Pilot Project to Assess Need and Initialize a Methodology to Groundtruth Existing Multi-beam and Side-scan Sonar Seafloor Charts

Award Number:

Performance Period: January 2006 – June 2008

Final Report Prepared on: 25 September 2008

Salvatore Genovese, Ph.D.
Marine Science Center
Northeastern University
430 Nahant Road
Nahant MA 01908
781.581.7370 x.311 voice
s.genovese@neu.edu

Abstract

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

Introduction

The need for accurate seafloor maps to support ocean resource management and develop new ocean policy is acute in the Gulf of Maine. This project employed commercial fishermen's knowledge of the ocean environment to evaluate the validity of existing U.S. Geological Survey (USGS) seafloor charts and to develop a systematic method to groundtruth areas that require further substantiation. In two focus group meetings, commercial fishermen reviewed existing side-scan and multi-beam sonar charts of an area extending from Cape Ann to Jeffery's Ledge and mark areas on the chart that conflict and correlate with their understanding of the seafloor environment. A sub-set of locations in state and federal waters prioritized by fishermen served as the pilot area to groundtruth the corresponding seafloor maps and to study physical properties of the seafloor. This sub-set of stations included sites noted by fishermen that require further data and also control areas that fishermen believe are appropriately represented by existing seafloor charts. A meter-square quadrat with fixed video and lights was constructed and real-time video was fed to a digital video recorder on the fishing vessel. Due to camera failure (i.e. flooding), an ROV, provided at no cost by Northeastern University was deployed. Video data were analyzed by the graduate student and were subsequently synthesized by the PI.

By collaborating with the local commercial fishing industry, this study will ultimately develop a cooperative, efficient method to groundtruth seafloor charts and improve the understanding of seafloor habitat. This project directly supports several new approaches to managing ocean resources, such as ecosystem-based management, ocean zoning and the Essential Fish Habitat provisions of the Magnuson-Stevens Act. An accurate

depiction of the seafloor is critical to inform regulatory decision-makers and increase knowledge of the structure and function of seafloor habitats in the Gulf of Maine.

Project Objectives

The objectives of this project were to determine the extent to which existing multi-beam and side-scan sonar charts require additional groundtruthing and interpretation, and to develop a method for groundtruthing existing seafloor charts in the identified areas. The pilot study area was in state waters and federal waters around Cape Ann, an area of diverse bottom habitat, prolific fishing, and increasing current and potential future use conflicts.

Participants

Dr. Salvatore Genovese (PI), is Director of Northeastern University's Three Seas Program and MS in Marine Biology Program. <s.genovese@neu.edu>

Dr. Madeleine Hall-Arber, anthropologist with Massachusetts Institute of Technology's Sea Grant College Program. <arber@mit.edu>

Anthony Wilbur, marine ecologist with the Massachusetts Office of Coastal Zone Management (CZM). <Tony.Wilbur@state.ma.us>

Captain BG Brown owns and operates his 32' vessel, *F/V Kathryn Leigh* out of her homeport of Gloucester. <wgbvbrown@yahoo.com>

David Bergeron was Executive Director of the MFP from its inception in 1995 until 2008. <dbergeron@mass-fish.org>

Olivia Free is the Collaborative Research Coordinator at the Massachusetts Fisherman's Partnership. <olivia@mass-fish.org>

Nicholas Richon served as a mate on the *F/V Kathryn Leigh* during the third and fourth days at sea.

Methods

To achieve project objectives, the following tasks were accomplished:

1) *Focus Group Meetings*: Dr. Madeleine Hall-Arber conducted two focus groups of local commercial fishermen who habitually fish in the area from Cape Ann to Jeffreys Ledge. It was critical for the groundtruthing of the charts that experienced, knowledgeable and currently active fishermen participate in the focus groups. Two recent collaborative projects sponsored by NEC have entailed fishermen asking other fishermen to map fishing grounds and relate their ecosystem observations. The community researchers from these two projects will be asked to recommend fishermen who demonstrated an awareness of bottom type and characteristics in the prior research. Approximately twenty individuals were invited to participate in the focus groups. Dr. Hall-Arber asked the fishermen to review the existing multi-beam and side-scan sonar charts that were developed by the USGS from 1994 to 1996 and to mark any areas that they feel misrepresent the bottom type or extent of a particular area of sediment on the charts in both state and federal waters. The existing charts show seafloor topography (bathymetry) and surficial geology as interpreted from backscatter intensity. Backscatter intensity is typically displayed as a gradient of color from red (hard bottom) to blue (soft bottom). The color gradient, at times, is not appropriate to the understanding of the seafloor by fishermen. Fishermen were asked to interpret existing color gradients of the bottom type and habitats found there and generate a prioritized set of areas to study.

2) *Summary Report*: Findings from focus groups and the resulting charts were synthesized into a working map by GIS staff at the Office of Massachusetts Coastal Zone Management (CZM), under the direction of Dr. Tony Wilbur, and were used as the basis for determining sampling sites. Sample stations were identified by a random stratified survey design, with strata including: (1) water depth, (2) multi-beam/side-scan sediment interpretation, (3) areas of fishermen-USGS map agreement, (4) areas of fishermen-USGS map disagreement, and (5) areas of 'concern' identified by fishermen. The areas of 'concern' may include portions of the seafloor that fishermen feel warrant more detailed investigation. Strata will be delineated in GIS and a minimum of one sample station per 1.0 km resolution will be sampled to ensure thorough characterization of the seafloor within the study area.

3) *Sampling Gear Construction*: To conduct the sampling, the participating fisherman and graduate student constructed and welded a durable stainless steel rod quadrat with a 1.0 m^2 field of view which would allow for quantification of seafloor features (sediment and biota) in the images. An underwater digital video camera and lights were fixed to the quadrat. Seafloor sediment will be qualitatively assessed within the quadrat (e.g., percent cover of sediment per quadrat).

4) *At Sea-Sampling*: Study areas were located from the focus group meetings that support a diversity of bottom types and allows the maximum number of samples to be collected. The field study will identify a sub-area of all locations identified in the focus group meetings to test the groundtruthing procedures. Working

together, the PIs, fisherman and graduate student will drop the quadrat on target sites identified by the random stratified design. Recorded video was digitally marked with GPS coordinates and still photographs (jpegs) were be collected from the video. The team completed sampling at 10 sites in a 8-10 hour day for a total of 4 research days during the spring months. No fishing gear was deployed during this project and no fish were caught or landed. Days-at-Sea were not used.

5) *Data Analysis and Reporting:* At the completion of the sampling period, the graduate student, under the supervision Dr. Genovese, analyzed data collected and synthesized findings on sediment types and sizes. Field data will be compared with the existing backscatter data displayed on seafloor maps to provide additional detail. These data can be compared to existing charts to demonstrate the variability in seafloor characteristics in the study area.

Data

Data collected is described for each of the data-related tasks listed in the Methods section:

1-2) *Focus Group Meetings* and *Summary Report*: These findings were synthesized in a report prepared by Anthony Wilbur on GIS Methodology which is based on the information collected from the Focus Group Meetings coordinated by Dr. Madeline Hall-Arber.

3) *Sampling Gear Construction*: no quantitative data collected.

4) *At Sea-Sampling*: Study areas were located from the focus group meetings that support a diversity of bottom types and allows the maximum number of samples to be collected. The field study will identify a sub-area of all locations identified in the focus group meetings to test the groundtruthing procedures. Working together, the PI, fisherman and graduate student dropped the quadrat on target sites identified by the random stratified design. Recorded video was digitally marked with GPS coordinates and still photographs (jpegs) were collected from the video. The team completed sampling at 10 sites in a 8-10 hour day for a total of 4 research days during the spring months. No fishing gear was deployed during this project and no fish were caught or landed. Days-at-Sea were not used.

5) *Data Analysis and Reporting:* At the completion of the sampling period, the graduate student, under the supervision Dr. Genovese, analyzed data collected and synthesized findings on sediment types and sizes. Field data will be compared with the existing backscatter data displayed on seafloor maps to provide additional detail. These data can be superimposed on the existing charts to demonstrate the variability in seafloor characteristics in the study area

Results and Conclusions

The Focus Group Meetings Summary Report and description of GIS Methodology is attached as Appendix I.

Data Collected from the At-Sea Sampling Days were concentrated at a total of 10 sampling stations. The meter-squared quadrat and drop camera package was deployed from the starboard side of the *F/V Kathryn Leigh* (Figure 1). Four stations were located near shore, and were chosen as test areas (Figure 2). The remaining six stations were located on Southern Jeffreys Ledge and were noted as areas of interest by fishermen (Figure 3). After an initial test day at sea, the next two At-Sea Sampling days were cut short due to flooding of the drop camera. The last day of sampling was completed using a Phantom 300 ROV provided by Northeastern University. All data reported here were collected with the ROV.

Related to the project's overall goal of groundtruthing seafloor maps, our data analysis was concentrated on distilling video data from the ocean's floor into two pieces of information easily interpreted by scientists and fishermen alike: 1) Percent cover analysis of the substratum at each station. 2) Grain Size frequency distributions at each station for pebble-and-larger grain sizes.

Substratum percent cover data was broadly divided into two categories, either sand/mud, or cobbles/boulders. For each sampling station digital ROV video was downloaded to computer disk, and 10 frames were grabbed for subsequent analysis. A grid of 200 random dots were superimposed over the image, and the substrate behind each dot was determined, thereby allowing mean percent cover of each substratum type as well as the interframe variation in percent cover to be determined (Figure 4). Comparing our data on substratum type (Figure 4) to that which is provided from the corresponding seafloor maps (Figure 2, 3), we see good agreement for the two datasets at every station. The only obvious exception is Station 1, which would be expected to be a soft substrate habitat dominated by sand/mud. Instead our data indicates a higher composition of cobbles/rock than would otherwise be expected. More sampling would be needed to determine if this is a small-scale phenomenon due to low sample size or the sampling of an atypical portion of this polygon.

Grain size frequency distribution data is also of interest to fishermen because it provides useful information regarding bottom type, and whether substratum characteristics would be detrimental to certain gear types (e.g. bottom trawls in boulder fields). At each of the 10 stations sampled, the diameter of gravel 1.5 cm and above were determined in 10 sample frames. A total of nearly 1100 pieces were analyzed, and these results are presented for each station in Figure 5 as a box plot. This presentation of the data shows the distribution of gravel sizes, and can be used as a predictive tool to forecast the likelihood of encountered boulders that could damage bottom gear.

Taken together, these two pieces of data provide a more detailed assessment of bottom type than would otherwise be ascertained from existing seafloor maps. In specific, they help provide detailed information regarding the variability in bottom type at a specific station. While the remote sampling techniques used to produce the seafloor maps can not be matched in terms of production speed, this pilot project demonstrated an ability to collect more detailed information on bottom type. Without a doubt, the major shortcoming of this project was the repeated failure of the drop camera. With the necessary funds required to obtain a robust and reliable instrument (the camera deployed cost $600) we could have increased our data collection four-fold.

Partnerships

There was good quality to the fisherman-scientist partnership, especially with respect to the At Sea Sampling. This research topic has been of mutual interest to fisherman and scientists, as demonstrated by the strong showing at the focus study group meetings, and could not have been accomplished without fisherman participation.

Impacts and Applications

This study successfully developed a cooperative and efficient method to groundtruth seafloor charts and improve the understanding of seafloor habitat. This project directly supported several new approaches to managing ocean resources, such as ecosystem-based management, ocean zoning and the Essential Fish Habitat provisions of the Magnuson-Stevens Act. An accurate depiction of the seafloor is critical to inform regulatory decision-makers and increase knowledge of the structure and function of seafloor habitats in the Gulf of Maine.

Related Projects

This project helped two MS in Marine Biology students at Northeastern University fulfill the internship requirement of their degree program. Additional funding for these students was provided by Northeastern University's Three Seas Program.

Presentations:

No presentations have been delivered to date.

Student Participation

Edward Baker <baker.e@neu.edu> and *William Boudreau* <boudreau.w@neu.edu> were Northeastern University MS in Marine Biology Graduate Students participating in this project in partial fulfillment of the internship requirement of their Professional Master's of Science Degree program.

Published reports and papers

No published reports or papers have been produced to date.

Images

To be provided separately.

Future research

Having demonstrated the ability to collect groundtruthing data, no future research is proposed at this time. Funding for additional sampling would improve the existing preliminary dataset and allow sampling of additional questionable areas.

Figure 1: Tony Wilbur, Captain BG Brown, and Edward Baker (L-R) deploying the meter-squared quadrat and drop camera instrument package aboard the *F/V Kathryn Leigh* in Gloucester Harbor.

Figure 2: Near Shore Sample Sites (Stations #1 – 4)

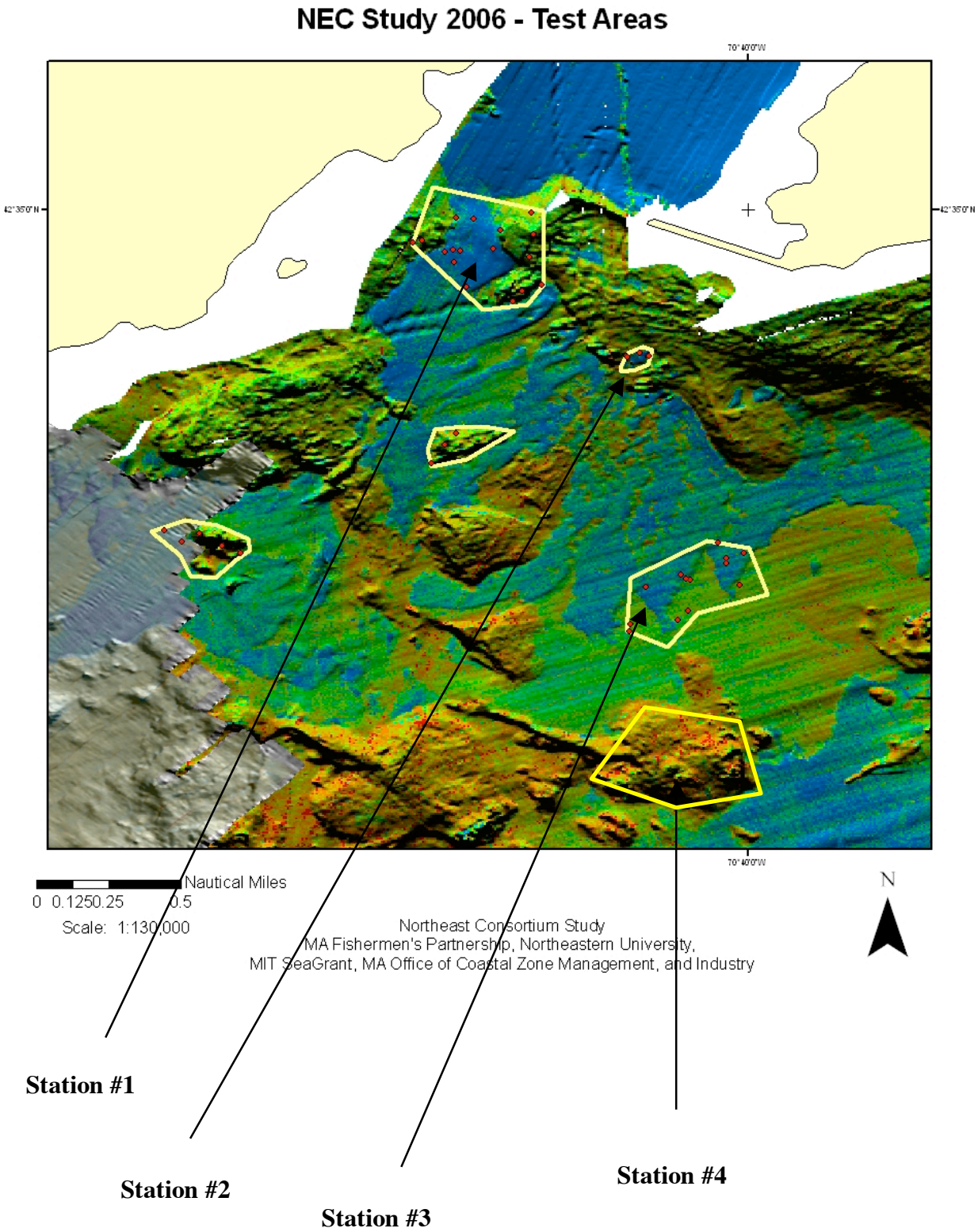


Figure 3: Jeffreys Ledge Sample Sites (Stations #5 - 10)

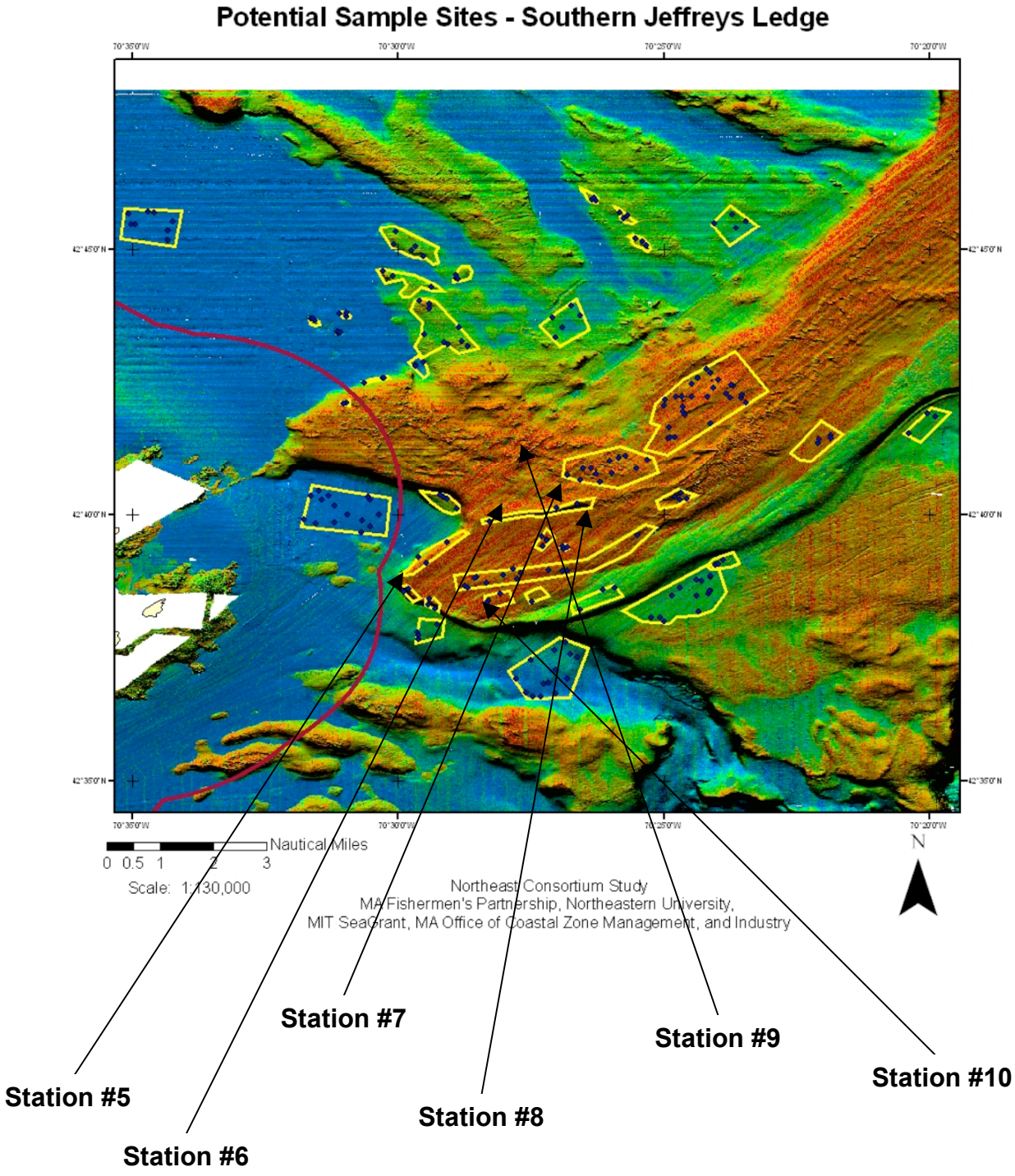


Figure 4: Substrate compositon as either sand/mud or cobble/rock bottom at the 10 sampling stations. Error bars represent one standard deviation from the mean value. N=10 video frames analyzed for each station.

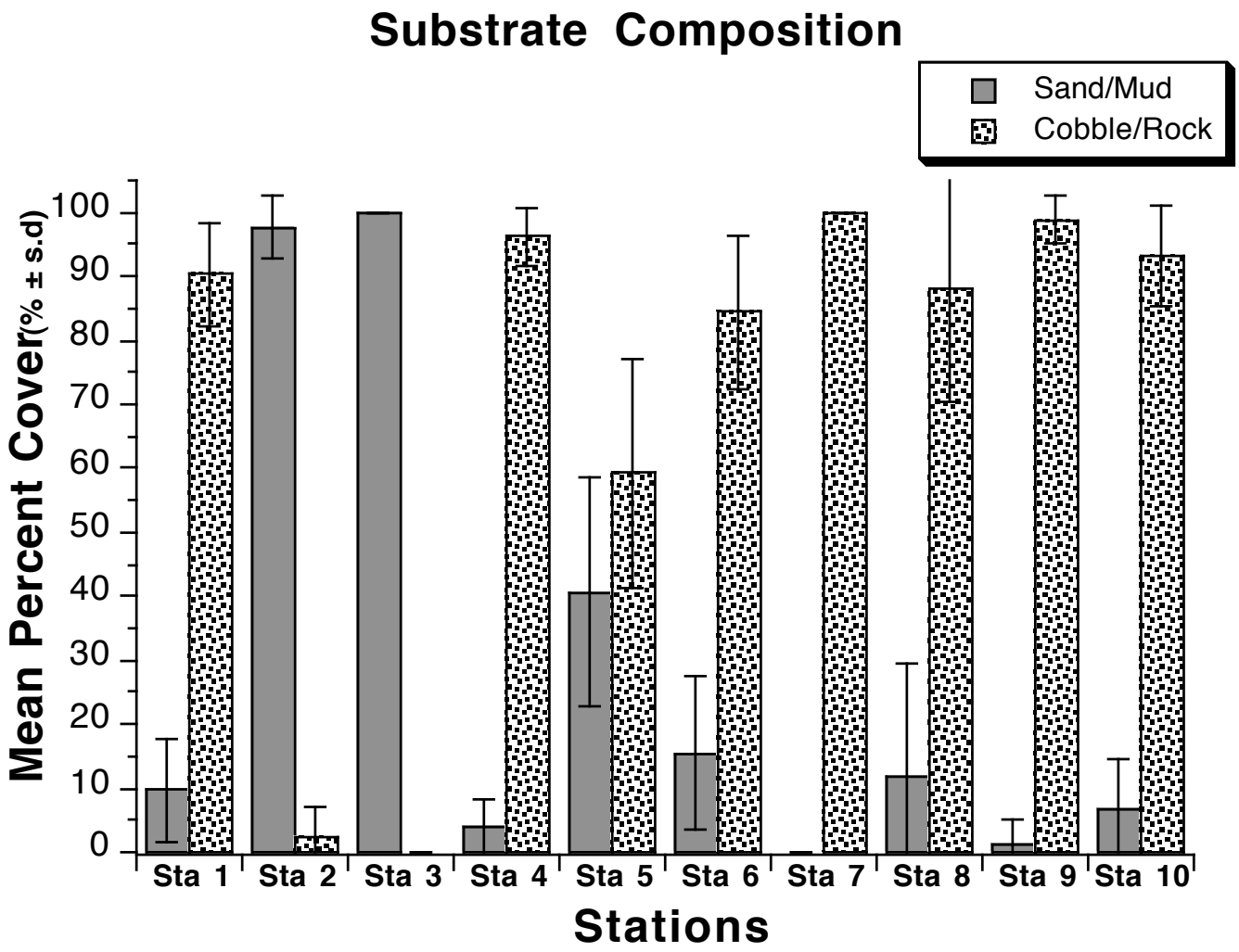
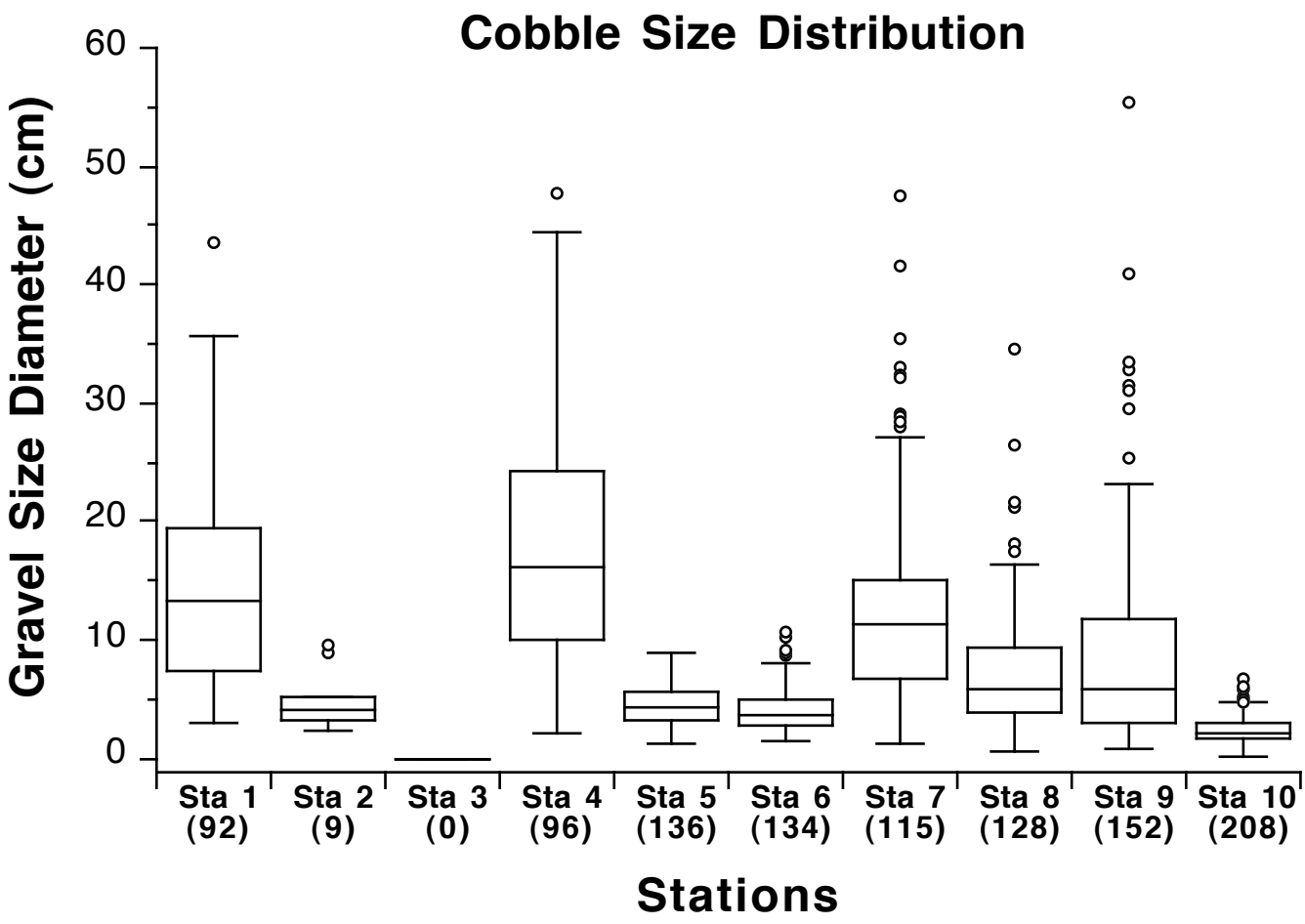


Figure 5: Box plots of gravel size diameters at each of the 10 stations sampled. The number in parentheses below each station number is sample size of gravel examined at that station. Each box encloses 50% of the data with the median gravel size displayed as a line. The top and bottom of the box mark the limits of ± 25% of the variable population. The lines extending from the top or bottom of each box mark the maximum and minimum values within the data set that fall within the range of 1.5 times the interquartile distance (the distance from the median line to the box bottom or top, respectively). Outliers are those points beyond this distance, and can be treated as rare events.



Appendix 1: GIS Analysis and Sampling Plan

NORTHEAST CONSORTIUM DEMONSTRATION STUDY
ASSESSING NEED AND INITIALIZING A METHODOLOGY TO GROUNDTRUTH EXISTING MULTIBEAM AND SIDESCAN SONAR SEAFLOOR MAPS

GIS ANALYSIS & SAMPLING PLAN

18 October 2006

Creating Polygons from Areas Identified by Fishermen

Several working meetings were organized to gather input from Gloucester fishermen on their knowledge of bottom types in local fishing grounds. A series of maps showing shaded relief, seafloor topography (bathymetry), and pseudocolor backscatter intensity for coastal waters surrounding Cape Ann were printed for fishermen to review at the working meetings (Figure 1).

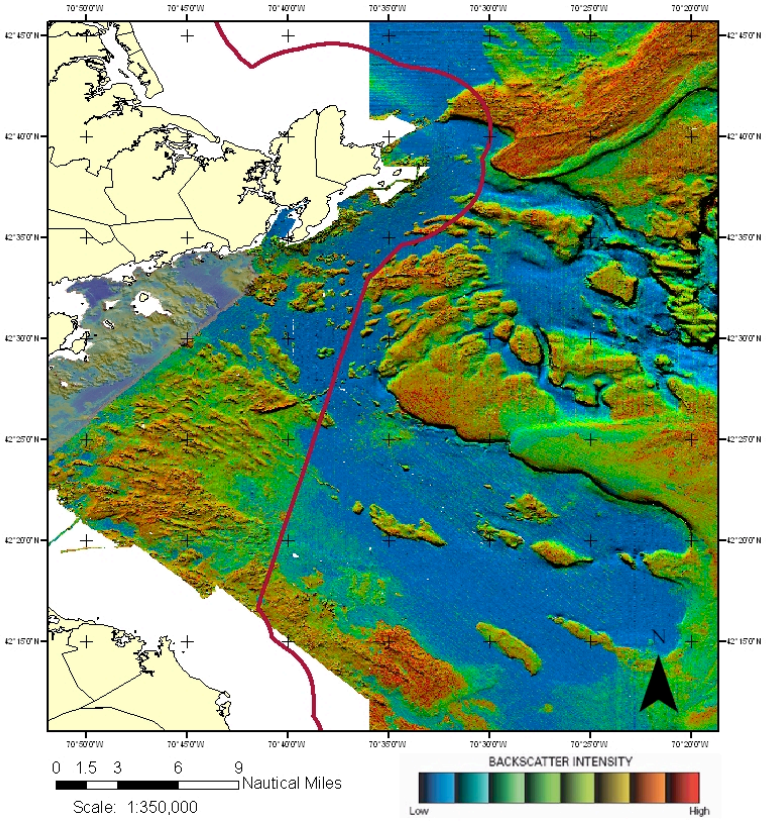


Figure 1. Study map showing shaded relief, seafloor topography and pseudocolor backscatter intensity.

Fishermen marked areas on the printed maps and described characteristics of the seafloor (e.g., substrate type and size). Locations identified by fishermen were digitized and georeferenced in ArcGIS through on-screen digitization (Figure 2). Individual polygons

were created by cross-referencing marks delineated by the fishermen on the printed maps with the source data (i.e., pseudocolor backscatter intensity) in GIS. Observations of seafloor characteristics for delineated areas were linked to the polygons and are found in GIS attribute tables.

Areas marked on maps by fishermen were organized in GIS by location: (1) southern Jeffreys Ledge, (2) northwestern Stellwagen Bank and (3) western Massachusetts Bay. Each geographic area contained many individual locations of varying size (Table 1).

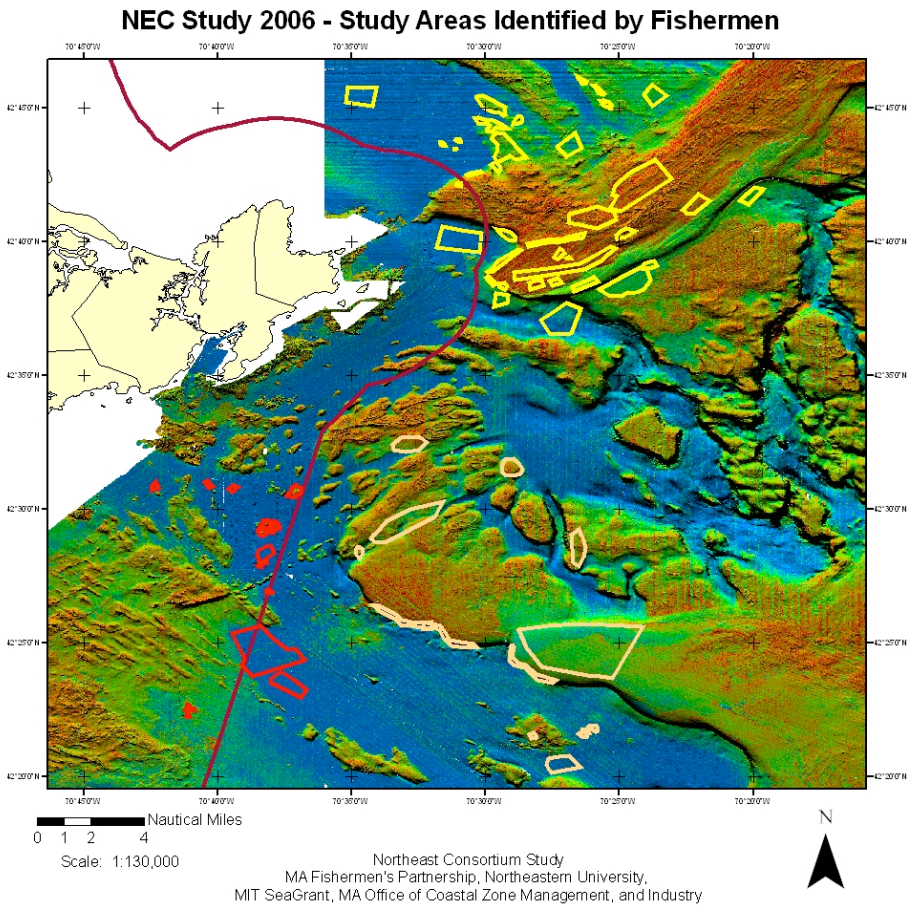


Figure 2. Georeferenced and digitized areas that were identified by fishermen at working meetings.

Identifying Sampling Points

Polygons created in GIS served as strata to design the sampling plan. The sampling strata differed in area. Hawth's Analysis Tools for ArcGIS (Beyer 2004) was used to generate random points in each strata. The density of random points generated was 0.5 points/100 hectares, with a minimum of three points per polygon (Table 1). See following figures for closer view of potential stations in three areas.

Table 1. Number of locations, area and number of potential sample stations for demonstration study.

LOCATION	# OF LOCATIONS	TOTAL AREA HECTARES	# OF POTENTIAL STATIONS
Southern Jeffreys Ledge	37	3,242.72	207
Northwestern Stellwagen Bank	12	2,931.32	156
Western Massachusetts Bay	19	1,045.32	95

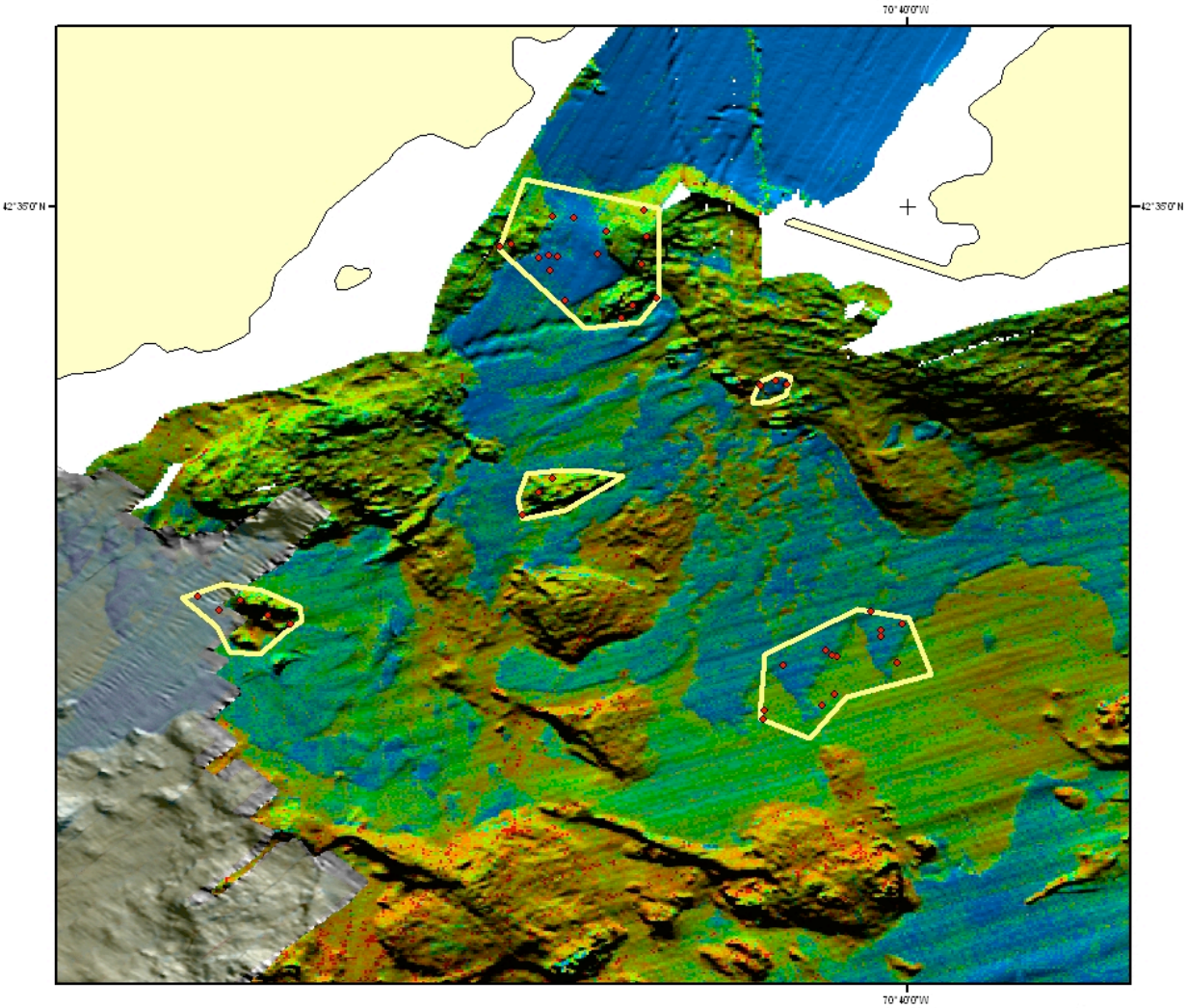
Nearshore Test

* Areas identified based on unique seafloor characteristics and areas that contain range of backscatter values.
* sample density = 5 samples / 100 hectares

References

Beyer, H. L. 2004. Hawth's Analysis Tools for ArcGIS. Available at http://www.spatialecology.com/htools.

NEC Study 2006 - Test Areas

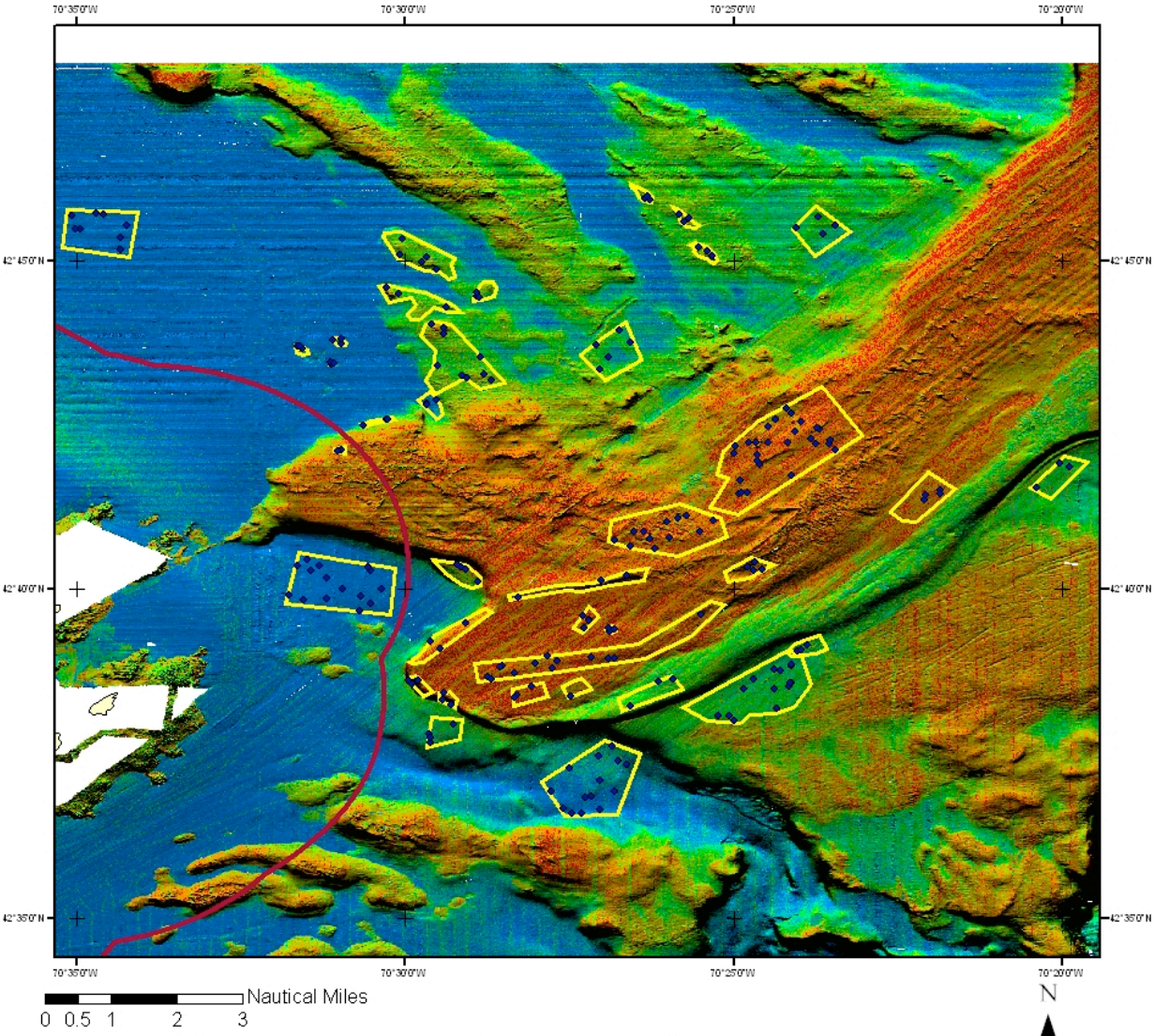


Nautical Miles
0 0.1250.25 0.5
Scale: 1:130,000

N

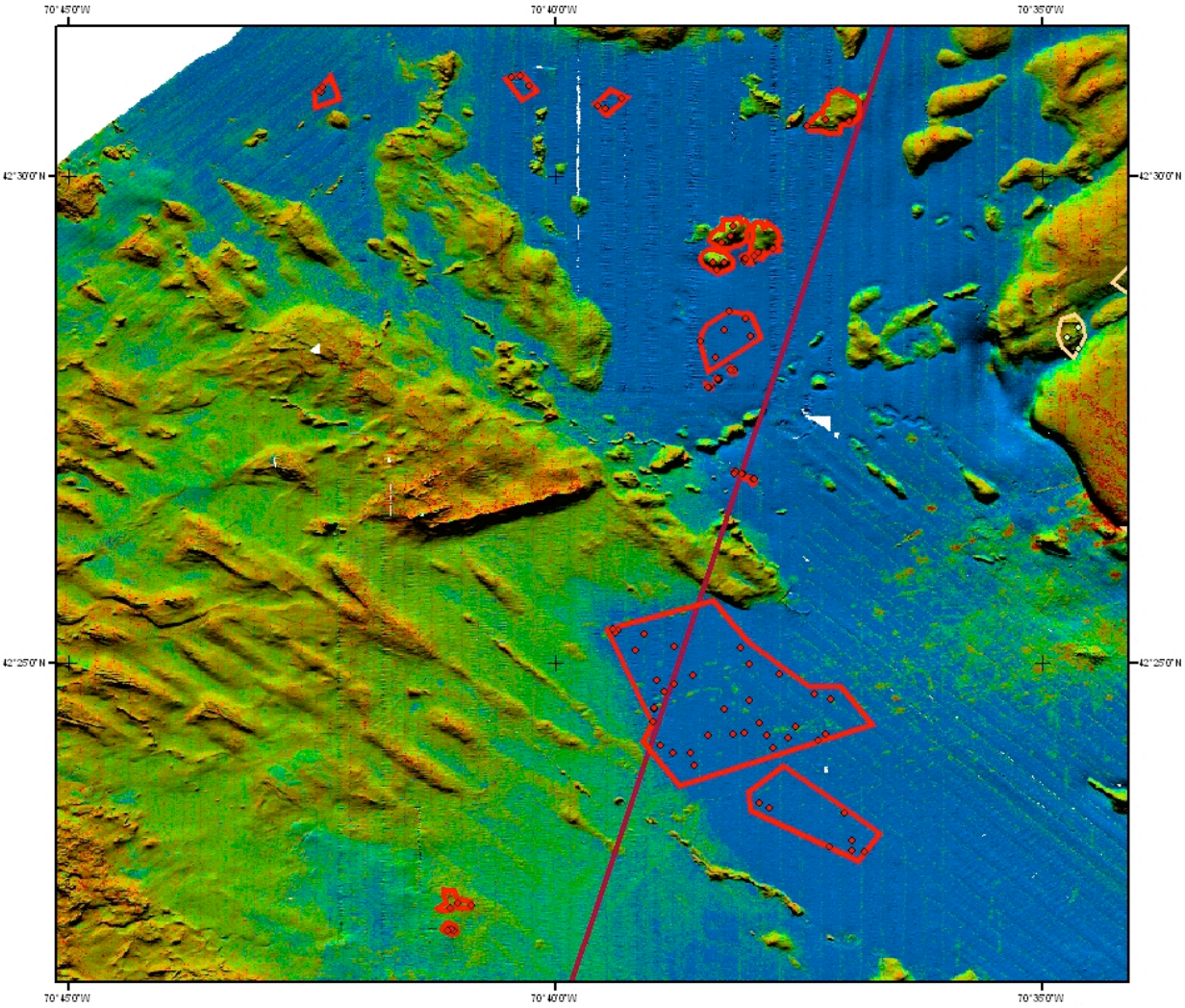
Northeast Consortium Study
MA Fishermen's Partnership, Northeastern University,
MIT SeaGrant, MA Office of Coastal Zone Management, and Industry

Potential Sample Sites - Southern Jeffreys Ledge



Northeast Consortium Study
MA Fishermen's Partnership, Northeastern University,
MIT SeaGrant, MA Office of Coastal Zone Management, and Industry

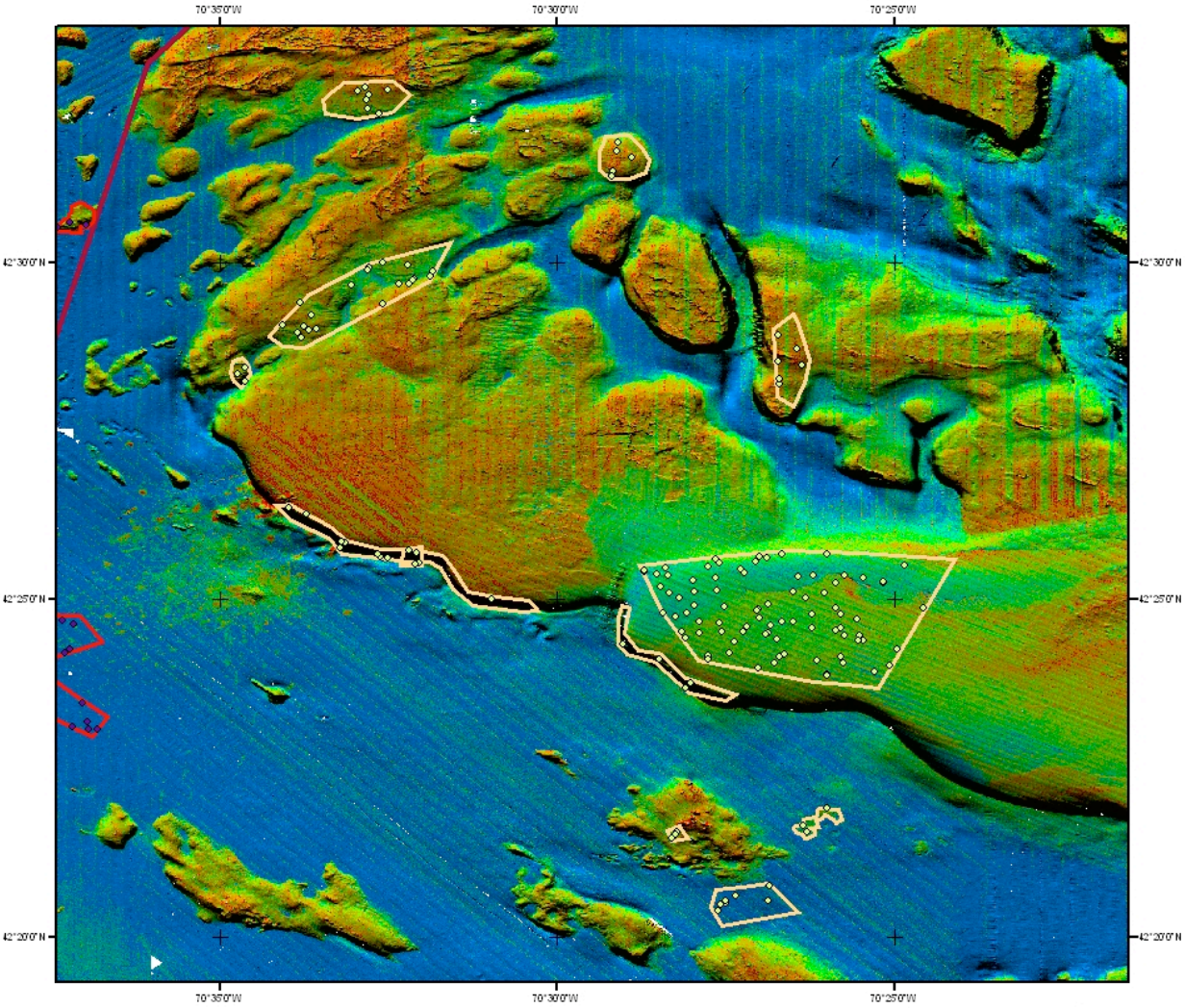
Potential Sample Sites - Massachusetts Bay



Scale: 1:130,000

Northeast Consortium Study
MA Fishermen's Partnership, Northeastern University,
MIT SeaGrant, MA Office of Coastal Zone Management, and Industry

Potential Sample Sites - NW Stellwagen Bank



Nautical Miles

0 0.5 1 2 3

Scale: 1:130,000

N

Northeast Consortium Study
MA Fishermen's Partnership, Northeastern University,
MIT SeaGrant, MA Office of Coastal Zone Management, and Industry