

Marine Habitat Mapping Technology Workshop for Alaska

Anchorage, Alaska • April 2–4, 2007

PROGRAM AND ABSTRACTS

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Monday April 2

7:15 am

Registration and coffee

8:15 am

Welcome, introduction, Alaska marine environments

Clarence Pautzke, North Pacific Research Board

8:30 am

Marine habitat mapping: What is it and why do managers need it?

Doug Woodby, Alaska Dept. of Fish & Game

Jon Kurland, NOAA NMFS Habitat Conservation Division

David Witherell, North Pacific Fishery Management Council

9:10 am

Multibeam echo sounding as a tool for fisheries habitat studies

Larry Mayer, Center for Coastal and Ocean Mapping, University of New Hampshire

9:50 am

Multibeam surveys for marine habitat: What can be expected from a multibeam survey?

Doug Lockhart, Fugro Pelagos, Inc.

10:30 am

Break (20 min)

10:50 am

NOAA NOS hydrographic charting in Alaska, and applications to habitat mapping

CDR Gerd Glang, NOAA NOS Office of Coast Survey

11:30 am

Bathymetric LIDAR surveys for marine habitat: What can be expected from an airborne bathymetric LIDAR survey?

Carol Lockhart, Fugro Pelagos, Inc.

12:10 pm

Lunch (1 hr 30 min)

1:40 pm

What you should and should not expect from towed high-frequency side scan sonar, compared to other forms of acoustic remote sensing

Lloyd Huff, Center for Coastal and Ocean Mapping, University of New Hampshire

2:20 pm

High-resolution multibeam, side-scan, and sub-bottom surveys of seamounts, submarine canyons, deep-sea fan channels, and gas seeps using the MBARI AUV *D. Allan B.*

Dave Caress, Monterey Bay Aquarium Research Institute

3:00 pm

Small-boat surveys in shallow water

Rob Hare, Canadian Hydrographic Service, Pacific Region

3:40 pm

Break (20 min)

4:00 pm

Surficial geology: The third dimension in habitat mapping

Vaughn Barrie, Geological Survey of Canada-Pacific

4:40 pm

Systematic seafloor habitat mapping of the British Columbia coast

Jim Galloway, Canadian Hydrographic Service, Pacific Region

5:30 pm – 8:00 pm

Poster Session and Reception

(abundant refreshments provided)

Tuesday

April 3

7:30 am

Coffee

8:00 am

**Conducting visual surveys with a small ROV in shallow water:
Lessons learned in San Juan Channel, Washington**
Bob Pacunski, Washington Dept. of Fish & Wildlife

8:40 am

Use of a shallow-water ROV in the northern Gulf of Alaska
Mike Byerly, Alaska Dept. of Fish & Game

9:00 am

**Sampling strategies and sources of uncertainty
associated with visual surveys of demersal fishes and
habitats using the occupied submersible *Delta***
Mary Yoklavich, NOAA NMFS Southwest Fisheries Science Center

9:30 am

**A review of habitat-based submersible surveys in
the Gulf of Alaska and the role of habitat mapping in
fisheries management and research in Alaska**
Victoria O'Connell, Coastal Marine Research, Sitka

10:00 am

Break (20 min)

10:20 am

**Rockfish live on rocks and trawls get stuck on rocks: The
development of new methods to monitor populations of West
Coast groundfish and their habitat using the SeaBED AUV**
Nick Tolimieri, NOAA NMFS Northwest Fisheries Science Center

11:00 am

Underwater video sleds from simple to complex: A series of versatile and cost-effective tools for habitat mapping

Chris Rooper, NOAA NMFS Alaska Fisheries Science Center

11:20 am

Video supervised numerical classification of acoustic data from Glacier Bay, Alaska

Guy Cochrane, U.S. Geological Survey

12:00

Lunch (1 hr 30 min)

1:30 pm

Video analysis, database management, and statistical analysis

Brian Tissot, Washington State University

2:10 pm

Marine benthic habitat classification: What's best for Alaska?

Gary Greene, Center for Habitat Studies, Moss Landing Marine Laboratories

2:50 pm

Twenty years of fish-habitat studies on Heceta Bank, Oregon

Brian Tissot, Washington State University

3:30 pm

Break (20 min)

3:50 pm

Do large-scale multibeam survey programs improve our knowledge of seafloor habitats? The example of the Irish National Seabed Survey (INSS)

Anthony Grehan, National University of Ireland

4:30 pm

Application of geoscience information to marine environmental management at the scale of continental margins: Australia's representative marine protected area program

Peter Harris, Geoscience Australia

5:10 pm

Summary

Steering Committee

5:30 pm

End formal sessions

Wednesday April 4

8:30 am – 11:00 am

Working groups, discussion/writing assignments

11:30 am – 12:00 pm

Reports from working groups

Marine Habitat Mapping: What Is It and Why Do Managers Need It?

Jon Kurland¹, Doug Woodby², and David Witherell³

¹NOAA Fisheries, Juneau, Alaska

²Alaska Department of Fish and Game, Juneau, Alaska

³North Pacific Fishery Management Council, Anchorage, Alaska

The waters off Alaska's coast support abundant and nationally significant populations of fish and marine mammals, yet resource managers lack basic information about the marine habitats that support this bounty. Fishermen and geologists can tell us broadly about the types of seafloor found in various areas—mud, sand, rocky pinnacles, scattered gravel, etc.—but such information tends to be patchy at best, and just like terrestrial environments, the seafloor can vary dramatically over a small area. To make informed decisions about human activities that affect the oceans, managers need fairly high-resolution maps of the physical and biological features that constitute habitat for fish, crabs, whales, sea lions, and other marine life. Habitat maps are important not only for fishery managers, who decide where and when fish can be caught as well as the allowable gears and quantities of catch, but also for decision makers regarding oil and gas development, marine mining, and other activities that can affect habitats for the marine life humans value. Marine habitat mapping can be defined as the collection and synthesis of physical and biological data necessary to differentiate environmental features that are meaningful to marine organisms—the features that make a particular area suitable or preferable for basic life functions such as feeding, breeding, and avoiding predators. Habitat maps, coupled with biological surveys, help scientists learn which environments contribute most to the growth, reproduction, and survival of marine species. Managers can use such habitat maps to design protective measures for necessary habitats with greater certainty about societal benefits. Ultimately, habitat maps and knowledge of habitat requirements for desired species may lead fishery managers to understand how much production of a given species can be expected per unit of habitat. In short, habitat mapping is a key element for improving the sustainable management of Alaska's living marine resources. This presentation will highlight several examples of marine habitat mapping and their value to management decisions.

Multibeam Echo Sounding as a Tool for Fisheries Habitat Studies

Larry Mayer and Luciano Fonseca

*University of New Hampshire, Center for Coastal and Ocean Mapping/
Joint Hydrographic Center, Durham, New Hampshire*

Our ability to survey and depict the seafloor radically changed with the introduction of multibeam echo-sounders and associated data processing techniques that can produce complete-coverage, high-resolution maps of relatively large areas of the seafloor. While first used for military, geophysical, and hydrographic applications, the combination of high spatial coverage along with great bathymetric detail has made multibeam echo-sounding a useful tool for benthic habitat mapping. Like all acoustic systems, both the range (and thus spatial coverage) and the resolution of multibeam echo-sounders scale with frequency; but unfortunately they scale in opposite directions, with low-frequencies resulting in long ranges but low resolution and high-frequencies resulting in high-resolution but short ranges. We are thus faced with a fundamental trade-off between spatial coverage and desired resolution and compromises must be sought that address the needs of a particular study. These trade-offs will be examined through the exploration of multibeam echo-sounder data sets collected in the Gulf of Alaska.

While the fundamental measurement provided by multibeam echo-sounders (bathymetry) offers, in conjunction with interactive visualization techniques, the possibility of spectacular depictions of the morphology of the seafloor (at many scales), most multibeam echo-sounders also produce a time-series of acoustic backscatter. Changes in acoustic backscatter can be very indicative of changes in seafloor type, but the production of acoustic backscatter mosaics is often a difficult and tedious task.

New work at the University of New Hampshire is developing approaches for rapidly producing very high-quality backscatter mosaics and for quantitatively analyzing the backscatter that comes from multibeam echo-sounders in a way that may lead to the direct identification of seafloor type. The new approaches (called GeoCODER and Angular Domain Analysis, ADA) first carefully correct the acoustic backscatter collected by a multibeam echo-sounder for a range of radiometric and geometric factors. The corrected backscatter is then geo-referenced to create a high-quality backscatter mosaic. A tool allows the extraction of backscatter vs. angle of incidence from selected regions of the seafloor and these extracted backscatter curves are then compared to a physics-based model of the interaction of sound with the seafloor. The inversion of this model is constrained by well-established physical property inter-relationships. The results are geo-referenced plots of acoustic impedance and seafloor roughness for the area surveyed. From the derived acoustic impedance values, other parameters like grain size and porosity can also be estimated. The application of these tools will be demonstrated on Gulf of Alaska multibeam echo-sounder data.

Multibeam Surveys for Marine Habitat: What Can Be Expected from a Multibeam Survey?

Doug Lockhart

Fugro Pelagos, Inc., San Diego, California

There is a wide range of multibeam survey instrumentation available for marine habitat surveys. The specifications of these systems and how they are deployed and operated will have a remarkable effect on the resolution, accuracy, and quality of the resulting data products. This talk focuses on what a non-surveyor should know about multibeam surveys in order to get the most out of their data.

Specific areas of discussion include

- Datum selection and control.
- Sounding resolution.
- Sounding error estimation and control.
- Backscatter processing.
- Data products.

The information is presented graphically using data examples to contrast various systems and techniques.

Bathymetric LIDAR Surveys for Marine Habitat: What Can Be Expected from an Airborne Bathymetric LIDAR Survey?

Carol Lockhart

Fugro Pelagos, Inc., San Diego, California

Shallow water airborne bathymetric LIDAR systems are beginning to be used for marine habitat studies. The specifications of these systems and how they are deployed and operated will have a remarkable effect on the resolution, accuracy, and quality of the resulting data products. This talk focuses on what a non-surveyor should know about airborne bathymetric LIDAR surveys in order to get the most out of their data.

Specific areas of discussion include

- Datum selection and control.
- Spot spacing (sounding resolution).
- Sounding error estimation and control.
- Orthophoto mosaic resolution and accuracy.
- Reflectance imagery (backscatter processing).
- Data products.

The information is presented graphically using data examples to contrast various systems and techniques.

What You Should and Should Not Expect from Towed High-Frequency Side-Scan Sonar, Compared to Other Forms of Acoustic Remote Sensing

Lloyd Huff

*University of New Hampshire, Center for Coastal and Ocean Mapping/
Joint Hydrographic Center, Durham, New Hampshire*

This presentation discusses the basics of acoustic remote sensing. The potential information content in measurements of backscatter depends on particulars of the system design. Important system parameters of side scan sonar include acoustic frequency, pulse length, beam width, and especially whether the measurements are qualitative or quantitative. For some acoustic remote sensing applications, the most important information is conveyed by the notable absence of backscatter because that may indicate the presence of an object lying on, or protruding out of, the seabed. In the context of mapping fishery habitats in Alaska and elsewhere, the notable absence of backscatter in measurements obtained via towed high-frequency side scan sonar is of limited usefulness. The operational deployment of towed side scan sonar, in particular whether it is towed close to the seabed or towed higher in the water column, can modify the potential utility of the backscatter measurements. The ability to infer information about the seascape in Alaska from the data provided by towed high-frequency side scan sonar is enhanced when the local slopes of the seabed are known. The presentation will discuss a variant of towed high-frequency side scan sonar which provides depth information that is derived as part of the acoustic remote sensing and how it can be applied to mapping benthic habitats in Alaska.

High-Resolution Multibeam, Side-Scan, and Sub-Bottom Surveys of Seamounts, Submarine Canyons, Deep-Sea Fan Channels, and Gas Seeps Using the MBARI AUV *D. Allan B.*

David W. Caress, Hans Thomas, Doug Conlin, Duane Thompson,
David Clague, Charles K. Paull, Jenny Paduan, Rendy Keaten,
W.J. Kirkwood, Rob McEwen, and Richard Henthorn
Monterey Bay Aquarium Research Institute, Moss Landing, California

The Monterey Bay Aquarium Research Institute (MBARI) has developed an autonomous seafloor mapping capability for high resolution mapping of the deep ocean seafloor. The *D. Allan B.* is a 21 inch diameter, *Dorado* class autonomous underwater vehicle (AUV) equipped with a 200 kHz multibeam sonar, 110 kHz and 410 kHz side scan sonars, and a 2-16 kHz sub-bottom profiler. All components of the vehicle are rated to 6,000 m depth. Using precise navigation and attitude data from an laser-ring-gyro-based inertial navigation system (INS) integrated with a Doppler velocity log sonar (DVL), the mapping AUV can image the deep-ocean seafloor and shallow subsurface structure with much greater resolution than is possible with sonars operated from surface vessels. Typical survey operations use a vehicle speed of 1.5 m per second (3 knots) and an altitude of 20 m to 100 m. The system can also be operated in an ROV-mounted configuration, allowing near-bottom surveys in very restricted terrain. The *D. Allan B.* has now been operated in a variety of settings, including submarine canyons (Monterey Canyon, Barkley Canyon), fan channels (Redondo Channel), seamounts (Axial Seamount, Davidson Seamount), methane hydrate outcrops and gas seeps (Santa Monica Basin, Barkley Canyon), and cable route surveys across continental margin slopes (Monterey Bay, Cascadia Margin). The bathymetry surveys achieve a vertical precision of 0.3 m; surveys from a 20 m altitude achieve sub-meter lateral resolution and surveys from 50-100 m altitudes achieve lateral resolutions less than 2 m. The sub-bottom profile data provides resolution of ~0.1 m with penetrations up to 50 m in soft sediments.

Rockfish Live on Rocks and Trawls Get Stuck on Rocks: The Development of New Methods to Monitor Populations of West Coast Groundfish and Their Habitat Using the SeaBED AUV

Nick Tolimieri¹, Elizabeth Clarke¹, and Hanumant Singh²

¹NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington

²Woods Hole Oceanographic Institution, Department of Applied Ocean Physics and Engineering, Woods Hole, Massachusetts

The primary habitat of many west coast groundfish is rocky and untrawlable. Therefore the usual methods and technologies, such as bottom trawls, provide less than ideal information for monitoring groundfish populations. New technologies need to be developed that will allow routine monitoring of groundfish in untrawlable areas. In addition, technologies are needed that are not extractive so that pristine or protected areas can remain so.

We have begun to test, modify, and employ the SeaBED AUV to map groundfish habitat and populations in a variety of areas and conditions. While not optimal for all applications, the system has a number of advantages over ROVs and manned submersibles. It is relatively inexpensive, small, and independent allowing it to be deployed from smaller vessels than subs or many ROVs. Precise bottom tracking, navigation, and collision avoidance allow the AUV to operate in complex, rocky habitat. A range of sensors including multibeam sonar, ADCP (acoustic Doppler current profilers), a high-resolution digital camera, the ability to create photo-mosaics, and chemical sensors that allow the vehicle to quantify and map habitat, invertebrates, and fish. We have also developed custom software to allow the efficient post-dive handling and processing of the data. A pilot study in 2005 quantified and detected difference in the abundance and biomass of rosethorn rockfish on different habitat types at two spatial scales, as well as define rosethorn substratum preferences.

We continue to test and modify the system including the addition of forward looking cameras for better species identification, DIDSON infrared cameras to quantify fish avoidance, and increased battery life for longer deployments. Concurrent software projects seek to automate the counting of fish and invertebrates from the digital photos.

Small-Boat Surveys in Shallow Water

Rob Hare

*Canadian Hydrographic Service, Pacific Region,
Hydrographic Surveys, Sidney, British Columbia, Canada*

The Canadian Hydrographic Service has for many years used small boats (launches) to conduct surveys in shallow water for the purposes of nautical charting. Prior to WW II, soundings would have been taken by leadline, providing depths and often some limited information about the seafloor type at each sample point. For about the next half-century, soundings were acquired by single-beam echo sounder which evolved from wide-beam analogue equipment to modern digital narrow-beam sounders with capacity for classification of the returning acoustic pulse (not discussed in this paper). Seabed samples (for charting purposes) were acquired in a separate operation involving either an armed leadline or grab samplers deployed using a winch.

In the last decade, most shallow-water surveys have been conducted using multibeam echo sounder systems (MBES): for practical reasons we limit the operational depths to about 10 meters. Bathymetric (phase-measuring) side scan sonars may allow us to look from this operational depth limit into the shoreline. For the moment, however, the way we collect bathymetry using these modern tools is leaving a gap between the low-water line and the adjacent survey data. More and more, the data acquired are being used less for navigational safety and more for myriad other applications.

This paper will look at some of the operational issues of acquiring high-resolution bathymetry and acoustic backscatter information in shallow water aboard hydrographic launches.

Surficial Geology: The Third Dimension in Habitat Mapping

J. Vaughn Barrie

Geological Survey of Canada-Pacific, Sidney, British Columbia, Canada

Surficial geological maps provide an understanding of the morphology, sediment type, physical properties, and origin of the sediment making up the seafloor. An understanding of the Quaternary history is critical for the understanding of the geomorphic features present, such as drowned beaches and berms, glacial deposits, and sedimentary bedforms. The life history of critical habitats, like sponge or coral reefs, can be better understood once the Quaternary chronological development is known. Marine surficial geology is primarily determined from sub-bottom acoustic surveys and sediment coring. Four broad categories of marine seismic sources for high-resolution studies are in common use today: (1) high-powered echo sounders (controlled waveform), (2) accelerating water mass (boomers), (3) implosive (air guns), and (4) explosive (sparker). For habitat mapping, the first two are the most common acoustic sources used for providing this third dimension, usually concurrent with multibeam bathymetric surveys. Sediment cores are usually obtained using free-falling piston cores or seafloor operating vibrocore technology. In addition, large bucket grabs and dredges are used to examine surficial sediments and benthic ecology.

Habitat maps are derived from the morphology, sediment distribution, and benthic ecology. However, to fully understand the 3-dimensional architecture of the habitat, knowledge of the surficial geology is also required. By bringing together all these data sets in a GIS environment it is then possible to analyze the geospatial information interactively allowing for iterative interpretations. For example, the spatial distribution of different groundfish species and particular surficial geological units in Hecate Strait, on the Pacific northwest coast of Canada, show a strong correlation. It is from these associations that a better understanding of the total ecosystem can be made and ultimately managed.

Systematic Seafloor Habitat Mapping of the British Columbia Coast

James L. Galloway

Canadian Hydrographic Service, Pacific Region, Sidney, British Columbia, Canada

The Canadian Hydrographic Service is systematically mapping bathymetry for inside waters of >50m depth along the British Columbia coast. The multibeam systems used to measure high-resolution depth also record acoustic backscatter information. This backscatter can be classified using commercial software (Qeuster Tangent Corp.) to provide detailed seafloor habitat information. The Canadian Hydrographic Service uses the Autocluster feature available in MULTIVIEW to optimize and standardize the principal components analysis. Acoustic backscatter is sensitive to variations in geology and also to biotic components in the demersal zone. Acoustic classification provides detailed habitat information in the benthic area, which is a significant component of the complete habitat picture. It is essential to validate acoustic measurements with habitat ground truth data, whether sediment samples or stock assessment for benthic zones. The CHS uses sediment samples to validate synoptic classification maps. These sediment samples are classified according to a modified Folk ternary scale that is effective for general classifications. Also, shallow water multibeam sonars are used to survey targeted areas of portions (<100 m) of Georgia Basin but the efficiency of these systems is limited; classification methodologies are applied to these data as well.

Most of southern Georgia Basin, including Juan de Fuca Strait, is complete for bathymetric measurements in deeper water but significant work remains in Hecate Strait, Queen Charlotte Sound, and all of the outer west coast of British Columbia. Acoustic backscatter classification is progressing for the surveyed regions, with one habitat map complete for Canadian Hydrographic Service chart 3463 in central Georgia Basin. Acoustic classification results will be presented, including a visual feedback tool that uses a replay of seafloor video showing the camera location on a georegistered classification map. This technique is often used when collecting samples and video (following a classification analysis) to provide real time validation of classification results.

Conducting Visual Surveys with a Small ROV in Shallow Water: Lessons Learned in San Juan Channel, Washington

Robert E. Pacunski¹, Wayne A. Palsson¹, H. Gary Greene², and Don Gunderson³

¹*Washington Department of Fish and Wildlife, Marine Fish Science Unit, Mill Creek, Washington*

²*Center for Habitat Studies, Moss Landing Marine Laboratories, Moss Landing, California*

³*University of Washington, School of Aquatic and Fishery Sciences, Seattle, Washington*

Small remotely operated vehicles (ROVs), often described as low-cost (<\$150K) or 2-man portable, have become valuable tools in the study of marine organisms and their habitats. The versatility and relative ease-of-use of these vehicles is enabling scientists and fishery managers to develop a better understanding of the marine ecosystem that has not been possible using conventional survey methodologies. The ability to safely and efficiently survey at depths beyond the reach of scuba divers and in complex habitats inaccessible to trawl surveys is helping to “fill the information gap” between nearshore and deep offshore habitats, thereby providing opportunities for more comprehensive management of our ocean resources than ever before.

Small ROVs are especially suited for use by natural resource agencies operating on limited budgets with minimal resources (i.e., vessels, personnel). Depending upon the vehicle and application, a small ROV can be deployed from vessels as small as 5 m by as few as two people. However, from our experience and those of others working in challenging marine conditions, we have learned that conducting safe, practical, and quantitative surveys with a small ROV requires that certain prerequisites be met in order to ensure success. This paper will focus on the technical aspects of designing and conducting shallow-water (<200 m) surveys with a small ROV based on our experience using a Deep Ocean Engineering Phantom HD2+2 ROV to survey benthic fish and habitat in San Juan Channel, Washington. Topics to be addressed include minimum equipment requirements, habitat-based survey design, ROV deployment protocols, tether management, camera calibration, data collection and analysis, ROV navigation and tracking, estimating transect length and width, and recent technological developments.

Use of a Shallow-Water ROV in the Northern Gulf of Alaska

Mike Byerly

Alaska Department of Fish and Game, Homer, Alaska

The Alaska Department of Fish and Game, Central Region, has recently begun conducting habitat-based groundfish assessments in the northern Gulf of Alaska (GOA) using a Deep Ocean Engineering, Phantom HD2+2 ROV. A description of the ROV systems used, deployment and transit methods, sampling design employed, data management, and habitat analysis and population estimation methods are presented. The strengths and weaknesses of ROV systems used will be discussed. The physical features of the coastal waters of the northern GOA offer operational challenges for ROV use with regard to sea state, currents, and seafloor topography. Established methods such as the use of a clump-weight, quality acoustic tracking system, standard protocols, and a vessel with good station-keeping ability can serve to diminish these challenges. High relief habitats are often important fish habitat but can be difficult to sample. Sampling designs were developed to maintain upslope ROV transits to increase the likelihood of collecting good quality video data, while maintaining randomness and reducing bias. The necessity of segmenting out transect segments with bad video quality introduces another type of bias, however, since the frequency of these segments tends to increase in higher relief habitats. Other challenges such as transect width estimation, and fish behavioral response and detection are also discussed. Logistic regression and odds ratios were used to analyze fish habitat use and the bootstrap method was used to estimate variance. Using dynamic segmentation, route features were produced for all microscale habitat measurements and fish observations, and layered over mesoscale remotely sensed bathymetry data.

Sampling Strategies and Sources of Uncertainty Associated with Visual Surveys of Demersal Fishes and Habitats Using the Occupied Submersible *Delta*

Mary Yoklavich

NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, California

Visual surveys of demersal fishes and their associated habitats are being conducted regularly in deep water (i.e., 30-350 m) along the west coast by numerous research groups using quantitative transect methods from the research submersible *Delta*. The use of *Delta* has been applied primarily to the characterization of essential fish habitats, with increasing applications to improve stock assessments and to evaluate gear impacts. Using *Delta* is no longer an unproven concept, but rather an accepted survey tool as demonstrated in more than 30 peer-reviewed publications since 1989. Maps of seafloor substrata and bathymetric data are commonly used to identify and quantify survey sites, which serves both to increase the cost-effectiveness of the submersible and provide the frame within which to distribute sampling effort. In turn, direct observations from *Delta* can be used to validate the interpretation of such habitat maps. Variables that are commonly estimated during *Delta* dives include number and length of fish, distance to a fish, and distance along a transect, from which habitat-specific species density, total abundance, and biomass can be calculated. During this talk we will consider some sources of potential error associated with these variables, as well as the advantages and some strategies for conducting visual surveys using *Delta*.

A Review of Habitat-Based Submersible Surveys in the Gulf of Alaska and the Role of Habitat Mapping in Fisheries Management and Research in Alaska

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The combination of benthic habitat mapping and submersible surveys in Alaska has a long history. The Alaska Department of Fish and Game (ADFG) has used habitat-based submersible surveys of yelloweye rockfish (*Sebastes ruberrimus*) as an established assessment technique for nearly two decades. Seafloor mapping off Alaska is also being integrated with identification of habitat areas of particular concern (HAPC), determining the effects of fishing on benthic habitats, and understanding basic ecological processes as well as stock assessments. We discuss several Alaska projects conducted by ADFG and the National Marine Fisheries Service (NMFS) Auke Bay Laboratory (ABL) that utilize habitat mapping technologies.

Yelloweye rockfish occur in rugged rocky terrain on the continental shelf, and are an important commercial species taken in directed, and bycatch bottom longline fisheries. The biomass of yelloweye is derived as the product of density, average weight, and area of habitat. Line transect surveys conducted from the submersible *Delta* are used to estimate density. Information used to identify rocky habitat include side scan, multibeam (ground truthed from the submersible), and commercial fishery logbook data. To date over 2,200 km² of the eastern Gulf of Alaska has been mapped for this project. Geophysical data reveal the extent of all rocky habitats, while fishermen target prime habitat. By assessing fish densities in all rockfish habitats, as delineated by geophysical surveys, a better indicator of stock condition is possible.

Multibeam data also allow us to clearly define boundaries of prime habitats, relevant to management decisions regarding marine reserves or definition of management units. The Edgcumbe Pinnacles Marine Reserve is the first no-take groundfish reserve in Alaska and has been extensively mapped and characterized using side scan and multibeam data. Submersible surveys of the reserve are greatly enhanced by using these geo-referenced habitat maps. Three HAPCs were established in Southeast Alaska by NMFS largely based on

opportunistic use of previous submersible survey data coupled in some cases with multibeam and habitat maps.

Since 2001, multibeam bathymetric and coregistered backscatter data were collected over several small areas (1,690 km²) within the major commercial fishing banks throughout the Gulf of Alaska. The Portlock Bank mapped area (790 km²) was recently analyzed as a case study for characterizing habitat in heavily fished grounds to understand whether habitats in current fishing grounds are vulnerable to ongoing fishing. The objective was to characterize habitat in heavily fished grounds to understand whether habitats in current fishing grounds are vulnerable to ongoing fishing activities. Existing biological data from the mapped area were assembled and evaluated, including fish counts from submersible dives, bottom-trawl survey data, and commercial bottom-trawl catch data. A density surface of the commercial fishing trawl hauls was created over the mapped area, which enabled the examination of patterns of fishing intensity by habitat type. These combined data sets may also help describe trawlable versus untrawlable habitat, an important component of the NMFS trawl survey.

These studies share some general conclusions. Multibeam and side scan sonar surveys allow small scale, detailed habitat maps to be constructed, which are important for understanding ecological associations of benthos and fishes. However, these benthic habitat maps based on side scan and multibeam data require ground truthing for validation of habitats. Once supported through in situ observations, these maps are useful for designing sampling protocol of submersible and fishery surveys.

Underwater Video Sleds from Simple to Complex: A Series of Versatile and Cost-Effective Tools for Habitat Mapping

Chris Rooper

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Underwater video sleds have been useful to researchers through their capabilities in substrate mapping, acoustic ground truthing, fish habitat research, and applications to fish stock assessment. Sleds can be designed to suit a variety of substrates and seafloor conditions. Typical designs include bottom contacting, bottom tending or sleds suspended in the water column. In general, underwater video sleds are easily modified and accessorized with lasers, lights, altimeters, tracking systems, and other electronic devices. Simple sleds can be outfitted for a few thousand dollars, while more technically diverse sleds can cost 100 times that amount. The trade-offs between design simplicity and potential data products are inevitable and difficult choices result.

Advantages of video sleds over other visual observation methods can include the portability, simplicity, low cost, resilience to extreme conditions, and ease of maintenance. However, video sleds can observe only small swaths of seafloor, can be difficult to track accurately, and have limited utility for examining small or detailed features. In general, fine-scale control of underwater positioning is not achievable. Significant limitations of video sleds usually necessitate a secondary source of ground truthing information for habitat mapping.

Although qualitative data is easily obtained from most sled applications, transmitting what is observed on the screen to an accurate number in a spreadsheet is often time consuming and difficult. The importance of visualizing the objectives, data needs, statistical methods, and model application *prior to* choosing an underwater video sled or survey design cannot be underestimated.

Video Analysis, Database Management, and Statistical Analysis

Brian Tissot

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A key component of submersible-based habitat studies is the extraction and analysis of data from large quantities of videotapes resulting from fieldwork. This stage of the project is tedious and time-consuming but requires careful management and integration of several diverse technologies and skills. Logging of data from videotapes requires training, quality control and assurance, and a well-designed database. A relational database is essential for integration of data from multiple sources, including habitat, fish and invertebrate data extracted from video, taxonomic classifications, oceanographic measures, navigation, and project metadata. Using queries, data can be exported for the database for data summaries, GIS, and statistical analyses. The principal statistical challenges for submersible studies revolve around replication, independence, and the power to detect meaningful changes over time.

Marine Benthic Habitat Classification: What's Best for Alaska?

H. Gary Greene

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Many different types of habitat classification schemes have been developed for the coastal and marine environments. These schemes range from site or topic specific types to broad approaches that cover large geographic regions. Many investigators tailor-made classification schemes that supported their specific interest at the time of their studies. However, comparison of habitat types from one study or from one region to another is generally not possible because of the incompatibilities of these schemes. Today with the intense effort of seafloor mapping and the support of geographic information systems (GIS) coordination of marine benthic habitat classification is necessary if habitats are to be evaluated on a regional basis.

Several types of habitat classification schemes will be presented, including a scheme developed at the Center for Habitat Studies and used in the characterization of marine benthic habitats in the deep offshore areas of Alaska. In the evaluation of a classification scheme it is critical to determine how user-friendly and adaptable a scheme is and if it can be used to evaluate all of the parameters considered critical for management purposes. Although many of the parameters needed to identify a habitat may not be easily included in a scheme, it may be possible to use seafloor conditions and other parameters as surrogates or proxies for particular habitat types. In this context the term "habitat" as applied to such schemes needs to be defined, as the word means different things to different investigators; thus "potential habitats" has been introduced as the descriptor for mapped seafloor conditions used as proxies for habitat.

Of critical importance to mapping habitat types is flexibility within the scheme that enables the user to mix and match or add and subtract attribute types to produce a map that specifically addresses his/her concern. However, standards for mapping such attributes need to be agreed upon. Although detailed coastal and shallow-water habitat mapping has been extensively developed using "top-down" classification schemes tied to the biology of the photic zone, the deepwater schemes are of a "bottom-up" form with their basis in the non-photoc realm that is strongly tied to the geologic substrate. Efforts need to be made to merge the two different types of schemes.

Video Supervised Numerical Classification of Acoustic Data from Glacier Bay, Alaska

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To examine and record geologic characteristics of the seafloor, investigate the relation between substrate types and benthic communities, and construct predictive maps of seafloor geomorphology and habitat distribution in Glacier Bay, Alaska, numerical classification of multibeam sonar data was supervised with more than 40 hours of geo-referenced submarine digital video collected in water depths of 15-370 m. Hypotheses were formulated that correlated general substrate type observed in video with bathymetric variance, backscatter variance, backscatter intensity, and slope. Each hypothesis was tested using a supervised decision-tree classification. Bathymetric depth classes were selected on the basis of biological and geological observations, as well as with an understanding of oceanographic patterns in the bay. Depths less than 75 m represent environments with the highest energy and a well-mixed surface layer. The 200 m boundary was selected on the basis of observed transitions in seafloor geology, benthic community structure, and oceanographic properties that occur bay-wide at this depth and represent a shift to conditions typical of deep-sea environments.

To summarize the benthic community variation relative to underlying environmental gradients, the video observation data were analyzed by ordination of transects and species using detrended correspondence analysis (DCA). The results of our analyses suggest that there are three general groups of benthic habitats: shallow-water high-current sand and cobble habitat; deepwater mud habitat; and moderate-depth cobble and mud habitat. Species distributions were most strongly associated with substrate type and current exposure.

Twenty Years of Fish-Habitat Studies on Heceta Bank, Oregon

Brian Tissot

Washington State University, Vancouver, Washington

Submersible studies on Heceta Bank, which began in 1987, have varied considerably over the years in response to changes in technology and research objectives. Overall, there has been a progression of approaches as change occurred in the capabilities of submersibles, the quality of video, the ability to develop detailed maps of the seafloor, and improvement in navigation. Early studies were exploratory and focused on characterization of fish-habitat relationships on small areas of the bank. With advances in seafloor mapping and the development of multibeam technology, a detailed map of the bank allowed for a more holistic approach to joint characterization of fish, habitat, and megafaunal invertebrates. These approaches include integration of submersible and multibeam data, mapping of fish and invertebrate distributions, and detailed habitat classifications.

Do Large-Scale Multibeam Survey Programs Improve Our Knowledge of Seafloor Habitats? The Example of the Irish National Seabed Survey (INSS)

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The Irish National Seabed Survey is a major government-funded initiative to comprehensively map the entire Irish Exclusive Economic Zone and Extended Continental Shelf (claim) using shipborne multibeam. This area is approximately ten times Ireland's land territory, amounting to over 700,000 square kilometers (270,000 square miles) of seafloor. The initial tranche of funding for the period 2000 to 2005 amounted to €32 million (c. \$42 million). Further funding was contingent on the successful completion of the first phase of mapping; therefore the decision whether to start mapping in shallow or in deep waters was crucial. The entire survey area was divided into three zones based on depth, i.e., Zone 1 (0-50 m), Zone 2 (50-200 m), and Zone 3 (200-4,500 m). Surveying of Zone 3 took place between 2000 and 2002 with an Irish survey contractor Global Ocean Technologies (GOTECH) Ltd. using two survey vessels fitted with Kongsberg Simrad EM120 and EM1002 multibeam (MB) systems. Over 450,000 square kilometers were successfully surveyed with standard maps produced covering an area of $2^{\circ} \times 1^{\circ}$ at 1:250 000 scale. The second phase of the National Seabed Survey called INFOMAR is now under way focusing on priority inshore areas and bays selected after extensive stakeholder consultation.

While the primary purpose of the survey (in the initial years) was to acquire high-resolution bathymetry data, backscatter from the multibeam and single channel seismic data were also collected. These data can provide useful information for discriminating substrate type essential for the production of habitat maps. A secondary program of seabed sampling for ground-truthing purposes was undertaken to support seabed classification. In this paper, we review a number of Irish and European projects that are using the Irish National Seabed Survey data set for the development of habitat maps.

Some of the issues highlighted will include

- The differential quality of backscatter obtained using high resolution shallow water MB compared with lower resolution deepwater MB.
- The need to overcome survey idiosyncrasies to maximize backscatter quality.
- The need to bridge the gap in resolution between shipborne MB and ground-truth seabed sampling, particularly in deep waters.
- The application of terrain analysis in the development of habitat suitability models.

Application of Geoscience Information to Marine Environmental Management at the Scale of Continental Margins: Australia's Representative Marine Protected Area Program

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In order to protect the biological diversity of marine life in Australia's Exclusive Economic Zone (EEZ), the commonwealth government has passed the Environmental Protection and Biodiversity Conservation (EPBC) Act. The Act is being implemented through preparation of regional marine plans (commenced in 2001) and by designing networks of representative marine protected areas (MPAs) in both commonwealth and state waters. In the absence of direct information about the distribution of seabed biodiversity, appropriate surrogates must be used instead. A major constraint is the short time frame available to managers to make decisions; only information that is readily accessible and available can be used under these circumstances.

Existing seabed bathymetry data were used to produce a geomorphic features map of the Australian EEZ. This map was used in conjunction with existing fish diversity information and other data to derive a Benthic Bioregionalisation (2005) that subdivides Australia's EEZ into 41 biologically unique provinces. Biophysical variables measured at broad spatial scales apart from bathymetry (and derived variables such as seabed slope) include ocean primary production, seabed sediment properties, temperature, and sediment mobilization due to waves and tides. To better characterize habitats on the Australian continental margin, Geoscience Australia has created "seascape" maps that integrate multiple layers of spatial data that are useful for the prediction of the distribution of biodiversity. We used ER-Mapper's unsupervised isoclass algorithm to simultaneously classify six variables, with equal weighting, to yield a range of statistically different classes. The broad spatial coverage provided by the analysis of biophysical data provides information complementary to knowledge of sites important to threatened or endangered species, to iconic sites of high conservation value, and to the available (mostly very limited) direct measurements of biodiversity (hot spots). Seascape and geomorphic habitat maps have assisted managers in Australia with broadscale marine planning and in the design of representative MPA networks.

Adding Ecological Context to EFH Models Using Ground Truthing Technologies

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Seafloor-mapping sonars produce acoustic returns that are a function of absorption and reflection by biological and geological materials. Subsequent ground truthing results in ecological interpretations of the acoustic information, and is thus vital to fish habitat mapping. We recently used three different devices in the eastern Bering Sea to ground truth acoustic backscatter and assemble a comprehensive understanding of the seafloor: (1) a Free Fall Cone Penetrometer (FFCPT, Brooke Ocean Technologies); (2) a SEABed Observation and Sampling System (SEABOSS, USGS); and (3) the second generation Towed Auto-Compensating Optical System (TACOS, AFSC). The FFCPT penetrates several meters into the seafloor and provides a profile of geotechnical properties of the sediment. The SEABOSS carries digital still and video cameras with strobe lights to image the seafloor surface, while simultaneously collecting a physical sample with a van Veen grab. The TACOS has a downward-looking industrial Firewire camera that produces high-resolution digital video frames that are mosaiced in post-processing to provide more extensive and informative imagery. These devices provide complementary information on the sedimentary and faunal characteristics of the seafloor and generate a multifaceted view of the physical and biological components of habitat. Such views improve our understanding of ecological relationships and guide the formulation of our fish habitat models.

Towed ROV Transects with Vehicle-Mounted Scanning Sonar Provide up to 100-Meter Swath Width for Detection and Real-Time Video Truthing of Crabs, Sea Stars, and Other Epibenthos

Mark Blakeslee

AquaLife Engineering, Kodiak, Alaska

AquaLife Engineering has provided ROV charters in Alaska waters since 1999 for a variety of marine biological, fisheries, and oceanographic projects. Some of these projects have involved searching for and surveying both bairdi and king crab, and we have utilized scanning sonar to increase our effectiveness.

In general, a visual survey using a towed ROV or sled provides a swath width of 1 to perhaps 3 meters. This range can be extended to as much as 100 meters using scanning sonar. An ROV towed on a bridle behind a depressor weight can be deviated laterally to provide video images of targets previously detected by the sonar at long range. By using this approach, the identity of various organisms can be correlated to the sonar signature of those targets once they are tracked into video range.

Video and sonar images are presented and compared for king crab, bairdi crab, sea star aggregations, and schools of juvenile tomcod. AquaLife assisted Gregg Rosenkranz of ADFG with the integration and deployment of a machine-vision towed video sled for scallop enumeration during summer 2006. The system was modeled after the HabCam video sled developed by Scott Gallager et al., at Woods Hole Oceanographic Institution (WHOI). Photos of the system and the resulting images are presented. Ongoing video image processing software development at WHOI and Los Alamos National Lab is expected to lead to automated habitat categorization and organism enumeration. This software may be extended to process sonar imagery as well.

Habitat-Based Groundfish Assessment Using a Shallow-Water ROV in the Northern Gulf of Alaska

Mike Byerly and Margaret Spahn

Alaska Department of Fish and Game, Homer, Alaska

Following examples of other successful habitat-based assessment programs, the Alaska Department of Fish and Game (ADFG), Central Region, is developing a population assessment program for demersal fishes—emphasizing lingcod and yelloweye rockfish—for coastal waters of the Gulf of Alaska off the Kenai Peninsula. By utilizing existing multibeam bathymetry, mapping additional study areas, and conducting ROV transect surveys, ADFG is moving toward a long-term goal of monitoring the abundance of important groundfish species within a network of locations in the Central Region.

In 2005, ADFG conducted an ROV survey along the Chiswell Ridge to estimate lingcod and yelloweye rockfish abundance. Rocky reef areas were delineated based upon both high resolution multibeam and lower resolution single beam bathymetry. ROV transect locations were selected using simple random sampling within delineated rocky reef polygons, and transect direction was chosen by random draw until an upslope transect could be achieved. Forty-four 0.5 km ROV transects were successfully completed.

A lingcod population estimate was derived, and lingcod habitat use was analyzed using logistic regression and odds ratios. Route features were produced for all microscale habitat measurements and lingcod observations, and layered over mesoscale remotely sensed bathymetry data. Both substrate type and relief were highly significant predictors of lingcod occurrence ($p < 0.005$). The odds of lingcod occurring in boulder substrate types were highest and decreased with boulder diameter. The odds of lingcod occurring in areas of high relief were much larger than in low relief substrates.

Habitat Mapping of the Sidney, B.C., Waterfront Using Acoustic and Video Imaging Techniques

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Seabed habitat mapping was conducted off Sidney, British Columbia, to a distance of approximately 300 m offshore. Surveys were carried out using high-frequency (390 kHz) side scan sonar, to provide 100% acoustic coverage of the substrates in the area, and the Seabed Imaging and Mapping System (SIMS) to provide high-resolution video images used to provide substrate ground-truth for the side scan sonar data and for characterization of the floral and faunal composition.

Five general habitat associations (combinations of substrate and biota) were mapped: (1) sand-pebble with eelgrass; (2) intertidal rock-boulder-cobble with rockweed and foliose green algae; (3) nearshore boulder-cobble with bladed kelp; (4) rocky reefs with large bladed kelps and *Agarum*; and (5) dense clay with piddock clams. These can be broadly categorized into immobile rock substrate that supports attached kelp and algal assemblages (22%) and mobile substrates, where rooted vegetation (eelgrass) or non-attached red algae dominate (76%).

In general terms, the substrates in the area are characterized by boulder-cobble or bedrock in nearshore areas, a zone of gravelly sand and sandy gravel to about 200 m offshore, and a discontinuous series of north-south-oriented bedrock reefs, veneered with cobble/boulder, along the eastern edge of the survey area.

The zone offshore from the Washington State Ferries facility is characterized by dense mud with piddock clams. This association results from propeller wash removing all surficial sediments and exposing the underlying dense, gray glaciomarine clay.

Mapping in Alaska for Fisheries Habitat and Nautical Charting

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Since 1998, Fugro Pelagos has collected more than 38,000 square kilometers of data offshore Alaska using both multibeam and LIDAR systems. Several Essential Fish Habitat surveys have been completed with multibeam systems tuned for backscatter for the Alaska Department of Fish and Game, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, and NOAA Undersea Research Program (NURP) West Coast and Polar Regions Center. However, the majority of these data have been collected under contract to the NOAA, National Ocean Service (NOS) to support their nautical charting efforts. The data collected for NOAA NOS are not specifically tuned for backscatter, but after 2003, snippets technology utilized during multibeam data collection allowed the data to be reprocessed for backscatter.

This poster provides an overview of the data that have been collected in Alaska by Fugro Pelagos. This includes specific survey areas, systems used, the type of data collected (multibeam for backscatter, multibeam for depth, multibeam for depth that can be reprocessed to obtain backscatter images, and LIDAR), and data examples.

Scientific Diving Methods for Ground Truthing Marine Habitat Maps

Shawn Harper, Stephen Jewett, and Brenda Konar

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Marine habitat mapping via remote sensing techniques requires in situ information in order to relate the remotely sensed data to real features. The process of gathering in situ information under these circumstances is known as ground truthing. Ground truthing helps to verify that the broadscale classifications of habitat, determined by remote sensing techniques, are accurate representations of reality by minimizing errors of commission and omission of the features to be displayed in large-scale maps.

Here we discuss how scientific diving can be used as a tool to accomplish ground truth requirements for marine habitat mapping in Alaska. We briefly summarize the following in situ methods scientific divers can employ that would be beneficial for ground truth requirements: underwater data sheet entries of visual assessments, photography, video, inclinometers, and rugosity measurements. We also discuss methods divers can use to subsample a site or transect so that quantitative descriptions can accompany qualitative characterizations of the habitat (i.e., swath transects, quadrats, and estimates of percent cover via random point contacts). Using these methods, scientific divers can gather detailed information at random locations from within multiple classification areas of important marine habitat in Alaska. This detailed information can then be used to minimize errors of commission and omission for large-scale habitat maps that are produced for management purposes.

Toward Quantitative Approach: Evaluating Impact of Bottom Trawls by Enhancing High-Resolution Side Scan Sonar Data Process

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A high-resolution side scan sonar system was deployed in the Bristol Bay region of the eastern Bering Sea to evaluate short-term impacts of bottom trawls on soft-bottom benthic habitats and to monitor or investigate the recovery process. In order to determine the seabed characteristic changes due to trawling, specialized procedures for side scan sonar data processing were developed in an attempt to deal with (1) the non-qualitative nature of side scan sonar; (2) geometric and beam pattern adjustments; and (3) tow body positioning.

The geometric adjustments in the data process include sonar slant range, prewhitening with incident angle, and fish roll compensation. The beam pattern adjustment model was based on the statistical results from the whole side scan data set of the Trawlex 2001 survey, and employed to estimate the combined effects of the transducer transmit and receive beam pattern, transmit source level, and receive sensitivity. These combined beam pattern effects were strongly influenced by the fish height above the sea bottom.

For geo-referencing the high-resolution side scan data, a model was developed to estimate the WGS-84 position of the tow body using parameters that were available in the data files, operator logs, and metadata. The geo-referencing precision was typically better than 10 meters, based on the several positions for targets that were identified on up to six different passes from different days.

The effects of two types of bottom trawls, scientific and commercial, were detectable and notably different. Pre and post trawl imagery will be presented.

Mapping Environmental Variables to Produce Essential Fish Habitat Models

Bob McConnaughey, Cynthia Yeung, Steve Syrjala, and Keith Smith

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We are developing quantitative models to explain the distribution and abundance of fish on the continental shelf of the eastern Bering Sea (EBS). This effort addresses the Essential Fish Habitat (EFH) mandate that applies to all life stages of all federally managed species. The large number of species, their considerable value, and the enormity of the U.S. EEZ dictate a descriptive approach that is both rigorous and efficient. In practice, we use systematic trawl survey data to identify EFH as those areas supporting high relative abundance. This approach presumes that density data reflect habitat utilization, and the degree to which a particular habitat is utilized is considered to be indicative of habitat quality. When the trawl data are combined with existing environmental data, preliminary models can be developed that spatially link fish abundance with relevant physical and biological variables. By this empirical method, habitat quality is judged through the eyes of fish (rather than the scientist).

Unfortunately, only limited environmental data are available for this purpose, and development of new variables is required for model improvements. For example, pilot studies with historical data demonstrated that surficial sediments are useful for characterizing EFH in the EBS. However, these data are sparse and additional sampling with grabs and cores would be prohibitively inefficient. For this reason, we are investigating more cost-effective methods such as acoustic seabed mapping. Ecological interpretation of these habitat measurements are based on diverse ground truthing information.

Using Acoustics to Characterize Sediments for Essential Fish Habitat Models

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²University of New Hampshire, Center for Coastal and Ocean Mapping, Durham, New Hampshire

The importance and broad scope of the Essential Fish Habitat (EFH) mandate requires a rigorous and efficient process for describing and mapping the habitats of federally managed species. To this end, we are developing quantitative habitat models for eastern Bering Sea (EBS) species, using density estimates from annual bottom trawl surveys and synoptic environmental data. Previous research with sparse historical data indicates that surficial sediments affect the distribution and abundance of EBS groundfish. However, traditional sampling with grabs and cores is impractical over large areas. Acoustic tools, on the other hand, are suitable for large-scale surveying but it is unknown if they measure the relevant properties of sediments.

Pilot studies with a split-beam echo sounder (38 kHz) and a side scan sonar (455 kHz) examined marginal contributions of acoustic data for explaining fish abundance in our habitat models. Preliminary results, after processing with proprietary software (QTCView and Sideview, Quester Tangent Corporation, Sidney, B.C.), indicate statistically significant but relatively minor contributions from the echo sounder data (4-12%; three taxa) as compared to the side scan sonar predictors (6-32%; six taxa).

Based on these findings, a definitive experiment was conducted in the EBS to compare the statistical value of normalized backscatter data from several different hull-mounted and towed systems, including a prototype long-range side scan sonar. Ultimately, the most advantageous system will be deployed in the EBS for extensive surveys that will enable improved groundfish-habitat models.

Extending the Functionality of the Consumer-Grade GPS for More Efficient Resource Assessment Mapping

Robert Mikol

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This poster presents a methodology for extending the geospatial data collection functionality of the consumer-grade GPS for circumstances that previously required very expensive equipment, software, and training. The approach involves the use of a waypoint naming protocol based on a user-defined data dictionary. These two procedures, used with a relational database and a geographic information system (GIS) can assist communities, organizations, and agencies in the collection of high quality, accurate, and sophisticated geospatial data under circumstances where funds and expertise are limited or nonexistent. Furthermore, the applications of this system are limitless. This poster presents applications of these protocols in fields relating to disaster response and assessment, trail mapping, and coastal resource assessment. Other applications are implied.

Alaska Bathymetry: Down to 50-Meter Resolution

Jim Noel and Steve Lewis

NOAA Fisheries, Alaska Region, Juneau, Alaska

This data set provides a complete polygon coverage of Alaska waters bathymetry, with resolutions ranging from 1,500 m down to 50 m. The resolution varies with local sampling density. Regions that have been intensively sampled are represented with high-resolution polygons, while more sparsely sampled areas have lower-resolution polygons. Data sources included the NGDC Hydrographic Surveys, Trackline Geophysics, and ETOPO2.

A super-product of this data set includes waters outside of Alaska waters.

Alaska's Surficial Seabed Characteristics

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Costly and labor-intensive ground truthing data, gathered through physical or virtual sampling of the seabed, is a key data type in mapping for habitat, along with bathymetry for depth and slope, backscatter imagery for large-scale bottom type determination, and biota identifications. Information about surficial seabed characteristics is also instrumental in understanding geologic history and processes, sediment transport issues, and the distribution of resources. Most reports discuss small areas of the seafloor, with rare regional investigations.

The USGS and collaborators are compiling hundreds of ground truthing reports, site-specific to regional, from all regions of Alaska's oceans into the usSEABED database (walrus.wr.usgs.gov/usseabed); these data are unified through the dbSEABED integration program (instaar.colorado.edu/~jenkinsc/dbseabed). usSEABED holds numeric point data from lab analyses and written descriptions for sediment texture and statistics, rocks or areas of hard bottom, common geochemical and geophysical parameters, and constituent components of the sediment such as, ash, coral, shells, epi- and in-fauna, and many others.

In Alaska, we are working to include data collected by the USGS, NOAA's National Ocean Service, the U.S. Navy, universities, oil companies, and other federal agencies, totaling hundreds of thousands of data points.

For this workshop, we present the work-in-progress for Alaska, seek further data and partners for usSEABED, and show some of the ways usSEABED data are being used elsewhere in the United States. We hope that usSEABED will provide an ongoing data source and data repository to aid the marine science community's understanding of benthic habitats as well as seafloor character, processes, and resources.

Characterizing Trawlable and Unrawlable Substrate Using Single Beam Echo Sounder Data to Improve Estimation of Commercial Groundfish Abundance

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Biennial trawl surveys conducted in the Gulf of Alaska by the National Marine Fisheries Service (NMFS) are a primary data source for estimation of commercial groundfish abundance. A perennial problem in the accurate estimation of groundfish biomass using trawl surveys is the unknown (but presumed large) amount of the continental shelf that is not fishable. Therefore a method for estimating the area of unrawlable seafloor is needed for Alaska. We examined single beam echo sounder data collected from a NMFS bottom trawl survey vessel along four transects previously classified as trawlable or unrawlable using videotape from a towed camera sled. Three simple models estimated the shape of the echo sounder seafloor reflection by measuring the slope, the peak amplitude, and tail characteristics. A classification-tree model was fit to the data from three transects, and the resulting model was fit to data collected at the fourth transect as a test. The classification tree model was able to predict accurately whether the seafloor was trawlable or unrawlable in 90% of the original data set. It was able to predict trawlable or unrawlable 75% of the time in the test data set. This approach, combined with ancillary data collected from the echo sounder (such as local slope and rugosity), holds promise for increasing our knowledge of the amount of trawlable and unrawlable seafloor within Alaska ecosystems, as well as providing a low-cost method of mapping the region.

Modeling Black Rockfish Locations Using Hydroacoustics and High Resolution Bathymetry

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Advances in fisheries acoustics have allowed for the plotting of individual fish in 3-dimensional space. Black rockfish present a good acoustic target, usually schooling in semi-pelagic, loose aggregates in which the individual fish can be relatively easily distinguished. Black rockfish are known to associate with specific bottom structures, with the location of fish aggregates persisting in the same localized area from year to year. When high-resolution bathymetry is available, these fish locations can be related to the bottom terrain. We attempt to use a specific methodology (Benthic Terrain Modeler) to relate areas of fish concentrations to the bottom characteristics of slope, aspect, rugosity, and a bathymetric position index.

The NOAA Pacific Hydrographic Branch gathered both multibeam and LIDAR bathymetry around the Shumagin Islands, in the western Gulf of Alaska, as part of its routine updating of navigational charts. Previous research had shown that many of the areas they covered were also excellent black rockfish habitat. Six areas of known rockfish abundance where high-resolution bathymetry (2 meter grid) was available were surveyed with a Biosonics DTX split beam echo sounder. Transects spaced at 50 meters were run and individual fish were located using Sonardata Echoview software's fish tracking module. The Benthic Terrain Modeler (BTM) tools for ArcGIS 9.x were then used to quantitatively describe the bathymetry in the transect area. Fish were found to associate within 30 m of specific substrates, but all structures meeting the criteria did not have fish concentrations.

Mapping Seabed Habitats in the Stellwagen Bank National Marine Sanctuary, Gulf of Maine

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The seabed of the Stellwagen Bank National Marine Sanctuary (SBNMS) in the western Gulf of Maine is a complex of geomorphic features and substrate types that owe their origin to sculpting by glacial ice movement, erosion and deposition of sediments during ice melting and sea level rise, and reworking by modern currents. The seabed has been mapped using multibeam echo sounder imagery and extensive ground truthing with video and photographic imagery and geological and biological sampling.

We use a new seabed classification scheme to map habitats based on substrate texture, seabed dynamics, the complexity of physical and biological structures on the seabed, and fauna. This approach has been applied to Quadrangle 6 of the SBNMS where sediment textures range from boulder ridges to muddy sand, and where substrates are immobile and/or seasonally mobile. We compiled interpretive maps of the quadrangle that show seabed topography, reflectivity, substrate type, sediment dynamics, habitats, and disturbance.

The habitats lie on the southeastern margin of Stellwagen Bank, on several nearby banks (Ninety Meter Banks), and in inter-bank basins. The mapped area deepens from west to east. The upper eastern flank of Stellwagen Bank (35-65 m) is a habitat (H3) of seasonally mobile coarse-grained sand formed into large ripples by storm currents. It is bounded to the east (55-90 m) by immobile coarse-grained sand (H6), and by a transitional habitat (H2, 45-55 m) of immobile gravel in mobile rippled sand that gives way, as water depth increases (50-75 m), to an immobile gravel habitat (H4) with boulder ridges (H1). Eastward, in deeper water along the bank's lower flank (70-90 m), immobile muddy coarse-grained sand deposits (H5) represent a drowned shoreline. The Ninety Meter Banks (90-120 m) are covered by immobile gravel (H4) with boulder ridges (H1) and are separated by deep basins (to 180 m) of immobile muddy sand (H7, H8).

Comparison of Echogram Measurements against Data Expectations and Assumptions for Distinguishing Seafloor Habitats

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Since the Quster Tangent Corporation's (QTC IMPACTTM) proprietary algorithms are unpublished, it is impossible to understand how QTC habitat classes are derived from single beam echo sounder reflections, and user processing errors may drive the QTC habitat classifications. We examined the algorithm outputs, or echogram measurements (EMs), that form the basis for habitat classification, and found significant, elementary problems such as multicollinearity and correlation with depth. Then we tested the EMs against assumptions that may be of broad interest to users and found that (1) the scale or range of EMs is not consistent with proper principal components analysis (PCA); and (2) the EMs may be created from more than just the first echo. While these problems may be entirely user-generated, the lack of transparency in habitat typing effectively hides these errors. Therefore we suggest users examine their QTC-generated EMs for similar properties before relying on the final habitat classification provided by the software.