishing activity remains a significant problem in this area. Enforcement is difficult due to the remote location and a “true test” of marine reserve performance can only be measured if there is a

change in enforcement level. Even relatively moderate levels of poaching can quickly deplete gains achieved by closure (Roberts and Polunin, 1991).

For the South Atlantic reserves, we only have data from one cruise, so little can be stated at this point. Three of the target species (speckled hind, snowy grouper and blueline tilefish) were observed during this study. However, the remaining targeted species (yellowedge grouper, misty grouper, warsaw grouper and tilefish) were not seen. The three species that were observed inhabit the shallowest depths (starting at 30m), while those species not seen are normally found in a depth over 60m. Since most of the ROV dives were done in areas shallower than 60 m, depth may explain why several of the targeted species were not found. Accordingly, since grouper and tilefish occupy slightly different habitat types, separate sites may have to be chosen for each group of species.

The South Atlantic MPAs may be put in effect as early as 2006, thus two years of data will be acquired and used to examine the population levels of these sites under fishing pressure. Location of the reserves is critical if enhancement of fishery yields is to occur (Stockhausen et al. 2000). It is hoped that the results from this initial study and our second cruise scheduled for April 2006 will aid the SAFMC in placement of the MPAs.

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A SPATIAL AND TEMPORAL ANALYSIS OF BUTTERFISH DISCARDS IN THE SMALL-MESH FISHERIES OF THE SOUTHERN NEW ENGLAND-MID ATLANTIC BIGHT REGIONS

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ABSTRACT

Annual discards of butterfish in USA Atlantic coast fisheries during 1989-2002 have been estimated to be more than twice the actual landings of butterfish, and these discards are hampering the recovery of the butterfish stock. Most butterfish discards occur in the small-mesh, directed, bottom trawl fisheries for longfin inshore squid (*Loligo pealeii*) and northern shortfin squid (*Illex illecebrosus*).

ArcGIS software was used to evaluate spatial and temporal trends in the distribution of butterfish discards in these small-mesh bottom trawl fisheries to assess whether areas exist in the Southern New England-Mid Atlantic Bight (SNE-MAB) regions that would allow the directed small-mesh fisheries to proceed with minimal bycatch of butterfish. As well, GIS analyses were conducted to assess the spatial overlap of butterfish and the two squid species using NEFSC bottom trawl survey data. The two sets of GIS results indicate that *Loligo* and butterfish co-occur throughout the SNE-MAB region during autumn and along the shelf edge during winter and spring. *Illex* and butterfish co-occurrence is concentrated along the shelf edge during autumn. These co-occurrence patterns generate high butterfish discards in the small-mesh trawl fisheries conducted during these seasons in these areas. These findings suggest that butterfish stock recovery would be significantly enhanced if discrete time/area closures were implemented in the small-mesh fisheries during these seasons.

ESITE: AN INTERACTIVE, ONLINE GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR STAKEHOLDER PARTICIPATION IN ENVIRONMENTAL SITING DECISION-MAKING

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ABSTRACT

An interactive, online geographic information system (GIS) was developed to enhance the involvement of stakeholders in the public participation processes of site selection issues in the marine environment. Displaying educational material and interactive maps of relevant data, this new tool allows users to input personal preferences for the criteria they value in the siting decision, and produces a map showing the most and least suitable sites according to the user's weighting of the criteria. Current decision-making processes focus on finding an optimum solution from a number of alternatives using an objective analysis of the criteria, but are often inaccessible to many stakeholders, and do not consider the fairness of the outcome to the stakeholders. This tool is intended to educate stakeholders and enhance their involvement in the public decision-making process.

To demonstrate the interactive, online GIS concept, a website called eSite was assembled, using as its case study the hypothetical issue of siting marine reserves within the Stellwagen Bank National Marine Sanctuary. Marine resource protection is a controversial issue with many stakeholders in New England, where fishing in the Gulf of Maine has a long history, and human activities have had significant impacts on the marine environment. Marine reserves are an emerging tool for protecting marine ecosystems and enhancing marine resources, and the siting of reserves is an important emerging issue.

ESite has been shown to be effective at increasing understanding of marine reserves and was perceived as a useful tool in improving the decision-making process. A public participation process is proposed, which takes advantage of the web-based mapping application. This tool has the potential to (1) improve communication with and education of stakeholders, (2) build capacity among stakeholders, (3) provide selection of suitable sites through criteria analysis, (4) improve the efficiency and acceptance of public participation processes, (5) enhance the quality and fairness of the siting decisions produced through public participation, and (6) expand to address siting issues in other aquatic and terrestrial ecosystems.

ESite demonstrates an application where a wide variety of GIS datasets from numerous sources were integrated to provide insights to management decisions. Given adequate data, the eSite concept could easily be applied to various fisheries-related siting issues from MPA designations to the optimization of fisheries regulation areas.

For more information, visit: http://dogfish.mit.edu/eSite/