

Marine Habitat Mapping Technology Workshop for Alaska
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ABSTRACTS -- INVITED SPEAKERS

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

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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

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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 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 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

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.

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

CDR Gerd Glang

Chief, Hydrographic Surveys Division
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Bathymetric LIDAR surveys for marine habitat: What can be expected from an airborne Bathymetric LIDAR survey?

Carol Lockhart

Fugro Pelagos, Inc., San Diego

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

Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of 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, sidescan, and subbottom 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, Richard Henthorn
Monterey Bay Aquarium Research Institute

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” diameter, *Dorado* class autonomous underwater vehicle (AUV) equipped with a 200 kHz multibeam sonar, 110 kHz and 410 kHz sidescan sonars, and a 2-16 kHz subbottom profiler. All components of the vehicle are rated to 6000 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/s (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 subbottom 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

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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, a high resolution digital camera, the ability to create photo-mosaics, and chemical sensors 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 was able to quantify and detect 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 additional forward looking cameras for better species ID, DIDSON and IR 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

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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 echosounder 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 echosounder systems (MBES): for practical reasons we limit the operational depths to about 10 metres. Bathymetric (phase-measuring) sidescan 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

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 or 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 echosounders (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 three 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

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Canadian Hydrographic Service, Pacific Region

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 principle 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 groundtruth 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 which 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 which 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

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Small remotely-operated vehicles (ROV's), 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 oceans resources than ever before.

Small ROV's 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

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Alaska Department of Fish and Game, Homer

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 sea floor 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 micro-scale habitat measurements and fish observations, and layered over meso-scale remotely sensed bathymetry data.

Sampling strategies and sources of uncertainty associated with visual surveys of demersal fishes and habitats using the occupied submersible *Delta*

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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 (ADF&G) 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 Alaskan projects conducted by the ADF&G 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 sidescan, multibeam (groundtruthed from the submersible), and commercial fishery logbook data. To date over 2,200 km² of the eastern Gulf 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 allows us to clearly define boundaries of prime habitats, relevant to management decisions regarding marine reserves or definition of management units. The Edgecumbe Pinnacles Marine Reserve is the first no-take groundfish reserve in Alaska and has been extensively mapped and characterized using sidescan 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 co-registered 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 was 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 sidescan 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 sidescan and multibeam data require

groundtruthing 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 groundtruthing, 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 groundtruthing 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

Washington State University Vancouver

A key component of submersible-based habitat studies is the extraction and analysis of data from large quantities of video tapes resulting from field work. 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 principle 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?

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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 Geographical 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 deep-water 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 sea floor, 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; deep-water 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

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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 join 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 programmes 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 sq. km (270,000 sq.mi) 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 (0-50m), Zone 2 (50-200m) and Zone 3 (200-4500m). 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 sq. kms were successfully surveyed with standard maps produced covering an area of 2° x 1° at 1:250 000 scale. The second phase of the

National Seabed Survey called INFOMAR is now underway focussing 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 programme 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 dataset 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 deep-water MB,
- The need to overcome survey idiosyncrasies to maximise 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 was 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 mobilisation due to waves and tides. To better characterise 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 6 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 broad-scale marine planning and in the design of representative MPA networks.