The Applicability of Sonars for Habitat Mapping: a Bibliography

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Introduction- The Applicability of Sonars for Habitat Mapping: A Bibliography

A great variety of biotic and abiotic factors define the habitats of marine species such that knowledge of their spatial and temporal variability can be used to understand biological patterns of distribution and abundance. The importance of habitats for the sustainable management of fishery stocks was formally acknowledged in the United States with passage of the Sustainable Fisheries Act in 1996. At that time, the Magnuson-Stevens Fishery Conservation and Management Act was amended to include new requirements to identify and protect essential fish habitat (EFH). By legal definition, EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Using the best scientific information, federal fishery management plans must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. In so doing, the plans should explain the physical, biological, and chemical characteristics of EFH and must also identify the specific geographic location or extent of habitats described as EFH.

The broad scope of the EFH mandate requires an efficient process for describing and mapping the habitats of federally managed species. Factors such as temperature, salinity, and depth are generally accepted as habitat-defining characteristics for marine fish and invertebrates, and synoptic data sets are frequently available. Research also indicates that surficial sediments are an important habitat factor for many species, with both direct and indirect effects on survival and growth. Traditional sampling with grabs and cores is, however, impractical over large areas and the availability of geo-referenced data is usually limited as a result. Acoustic methods, on the other hand, are suitable for large-scale surveying and show great promise as a substitute for direct-sampling methods, but they are still at a "nascent" stage of development (Anderson et al. 2008) and have not been proven for EFH purposes.

The complex relationship between acoustic returns and seafloor sediments has been actively studied for decades. According to Holliday (2007)[1], as many as 80 different parameters have been used to describe the physical and material properties of the seafloor, of which 6 to 12 of these may have major influence on acoustic returns from the seabed. This complexity limits the utility of conventional ground-truthing with grabs. Overall, each seabed type has a characteristic acoustic return, although that return is not unique because many of the parameters are confounded. As a result, accurate characterization of seabed types from acoustic returns is problematic because different combinations of grain size, surface roughness, and slope, for example, can have the same acoustic properties (the so-called "inverse problem"). The situation is even more complex, given the seabed frequently is not static due to time-varying forces such as waves, currents, certain fishing activities, and natural biological processes. Notwithstanding the challenges of interpretation, many useful applications of sonars for habitat mapping have been reported in the scientific literature.

The primary focus of this bibliography is benthic habitat characterization using backscatter and bathymetric data from multibeam echo sounders, single-beam echo sounders, and side scan

sonars. The coverage ranges from methods for acquiring and processing data, data extraction and synthesis from imagery, production and use of habitat maps for fishery management and other purposes, modeling species distributions using processed data, and some relevant theoretical treatments. The bibliography was compiled from extensive searches of online literature databases, as well as secondary reviews of literature cited in the selected references. The collection includes peer-reviewed articles, as well as state and Federal reports, conference papers, cruise reports, bulletins, and books. The abstracts and keywords for each reference were obtained from the original source whenever possible. If one or the other was not available for use, a brief summary and/or keywords were added. Links were only provided at the request of the publisher. Some papers were excluded due to lack of availability of copyright permissions.

This bibliography can be found online as a searchable, dynamic database at http://access.afsc.noaa.gov/sonarHabMap/search.php .

Acknowledgments

We would like to thank all of the authors and publishers who granted permission to include copyrighted works, especially ProQuest (www.proquest.com) for their considerable contributions.

We would like to thank Jim Lee (AFSC) in his assistance in obtaining style guidelines because of publisher requests.

We would like to thank Sarah Schwartz (USDDC Office of General Council) in her assistance in copyright law.

[1] Holliday, D. V. 2007. Theory of sound-scattering from the seabed. Pages 13-23 in Anderson, J., Holliday, V., Kloser, R., Reid, D., and Simard, Y. (ed). Acoustic seabed classification of marine physical and biological landscapes. ICES Cooperative Research Report no. 286. Copenhagen.

Able, K. W., D. C. Twichell, C. B. Grimes, and R. S. Jones. 1987. Sidescan sonar as a tool for detection of demersal fish habitats. Fish. Bull., U.S. **85**:725-737.

Keywords: habitat preferences, side scan sonar, sonar, marine, *Caulolatilus*, habitat selection, *Lopholatilus*, methodology

Abstract: Sidescan sonar can be an effective tool for the determination of the habitat distribution of commercially important species. This technique has the advantage of rapidly mapping large areas of the seafloor. Sidescan images (sonographs) may also help to identify appropriate fishing gears for different types of seafloor or areas to be avoided with certain types of gears. During the early stages of exploration, verification of sidescan sonar sonographs is critical to successful identification of important habitat types. Tilefishes (*Lopholatilus* and *Caulolatilus*) are especially good target species because they construct large burrows in the seafloor or live around boulders, both of which are easily detectable on sonographs. In some special circumstances the estimates of tilefish burrow densities from sonographs can be used to estimate standing stock. In many localities the burrow and boulder habitats of tilefish are shared with other commercially important species such as American lobsters. *Homarus americanus*: cusk. *Brosme brosme*; and ocean pout. *Macrozoarces americanus*.

Allen, Y. and C. Wilson, H. Roberts, and J. Supan. 2004. Using sidescan sonar to assess the impact and persistence of natural and anthropogenic disturbance to low-relief oyster habitats in coastal Louisiana. In: Proceedings of the Gulf and Caribbean Fisheries Institute. **55**:1006-1007.

Keywords: sidescan sonar, oyster habitat, Louisiana

Abstract: Traditional methods used to assess oyster reef distribution and condition are only able to provide subjective point information which is often poorly georeferenced. Maps of oyster habitat in shallow waters are therefore typically extremely generalized, giving few details about the true distribution, character and dynamics of reefs. Sidescan sonar offers a significant advantage for oyster reef assessment in the turbid waters of coastal Louisiana. We used sidescan sonar in ultra-shallow (<2m) waters to completely image over 19 000 ha in Louisiana estuaries in advance of an impending freshwater diversion project. We also conducted four years of intense annual surveys in a more restricted area (320 ha) with a diversity of reef types and culture intensity to examine natural and anthropogenic impacts on oyster reef extent and character. Our intensive surveys identified older stable reefs which had not been actively worked. Shell abundance and structure on these reefs were high, but oyster meat productivity was low. Areas of intense oyster culture were characterized by low relief reefs that frequently showed distinct evidence of scarring from dredging and other anthropogenic sources. Smaller scars caused by oyster dredging typically healed through the within

time period of our study while larger anthropogenic scarring did not diminish over the four years. We also deployed the sonar towfish over an area immediately before and after both seeding and harvesting to establish a quantitative relationship with sonar reflectance. These relationships can be further used to predict the impact of harvesting and seeding on the extent oyster habitat. Demographic comparison of red snapper (*Lutjanus campechanus*) from the Atlantic and Gulf of Mexico. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Allen, Y. C., C. A. Wilson, H. H. Roberts, and J. Supan. 2005. High resolution mapping and classification of oyster habitats in nearshore Louisiana using Sidescan Sonar. Estuaries **28**:435-446.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007/BF02693925

Anderson, J. T., D. Van Holliday, R. Kloser, D. G. Reid, and Y. Simard. 2008. Acoustic seabed classification: current practice and future directions. ICES J. Mar. Sci. **65**:1004-1011.

Keywords: acoustic, classification, echosounders, habitat, landscape, mapping, marine, multibeam, seabed, sidescan, single beam, sonar.

Abstract: Acoustic remote sensing of the seabed using single-beam echosounders, multibeam echosounders, and sidescan sonars combined and individually are providing technological solutions to marine-habitat mapping initiatives. We believe the science of acoustic seabed classification (ASC) is at its nascence. A comprehensive review of ASC science was undertaken by an international group of scientists under the auspices of ICES. The review was prompted by the growing need to classify and map marine ecosystems across a range of spatial scales in support of ecosystem-based science for ocean management. A review of the theory of sound-scattering from seabeds emphasizes the variety of theoretical models currently in use and the ongoing evolution of our understanding. Acoustic-signal conditioning and data quality assurance before classification using objective, repeatable procedures are important technical considerations where standardization of methods is only just beginning. The issue of temporal and spatial scales is reviewed, with emphasis on matching observational scales to those of the natural world. It is emphasized throughout that the seabed is not static but changes over multiple time-scales as a consequence of natural physical and biological processes. A summary of existing commercial ASC systems provides an introduction to existing capabilities. Verification (ground-truthing) methods are reviewed, emphasizing the difficulties of matching observational scales with acoustic-backscatter data. Survey designs for ASC explore methods that extend beyond traditional oceanographic and fisheries survey techniques. Finally, future directions for

acoustic seabed classification science were identified in the key areas requiring immediate attention by the international scientific community. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Appeldoorn, R. S., J. A. Rivera, and M. C. Prada. 2001. Mapping benthic habitats using side scan sonar. p. 402-414. *In* Proceedings of the Gulf and Caribbean Fisheries Institute. Gulf and Caribbean Fisheries Institute, Harbor Branch Oceanographic Institution, Inc.

Keywords: habitat mapping, active sensors, side scan sonar

Abstract: Detailed, but large scale habitat mapping is necessary if fisheries researchers are to investigate habitat-species distributions on spatial scales relevant to fisheries management and marine conservation, and identify essential fish habitats and the qualities that underlie their importance. The latter will include both the immediate structural qualities of a given area and the linkages among surrounding habitats. Knowledge of the underlying structure of habitat function should allow simple rules to be developed for future identification and protection of critical habitats. Despite over 40 years of concentrated academic investigation in the area of La Parguera, Puerto Rico, including geological mapping, there is no comprehensive habitat map suitable for large-scale biological studies. Developing such a map is now feasible using remote sensing and geographic information system (GIS). We are using side scan sonar (SSS) to develop a habitat map extending from the shoreline to the edge of the insular platform and covering over 20 nautical miles square (nm^2). SSS is advantageous over airborne remote sensing in its greater depth range and greater resolution. The SSS associated navigation equipment (computer, software, DGPS) and electric winch are mounted on a 22-ft vessel. A 300 kHz transducer is towed over 100-m wide paths to collect bottom images. To create larger views, georeferenced mosaics are generated from individual images using GIS technology. To date we have identified broad areas of habitat and located unknown patch reefs in otherwise soft-sediment areas. At 300 kHz, metal-frame fish traps were not detected, although evidence of their effect on corals were. Although SSS technology is valuable, its success requires proper logistical set-up, plus expertise in computers and electronics.

Armstrong, A. A. and L. Mayer. 2000. The NOAA/UNH Joint Hydrographic Center and the UNH Center for Coastal and Ocean Mapping: An educational and research partnership of the Federal Government, the University of New Hampshire and Ocean Industry. p. 705-709. *In* Proceedings of the Oceans 2000 MTS/IEEE - Where Marine Science and Technology Meet, Vols 1-3, Heriot-Watt University Ocean Systems Laboratory

Keywords: ocean mapping technology, hydrography, C-COM/JHC

Abstract: Ocean mapping technology is becoming an increasingly important tool in the full range of ocean-related enterprise. Moving well beyond its initial base in

hydrographic surveying and nautical charting, ocean mapping has become a critical component of offshore oil exploration and development, submarine cable routing and installation, and geologic and essential fish habitat mapping. The technology of ocean mapping has blossomed rapidly in the past decade with the introduction of multibeam sonar, high-resolution side scan sonar, airborne lidar bathymeters, and laser line scan recorders. The next decade will likely see increased demand for ocean mapping data and continued demand for even more sophisticated ocean mapping technology. In response to this increased demand for ocean mapping data and the increasing complexity of ocean mapping technology, the National Oceanic and Atmospheric Administration (NOAA) and the University of New Hampshire (UNH) have established the complementary Joint Hydrographic Center (JHC) and Center for Coastal and Ocean Mapping (C-COM). The JHC is a NOAA/UNH partnership, and C-COM is a University organization with growing private sector participation. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Atallah, L., and P. Probert Smith. 2004. How useful is bathymetric information in the classification of high frequency sonar surveys? J. Acoust. Soc. Am. **116**:2487-2487.

Keywords: seabed classification, bathymetric data, machine learning

Abstract: In a number of sonar studies, bathymetric information is used to correct and visualise amplitude data. This work proposes a method which combines amplitude features (describing backscattering strength and sonar texture) with bathymetric features (indicating seafloor variability) for sonar classification. Features are selected per window (of user defined size) and areas around grab samples in a survey are used for training. The importance of different features is investigated in this study, and highlighted by feature selection algorithms as well as by scatter plots exploring the training areas. Classification rates are significantly improved when both amplitude and bathymetry features are used. The method is applied to a sidescan bathymetric sonar dataset taken in Hopvågen bay-Norway. Copyright 2004, reproduced with permission from Acoustical Society of America.

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Auster, P. J., K. Joy, and P. C. Valentine. 2001. Fish species and community distributions as proxies for seafloor habitat distributions: the Stellwagen Bank National Marine Sanctuary example (Northwest Atlantic, Gulf of Maine). Environ. Biol. Fishes **60**:331-346.

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Auster, P. J., J. Lindholm, and P. C. Valentine. 2003. Variation in habitat use by juvenile Acadian redfish, *Sebastes fasciatus*. Environ. Biol. Fishes **68**:381-389.

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Keywords: Landsat ETM+, neural networks, *Posidonia*, raster-GIS, sea bottom current magnitude, sea bottom salinity, sea bottom temperature

Abstract: Within the framework of the 3-year project "Mapping the habitats of the Republic of Croatia" the marine benthic habitats of the entire Croatian maritory were mapped. The supralittoral and the mediolittoral were mapped as a function of the coastal lithology and the presumed levels of human impact (both in scale of 1:100,000). The infralittoral was mapped on the basis of spatial modelling (using neural networks as a modelling tool, data about habitats collected by fieldwork as the independent variable for training and testing the model, and the digital bathymetrical model, the distance from coast, the second spectral channel of Landsat ETM+ satellite image and the sea bottom sea temperature, salinity and current magnitude, as dependent variables). The circalittoral and the bathyal were mapped by overlapping and reinterpretation of the existing spatial databases (bathymetry and lithology) within the framework of the raster- GIS. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Barberá, C., J. Moranta, F. Ordines, M. Ramón, A. de Mesa, M. Díaz-Valdís, A. M. Grau, and E. Massutí. 2012. Biodiversity and habitat mapping of Menorca Channel (western Mediterranean): implications for conservation. Biodivers. Conserv. **21**:701-728.

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Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

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Keywords: ecological zonation, GIS, ocean policy

Abstract: To better understand the possible relationships between the geology of the seabed and the associated biological communities, a multibeam sonar survey over New Zealand Star Bank in the eastern Bass Strait was conducted. A hierarchical method of benthic habitat mapping was applied to the secondary biotope and biological facies levels at the site (< 10 km) scale. Four secondary biotopes and four biological facies have been defined on the basis of geomorphology revealed by the bathymetry model and the results of statistical analysis of the sediment and underwater video transect data over the bank. The major differences that control the distribution of biological communities in the New Zealand Star Bank area appear to be related to variations in substrate. (1) Hard-ground features related to high-relief granite outcrops are associated with diverse and abundant sessile and motile fauna. These faunal communities may be biologically modified to patchy barrens habitat by grazing urchins. (2) Unconsolidated sediment on a flat seabed is associated with sparse small sponges on the inner shelf. On the middle shelf and seaward of bank, the flat and muddy seabed supports a community dominated by infauna. (3) Unconsolidated sediment on a low-relief seabed is associated

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with an increase in the density and sizes of sponges concentrated on any low-relief feature raised above the surrounding flat seabed.

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Keywords: SeaWASP,bathymetry, twin hull, shallow water

Abstract: Students with Santa Clara University (SCU) and the Monterey Bay Aquarium Research Institute (MBARI) are developing an innovative platform for shallow water bathymetry. Bathymetry data is used to analyze the geography, ecosystem, and health of marine habitats. Current methods for shallow water measurements typically involve large manned vessels that are costly to operate and that may pose a danger to themselves and 1he environment in shallow, semi-navigable waters. Small vessels, however, are prone to disturbances by shallow water waves, tides, and currents, thereby requiring more instrumentation and computation to accurately process bathymetric data. The SCU/MBARI autonomous surface vessel, SeaWASP, is designed to operate safely and stably in waters as shallow as 1 m without significant manned support in order to produce cost-effective and high-quality bathymetric maps. The SeaWASP design introduces several key design innovations in order to provide high-quality maps with a platform that is safe, stable, and inexpensive. A small waterplane area twin hull (SWATH) design features a submerged dual hull, a small waterplane area, and a high mass-to-damping ratio, thereby making the craft less prone to disturbances. Precision sensing, autonomous control, and platform-level configuration planning and control algorithms are used to navigate the boat along desirable trajectories in support of efficient map generation and to implement low-cost unpiloted operations. Bathymetry is measured with multi-beam sonar in concert with Doppler Velocity Logger and GPS sensors. The vessel has been operated successfully in several open water test environments, including Elkhorn Slough. Stevens Creek Reservoir, and Lake Tahoe. all in California. It is currently in the final stages of integration and test for its first major science mission at Orcas Island. San Juan Islands. WA, in 2009. Final deployment will be at the National Oceanographic and Atmospheric Administration's (NOAA's) Kasitsna Bay Laboratory in Alaska as one element of a multi-system remote observatory. SeaWASP has been developed in partnership with SCU, MBARI, the University of Alaska-Fairbanks, and NOAA's West Coast and Polar Regions Undersea Research Center. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Bellman, M. A., S. A. Heppell, and C. Goldfinger. 2005. Evaluation of a US west coast groundfish habitat conservation regulation via analysis of spatial and temporal patterns of trawl fishing effort. Can. J. Fish. Aquat. Sci. **62**:2886-2900.

Abstract: We examined the extent to which the 2000 Pacific Fishery Management Council footrope restriction shifted and reduced trawl fishing effort on Oregon fishing grounds, related these changes to the seafloor habitat type over which they occurred, and developed methods for enhancing spatial review of fishing effort. Density analysis of trawl start locations demonstrated how fishing efforts increased and decreased in relation to habitat distribution and fishery management actions between 1995 and 2002. Trawl effort patterns exhibited significant interannual variability and were patchy in distribution. Tow end-point locations from 1998 to 2001 were retrieved from manual logbooks for five reference sites located in proximity to rocky habitat. Trawl towlines were mapped and demonstrated a marked enhancement of fine-scale fishing effort resolution. Spatial shifts in fishing intensity (measured as kilometres towed) away from rock habitat were evident at all reference sites after the footrope restriction, with an average reduction of 86%. Some slight shifts into surrounding unconsolidated sediments also occurred. Our results indicate that the footrope restriction, in conjunction with associated landing limits, was effective in protecting rocky habitats from trawl fishing impacts. Continued spatial monitoring of trawl data would assist in fishery management assessment of conservation objectives for depleted groundfish and essential fish habitat protection.

Blondel, P., V. Huvenne, and V. Huhnerbach. 2006. Multi-frequency acoustics of deep-water coral habitats and textural characterization. p. 379-384. *In* Proceedings of the 8th European Conference on Underwater Acoustics, Cintal - University of Algarve, Faro (Portugal).

Abstract: Deep-water corals are found in many ocean margins. They often build structures or reefs, from a few metres to kilometres long and up to several tens of metres high. These structures are highly vulnerable to human activities; an increasing number have been identified and are now protected. Acoustic techniques such as multibeam and side scan sonar are ideal to investigate these deep habitats. This article presents side scan sonar imagery collected repeatedly over several deep-water coral habitats, using different instruments and/or different frequencies. All data was processed with the same software (PRISM, NOC) and subsequently classified with the same software (TexAn, Bath). The TexAn maps of different surveys over a particular area prove to be comparable, clearly identifying different habitat types (such as coral framework, coral rubble, background sediment etc.). This work aims to give a general methodology for interpreting side scan sonar imagery from coral reefs, thus simplifying the tasks of habitat mapping and marine resource management.

Bornhold, B. D., C. V. Jay, R. McConnaughey, G. Rathwell, K. Rhynas, and W. Collins. 2005. Walrus foraging marks on the seafloor in Bristol Bay, Alaska: a reconnaissance survey. Geo-Mar. Lett. **25**:293-299.

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Brown, C. J. and J. S. Collier. 2007. Mapping benthic habitat in regions of gradational substrata: An automated approach utilising geophysical, geological, and biological relationships. Estuar. Coast. Shelf. Sci. **78**:203-214.

Keywords: sidescan sonar, benthic habitat, seabed properties, acoustic classification

Abstract: The relationship between acoustic backscatter, sediment characteristics and benthic habitat is examined using high-resolution sidescan sonar data collected at the Loch Linnhe artificial reef site on the west coast of Scotland. The site is typical for the continental shelf of NW Europe, with a mix of seabed environments from muddy to coarse, stony substrata on a 10-100m length scale. A sidescan sonar mosaic was produced and classified according to derived backscatter parameters (mean, median and standard deviation of the backscatter values) using an unsupervised classification procedure. The accuracy of the final classified map was assessed by comparison with a ground-truthing survey in which the biological habitat was derived from underwater video footage. The sidescan correctly predicted seabed surface characteristics of observed biological habitat with 78% accuracy. A second, and more challenging test of the acoustic data to correctly predict biological habitat was made by comparing it with data from 21 grab sampling stations. These stations were divided into three groups using multivariate statistical techniques based on their backscatter properties. Benthic assemblage structure was found to be significantly distinct between the high and low, and the medium and low backscatter stations. There was a low to moderate but significant correlation between the multivariate patterns of acoustic backscatter, benthic assemblage structure, and particle size distribution. The work shows that even in areas with subtle and gradational changes in substratum, the sidescan was able to predict biological community with an acceptable accuracy. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Brown, C. J., K. M. Cooper, W. J. Meadows, D. S. Limpenny, and H. L. Rees. 2001. Small-scale mapping of sea-bed assemblages in the Eastern English Channel using sidescan sonar and remote sampling techniques. Est. Coast. Shelf. Sci. **54**:263-278.

Keywords: mapping, sidescan sonar, biotope, habitat, benthic community

Abstract: A survey was conducted in the eastern English Channel to investigate the use of sidescan sonar, used in conjunction with traditional biological sampling methods, to map the variety and distribution of benthic biotopes (i.e. sea bed habitats and their associated biological communities). An area of sea-bed, approximately 28 km x 12 km in size, offshore from Shoreham, U.K., was surveyed using a digital sidescan sonar system and a mosaic of the output was produced covering 100% of the survey area. This was used to divide the area into acoustically distinct regions, around which subsequent benthic ground-truth surveys were designed. Benthic communities and sediment types within each of the these regions were sampled using a Hamon grab fitted with a video camera, and using a heavy duty 2-m beam trawl. Further information concerning the sea-bed was obtained through the application of additional video and photographic techniques. Substrates within each acoustic region were generally homogeneous in distribution, and sediment types ranged across the survey area from cobbles and coarse gravel through to muddy sands. Analysis of the faunal data revealed the presence of statistically distinct biological assemblages within most of the acoustic regions, although species similarity between samples collected from within each acoustic area was often low. Using a combination of all the data sets, five discrete biotopes could be identified and mapped across the area. The application of acoustic techniques, used in conjunction with biological sampling techniques, to map the distribution of sea-bed habitats and associated benthic communities is discussed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

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Brown, C. J., A. J. Hewer, W. J. Meadows, D. S. Limpenny, K. M. Cooper, H. L. Rees, and C. M. G. Vivian. 2001. Mapping of gravel biotopes and an examination of the factors controlling the distribution, type and diversity of their biological communities. Book Monograph 0308-5589.

Keywords: species diversity, biotopes, community composition

Abstract: The production of high-resolution biotope maps of the seabed will assist in future site-specific environmental assessments of potential aggregate dredging areas, and would be of value during any subsequent environmental monitoring activities. The issue of extraction licences by the Crown Estate is subject to a favourable Government View, with the Department for Environment, Food and Rural Affairs (DEFRA) being an influential contributor, therefore the development and evaluation of the utility of mapping techniques in such applications is appropriate to ensure that the best scientific advice is available to underpin the fisheries and marine environment concerns that are DEFRA's policy remit. This report details work conducted by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) over the course of a three year research programme. The main objectives were to assess the utility of seabed mapping techniques for surveying habitats, and to investigate the factors controlling the distribution, type and diversity of their associated biological communities. A range of acoustic techniques were evaluated in the first year of the project, and sidescan sonar was selected as the main acoustic mapping system for use in subsequent surveys. In addition, two acoustic ground discrimination systems (AGDS), RoxAnn and QTC-View, were also chosen for use alongside the sidescan sonar system. Four sites were selected in the eastern English Channel to evaluate the mapping techniques. The main site for study was offshore from Shoreham (28 km x 12 km in area). The site was selected as it offered a range of sediment types which were relatively homogeneous in their distribution, and would therefore offer an environment in which the relationship between acoustic output, physical habitat type and biological assemblage structure could be investigated. The other three sites, at Hastings, the eastern Isle of Wight and Dungeness (all 12 km x 4 km in area) were chosen to offer a wider range of substrata of varying degrees of spatial complexity (sediment patchiness) over which the techniques developed at Shoreham could be tested. Each site was intensively surveyed using a digital sidescan sonar system. A mosaic of the sidescan sonar data was produced to provide 100% spatial coverage maps at each location. This was then divided into acoustically distinct regions which, following ground-truthing using underwater video, were found to relate to discrete habitat types.

Brown, C. J., A. Mitchell, D. S. Limpenny, M. R. Robertson, M. Service, and N. Golding. 2005. Mapping seabed habitats in the Firth of Lorn off the west coast of Scotland: evaluation and comparison of habitat maps produced using the acoustic ground-discrimination system, RoxAnn, and sidescan sonar. ICES J. Mar. Sci. **62**:790-802.

Abstract: In September 2003 a national workshop took place in the United Kingdom with the aim of assessing the accuracy of the acoustic ground-discrimination system (AGDS), RoxAnn™, as a tool for mapping seabed habitats in Special Areas of Conservation (SACs). A heterogeneous area of seabed, approximately 1km² in size, was selected for the study. The area was first surveyed using a sidescan-sonar system and a

mosaic of the output was produced covering 100% of the survey area. Interpretation of the mosaic identified three acoustically distinct seabed types, the spatial distributions of which were mapped. Four RoxAnn data sets were then collected over the same area of seabed applying different survey parameters (e.g. different survey grids, track spacing, survey vessels, survey speeds, and RoxAnn systems). Extensive ground-truthing was carried out involving 26 drop-down video stations, and from these data six benthic classes (seabed habitats) were identified. Following interpolation of the RoxAnn track-point data to produce full spatial-coverage data, these six-seabed habitat categories were used to conduct supervised classification of the RoxAnn data to produce full-coverage habitat maps of the area for each of the four RoxAnn data sets. Comparisons were then made between the four RoxAnn maps and the sidescan-sonar interpreted map. The accuracy of each map was assessed and the application of this mapping approach for mapping seabed habitats in SACs is discussed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Brown, C. J., J. A. Sameoto, and S. J. Smith. 2012. Multiple methods, maps, and management applications: Purpose made seafloor maps in support of ocean management. J. Sea Res. **72**:1-13.

Abstract: The establishment of multibeam echosounders (MBES) as a mainstream tool in ocean mapping has facilitated integrative approaches toward nautical charting, benthic habitat mapping, and seafloor geotechnical surveys. The inherent bathymetric and backscatter information generated by MBES enables marine scientists to present highly accurate bathymetric data with a spatial resolution closely matching that of terrestrial mapping. Furthermore, developments in data collection and processing of MBES backscatter, combined with the quality of the co-registered depth information, have resulted in the increasing preferential use of multibeam technology over conventional sidescan sonar for the production of benthic habitat maps. A range of post-processing approaches can generate customized map products to meet multiple ocean management needs, thus extracting maximum value from a single survey data set. Based on recent studies over German Bank off SW Nova Scotia, Canada, we show how primary MBES bathymetric and backscatter data, along with supplementary data (i.e. in situ video and stills), were processed using a variety of methods to generate a series of maps. Methods conventionally used for classification of multi-spectral data were tested for classification of the MBES data set to produce a map summarizing broad bio-physical characteristics of the seafloor (i.e. a benthoscape map), which is of value for use in many aspects of marine spatial planning. A species-specific habitat map for the sea scallop *Placopecten magellanicus* was also generated from the MBES data by applying a Species Distribution Modeling (SDM) method to spatially predict habitat suitability, which offers tremendous promise for use in fisheries management. In

addition, we explore the challenges of incorporating benthic community data into maps based on species information derived from a large number of seafloor photographs. Through the process of applying multiple methods to generate multiple maps for management applications, we demonstrate the efficient use of survey data sets to maximize the benefit to a wide number of potential end users, and to facilitate the move toward an ecosystem-based approach to management. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Brown, C. J., S. J. Smith, P. Lawton, and J. T. Anderson. 2011. Benthic habitat mapping: A review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques. Estuar. Coast. Shelf. Sci. **92**:502-520. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Keywords: side scan sonar, multi-beam sonar, single-beam sonar, classification, remote sensing, community

Abstract: This review examines the various strategies and methods used to produce benthic habitat maps using acoustic remote sensing techniques, coupled with in situ sampling. The applications of three acoustic survey techniques are examined in detail: single-beam acoustic ground discrimination systems, sidescan sonar systems, and multi-beam echo sounders. Over the past decade we have witnessed the nascence of the field of benthic habitat mapping and, on the evidence of the literature reviewed in this paper, have seen a rapid evolution in the level of sophistication in our ability to image and thus map seafloor habitats. As acoustic survey tools have become ever more complex, new methods have been tested to segment, classify and combine these data with biological ground truth sample data. Although the specific methods used to derive habitat maps vary considerably, the review indicates that studies can generally be categorized into one of three over-arching strategies; 1) Abiotic surrogate mapping; 2) Assemble first, predict later (unsupervised classification); 3) Predict first, assemble later (supervised classification). Whilst there is still no widely accepted agreement on the best way to produce benthic habitat maps, all three strategies provide valuable map resources to support management objectives. Whilst there is still considerable work to be done before we can answer many of the outstanding technological, methodological, ecological and theoretical questions that have been raised here, the review concludes that the advent of spatial ecological studies founded on high-resolution environmental data sets will undoubtedly help us to examine patterns in community and species distributions. This is a vital first step in unraveling ecological complexities and thus providing improved spatial information for management of marine systems.

Brown, C. J., B. J. Todd, V. E. Kostylev, and R. A. Pickrill. 2011. Image-based classification of multibeam sonar backscatter data for objective surficial sediment mapping of Georges Bank, Canada. Cont. Shelf Res. **31**:S110-S119.

Keywords: multibeam sonar, acoustic backscatter, acoustic classification, Georges Bank, seabed mapping, seabed properties

Abstract: Developments in acoustic survey techniques, in particular multibeam sonar, have revolutionised the way we are able to image, map and understand the seabed environment. It is now cost effective to image large areas of the seafloor using these techniques, and the information from such surveys provides base line data from which thematic maps of the seabed environment, including maps of surficial geology, can be derived when interpreted in conjunction with in-situ ground truthing data. Traditional methods for the interpretation of acoustic backscatter rely on experienced interpretation by eye of grey-scale images produced from the data. However, interpretation of data can be subjective, and new developments in semi-automated backscatter classification software offer an objective method of segmentation of acoustic backscatter data into acoustically similar regions, but are not yet well tested or accepted. A large multibeam sonar data set from Georges Bank, Canada, was classified using the backscatter classification software, QTC-Multiview. Data from 4800km^2 of seabed were classified and results were compared with 110 ground truthing stations to assess the performance of the classification for geological discrimination. The relationship between backscatter metrics derived from the classification software and benthic geological characteristics were explored using statistical methods. Results suggest that image-based backscatter classification shows considerable promise for interpretation of multibeam sonar data for the production of geological maps. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Buhl-Mortensen, L., P. Buhl-Mortensen, M. F. J. Dolan, J. Dannheim, V. Bellec, and B. Holte. 2012. Habitat complexity and bottom fauna composition at different scales on the continental shelf and slope of northern Norway. Hydrobiologia **685**:191-219.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs10750-011-0988-6

Buhl-Mortensen, P., M. Dolan, and L. Buhl-Mortensen. 2009. Prediction of benthic biotopes on a Norwegian offshore bank using a combination of multivariate analysis and GIS classification. ICES Journal of Marine Science **66**:2026-2032.

Keywords: benthic biodiversity, habitat mapping, habitat prediction

Abstract: This study is part of the multidisciplinary seabed mapping programme MAREANO (Marine AREAdatabase for NOrwegian coast and sea areas). The mapping programme includes acquisition of multibeam bathymetry and acoustic backscatter data

together with a comprehensive, integrated biological and geological sampling programme. The equipment used includes underwater video, boxcorer, grab, hyperbenthic sled, and beam trawl. The Tromsoeflaket offshore bank was used as a case-study area to develop suitable methods for mapping habitats and biotopes. A procedure for producing maps of predicted biotopes is described that combined information on the distribution of biological communities with environmental factors and indicators. Detrended correspondence analysis (DCA) was used to relate bottom environment [including multiscale physical descriptors of the seabed derived from multibeam echosounder (MBES) data] and faunal distribution to find the best physical biotope descriptors. DCA of 252 video samples (sequences 200 m long) revealed six groups of locations representing different biotopes. These were characterized by different compositions of species, substrata, depths, and values for terrain parameters. Prediction of biotope distribution was performed using a supervised GIS classification with the MBES-derived physical seabed descriptors with the strongest explanatory ability (depth, backscatter, and broad-scale bathymetric position index) identified by the DCA. The species diversity of the identified biotopes was described from the content of the bottom samples. For future MAREANO cruises, an important task will be to ground-truth predictions of habitat and biotopes and to test the reliability of these predictions in the wider MAREANO area.

Butler, J., M. Neuman, D. Pinkard, R. Kvitek, and G. Cochrane. 2006. The use of multibeam sonar mapping techniques to refine population estimates of the endangered white abalone (*Haliotis sorenseni*). Fish. Bull., U.S. **104**:521-532.

Keywords: white abalone, conservation, ecological distribution, stock assessment, population density, unmanned vehicles, multibeam sonar

Abstract: Multibeam sonar mapping techniques provide detailed benthic habitat information that can be combined with the data on species-specific habitat preferences to provide highly accurate calculations of populations in a particular area. The amount of suitable habitat available for the endangered white abalone (*Haliotis sorenseni*) was quantified to aid in obtaining an accurate estimate of the number of remaining individuals at two offshore banks and one island site off the coast of southern California. Habitat was mapped by using multibeam sonar survey techniques and categorized by using rugosity and topographic position analysis. Abalone densities were evaluated by using a remotely operated vehicle and video transect methods. The total amount of suitable habitat at these three sites was far greater than that previously estimated. Therefore, although present estimates of white abalone densities are several orders of magnitude lower than historic estimates, the total population is likely larger than previously reported because of the additional amount of habitat surveyed in this study.

Calvert, J., J. A. Strong, M. Service, C. McGonigle, and R. Quinn. 2014. An evaluation of supervised and unsupervised classification techniques for marine benthic habitat

mapping using multibeam echosounder data. ICES J. Mar. Sci.: Journal du Conseil **72**:1498-1513.

Abstract: Marine habitat mapping provides information on seabed substrata and faunal community structure to users including research scientists, conservation organizations, and policy makers. Full-coverage acoustic data are frequently used for habitat mapping in combination with video ground-truth data in either a supervised or unsupervised classification. In this investigation, video ground-truth data with a camera footprint of 1 m^2 were classified to level 4 of the European Nature Information System habitat classification scheme. Acoustic data with a horizontal resolution of 1 m^2 were collected over an area of 130 km^2 using a multibeam echosounder, and processed to provide bathymetry and backscatter data. Bathymetric derivatives including eastness, northness, slope, topographic roughness index, vector rugosity measure, and two measures of curvature were created. A feature selection process based on Kruskal-Wallis and post hoc pairwise testing was used to select environmental variables able to discriminate ground-truth classes. Subsequently, three datasets were formed: backscatter alone (BS), backscatter combined with bathymetry and derivatives (BSDER), and bathymetry and derivatives alone (DER). Two classifications were performed on each of the datasets to produce habitat maps: maximum likelihood supervised classification (MLC) and ISO Cluster unsupervised classification. Accuracy of the supervised habitat maps was assessed using total agreement, quantity disagreement, and allocation disagreement. Agreement in the unsupervised maps was assessed using the Cramer's V coefficient. Choice of input data produced large differences in the accuracy of the supervised maps, but did not have the same effect on the unsupervised maps. Accuracies were 46, 56, and 49% when calculated using the sample and 52, 65, and 51% when using an unbiased estimate of the population for the BS, BSDER, and DER maps, respectively. Cramer's V was 0.371, 0.417, and 0.366 for the BS, BSDER, and DER maps, respectively. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Carlson, P. R., P. N. Hooge, and G. R. Cochrane. 2005. Discovery of 100-160-year-old iceberg gouges and their relation to halibut habitat in Glacier Bay, Alaska. Am. Fish Soc. **41**: 235-243.

Abstract: Side-scan sonar and multibeam imagery of Glacier Bay, Alaska, revealed complex iceberg gouge patterns at water depths to 135 m on the floor of Whidbey Passage and south to the bay entrance. These previously undiscovered gouges likely

formed more than 100 years ago as the glacier retreated rapidly up Glacier Bay. Gouged areas free of fine sediment supported greater biodiversity of Pacific halibut *Hippoglossus stenolepis* than nearby sediment-filled gouges, probably due to increased habitat complexity. Small Pacific halibut were found more frequently in sediment-free gouged areas, presumably due to higher prey abundance. In contrast, large Pacific halibut were found more frequently on soft substrates such as sediment-filled gouges, where they could bury themselves and ambush prey.

Carpenter, M. 2011. Benthic habitats of a sub-Arctic - The case study of Okak Bay, Labrador. Thesis, Memorial University of Newfoundland. Newfoundland, Canada.

Keywords: resource management, sedimentation, estuaries, habitat classification.

Abstract: The objective of this thesis is to classify and map the nature and distribution of benthic marine habitats of Okak Bay. Okak Bay is an irregularly shaped, generally shallow, low elevation estuary best described as a fiard, on the central Labrador coast. Supervised classification of multibeam sonar bathymetry and backscatter data ground-truthed with substrate and biotic samples were used to map the seafloor. Cluster analysis of grain size data from 123 substrate samples indicated 7 classes: mud, sandy mud, sandy, gravelly mud, gravelly sand, kelp and bedrock/boulder. Analysis of similarity and similarity percentage analysis show that the 7 substrates support 5 statistically distinct habitats, divided into soft-bottom: mud, sandy mud, and gravelly sandy mud; and hard-bottom: kelp and bedrock/boulder. Key species comprising the soft-bottom habitats are deposit-feeding bivalves and polychaete, whereas encrusting epifauna dominates the hard-bottom habitats. The accuracy of the substrate and habitat maps was assessed at 71% and 82%, respectively. A sensitivity analysis of habitats to potential stressors suggests that kelp and gravelly sandy mud are most vulnerable to a variety of impacts including the majority of fishing activities and physical environment changes such as increases in turbidity and sedimentation, and steps should be taken to protect representative areas. The distribution and nature of habitats within Okak Bay differed significantly from others Labrador fiords, supporting the hypothesis that fiards are distinct marine estuarine systems, both physically and oceanographically, and developing a better understanding of these habitats will contribute to resource management initiatives within the central Labrador region as a whole. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Che Hasan, R., D. Ierodiaconou, and L. Laurenson. 2012. Combining angular response classification and backscatter imagery segmentation for benthic biological habitat mapping. Estuar. Coast. Shelf Sci. **97**:1-9.

Keywords: angular response, supervised classification, backscatter imagery, segmentation, biological, habitat maps

Abstract: Backscatter information from multibeam echosounders (MBES) have been shown to contain useful information for the characterisation of benthic habitats. Compared to backscatter imagery, angular response of backscatter has shown advantages for feature discrimination. However its low spatial resolution inhibits the generation of fine scale habitat maps. In this study, angular backscatter response was combined with image segmentation of backscatter imagery to characterise benthic biological habitats in Discovery Bay Marine National Park, Victoria, Australia. Angular response of backscatter data from a Reson Seabat 8101 MBES (240 kHz) was integrated with georeferenced underwater video observations for constructing training data. To produce benthic habitat maps, decision tree supervised classification results were combined with mean shift image segmentation for class assignment. The results from mean angular response characteristics show effects of incidence angle at the outer angle for invertebrates (INV) and mixed red and invertebrates (MRI) classes, whilst mixed brown algae (MB) and mixed brown algae and invertebrates (MBI) showed similar responses independent from incidence angle. Automatic segmentation processing produce over segmented results but showed good discrimination between heterogeneous regions. Accuracy assessment from habitat maps produced overall accuracies of 79.6% (Kappa coefficient = 0.66) and 80.2% (Kappa coefficient = 0.67) for biota and substratum classifications respectively. MRI and MBI produced the lowest average accuracy while INV the highest. The ability to combine angular response and backscatter imagery provides an alternative approach for investigating biological information from acoustic backscatter data. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Cholwek, G., J. Bonde, X. Li, C. Richards, and K. Yin. 2000. Processing RoxAnn sonar data to improve its categorization of lake bed surficial substrates. Mar. Geophys. Res. **21**:409-421.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1023%2FA%3A1026525326823

Clements, A. J., J. A. Strong, C. Flanagan, and M. Service. 2010. Objective stratification and sampling-effort allocation of ground-truthing in benthic-mapping surveys. ICES J. Mar. Sci. **67**:628-637.

Keywords: benthic habitat mapping, ground-truthing, optimum allocation analysis, remote sensing, stratified sampling

Abstract: The application of statistical procedures for objective stratification of sampling effort during map ground-truthing is presented. Marine benthic mapping is usually undertaken in two stages: a remotely sensed acoustic survey followed by ground-

truthing to confirm ground-type and habitat classification. The objective of this study was to assess the application of optimum allocation analysis (OAA) through the use of remotely sensed data to direct expensive ground-truthing sampling effort. At an offshore site in the Irish Sea, classification of remotely sensed data, namely bathymetry and slope angle, generated six predicted ground-types. Calculated data variances within each ground-type were assumed to be a predictor of substratum heterogeneity, and these were used in an OAA to apportion ground-truthing effort objectively within each ground-type in order to achieve a set level of sampling precision. The sampling effort recommended by the OAA was realistic and practical with regard to video footage, but the collection of grabs was limited by resource constraints. The coefficient of variation (CV) of the video ground-truthing data matched that estimated by OAA, but the inability to collect all the recommended grabs resulted in CVs greater than expected for sediment grain-size parameters. The efficient identification of substratum classes using OAA represents a first stage whereby this method could direct ground-truthing that could ultimately be used for habitat mapping. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Cochrane, G. R. and K. D. Lafferty. 2002. Use of acoustic classification of sidescan sonar data for mapping benthic habitat in the Northern Channel Islands, California. Cont. Shelf Res. **22**:683-690.

Keywords: marine geology, benthic habitat, sidescan sonar, seafloor mapping, White abalone, USA, California, Channel islands

Abstract: Highly reflective seafloor features imaged by sidescan sonar in nearshore waters off the northern Channel Islands (California, USA) have been observed in subsequent submersible dives to be areas of thin sand covering bedrock. Adjacent areas of rocky seafloor, suitable as habitat for endangered species of abalone and rockfish, and encrusting organisms, cannot be differentiated from the areas of thin sand on the basis of acoustic backscatter (i.e. grey level) alone. We found second-order textural analysis of sidescan sonar data useful to differentiate the bottom types where data is not degraded by near-range distortion (caused by slant-range and ground-range corrections), and where data is not degraded by far-range signal attenuation. Hand editing based on submersible observations is necessary to completely convert the sidescan sonar image to a bottom character classification map suitable for habitat mapping. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Coggan, R. and M. Diesing. 2011. The seabed habitats of the central English Channel: A generation on from Holme and Cabioch, how do their interpretations match-up to modern mapping techniques? Cont. Shelf Res. **31**:S132-S150.

Keywords: seabed mapping, habitat classification, continental shelf, English Channel, La Manche

Abstract: In the latter half of the 20th century, Norman Holme and Louis Cabioch reported separate programmes of work describing the benthic fauna and habitats of the 'English' Channel (La Manche). Holme was based in southern England, while Cabioch was based in northern France, and both developed their own interpretation of the Channel ecosystem, describing similar geographical patterns in habitats and fauna that reflect the notable environmental gradients of the area. Both produced a 'map' of sorts to show the distribution of the different benthic communities they had identified. These interpretations were based predominantly on samples collected by small dredges and only in the later years made use of the (then) emerging technologies of underwater cameras and acoustic systems. A generation on, these technologies have reached a level of maturity and reliability that enable them to be used routinely on seabed surveys. We have recently completed a habitat mapping survey over an extensive area of the central Channel using acoustic, photographic and traditional grab sampling techniques to derive full-coverage modelled maps classifying biotopes according to the EUNIS habitat classification scheme. We were curious to see how the interpretations made by Holme and Cabioch for this area compared to our own, and found they were entirely consistent. We also found that we were able to match many of the faunal associations described by Holme, Cabioch and their co-workers to biotope classes currently listed in the EUNIS classification; a process we termed as 'translation'. We subsequently developed a modelled EUNIS habitat map for the entire Channel, allowing us to expand the geographical scope of our comparison. Working at EUNIS level 3, we overlaid a 'translated' map of Holme's point sampling stations on our full-coverage modelled map and scored where they matched, resulting in 64% overall agreement, 82% for sublittoral coarse sediments, 72% for sublittoral sands, 27% for sublittoral muds and 0% for sublittoral mixed sediments. A similar assessment was not feasible for Cabioch's maps, as these presented poly-lines showing the limits of distribution of certain faunal groups. However, simple inspection revealed a reasonable degree of consistency for the 'whole Channel' area among his maps, a French seabed typology map and our modelled EUNIS map. Our new map is a significant improvement on similar EUNIS maps for the Channel area generated recently by the MESH and REBENT projects, providing greater detail and overcoming some obvious limitations of the previous maps. The degree of consistency between the 20th and 21st century maps points to the potential utility of legacy data to ground-truth modern acoustic survey data until such time that modern ground-truth surveys can be completed. Such an approach would help satisfy the urgent demand for reliable habitat maps, generated by policy initiatives such as the European Union's Habitats Directive and Marine Strategy Framework Directive. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Collier, J. S. and C. J. Brown. 2005. Correlation of sidescan backscatter with grain size distribution of surficial seabed sediments. Mar. Geol. **214**:431-449.

Abstract: The dependence of acoustic backscatter on sediment grain size distribution is examined using dual frequency (100 and 410 kHz) sidescan sonar and 22 sediment grab samples from the Loch Linnhe artificial reef site on the west coast of Scotland.
The sidescan data were processed to remove an empirically estimated average grazing angle dependence on backscatter. The processed data were analysed by forming histograms of pixels extracted from a 20 m^2 box around each ground truth site. A positive correlation (r=0.73) between mean backscatter intensity and mean grain size was obtained, i.e., the coarsest samples had the brightest backscatter. A positive correlation (r=0.59) was also found between the standard deviations of the backscatter and grain size distributions, i.e., poorly sorted sediments gave the most variable backscatter. The performance of the sidescan data was compared to results from a co-incident single-beam echo-sounder RoxAnn survey. The RoxAnn roughness index E1 compared well with the sidescan, whilst the RoxAnn hardness index E2 did not. This may be due to a physical link between the acoustic measures. The comparison showed the sidescan to have delivered a significantly higher-resolution image of the seabed for a similar amount of ship-time. Imaging of the artificial reef modules themselves was found to be frequency dependent. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Collins, W., R. Gregory, and J. Anderson. 1996. A digital approach to seabed classification. Sea Technol. **37**:83-87.

Abstract: Seabed classification is the organization of seabed types into discrete units based on characteristics of the acoustic response. The QTC View developed by Quester Tangent Corp. (Sidney, B.C., Canada) utilizes the acoustic signal generated by an echosounder to map the seabed. Through digital processing and statistical analysis, a catalogue of seabed classes can be developed, giving the user a flexible and systematic tool for many applications. Habitat assessment for juvenile cod (*Gadus morhua*) is just one application of this acoustic method. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Copeland, A., E. Edinger, R. Devillers, T. Bell, P. LeBlanc, and J. Wroblewski. 2013. Marine habitat mapping in support of Marine Protected Area management in a subarctic fjord: Gilbert Bay, Labrador, Canada. J. of Coast. Conserv. **17**:225-237.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs11852-011-0172-1

Costa, B. M., and T. A. Battista. 2013. The semi-automated classification of acoustic imagery for characterizing coral reef ecosystems. International Journal of Remote Sensing **34**:6389-6422.

Keywords: classification, semi-automation, coral reef, habitat

Abstract: Coral reef habitat maps describe the spatial distribution and abundance of tropical marine resources, making them essential for ecosystem-based approaches to planning and management. Typically, these habitat maps have been created from optical and acoustic remotely sensed imagery using manual, pixel- and object-based classification methods. However, past studies have shown that none of these classification methods alone are optimal for characterizing coral reef habitats for multiple management applications because the maps they produce (1) are not synoptic, (2) are time consuming to develop, (3) have low thematic resolutions (i.e. number of classes), or (4) have low overall thematic accuracies. To address these deficiencies, a novel, semi-automated object- and pixel-based technique was applied to multibeam echo sounder imagery to determine its utility for characterizing coral reef ecosystems. This study is not a direct comparison of these different methods but rather, a first attempt at applying a new classification technique to acoustic imagery. This technique used a combination of principal components analysis, edge-based segmentation, and Quick, Unbiased, and Efficient Statistical Trees (QUEST) to successfully partition the acoustic imagery into 35 distinct combinations of (1) major and (2) detailed geomorphological structure, (3) major and (4) detailed biological cover, and (5) live coral cover types. Thematic accuracies for these classes (corrected for proportional bias) were as follows: (1) 95.7%, (2) 88.7%, (3) 95.0%, (4) 74.0%, and (5) 88.3%, respectively. Approximately half of the habitat polygons were manually edited (hence the name `semi-automated') due to a combination of mis-classifications by QUEST and noise in the acoustic data. While this method did not generate a map that was entirely reproducible, it does show promise for increasing the amount of automation with which thematically accurate benthic habitat maps can be generated from acoustic imagery.

Link: http://www.tandfonline.com/doi/abs/10.1080/01431161.2013.800661

Costa, B., J. C. Taylor, L. Kracker, T. Battista, and S. Pittman. 2014. Mapping reef fish and the seascape: using acoustics and spatial modeling to guide coastal management. PLoS ONE **9**:e85555.

Keywords: reef fish, coral reef, habitat, resource management

Abstract: Reef fish distributions are patchy in time and space with some coral reef habitats supporting higher densities (i.e., aggregations) of fish than others. Identifying and quantifying fish aggregations (particularly during spawning events) are often top priorities for coastal managers. However, the rapid mapping of these aggregations using conventional survey methods (e.g., non-technical SCUBA diving and remotely operated cameras) are limited by depth, visibility and time. Acoustic sensors (i.e., splitbeam and multibeam echosounders) are not constrained by these same limitations, and were used to concurrently map and quantify the location, density and size of reef fish along with seafloor structure in two, separate locations in the U.S. Virgin Islands. Reef fish aggregations were documented along the shelf edge, an ecologically important ecotone in the region. Fish were grouped into three classes according to body size, and relationships with the benthic seascape were modeled in one area using Boosted Regression Trees. These models were validated in a second area to test their predictive performance in locations where fish have not been mapped. Models predicting the density of large fish (≥29 cm) performed well (i.e., AUC=0.77). Water depth and standard deviation of depth were the most influential predictors at two spatial scales (100 and 300 m). Models of small (≤11 cm) and medium (12–28 cm) fish performed poorly (i.e., AUC=0.49 to 0.68) due to the high prevalence (45–79%) of smaller fish in both locations, and the unequal prevalence of smaller fish in the training and validation areas. Integrating acoustic sensors with spatial modeling offers a new and reliable approach to rapidly identify fish aggregations and to predict the density large fish in un-surveyed locations. This integrative approach will help coastal managers to prioritize sites, and focus their limited resources on areas that may be of higher conservation value.

Costa, B. M., T. A. Battista, and S. J. Pittman. 2009. Comparative evaluation of airborne LiDAR and ship-based multibeam SoNAR bathymetry and intensity for mapping coral reef ecosystems. Remote Sens. Environ. **113**:1082-1100.

Abstract: Large areas of the world's coastal marine environments remain poorly characterized because they have not been mapped with sufficient accuracy and at spatial resolutions high enough to support a wide range of societal needs. Expediting the rate of seafloor mapping requires the collection of multi-use datasets that concurrently address hydrographic charting needs and support decision-making in ecosystem-based management. While active optical and acoustic sensors have previously been compared for the purpose of hydrographic charting, few studies have evaluated the performance and cost effectiveness of these systems for providing benthic habitat maps. Bathymetric and intensity data were collected in shallow water (<50 m depth) coral reef ecosystems using two conventional remote sensing technologies: (1) airborne Light Detection and Ranging (LiDAR), and (2) ship-based multibeam (MBES) Sound Navigation and Ranging (SoNAR). A comparative assessment

using a suite of twelve metrics demonstrated that LiDAR and MBES were equally capable of discriminating seafloor topography (r=>0.9), although LiDAR depths were found to be consistently shallower than MBES depths. The intensity datasets were not significantly correlated at a broad 4x5 km spatial scale (r=-0.11), but were moderately correlated in flat areas at a fine 4x500 m spatial scale (r=0.51), indicating that the LiDAR intensity algorithm needs to be improved before LiDAR intensity surfaces can be used for habitat mapping. LiDAR cost 6.6% less than MBES and required 40 fewer hours to map the same study area. MBES provided more detail about the seafloor by fully ensonifying high-relief features, by differentiating between fine and coarse sediments and by collecting data with higher spatial resolutions. Surface fractal dimensions and fast Fourier transformations emerged as useful methods for detecting artifacts in the datasets. Overall, LiDAR provided a more cost effective alternative to MBES for mapping and monitoring shallow water coral reef ecosystems (<50 m depth), although the unique advantages of MBES may make it a more appropriate choice for answering certain ecological or geological questions requiring very high resolution data. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Cunningham, S., H. M. Guzman, and R. Bates. 2013. The morphology and structure of the Hannibal Bank fisheries management zone, Pacific Panama using acoustic seabed mapping. Rev. Biol. Trop. **61**:1967-1979.

Keywords: acoustic remote sensing, side scan sonar, commerically important fish

Abstract: The Hannibal Bank sits within the Coiba UNESCO World Heritage Site in Pacific Panama and is also a fisheries management zone. Despite the protected status of the area and the importance of the Bank for commercial fish species such as snapper and tuna, the seamount has received no detailed survey except some collection of organisms. This study mapped the major topographic features and complexity of the Hannibal Bank seamount using acoustic remote sensing. A survey area of around 125km^2 was defined using existing charts and side-scan sonar data were collected during July 2008. A bathymetric output was imported to ArcGIS where a digital bathymetric model and slope map were created. The Benthic Terrain Modeler (BTM) extension for ArcGIS was used to calculate bathymetric position index and rugosity, and used to create a map of zones representing the various seabed morphology zones. The Hannibal Bank is an elongated, triangular guyot (flat topped seamount), which ranges in depth from 53m to 416m, covers an area of 76km^2 and is 14.4km long and 7.1km wide. Hannibal Bank is composed of steep slopes, more gentle slopes, top of the seamount, crests (elevated ridges at the top of the pinnacles), rugose areas (on crests, top of seamount and slope), gullies and pinnacles. The bank is asymmetric in nature with the Northerly side having a relatively gentle slope with gullies across the surface compared to the SouthWest side which is far steeper and more rugose. There are two pinnacles to the North and South East of the bank that range in depth from 180 to 333m. Rocky substrate makes up 22.6km^2 of the bank and sediment 37.8km^2. The bank and its

steeply sided, rugose areas and pinnacles provide upright structures which can disrupt and topographically enhance currents, increasing productivity. The rugose areas of Hannibal Bank should be primary targets for further research efforts as they may contain corals and their rugosity indicates that these should be some of the highest faunal diversity areas of the bank. Hannibal Bank is likely to become vulonerabe due to increasing pressure in the future through climate change and fishing and this study has produced valuable information to assist in the future mapping and management of habitats, associated species and fisheries.

Cutter, G. R., Jr., L. A. Mayer, and L. G. Ward. 2004. Relationships between seafloor substrates, benthic epifauna, and spatial properties of multibeam echosounder bathymetry and backscatter data. J. Acoust. Soc. Am. **116**:2486.

Keywords: geomorphology, multibeam sonar, video ground truth

Abstract: The seafloor in the mouth of the Piscataqua Estuary, near Portsmouth, New Hampshire, contains several geomorphological regions that are evident in bathymetric data from multibeam sonar soundings. Those morphological regions generally are associated with surficial sediment type classes previously identified from sediment samples. We demonstrate that the morphologies are distinguishable using parameters from models of spatial variation for gridded depth soundings and backscatter values. Ground-truth seafloor-video transects data suggest that apparent facies and morphological regions are associated with different surficial sediment classes and rates of facies transitions. We show that the spatial variability of depth and backscatter is associated with the substrate transition rate, the number of microhabitats (microfacies), and distribution of certain epifauna identified using video. We show that, in some cases, a single region defined based upon spatial morphological attributes from depth data and apparent sedimentological attributes from backscatter data represented several benthic habitats. The results suggest that although we can use spatial variability of depth or backscatter to segment the seafloor into apparent facies or habitat class regions, some of the regions will have unpredicted associated microhabitats and organisms. The results have implications for habitat-specific assessment of organisms. Copyright 2004, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/116/4/10.1121/1.4784929

Cutter, G. R., and D. A. Demer. 2014. Seabed classification using surface backscattering strength versus acoustic frequency and incidence angle measured with vertical, split-beam echosounders. ICES J. Mar. Sci. **71**:882-894.

Keywords: multifrequency biplanar interferometric imaging, normal incidence, rockfish, seabed backscatter, *Sebastes*, spectral, specular, surficial, geology

Abstract: The multifrequency biplanar interferometric imaging technique (MBI) is applied to data from vertical, split-beam echosounders to produce sub-beam estimates of seabed surface-backscattering strength (S_s), incidence angle (Θ), and roughness (R). A simple model is used to quantify the variation of S_s versus $\Theta=\{2\text{-}20°\}$ and acoustic frequency, f = {18, 38, 70, 120 and 200 kHz}. The coefficients of the angle- and frequency-dependent terms of the model indicate seabed material properties, principally small- and large-scale roughness and hardness. These indices are combined with the estimates of Θ and R to classify the seabed using unsupervised cluster analysis. This technique is applied to data from the Forty-Three-Fathom Bank, a seamount in the Southern California Bight. The resulting seabed classifications are consistent with the surficial lithology and the spatial distribution of known rockfish *(Sebastes spp.)* habitat. The method should be generally applicable to seabed classification. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Cutter, G. R., Jr., L. Berger, and D. A. Demer. 2010. A comparison of bathymetry mapped with the Simrad ME70 multibeam echosounder operated in bathymetric and fisheries modes. ICES J. Mar. Sci. **67**:1301-1309.

Abstract: The Simrad ME70 multibeam echosounder was designed for quantitative fisheries research and is currently installed on Ifremer's fishery survey vessel (FSV) "Thalassa" and each of the new, quiet, NOAA FSVs. The ME70 has configurable beams and transmits in the range 70-120 kHz to provide calibrated, acoustic-backscattering data throughout the detection range (fisheries mode, FM). With optional hardware and software, the ME70 can also collect soundings that potentially meet International Hydrographic Organization's S-44 Order 1 standards (bathymetric mode, BM). Furthermore, with custom algorithms and software, bathymetric data can be obtained from the ME70 operating in FM, and volume backscatter can be sampled from the ME70 operating in BM. This flexibility allows data to be concurrently collected on fish and their seabed habitat. A method is described for processing the echo amplitude and phase data from multiple split-beams formed in FM to estimate seabed range, slope, and roughness. The resulting bathymetry is compared with that collected with the ME70 operating in BM in the same area of the Bay of Biscay. A proposal is made for software development to facilitate dual-use data processing. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Cutter, G. R., Jr., Y. Rzhanov, and L. A. Mayer. 2003. Automated segmentation of seafloor bathymetry from multibeam echosounder data using local Fourier histogram texture features. J. Exp. Mar. Biol. Ecol. **285-286**:355-370.

Abstract: Patterns of seafloor topography represent regions of geomorphological feature types and the physiography governing the spatial distributions of benthic habitats. Topographic variability can be considered seafloor texture and can be remotely sensed by acoustic and optical devices. Benthic habitat delineations often involve distinctions based upon seafloor morphology and composition based upon acoustic data maps that are ground-truthed by optical imaging tools. Habitat delineations can be done manually, however, automation of the procedure could provide more objectivity and reproducible map products. Recently a technique using Fourier transforms (FT) to produce texture features called local Fourier histograms (LFH) has been used successfully to classify standard textures in grayscale images and automatically retrieve digital images from archives according to texture content [Zhou, F. Feng, J. Shi, Q. 2001. Texture feature based on local Fourier transform, ICIP Conference Proceedings, I Sr. 0-7803-6725-1/01.]. We implemented a modified form of that approach by varying the spatial scales at which local Fourier histograms were calculated. A modified LFH texture feature classification technique was applied to multibeam echosounder (MBES) data from Piscataqua River, New Hampshire, USA, for automatic delineation of a seafloor topographic map into regions of distinct geomorphology and apparent benthic habitats. Automated segmentations were done by the LFH method on 1-m gridded MBES data, applying the local Fourier transform, used to generate the LFH, at spatial scales from 1 to 5 m. Seven seafloor texture classes were identified, corresponding to the primary substrate types and configurations in the study area as well as some previously unidentified regions and transitional zones. The texture regions serve as a physical habitat model for the seafloor, a basis for predicting benthic faunal inhabitants, their areal distributions, and serving as sampling strata for ground-truthing efforts. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Dartnell, P. and J. V. Gardner. 2004. Predicting seafloor facies from multibeam bathymetry and backscatter data. Photogramm. Eng. Remote Sens. **70**:1081-1091.

Abstract: An empirical technique has been developed that is used to predict seafloor facies from multibeam bathymetry and acoustic backscatter data collected in central Santa Monica Bay, California. A supervised classification used backscatter and sediment data to classify the area into zones of rock, gravelly-muddy sand, muddy sand, and mud. The derivative facies map was used to develop rules on a more sophisticated hierarchical decision-tree classification. The classification used four images, the acoustic-backscatter image, together with three variance images derived from the bathymetry and backscatter data. The classification predicted the distribution of seafloor facies of rock, gravelly-muddy sand, muddy sand and mud. An accuracy

assessment based on sediment samples shows the predicted seafloor facies map is 72 percent accurate.

Davis, K. S., N. C. Slowey, I. H. Stender, H. Fiedler, W. R. Bryant, and G. Fechner. 1996. Acoustic backscatter and sediment textural properties of inner shelf sands, northeastern Gulf of Mexico. Geo-Mar. Lett. **16**:273-278.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2FBF01204520

Diesing, M., R. Coggan, and K. Vanstaen. 2009. Widespread rocky reef occurrence in the central English Channel and the implications for predictive habitat mapping. Estuar. Coast. Shelf Sci. **83**:647-658.

Keywords: habitat, seafloor mapping, rocks, reefs, continental shelves, sediment transport, Europe, English Channel

Abstract: Reefs are one of the marine habitats listed in Annex I of the European Union's Habitats Directive, which aims to establish a coherent European ecological network of Special Areas of Conservation. EU Member States are required to prepare and propose a national list of sites for evaluation under the scheme, but currently the occurrence of reefs in the United Kingdom's nearshore and offshore areas is not well documented. Here we report on our search for rocky reefs in the central English Channel, which unexpectedly revealed an extensive reef system covering an area of 1100km^2. Prior to our work, it was generally perceived that the seabed in this area comprised mostly gravel, with a few isolated rock outcrops. Our approach to determining the location, extent and character of these reefs incorporated broad, medium and fine-scale analyses over a 3200km^2 area of seabed, using single- and multi-beam acoustic data, ground-truthed by underwater video and stills imagery. A benthic terrain model was developed in ArcGIS to map topographic features at the broad and medium scales. Biotope assignments were made at the fine scale through detailed analysis of video footage obtained from 30 sampling stations. The study area has a complex geological history and lies at the centre of a major bedload-parting zone. Together, these strongly influence the seabed character and the distribution of biotopes. An integrated assessment of the physical and biological features was used to map the study area to level 4 of the EUNIS habitat classification system. Similar physical conditions exist in other areas of the UK continental shelf, raising the prospect of predicting where other rocky reef systems might occur. In the absence of a co-ordinated national seabed survey programme, such predictions, coupled with interpretation of existing single-beam bathymetry data, can help prioritise areas where limited survey resources could be most effectively deployed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Diesing, M., S. L. Green, D. Stephens, R. M. Lark, H. A. Stewart, and D. Dove. 2014. Mapping seabed sediments: Comparison of manual, geostatistical, object-based image analysis and machine learning approaches. Cont. Shelf Res. **84**:107-119.

Abstract: Marine spatial planning and conservation need underpinning with sufficiently detailed and accurate seabed substrate and habitat maps. Although multibeam echosounders enable us to map the seabed with high resolution and spatial accuracy, there is still a lack of fit-for-purpose seabed maps. This is due to the high costs involved in carrying out systematic seabed mapping programmes and the fact that the development of validated, repeatable, quantitative and objective methods of swath acoustic data interpretation is still in its infancy. We compared a wide spectrum of approaches including manual interpretation, geostatistics, object-based image analysis and machine-learning to gain further insights into the accuracy and comparability of acoustic data interpretation approaches based on multibeam echosounder data (bathymetry, backscatter and derivatives) and seabed samples with the aim to derive seabed substrate maps. Sample data were split into a training and validation data set to allow us to carry out an accuracy assessment. Overall thematic classification accuracy ranged from 67% to 76% and Cohen[3] kappa varied between 0.34 and 0.52. However, these differences were not statistically significant at the 5% level. Misclassifications were mainly associated with uncommon classes, which were rarely sampled. Map outputs were between 68% and 87% identical. To improve classification accuracy in seabed mapping, we suggest that more studies on the effects of factors affecting the classification performance as well as comparative studies testing the performance of different approaches need to be carried out with a view to developing guidelines for selecting an appropriate method for a given dataset. In the meantime, classification accuracy might be improved by combining different techniques to hybrid approaches and multi-method ensembles. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Dowdeswell, J. A., N. H. Kenyon, and J. S. Laberg. 1997. The glacier-influenced Scoresby Sund Fan, East Greenland continental margin: evidence from GLORIA and 3.5kHz records. Mar. Geol. **143**:207-221.

Abstract: A major submarine fan (gradient about 2°) offshore of the Scoresby Sund fjord system is indicated by the crescentic shape of the shelf break. GLORIA long-range side-scan sonar imagery was obtained over about 20,000 km 2 of the fan along with 1000 km of 3.5 kHz records. Three acoustic facies were defined from GLORIA backscatter signatures and sea-floor morphology and sediment acoustic character on

3.5 kHz records. Facies 1 includes a series of acoustically transparent features (0.5-2 km in width), elongate downslope, with irregular surface topography, which are interpreted as debris flows. This makes up the bulk of relatively recent sedimentation on the upper fan. Diamictic sediments in a core support a debris-flow origin. Facies 2 is featureless on GLORIA images. 3.5 kHz profiles reveal irregular former sea-floor morphology, above which is a draping unit (<15 m thick). This northern region of the fan is a less active area where hemipelagic sediments and limited ice-rafted debris overlie older material formed by past debris-flow activity. The more distal area of the adjacent ocean basin has a flat floor with parallel sub-bottom reflectors of Facies 3. This facies is probably an area of low-energy hemipelagic sedimentation, punctuated by occasional ice rafting and turbidity current activity. The debris flows interpreted from GLORIA and 3.5 kHz data are basic building blocks in the long-term development of the Scoresby Sund Fan. Glacier-influenced fan volume is about 15,000 ± 5000 km^3 , based on seismic reflection studies. During full glacials in East Greenland, the inland ice sheet advances to fill the Scoresby Sund fjord system and extends across the shelf to reach the shelf break in some glacial cycles. Debris flows form in areas of most rapid sediment flux. The Scoresby Sund Fan is relatively similar to the Storfjorden Fan on the eastern Polar North Atlantic margin, but differs from the larger Bear Island Fan in having a steeper fan gradient, much smaller debris flows and no large-scale slides. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Dworski, J. G. and D. Jackson. 1994. Spatial and temporal variation of acoustic backscatter in the STRESS experiment. Cont. Shelf Res. **14**:1221-1237.

Keywords: acoustics, sediment transport, data acquisition, particle size, spatial distribution, temporal distribution

Abstract: Acoustic backscatter measurements were made of the seabed with a bottom mounted, circularly scanning sonar. The placement was at 91 m depth, mid-shelf of Northern California (38° 34' N), site C3 of the experiment STRESS I (1988-C1989). The expectation was that sonar images (70 m radius, 12,000 m^2) would provide a means of observing, over a large field of view, changes in the bottom due to storm-induced sediment transport and due to bioturbation. This expectation was supported in part by towed sonar measurements at 35 kHz over a sandy area in the North Sea, where dramatic spatial variation in the level of the backseattered signal was observed during an Autumn storm on scales of a few km with no concomitant change in sediment grain size (JACKSON et al. (1986) The Journal of the Acoustical Society of America, **80**, 1188-1199). It appeared possible that storm-driven sediment transport might have been responsible for this patchiness, by altering bottom roughness and by redeposition of suspended material. At the California site, a conventional sonar processing of our data from the STRESS experiment reveals no such dramatic change in backscattered signal level due to storms. The sonar images contain random structures whose time evolution is subtle and difficult to interpret. A much clearer picture of temporal and spatial

variations emerges from a processing scheme involving cross-correlation of time-separated acoustic views of the bottom. In effect, the sequence of correlation data images produces a movie in which patches of activity are seen to develop as functions of time. It appears that most of this activity is biological rather than hydrodynamic. A tentative explanation is two-fold. The bottom shear stress might have been considerably greater at the North Sea site (with depth only one-half of the California site). The seafloor at the California site was silty-clayey, and backscatter from such floor is less sensitive to the water-floor interface shape and roughness than it would be to the same parameters of a sandy bottom. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Edsall, T. A., T. P. Poe, R. T. Nester, and C. L. Brown. 1989. Side-scan sonar mapping of lake trout spawning habitat in northern Lake Michigan. N. Am. J. Fish. Manag. **9**:269-279.

Keywords: sustainability, historical account, habitat selection, fishery management, substrates, data bases, stocking (organisms), spawning grounds, habitat, fish, bathymetry, survival, sanctuaries, sonar, spawning

Abstract: Native stocks of lake trout *Salvelinus namaycush* were virtually or completely extirpated from the lower four Great Lakes by the early 1960s. The failure of early attempts to reestablish self-sustaining populations of lake trout was attributed partly to the practice of stocking hatchery reared juveniles at locations and over substrates that had not been used in the past for spawning by native fish. Subsequent attempts to improve the selection of stocking locations were impeded by the lack of reliable information on the distribution of substrates on historical spawning grounds. Here we demonstrate the potential of side-scan sonar to substantially expand the data base needed to pinpoint the location of substrates where lake trout eggs, fry, or juveniles could be stocked to maximize survival and help ensure that survivors returning to spawn would encounter suitable substrates. We also describe the substrates and bathymetry of large areas on historical lake trout spawning grounds in the Fox Island Lake Trout Sanctuary in northern Lake Michigan. These areas could be used to support a contemporary self-sustaining lake trout population in the sanctuary and perhaps also in adjacent waters.

Link: http://www.tandfonline.com/doi/abs/10.1577/1548-8675%281989%29009%3C0269%3ASSSMOL%3E2.3.CO%3B2

Edwards, B. D., P. Dartnell, and H. Chezar. 2003. Characterizing benthic substrates of Santa Monica Bay with seafloor photography and multibeam sonar imagery. Mar. Environ. Res. **56**:47-66.

Keywords: benthic fauna, benthic habitat, multibeam sonar, sediment, shelf, slope, Southern California, substrate

Abstract: Seafloor photography from three cruises is combined with multibeam sonar imagery to characterize benthic substrates and associated fauna of Santa Monica Bay, California. The multibeam EM1000 imagery was collected in 1996. Two sampling cruises (in 1998 and 1999) provided photographs at 142 sites throughout the Bay; a final cruise (in 2000) collected still photographs and continuous video along nine transects on the mainland shelf from Pt. Dume to the Palos Verdes peninsula. Muddy substrates (typically low backscatter) were the predominant habitat throughout the Santa Monica Bay, from the 20 m isobath to the adjacent Santa Monica basin floor (780 m). Bioturbation was pervasive as evidenced by abundant open burrows, mounds, and faunal tracks and trails. Sandy substrates (typically intermediate to high backscatter) were restricted to the innermost mainland shelf and a narrow outer shelf band north of Santa Monica Canyon. Cobble and gravel substrates (high backscatter) were restricted to the innermost shelf south of El Segundo and limited parts of the shelf edge. Rocky substrates (high backscatter) with interspersed patches of sand and gravel occurred on the high-relief marginal plateau and along parts of the shelf break offshore of Malibu. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Ehrhold, A., D. Hamon, and B. Guillaumont. 2006. The REBENT monitoring network, a spatially integrated, acoustic approach to surveying nearshore macrobenthic habitats: application to the Bay of Concarneau (South Brittany, France). ICES J. Mar. Sci. **63**:1604-1615.

Keywords: benthic habitats, grab sampling, maerl, ortho-rectified aerial photography, pockmark, sediment, sidescan sonar, submarine video

Abstract: A 200-km² area in the Bay of Concarneau on the South Brittany coast was surveyed acoustically using different sidescan sonars (a 100-kHz EdgeTech DF1000, and a 240-kHz Reson SeaBat 8101). The area corresponds to a sector of the REBENT network. It was selected for its physical and biological characteristics, reflecting the sedimentary heterogeneity and biological diversity of Brittany's coastal seafloors. The work presented here illustrates the methodology for mapping subtidal seabed habitats in the context of the network. Backscatter mosaics were produced covering 100% of the survey area. Extensive ground-truthing was carried out involving 93 Shipek grab samples and 25 drop-down video profiles. From interpretation of the acoustic facies, 40 biological soft-bottom stations were sampled using a Hamon grab to characterize macrobenthic communities (>2mm). The results indicated considerable variation in backscatter responses in relation to high densities of macrobenthic species (*Lithothamnion, Asterias, Haploops, Maldane, Ophiocomina*), and a wide variety of substratum types present within a relatively small area. Dense biocenoses of maerl were accurately surveyed from 20-m to <5-m depth (Lower Astronomical Tide; LAT). Boundaries of *Haploops* communities are associated with dense small pockmarks in the centre of the bay. The relationships between sediment sometimes colonized by

macrobenthic species and backscatter responses are discussed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Elvenes, S., M. F. J. Dolan, P. Buhl-Mortensen, and V. K. Bellec. 2014. An evaluation of compiled single-beam bathymetry data as a basis for regional sediment and biotope mapping. ICES J. Mar. Sci. **71**:867-881.

Keywords: benthic biotopes, habitat mapping, MAREANO, Maxent, multibeam bathymetry, sediment grain size, single-beam bathymetry, spatial, modelling, terrain variables

Abstract: Maps of surficial sediment distribution and benthic habitats or biotopes provide invaluable information for ocean management and are at the core of many seabed mapping initiatives, including Norway's national offshore mapping programme MAREANO (www.mareano.no). Access to high-quality multibeam echosounder data (bathymetry and backscatter) has been central to many of MAREANO's mapping activities, but in order to maximize the cost-effectiveness of future mapping and ensure timely delivery of scientific information, seabed mappers worldwide may increasingly need to look to existing bathymetry data as a basis for thematic maps. This study examines the potential of compiled single-beam bathymetry data for sediment and biotope mapping. We simulate a mapping scenario where full coverage multibeam data are not available, but where existing bathymetry datasets are supplemented by limited multibeam data to provide the basis for thematic map interpretation and modelling. Encouraging results of sediment interpretation from the compiled bathymetry dataset suggest that production of sediment grain size distribution maps is feasible at a 1:250 000 scale or coarser, depending on the quality of available data. Biotope modelling made use of full-coverage predictor variables based on (i) multibeam data, and (ii) compiled single-beam data supplemented by limited multibeam data. Using the same response variable (biotope point observations obtained from video data), the performance of the respective models could be assessed. Biotope distribution maps based on the two datasets are visually similar, and performance statistics also indicate there is little difference between the models, providing a comparable level of information for regional management purposes. However, whilst our results suggest that using compiled bathymetry data with limited multibeam is viable as a basis for regional sediment and biotope mapping, it is not a substitute. Backscatter data and the better feature resolution provided by multibeam data remain of great value for these and other purposes. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Elwany, M. H. S., T. J. Norall, N. Marshall, and R. S. Grove. 2007. Using sonar surveys for designing the Wheeler North Reef at San Clemente, California. Shore Beach **75**:44-51.

Abstract: Construction of a 150-acre artificial reef at San Clemente, California, which is designed to support the growth of giant kelp, is expected to be completed in the summer of 2008. The project was conducted in two phases. Phase 1, completed in September 1999, involved constructing a 22.4-acre experimental artificial reef, which was then monitored for five years and found to be successful. Phase 2, which is nearing completion, involved 127.6 acres of nearshore ocean floor. For such a project, a thorough geophysical/geological evaluation of the candidate site is critical, and it is necessary to acquire reliable, detailed seafloor sonar data to properly design and locate the reef. This is especially true when giant kelp (*Macrocystis pyrifera*) communities are involved, which grow best on low-relief reefs. The Wheeler North Reef is planned mitigation for impacts of the nearby San Onofre Nuclear Generating Station on kelp bed communities. Kelp generally grows only on exposed hard substrate, and the success of an artificial reef kelp community can be dramatically impacted by habitat burial, sand scour, and substrate subsidence. The sonar mapping and sea-floor environmental assessment at the Wheeler North Reef site proved critical for the project approval process by the responsible regulatory and resource agencies. In general, the siting of artificial reefs to support kelp involves at least three shared seafloor criteria that rely on accurate sonar results. These criteria were addressed in the siting of the Wheeler North Reef by using the several sonar techniques described and compared in this paper. The sonar techniques presented here have a wide range of applications in coastal engineering projects and environmental impact studies. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Erdey-Heydorn, M. D. 2008. An ArcGIS seabed characterization toolbox developed for investigating benthic habitats. Mar. Geod. **31**:318-358.

Abstract: Using data sets collected north of San Francisco Bay (CA) an ArcGIS classification toolset was developed using supervised image classification tools to characterize potential shallow marine benthic habitats. First-derivative images and a topographic algorithm, called Bathymetric Position Index were created from the bathymetry data set using ArcGIS Spatial Analyst tools. Backscatter intensity was also analyzed by creating training samples based on the collected sediment samples and then applying multivariate statistical tools to delinate textural classes. The data collected revealed a rugged and complex seafloor and imaged in detail basement and bedrock outcrops, sand and gravel bedforms, and flat sediment covered seabed.

Link: http://www.tandfonline.com/doi/full/10.1080/01490410802466819

Eyre, B. D. and D. Maher. 2010. Mapping ecosystem processes and function across shallow seascapes. Cont. Shelf Res. **31**:S162-S172.

Abstract: Shallow sub-tropical and warm temperate east Australian coastal lagoons and estuaries were used as case studies to develop a system for assigning functional value to shallow seascapes. Nine habitat classes (mangroves, sands/muds with large burrowing macrofauna, stable seagrass communities, ephemeral seagrass communities, channels, subtidal shoals, intertidal shoals, depositional mud basins, permeable sands) and ten ecosystem processes (gross benthic production, gross benthic respiration, net benthic production, net benthic respiration, benthic dissolved organic and inorganic nitrogen fluxes, denitrification, denitrification efficiency, n-fixation and secondary production) were used to assign functional values and construct maps. These functional value maps of ecosystem processes and overall functional value were used to identify "hot spots" that have high conservation value. Some habitats had a high overall functional value across all 4 systems (e.g. stable seagrass communities), while other habitats had a high overall functional value in some systems and a low overall functional value in other (e.g. channels). A case study from southern Moreton Bay was used to illustrate the application of the process functional value and overall functional maps. A comparison of these maps with a map of impact (decrease in light), associated with the discharge from a wastewater treatment facility, showed that areas of highest impact coincide with open water benthic habitat of medium overall functional value. Areas of low impact were mostly in areas of highest overall functional value. Comparison of the map of impact with maps of the individual benthic processes showed that the functional value of net benthic production was medium in the high-impact areas suggesting there may be some loss of net primary production from southern Moreton Bay associated with the wastewater discharges. This type of impact would not have been detected by standard environmental assessments. A multiple overlay of maps of the functional value of each benthic process, the overall benthic functional value and the potential impacts would improve our understanding, and assist with the management and conservation, of shallow coastal systems. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Ferrini, V. L. and R. D. Flood. 2005. A comparison of Rippled Scour Depressions identified with multibeam sonar: Evidence of sediment transport in inner shelf environments. Cont. Shelf Res. **25**:1979-1995.

Abstract: Rippled scour depressions (RSDs) are distinct morphologic and textural features that have been observed in numerous nearshore environments as depressions

containing coarse rippled sediments. The nature and significance of these features can be better understood with the use of multibeam sonar systems that acquire high-resolution bathymetry and co-registered backscatter intensity data and reveal both the small-scale characteristics of RSDs and larger-scale seabed patterns associated with them. In this paper, we compare RSDs identified in high-frequency (300kHz) multibeam sonar surveys on the inner shelves of southwest Washington, northern California and Long Island, New York. RSDs at these sites are evident as distinct features that are generally up to 1m deeper than the adjacent seabed and exhibit high acoustic backscatter intensity due to the presence of coarse sediments, typically gravel. Shore parallel oscillatory ripples (typically 1m wavelength) exist within the coarse material associated with RSDs and are attributed to wave-orbital motion. We propose a classification of RSDs based on their morphology and textural characteristics as well as the larger-scale seabed patterns associated with them, which together provide insight about the processes that affect their development and evolution. The RSDs described here are apparently the result of localized flow that can redistribute significant volumes of sediment in the nearshore zone under a range of energetic regimes over relatively short time scales. One type of linear shore-normal RSD always corresponds to larger-scale low-amplitude transverse bedforms that appear to be related to longshore currents. Some of these low-amplitude bedforms migrated as much as 50-150m over 2 years. Another type of elongate RSD, appears to be relatively stable over time, is characterized by bathymetric and textural asymmetry with one distinct upcurrent edge and one diffuse downcurrent edge, and is apparently a result of transverse flow. Other irregularly shaped nearshore RSDs that can be created and destroyed on time scales of less than 1 year, are the result of localized erosion and accretion of up to 1m, and are distributed rhythmically along-shore in water depths of 8-16m suggesting that they are related to hydrodynamics associated with the breaker zone. The characteristics of RSDs elucidated by high-frequency multibeam sonar data provide evidence of a variety of physical processes associated with RSDs and emphasize the importance of these features with respect to sediment transport on the inner shelf. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Ferrini, V. L. and R. D. Flood. 2006. The effects of fine-scale surface roughness and grain size on 300 kHz multibeam backscatter intensity in sandy marine sedimentary environments. Mar. Geol. **228**:153-172.

Keywords: multibeam sonar, backscatter intensity, remote sediment characterization, PCA

Abstract: High-frequency acoustic backscatter intensity that is returned from sediment is affected by a number of seabed characteristics including sediment grain size distribution, the nature and magnitude of seabed surface roughness, and volume scattering by subsurface scatterers. In order to develop quantitative remote sediment classification techniques, it is important to determine the relative and combined effects

of the dominant variables to which the acoustic signal is sensitive. Data used in this study were collected at two sandy sites off the south shore of Long Island, New York, and include 300 kHz multibeam (Simrad EM 3000) backscatter intensity data as well as grab samples and stereo bottom photographs. Multivariate statistical analyses were used to investigate the relationships between grain size properties, seabed roughness, and backscatter intensity at a number of sample locations at each study site encompassing a moderate range of backscatter intensities from -32.5 to -24 dB. The results of this study demonstrate that the relative importance of variables that affect backscatter intensity varies at different sites, suggesting that backscatter intensity alone cannot be used to quantitatively predict seabed characteristics. However, our study indicates that in sandy sediments, the median grain size, the standardized magnitude of seabed roughness, and the sorting of sediment can together be used to predict 300 kHz backscatter intensity with high significance, and that the relative importance of these variables varies from site to site. We present an empirical model derived from a combined dataset that includes two sites of similar sedimentary and hydrodynamic conditions to predict the magnitude of seabed roughness based on backscatter intensity and sediment grain size characteristics. The spatially coherent patterns in predicted seabed surface roughness revealed through the use of this kind of model greatly improve our understanding of variations in backscatter intensity in sandy marine sedimentary environments. As a result, the multivariate statistical approach that we employ improves our overall ability to remotely assess the details of the sedimentary environment that are significant with respect to benthic habitats and physical processes, and are applicable to other geophysical datasets including sidescan sonar data. cal processes, and are applicable to other geophysical datasets including sidescan sonar data. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Fonseca, L. and B. Calder. 2005. Geocoder: An efficient backscatter map constructor. p. 1-9. *In* Proceedings of the U.S. Hydrographic Conference, San Diego, California.

Keywords: geocoder, backscatter, ARA

Abstract: The acoustic backscatter acquired by multibeam and sidescan sonars carries important information about the seafloor morphology and physical properties, providing valuable data to aid the difficult task of seafloor characterization, and important auxiliary information for a bathymetric survey. One necessary step towards this characterization is the assemblage of more consistent and more accurate mosaics of acoustic backscatter. For that, it is necessary to radiometrically correct the backscatter intensities registered by these sonars, to geometrically correct and position each acoustic sample in a projection coordinate system and to interpolate properly the intensity values into a final backscatter map.

Geocoder is a software tool that implements the ideas discussed above. Initially, the original backscatter time series registered by the sonar is corrected for angle varying gains, for beam pattern and filtered for speckle removal. All samples of the time series are preserved during all the operations, ensuring that the full data resolution is used for the final mosaicking. The time series is then slant-range corrected based on a bathymetric model, in the case of sidescan, or based on beam bathymetry, in the case of the multibeam. Subsequently, each backscatter sample of the series is geocoded in a projected coordinate system in accordance to an interpolation scheme that resembles the acquisition geometry. An anti-aliasing algorithm is applied in parallel to the mosaicking procedure, which allows the assemblage of mosaics at any required resolution. Overlap among parallel lines is resolved by a priority table based on the distance of each sample from the ship track; a blending algorithm is applied to minimize the seams between overlapping lines. The final mosaic exhibits low noise, few artifacts, reduced seams between parallel acquisition lines and reduced clutter in the near-nadir region, while still preserving regional data continuity and local seafloor features.

Fonseca, L. and L. Mayer. 2007. Remote estimation of surficial seafloor properties through the application Angular Range Analysis to multibeam sonar data. Mar. Geophys. Res. **28**:119-126.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs11001-007-9019-4

Foote, K. G. 2008. Marine ecosystem acoustics: contributions of sonar technology. J. Acoust. Soc. Am. **123**: 3104.

Keywords: sonar, ecosystems, active sonar systems, marine vessels, acoustic echoes

Abstract: Sonar is considered in the widest sense as an acoustic system consisting of a transmitter and receiver of underwater sound. It may be monostatic, bistatic, or multi-static; narrowband or broadband; with one or more fixed, rotating, or electronically formed beams. Transducers may be mounted on hulls of vessels and autonomous underwater vehicles, fixed structures, or seafloor; towed; or suspended. Spatial scales may be sampled from millimeters to thousands of kilometers; corresponding temporal scales vary from a fraction of a second, as in target-tracking, to seasons, as in observing animal migration. Several sonar types are described. Contributions of sonar technology to ecosystem studies, both actual and potential, are noted. These include, for example, fine-scale surveying of pelagic and semi-demersal fish by scientific echo sounder; mapping of the three-dimensional structure of fish aggregations and bathymetry by multibeam sonar; quantification of benthic egg beds of the squid *Loligo opalescens* by side scan sonar; and large-scale surveying of swimbladdered fish by parametric sonar. Each of these sonar systems has potential for detection, quantification, and

classification of marine organisms, as well as for characterization of the habitat, hence yielding the kind of information that is required for ecosystem assessment and management. Copyright 2008, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/123/5/10.1121/1.2932974

Foote, K. G., R. T. Hanlon, P. J. Iampietro, and R. G. Kvitek. 2004. Acoustic mapping of squid egg clusters and their bottom habitat in Monterey Bay, California. J. Acoust. Soc. Am. **116**:2487-2487.

Keywords: side scan sonar, squid, eggs, multibeam sonar

Abstract: Clusters of gelatinous egg capsules, known as mops or beds, of the market squid (*Loligo opalescens*) were mapped in a shallow-water, sandy habitat of Monterey Bay, California. The benthic egg clusters were imaged using an EdgeTech 272-TD dual-frequency side scan sonar towed from R/V MACGINITIE, an 8-m-long survey vessel, with data recorded on a Triton Elics International Isis digital data acquisition system. Verification of target identity was accomplished independently by video photography from a remotely operated vehicle. The survey area included a 4-km stretch of sandy seafloor between Lover's Point and Cannery Row in Monterey at depths of 15–30 m. The study area had previously been mapped using the RESON SeaBat 8101 240-kHz multibeam sonar. Resulting high-resolution bathymetric data, with 1-m resolution, were used during the survey planning and execution. Squid egg clusters were clearly visible in the very-high-resolution, 400-kHz backscatter imagery, with pixel size 10–20 cm, recorded from the towed side scan sonar. The concentration of egg clusters was greatest along a sloping feature believed to be a submarine fault. Egg mops with diameter as small as 0.5 m were distinguishable. Copyright 2004, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/116/4/10.1121/1.4784931

Foote, K. G. 2009. Acoustic methods: Brief review and prospects for advancing fisheries research. Pages 313-343 *in* R. J. Beamish and B. J. Rothschild, editors. Future of Fisheries Science in North America. Springer Netherlands.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/chapter/10.1007%2F978-1-4020-9210-7_18

Foster, G., V. S. Ticzon, B. M. Riegl, and P. J. Mumby. 2011. Detecting end-member structural and biological elements of a coral reef using a single-beam acoustic ground discrimination system. Int. J. Remote Sens. **32**:7749-7776.

Keywords: benthic habitat, single beam, supervised classification

Abstract: A thematic map of benthic habitat was produced for a coral reef in the Republic of Palau, utilizing hydroacoustic data acquired with a BioSonics DT-X echosounder and a single-beam 418 kHz digital transducer. This article describes and assesses a supervised classification scheme that used a series of three discriminant analyses (Das) to refine training samples into end-member structural and biological elements utilizing E1' (leading edge of first echo), E1 (trailing edge of first echo), E2 (complete second echo), fractal dimension (first echo shape) and depth as predictor variables. Hydroacoustic training samples were assigned to one of six predefined groups based on the plurality of benthic elements (sand, sparse submerged aquatic vegetation (SAV)) rubble, pavement, rugose hardbottom, branching coral) that were visually estimated from spatially co-located ground-truthing videos. Records that classified incorrectly or failed to exceed a minimum probability of group membership were removed from the training data set until only 'pure' end-member records remained. This refinement of 'mixed' training samples circumvented the dilemma typically imposed by the benthic heterogeneity of coral reefs, that is either train the acoustic ground discrimination system (AGDS) on homogeneous benthos and leave the heterogeneous benthos unclassified, or attempt to capture the many 'mixed' classes and overwhelm the discriminatory capability of the AGDS. It was made possible by a conjunction of narrow beam width (6.4°) and shallow depth (1.2 to 17.5 m), which produced a sonar footprint small enough to resolve the microscale features used to define benthic groups. Survey data classified from the third-pass training DA were found to: (i) conform to visually apparent contours of satellite imagery, (ii) agree with the structural and biological delineations of a benthic habitat map (BHM) created from visual interpretation of IKONOS imagery and (iii) yield values of benthic cover that agreed closely with independent, contemporaneous video transects. The methodology was proven on a coral reef environment for which high-quality satellite imagery existed, as an example of the potential for single-beam systems to thematically map coral reefs in deep or turbid settings where optical methods are not applicable.

Link: http://www.tandfonline.com/doi/full/10.1080/01431161.2010.527396

Foster, G., B. K. Walker, and B. M. Riegl. 2009. Interpretation of single-beam acoustic backscatter using lidar-derived topographic complexity and benthic habitat classifications in a coral reef environment. J. Coastal Res. **53**:16-26.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://www.jcronline.org/doi/abs/10.2112/SI53-003.1

Foster-Smith, R. L., C. J. Brown, W. J. Meadows, W. H. White, and D. S. Limpenny. 2004. Mapping seabed biotopes at two spatial scales in the eastern English Channel. Part 2. Comparison of two acoustic ground discrimination systems. J. Mar. Biol. Assoc. UK **84**:489-500.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link:

Freitas, R., F. Ricardo, F. Pereira, L. Sampaio, S. Carvalho, M. Gaspar, V. Quintino, and A. M. Rodrigues. 2011. Benthic habitat mapping: Concerns using a combined approach (acoustic, sediment and biological data). Est. Coast. Shelf Sci. **92**:598-606.

Keywords: benthic macrofauna, surf zone, sediments, hydrodynamic conditions, acoustic diversity, QTC VIEW Series V

Abstract: Near-shore benthic biotopes, in the 2-30m depth range, were analyzed and mapped using a combination of biological, sedimentary and acoustic data to interrogate the utility of these methods. The surveyed area covered approximately 270km^2, along 80km of the Southeast coast of Portugal. The acoustic data were acquired with a single beam ground discrimination system (QTC VIEW, Series V), connected to a dual frequency echo sounder (50 and 200kHz). Sediment grain size and macrofaunal community data were obtained by grab sampling at 88 sites. The sedimentary and the biological data were subjected to classification and ordination analysis and the acoustic data obtained with the two frequencies were analyzed individually with the QTC IMPACT (v3.4) software and classified into acoustic classes. The affinity groups obtained with the three datasets were mapped using a Geographic Information System. The study area showed an inshore-offshore pattern with sands ranging from very fine to very coarse, revealing a sediment distribution in the near-shore shelf comprised by two main areas; a very fine/fine sand area up to 7-10m depth and a very coarse/coarse sand area offshore. In turn, the biological data also showed an inshore-offshore pattern, identifying two main biological assemblages: fine/very fine sand and coarse/very coarse sand communities. Furthermore, the biological pattern clearly reflected the hydrodynamic conditions of the area, from highly hydrodynamic shallow depth to the calmer deeper areas. Accordingly, species richness and densities were lower at shallow areas than at deeper depth. The acoustic data identified the prevailing biosedimentary gradients along the inshore-offshore direction. Overall, the results obtained here showed that the acoustic system could identify two main areas based on sediment grain size, which closely related to the two main biological communities (groups A and B). This study indicates the importance of combining several layers of information in order to increase the spatial resolution of the main biotope distribution (validating the acoustic

data) and detail their sub-divisions (ground-truth sampling). Furthermore, we show that designing ground-truth samples on the basis of the acoustic diversity data allows the biological data to aspeaka for itself. In general, acoustic techniques are used as a means to optimize ground-truth sampling. This will only be valid if acoustics can capture all the essence of biotope heterogeneity. If this is not the case, special attention should be given when using broad scale methods (acoustic remote sensing) devoted to biotope mapping. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Freitas, R., S. Silva, V. Quintino, A. M. Rodrigues, K. Rhynas, and W. T. Collins. 2003. Acoustic seabed classification of marine habitats: studies in the western coastal-shelf area of Portugal. ICES J. Mar. Sci.: Journal du Conseil **60**:599-608.

Keywords: acoustic seabed classification, benthic biotopes, coastal shelf, habitat mapping, Portugal, QTC VIEW

Abstract: Two single-beam, seabed-classification systems, QTC VIEW Series IV and QTC VIEW Series V, were used to identify and map biosedimentary gradients in a mid-shelf area off Western Portugal. The survey area has a moderate slope, a depth ranging from 30 to 90m along a 3.5-km axis perpendicular to the shoreline, and is characterized by smooth sedimentary and biological gradients. Ground truth for sediment grain size and macrofaunal communities was based on grab sampling at 20 sites. The sedimentary and biological data were analysed using classification and ordination techniques. The acoustic data were analysed with qtc impact software and classified into acoustic classes. The affinity groups obtained in each data set were mapped using a Geographics Information System. All showed good agreement and identified prevailing gradients along a northwest-southeast direction. Three acoustic classes were identified, corresponding to the predominant sediment types, namely fine sand with low silt and clay content, silty, very fine sand, and mud. A close relationship with benthic communities was also verified, although less marked because benthic communities continuously change along the northwest-southeast gradient. Overall, the acoustic system coupled with ground-truthing data was able to discriminate and characterize the various benthic biotopes in the survey area. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Galparsoro, I., A. Borja, and M. C. Uyarra. 2014. Mapping ecosystem services provided by benthic habitats in the European North Atlantic Ocean. Frontiers in Marine Science **1**:1-14.

Keywords: ecosystem service, benthic habitat, Regional Seas, marine stategy framework directive, habitat classification

Abstract: Mapping and assessing the ecosystem services provided by benthic habitats are a highly valuable source of information for understanding their current and potential benefits to society. The main objective of this investigation is to assess and map the ecosystem services provided by benthic habitats of the European North Atlantic Ocean, in the context of "Mapping and Assessment of Ecosystems and their Services" (MAES) programme, the European Biodiversity Strategy and the implementation of the Marine Strategy Framework Directive. In total, 62 habitats have been analysed in relation to 12 ecosystem services over 1.7 million km^2. Results indicated that more than 90% of the mapped area provides biodiversity maintenance and food provision services; meanwhile grounds providing reproduction and nursery services are limited to half of the mapped area. Benthic habitats generally provide more services closer to shore than offshore and in shallower waters. This gradient is likely to be explained by difficult access (i.e., distance and depth) and lack of scientific knowledge for most of the services provided by distant benthic habitats. This research has provided a first assessment of the benthic ecosystem services at Atlantic European scale, with the provision of ecosystem services maps and their general spatial distribution patterns. Related to the objectives of this research, the conclusions are: (i) benthic habitats provide a diverse set of ecosystem services, being the food provision and biodiversity maintenance services the ones that are more extensively represented. In addition, other regulating and cultural services are provided in a more limited area; and (ii) the ecosystem services assessment categories are significantly related to the distance to the coast and with depth (higher near the coast and in shallow waters).

Gardner, J. V., K. J. Sulak, P. Dartnell, L. Hellequin, and B. Calder. 2000. Cruise Report RV OCEAN SURVEYOR Cruise O-1-00-GM. The bathymetry and acoustic backscatter of the Pinnacles Area, Northern Gulf of Mexico. U.S. Geological Survey. Menlo Park, California.

Keywords: multibeam, fish habitat, deep reef

Abstract: An extensive deep (approx. 100 m) reef tract occurs on the Mississippi-Alabama outer continental shelf (OCS). The tract, known as 'The Pinnacles', is apparently part of a sequence of drowned reef complexes along the '40-fathom' shelf edge of the northern Gulf of Mexico (Ludwick and Walton, 1957). It is critical to determine the accurate geomorphology of deep-reefs because of their importance as benthic habitats for fisheries. Our objective was to map as large an area of the outer shelf deep reefs off Alabama- Mississippi as the project budget allowed using a state- of-the-art multibeam mapping system. The cruise used a Kongsberg Simrad EM1002, the latest generation of highresolution multibeam mapping systems (HRMBS). The EM1002 produces both accurate georeferenced bathymetry and coregistered, calibrated, acoustic backscatter.

Gardner, J. V., P. Dartnell, L. A. Mayer, and J. E. Hughes Clarke. 2003. Geomorphology, acoustic backscatter, and processes in Santa Monica Bay from multibeam mapping. Mar. Environ. Res. **56**:15-46.

Keywords: geomorphology, submarine canyons, multibeam, backscatter, california borderland

Abstract: Santa Monica Bay was mapped in 1996 using a high-resolution multibeam system, providing the first substantial update of the submarine geomorphology since the initial compilation by Shepard and Emery [(1941) Geol. Soc. Amer. Spec. Paper 31]. The multibeam mapping generated not only high-resolution bathymetry, but also coregistered, calibrated acoustic backscatter at 95 kHz. The geomorphology has been subdivided into six provinces; shelf, marginal plateau, submarine canyon, basin slope, apron, and basin. The dimensions, gradients, and backscatter characteristics of each province is described and related to a combination of tectonics, climate, sea level, and sediment supply. Fluctuations of eustatic sea level have had a profound effect on the area; by periodically eroding the surface of Santa Monica plateau, extending the mouth of the Los Angeles River to various locations along the shelf break, and by connecting submarine canyons to rivers. A wetter glacial climate undoubtedly generated more sediment to the rivers that then transported the increased sediment load to the low-stand coastline and canyon heads. The trends of Santa Monica Canyon and several bathymetric highs suggest a complex tectonic stress field that has controlled the various segments. There is no geomorphic evidence to suggest Redondo Canyon is fault controlled. The San Pedro fault can be extended more than 30 km to the northwest by the alignment of a series of bathymetric highs and abrupt changes in direction of channel thalwegs. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Gardner, J. V., L. A. Mayer, J. E. Hughes Clarke, and A. Kleiner. 1998. High-resolution multibeam bathymetry of East and West Flower Gardens and Stetson Banks, Gulf of Mexico. Gulf of Mexico Science **16**:131-143.

Keywords: multibeam sonar, geomorphology, bathymetric surveys, bottom topography, seafloor mapping

Abstract: The 1990s have seen rapid advances in seafloor mapping technology. Multibeam sonars are now capable of mapping a wide range of water depths with beams as narrow as 1°, and provide up to a 150° swath. When these multibeam sonars are coupled with an extremely accurate vehicle motion sensor and very precise navigation, they are capable of producing unprecedented images of the seafloor. This technology was used in December 1997 to map the East and West Flower Gardens and Stetson Banks, Gulf of Mexico. The results from this survey provide the most accurate maps of these areas yet produced and reveal features at submeter resolution never mapped in these areas before. The digital data provide a database that should become the fundamental base maps for all subsequent work in this recently established National

Marine Sanctuary. Reproduced with permission from The Marine Environmental Science Consortium.

Gardner, C., D. Devries, D. Naar, and B. Donahue. 2010. Mapping hard bottom reef fisheries habitat off Northwest Florida – needs, methods, and status. In: Proceedings of the Gulf and Caribbean Fisheries Institute. **63**: 505.

Keywords: stock assessment, bathymetry, unmanned vehicles, cameras, fishery surveys, side scan sonar, fishery management, backscatter, reef fish

Abstract: The west Florida shelf (WFS) supports some of the most valuable reef fish fisheries in the U.S. Gulf of Mexico. However, very little of its area has been mapped with enough resolution to accurately locate and quantify the hard/live bottom habitat these fisheries are so strongly tied to. Such maps are essential for designing an efficient fishery independent survey of reef fishes, enabling pre-stratification by habitat, and thereby minimizing variance and optimizing survey resources. Accurate habitat maps will also be critical for ecosystem based fisheries management and marine spatial planning. In support of a recently expanded fishery independent reef fish survey, the Panama City NMFS lab began mapping cross-shelf transects on the northern WFS using multibeam and side scan sonar. Two transects ~ 1.5-2.5 X 30 nm were mapped with a 300 kHz multibeam sonar and seventeen single swath cross-shelf transects ~20-30 nm X 150 m were mapped using a 600 kHz side scan sonar. An inexpensive live video drop camera and occasionally an ROV were used for visual ground truthing. Although the multibeam provided bathymetry and backscatter data at very high resolution, the side scan hardware and software was much more user friendly and provided data on which hard/live bottom habitat could, after a very short learning curve, be easily identified. Given the scale of most interest for fisheries-related needs, the 600 kHz side scan sonar may be the most cost-effective tool for our purposes.

Goff, J. A., H. C. Olson, and C. S. Duncan. 2000. Correlation of side-scan backscatter intensity with grain-size distribution of shelf sediments, New Jersey margin. Geo-Mar. Lett. **20**:43-49.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs003670000032

Goff, J. A., D. L. Orange, L. A. Mayer, and J. E. Hughes Clarke. 1999. Detailed investigation of continental shelf morphology using a high-resolution swath sonar survey: the Eel margin, northern California. Mar. Geol. **154**:255-269.

Keywords: continental shelf, Eel River, swath bathymetry, sidescan backscatter

Abstract: The Eel shelf, northern California, lies within an active compressional tectonic margin subject to abundant terrigenous sediment input from the Eel River. A recent high-resolution swath sonar survey provides us with the opportunity to investigate seafloor morphology and acoustic backscatter patterns within this dynamic region. Our analysis of the statistical character of bathymetry demonstrates a clear separation into large- and small-scale morphologies at a similar to 3-10 km scale, with smaller-scale morphology heavily damped relative to large-scale morphology. The Eel shelf bathymetry is subtle, but several structures can be readily discerned in a residual bathymetry formed by removal of the downslope gradient. Some shelf structures are evidently related to depositional processes (as evidenced by correlation with 100-yr sediment accumulation rates), whereas others appear related to tectonic processes (as evidenced by correlation with subsurface synclines and anticlines). The sidescan structure of the shelf is dominated by the low backscatter over the Eel and Mad River subaqueous deltas, evidently associated with the sand-to-mud transition. However, contrary to usual correlations between backscatter and grain size, in this situation higher backscatter is associated with the muddy sediments. In addition, we observe a series of shore-perpendicular striations, or `ribbons', spaced similar to 0.2-1.0 km apart, which extend northward from the Eel River subaqueous delta and lie at or near the sand-to-mud transition. Some aspects of ribbon morphology suggest that they may be associated with down-slope flows. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Gordon, D. C., Jr., E. L. R. Kenchington, K. D. Gilkinson, D. L. McKeown, G. Steeves, M. Chin-Yee, W. P. Vass, K. Bentham, and P. R. Boudreau. 2000. Canadian imaging and sampling technology for studying marine benthic habitat and biological communities, ICES 2000 Annual Science Conference, Bruges, Belguim, ICES Paper CM 2000/T:07

Keywords: seafloor mapping, image enhancement, man-induced effects, videotape recordings, habitat equipment

Abstract: The systematic mapping of marine benthic habitat and biological communities requires specialized oceanographic instrumentation. During the past ten years, as part of research programs investigating the effects of mobile fishing gear and offshore hydrocarbon development, Canadian scientists and engineers have developed a suite of tools for imaging and sampling seabed habitats over different spatial scales. Towcam is a towed vehicle which collects continuous but low-resolution video imagery of the seabed over a large area (i.e. 1-10 km transects). Campod is an instrumented tripod equipped with two video cameras and a 35-mm camera with 250-frame capacity. It is deployed while the ship is on station, or slowly drifting, and collects both general reconnaissance video and high-resolution imagery from a small area of the seabed. A hydraulically operated videograb, which uses the same conductor cable and winch as Campod, collects sediment and organisms from an area of 0.5 m^2. Video cameras allow the operator to select the exact area of seabed to sample and to ensure that the grab closes

properly. These three instruments are briefly described and examples of their application on the continental shelf off Eastern Canada provided. These and comparable tools used by other ICES countries, when used in conjunction with acoustic survey tools (multibeam, seismic, side scan, RoxAnn, QTCview, etc.), make possible the classification and mapping of marine benthic habitat and biological communities over large areas.

Greene, H. G. and J. E. Tilden. 2002. Using multibeam bathymetry to characterize rockfish habitat in San Juan County, WA marine reserves. 1st Biennial Marine Ecosystem Health Program Science Symposium, Rosario Resort, Orcas Island, WA.

Keywords: habitat, environment management, bathymetry, marine parks, backscatter

Abstract: The establishment of marine protected areas (MPAs) has recently become an important part of marine resource management efforts around the work and in San Juan County. Rockfish are economically important bottomfish whose populations have declined since the 1970's to such an extent that they are being considered threatened or endangered under the Endangered Species Act. During October of 2000, Moss Landing Marine Laboratories, Center for Habitat Studies surveyed five sites within the San Juan Archipelago (SJA) using a RESON 8101 multibeam bathymetric system. Both bathymetry and backscatter data were collected, although the system was maximized for the collection of accurate bathymetry. The main objective of this survey was to gather high-resolution bathymetric data to be used in mapping adult and juvenile rockfish habitat as part of an effort to identify potential marine reserves within the SJA. Sites were chosen based upon previous knowledge of the area's physical, oceanographic, and biological conditions. Surveys were undertaken within San Juan Channel, southern Haro Strait, and southern Rosario Strait. Areas of rugged rocky seafloor were identified using both qualitative and quantitative methods, and were interpreted to be potential adult and juvenile rockfish habitat. Potential habitat bridges radiating outward from protected areas were outlined based upon visual interpretation of multibeam imagery. Three voluntary no-take reserves (VNTZs), Pile Point, Charles Island, and Bell Island established by the San Juan County Marine Resource Committee in 1997, were evaluated based upon the presence of potential adult and juvenile rockfish habitat and the existence of possible habitat bridges that radiate outward from the protected areas. Results show that Pile Point, Charles Island, and Bell Island VNTZs appear to contain viable refugia for adult and juvenile rockfish and prospective habitat bridges that radiate outward from the VNTZs. Alternative reserve locations were also identified that may provide protection for species other than bottomfish.

Greene, H. G., V. M. O'Connell, and C. K. Brylinsky. 2011. Tectonic and glacial related seafloor geomorphology as possible demersal shelf rockfish habitat surrogates- examples along the Alaskan convergent transform plate boundary. Cont. Shelf Res. **31**:S39-S53.

Keywords: surrogates, marine benthic habitats, tectonics, glacial, Alaska, groundfish

Abstract: Seafloor geology plays a major role in habitat formation and can be used to remotely identify key habitats for some commercially important fish species. We have used a combination of side-scan sonar mosaics, multibeam bathymetry, and backscatter data, and in situ observations and video from the submersible Delta to investigate marine benthic habitats in the Eastern Gulf of Alaska. The intent of this paper is to review the results of previous marine benthic habitat mapping efforts completed by us along the transform plate boundary of Alaska and to present new information that show how volcanic, plutonic, and glacial submarine geomorphology can be used to identify potentially important discrete habitat areas. Demersal shelf rockfish, a seven-species management complex of nearshore rockfish, including yelloweye rockfish (Sebastes ruberrimus), are found in rugged and highly rugose geomorphologic features. Eroded volcanic edifices, lava fields, and a pit crater, as well as a small shutterridge, deformed and differentially eroded sedimentary bedrock, and highly fractured and faulted plutonic rock outcrops are features that attract adult rockfish. Volcanic edifices that lie along the leaky (magma-conducting) Fairweather transform fault system intercept ocean currents, in turn producing upward eddies that bring nutrients to species residing on the features. We show that geologic processes such as fault deformation, volcanism, and glaciation are critical to the development of Essential Fish Habitats (EFH) for demersal shelf rockfish. Our work is the first attempt to determine a common geologic link between desperate commercial fishing areas in SE Alaska, USA, and to suggest how tectonic and glacial processes, including sea level rise and transgression, can be used to identify seafloor geologic characteristics as surrogates for marine groundfish habitats. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Greene, G., V. M. O'Connell, C. Brylinsky. 2006. Newly discovered volcanic edifices in SE Alaska, USA found to be unique fisheries habitats, American Geophysical Union] **36**.

Keywords: commercial fishing, resource management, recruitment, volcano, multibeam

Abstract: During the past three years we have been focusing on the assessment of fisheries-targeted yelloweye (*Sebastes ruberrimus*) rockfish and lingcod (*Ophiodon elongatus*) that are heavily concentrated on and around volcanic edifices in SE Alaska, USA. These volcanic structures have recently been imaged using a Reson`8111 (100 kHz) and a 8150 (240 kHz) SeaBat sonar wide-swath multibeam bathymetry and backscatter seafloor mapping systems operated by Fugro Pelagos, Inc. under contract to the Alaska Department of Fish and Game. Spectacular images of a partially eroded volcanic cone located on Fairweather Ground, a major commercial bottom fish fishing ground, and a one kilometer diameter caldera or pit-crater with associated cinder cones and lava flows located on the continental shelf due west of Cape Addington have been examined in situ using the human occupied submersible Delta. We found that the volcanic rock and rubble provide ideal habitat for an assemblage of commercially targeted fishes consisting of adult yelloweye, juvenile yelloweye, tiger (*S. nigrocinctus*), quillback (*S. Maliger*), rosethorn (*bakran-petricioli*), and other rockfishes and lingcod.

This assemblage of bottom fishes are similar to that found associated with the volcanic cones of the Edgecumbe lava field offshore of Sitka, Alaska that are presently set aside as no-take zones for both commercial and recreational fishing because of their large diversity and abundances of fishes in a small area and in close proximity to fishing ports. Concerns for over- fishing of the newly discovered volcanic edifices exist. Our initial examination of the volcanic edifices suggests that these features are not only geologically unique, as they lie along a transform fault plate boundary and not in a volcanic province, but are biologically unique in that they provide extreme relief, roughness or rugosity, and project steeply above flat seafloor in such a way as to interrupt oceanographic circulation and provide up-welled nutrients, among other things. The primary structure and eroded products of these volcanic features provide refugia, foraging habitats, nutrients, substrate for biological habitats, and opportunity for recruitment including protection from predation for larval and juvenile fishes, all within a relatively small area compared to the entire SE Alaskan continental shelf. These features warrant further intense comprehensive study to determine their possible enhanced contribution to recruitment and sustainability of groundfishes. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Greene, H. G., M. M. Yoklavich, R. M. Starr, V. M. O'Connell, W. W. Wakefield, D. E. Sullivan, J. E. McRea, Jr., and G. M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Oceano. Acta **22**:663-678.

Keywords: habitat, universal classification, benthic, fisherier management

Abstract: A standard, universally useful classification scheme for deepwater habitats needs to be established so that descriptions of these habitats can be accurately and efficiently applied among scientific disciplines. In recent years many marine benthic habitats in deep water have been described using geophysical and biological data. These descriptions can vary from one investigator to another, which makes it difficult to compare habitats and associated biological assemblages among geographic regions. Using geophysical data collected with a variety of remote sensor systems and in situ biological and geologic observations, we have constructed a classification scheme that can be used in describing marine benthic habitats in deep water. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Greenstreet, S. P. R., I. D. Tuck, G. N. Grewar, E. Armstrong, D. G. Reid, and P. J. Wright. 1997. An assessment of the acoustic survey technique, RoxAnn, as a means of mapping seabed habitat. ICES J. Mar. Sci. **54**:939-959.

Keywords: RoxAnn, seabed sediment habitat, mapping, acoustic survey, False Colour Composite Image analysis, habitat selection

Abstract: RoxAnn acoustic surveys of the inner Moray Firth, undertaken in September/October 1995 and January 1996, were used to map seabed habitat on the basis of two sediment characteristics, "roughness" (E1) and "hardness" (E2). The traditional analytical method of fitting a "box pattern" to E1 vs. E2 scatter plots was compared with a more objective method using False Colour Composite Image (FCCI) and cluster analysis. Although both methods produced similar maps, the latter provided greater between survey consistency. Six to seven sediment types were indicated by RoxAnn, however ordination analysis of sediment samples indicated that some of the FCCI clusters could not be separated on the basis of their particle size distributions. This may have been due to a degree of depth sensitivity, but it is also possible that RoxAnn was responding to other physical or biotic seabed features other than just particle size. After combining RoxAnn FCCI clusters where ground-truthing grab samples had shown the particle size distributions to be similar, it was evident that RoxAnn could distinguish three main sediment habitats with certainty. On this basis, the RoxAnn derived maps compared well with maps obtained from British Geological Survey data. Finally we examined the distributions of four flatfish species to determine whether these were in any way related to the different sediment habitats identified by RoxAnn©. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Grizzle, R. E., M. A. Brodeur, H. A. Abeels, and J. K. Greene. 2008. Bottom Habitat Mapping Using Towed Underwater Videography: Subtidal Oyster Reefs as an Example Application. J. Coast. Res. **24**:103-109.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://www.jcronline.org/doi/abs/10.2112/06-0672.1

Grossman, E., A. Stevens, C. Curran, C. Smith, and A. Schwartz. 2007. Bathymetry, Substrate and Circulation in Westcott Bay, San Juan Islands, Washington. Page 42 Open-file Report. U.S. Geological Survey.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://pubs.usgs.gov/of/2007/1305/

Hamilton, L. J. and I. Parnum. 2011. Acoustic seabed segmentation from direct statistical clustering of entire multibeam sonar backscatter curves. Cont. Shelf Res. **31**:138-148.

Keywords: acoustic backscatter data, multibeam sonar, multivariate analysis, seafloor classification, statistical clustering

Abstract: A fast, simple method is presented to obtain acoustic seabed segmentation from multibeam sonar backscatter data, for situations where processed backscatter curves are already available. Unsupervised statistical clustering is used to classify multibeam sonar backscatter curves in their entirety, with the curves essentially treated as geometrical entities. High variability in the backscatter curves is removed by along-track averaging prior to clustering, and no further preprocessing is required. The statistical clustering method is demonstrated with RESON 8125 multibeam sonar data obtained in two bathymetrically complex environments. These are a sandwave field in Keppel Bay, Queensland, and an area of inter-island sand, reef, seagrass, and rhodolith beds in Esperance Bay, Western Australia. The resulting acoustic charts are visually compelling. They exhibit high spatial coherence, are largely artifact free, and provide spatial context to comparatively sparse grab samples with relatively little effort. Since the backscatter curve is an intrinsic property of the seafloor, the mappings form standalone charts of seafloor acoustic properties. In themselves they do not need ground truthing. Conceptually, use of the full angular backscatter curve should form the primary means of obtaining acoustic seabed segmentation. However, this is dependent on the scale and configuration of seabed backscatter features compared to the dimensions of the averaged swathe used to obtain reliable realisations of the backscatter curve. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Haris, K., B. Chakraborty, B. Ingole, A. Menezes, and R. Srivastava. 2012. Seabed habitat mapping employing single and multi-beam backscatter data: A case study from the western continental shelf of India. Cont. Shelf Res. **48**:40-49.

Abstract: Acoustic backscatter from multi-beam echo-sounder (MBES) and dual-frequency single-beam echo-sounding systems (SBES) operable at 95kHz and 33/210kHz, respectively, were used to study the distribution of sediment texture and benthic macro-fauna along the central part of the western continental shelf of India (off Goa). To characterize the continental shelf seafloor, single-beam and multi-beam backscatter signals were acquired along with grab sediment samples. The relationships between processed acoustic backscatter strength, grain size, and benthic macro-fauna abundance were demonstrated employing clustering technique (PCA) and Geographic Information System (GIS) based mapping. The clustering analysis delineated that the backscatter values at three frequencies are strongly correlated with both substrate type and faunal functional groups. The preferences of deposit feeders (soft body benthic macro-fauna) for the fine-sediment regions and filter feeders (hard body benthic macro-fauna) for coarse sediment regions were linked to the variations in sediment granulometry as well as backscatter strengths in the study area. This study further demonstrates the utility of high frequency backscatter data employing echo-sounding systems towards the interpretation of seafloor sediments and benthic habitat

characteristics across large areas of seafloor. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Harris, B. P. and K. D. E. Stokesbury. 2010. The spatial structure of local surficial sediment characteristics on Georges Bank, USA. Cont. Shelf Res. **30**:1840-1853.

Keywords: Georges Bank, gravel, quadrat, sediment mapping, spatial analysis, underwater video

Abstract: Georges Bank is one of the world's most productive marine ecosystems, but the lack of accurate broad-scale sediment maps presently limits habitat assessments and spatial fisheries management. From 1999 to 2009 we surveyed 36,669km^2 of Georges Bank using 2.8 and 0.6m^2 quadrats viewed with live underwater video (video quadrats). The sediment types observed in 61,604 quadrats were used to map and evaluate spatial structure of local surficial sediment coarseness, dominance, heterogeneity, and maximum size characteristics at a 1km^2 spatial resolution. Sand dominated sediment covered 62% of the study area, and there was a logarithmic decline in coverage by larger, coarser and more heterogeneous sediments. Gravel dominated sediments covered 38% of the study area and were more than twice as abundant as previously estimated. A 12,890km^2 swath of gravel dominated seabed stretched from Cape Cod to northeastern Georges Bank consistent with estimates of prehistoric glacial extent. Within the swath there were 14 large gravel outcrops (15-2743km^2) . This work increases the spatial resolution of sediment information available for habitat assessments and spatial fisheries management on Georges Bank by two orders of magnitude. The four sediment characteristics we evaluated support further detailed investigations of the Bank's benthos, including the influences of surficial sediment characteristics on species and community distributions, and more spatially accurate estimates of seabed roughness. Finally, this work demonstrates the use of video quadrats as an alternative to traditional grab sampling and modern acoustic sampling for continental shelf-scale mapping. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Hasan, R. C., D. Ierodiaconou, L. Laurenson, and A. Schimel. 2014. Integrating multibeam backscatter angular response, mosaic and bathymetry data for benthic habitat mapping. PLoS ONE **9**:e97339.

Keywords: habitat, multibeam, backscatter, angular resonse

Abstract: Multibeam echosounders (MBES) are increasingly becoming the tool of choice for marine habitat mapping applications. In turn, the rapid expansion of habitat mapping studies has resulted in a need for automated classification techniques to efficiently map benthic habitats, assess confidence in model outputs, and evaluate the

importance of variables driving the patterns observed. The benthic habitat characterisation process often involves the analysis of MBES bathymetry, backscatter mosaic or angular response with observation data providing ground truth. However, studies that make use of the full range of MBES outputs within a single classification process are limited. We present an approach that integrates backscatter angular response with MBES bathymetry, backscatter mosaic and their derivatives in a classification process using a Random Forests (RF) machine-learning algorithm to predict the distribution of benthic biological habitats. This approach includes a method of deriving statistical features from backscatter angular response curves created from MBES data collated within homogeneous regions of a backscatter mosaic. Using the RF algorithm we assess the relative importance of each variable in order to optimise the classification process and simplify models applied. The results showed that the inclusion of the angular response features in the classification process improved the accuracy of the final habitat maps from 88.5% to 93.6%. The RF algorithm identified bathymetry and the angular response mean as the two most important predictors. However, the highest classification rates were only obtained after incorporating additional features derived from bathymetry and the backscatter mosaic. The angular response features were found to be more important to the classification process compared to the backscatter mosaic features. This analysis indicates that integrating angular response information with bathymetry and the backscatter mosaic, along with their derivatives, constitutes an important improvement for studying the distribution of benthic habitats, which is necessary for effective marine spatial planning and resource management.

Hasan, R. C., D. Ierodiaconou, and J. Monk. 2012. Evaluation of four supervised learning methods for benthic habitat mapping using backscatter from multi-beam sonar. Remote Sens. **4**:3427-3443.

Abstract: An understanding of the distribution and extent of marine habitats is essential for the implementation of ecosystem-based management strategies. Historically this had been difficult in marine environments until the advancement of acoustic sensors. This study demonstrates the applicability of supervised learning techniques for benthic habitat characterization using angular backscatter response data. With the advancement of multibeam echo-sounder (MBES) technology, full coverage datasets of physical structure over vast regions of the seafloor are now achievable. Supervised learning methods typically applied to terrestrial remote sensing provide a cost-effective approach for habitat characterization in marine systems. However the comparison of the relative performance of different classifiers using acoustic data is limited. Characterization of acoustic backscatter data from MBES using four different supervised learning methods to generate benthic habitat maps is presented. Maximum Likelihood Classifier (MLC), Quick, Unbiased, Efficient Statistical Tree (QUEST), Random Forest (RF) and Support Vector Machine (SVM) were evaluated to classify angular backscatter

response into habitat classes using training data acquired from underwater video observations. Results for biota classifications indicated that SVM and RF produced the highest accuracies, followed by QUEST and MLC, respectively. The most important backscatter data were from the moderate incidence angles between 30° and 50°. This study presents initial results for understanding how acoustic backscatter from MBES can be optimized for the characterization of marine benthic biological habitats.

Hewer, A. J., C. J. Brown, W. J. Meadows, D. S. Limpenny, K. M. Cooper, and H. L. Rees. 2002. Mapping of gravel biotopes: An integrated approach. p. 1-18 ICES Council Meeting Documents. Copenhagen, Denmark.

Keywords: habitat mapping, sidescan sonar, biotope classification

Abstract: Four sites were selected in the eastern English Channel to assess the utility of seabed mapping techniques for surveying gravelly habitats. Each site was intensively surveyed using a digital side scan sonar system. A mosaic of the side scan sonar data was produced to provide 100% spatial coverage maps at each location. Each mosaic was then divided into acoustically distinct regions. The regions were sampled using a suite of physical sampling and optical techniques. The main sampling tools were a 0.1 m² Hamon grab fitted with a video camera and light and a heavy duty 2m beam trawl which were used to characterize the benthic communities and sediment characteristics within each region. Relationships between acoustic regions, physical habitat characteristics and assemblages were then investigated using a range of univariate and multivariate techniques. Results from these analyses were used to identify discrete biotopes at each site. In most acoustic regions, particularly where there was a high degree of sediment homogeneity within discrete habitat boundaries, statistically distinct assemblages were identified. The situation was less clear where the seabed consisted of a complex arrangement of sediment types. Further work is currently underway to evaluate these and other techniques in soft sediments and at different spatial scales.

Huang, Z., S. L. Nichol, J. P. W. Siwabessy, J. Daniell, and B. P. Brooke. 2012. Predictive modelling of seabed sediment parameters using multibeam acoustic data: A case study on the Carnarvon Shelf, Western Australia. Int. J. Geogr. Inf. Sci. **26**:283-307.

Keywords: multibeam acoustic, predictive modelling, seabed sediment

Abstact: Seabed sediment textural parameters such as mud, sand and gravel content can be useful surrogates for predicting patterns of benthic biodiversity. Multibeam sonar mapping can provide near-complete spatial coverage of high-resolution bathymetry and backscatter data that are useful in predicting sediment parameters. Multibeam acoustic data collected across a ~1000 km² area of the Carnarvon Shelf, Western Australia, were used in a predictive modelling approach to map eight seabed sediment parameters. Four machine learning models were used for the predictive modelling: boosted decision tree, random forest decision tree, support vector machine

and generalised regression neural network. The results indicate overall satisfactory statistical performance, especially for %Mud, %Sand, Sorting, Skewness and Mean Grain Size. The study also demonstrates that predictive modelling using the combination of machine learning models has provided the ability to generate prediction uncertainty maps. However, the single models were shown to have overall better prediction performance than the combined models. Another important finding was that choosing an appropriate set of explanatory variables, through a manual feature selection process, was a critical step for optimising model performance. In addition, machine learning models were able to identify important explanatory variables, which are useful in identifying underlying environmental processes and checking predictions against the existing knowledge of the study area. The sediment prediction maps obtained in this study provide reliable coverage of key physical variables that will be incorporated into the analysis of covariance of physical and biological data for this area.

Link: http://www.tandfonline.com/doi/pdf/10.1080/13658816.2011.590139?redirect=1

Huff, L. C. and R. A. McConnaughey. 2013. Calibration schema for a long-range, fishery research side scan sonar. *In* Proceedings of the 2013 Oceans - San Diego. p. 1-5, IEEE

Keywords: calibration, source level, backscatter, fish habitat, side scan sonar

Abstract: The NOAA National Marine Fisheries Service owns two Long- Range, Fishery-Research Side Scan Sonars (Klein model 7180). Having recognized a number of serious shortcomings in the original design and implementation of the 7180, NOAA embarked on an upgrade of the 7180 to bring the 7180's performance closer to the requirements of fish-habitat researchers for radiometrically adjusted backscatter observations from a calibrated sonar. With three-meter long mechanically curved arrays, it is difficult/impractical to calibrate the 7180 side scan sonar using conventional methods. However, given the recognized importance of calibrated and radiometrically adjusted backscatter data for fishery research, a schema was developed for the 7180 that built on, and extended, the protocol for calibration of multibeam sonar [1]. This paper describes the cascade calibration schema and presents results from applying it to the upgraded 7180 during a recent survey in the eastern Bering Sea. With this method, it is now possible to trace the 7180 backscatter levels to a recognized standard and to detect the onset of discrepancies among the several spatially overlapping measures of backscatter. This advances the fishery-research goal of consistent seabed characterization across wide swaths of the seabed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Hughes Clarke, J., B. W. Danforth, and P. Valentine. 1997. Areal seabed classification using backscatter angular response at 95 kHz. In: Proceedings of the High Frequency Acoustics in Shallow Water. **45**:243-250.

Keywords: sediment classification, ARA

Abstract: A sediment classification scheme is developed based on the angular response (AR) of the seabed backscatter strength. The AR is characterised based on its mean level and slope over predefined angular sectors, and the presence or absence of abrupt changes in slope. Because the AR is derived from a finite area a test is performed to recognise the presence of sediment boundaries. The AR curves are shown to provide improved discrimination over angle invariant methods.

Hughes Clarke, J. E., L. A. Mayer, and D. E. Wells. 1996. Shallow-water imaging multibeam sonars: A new tool for investigating seafloor processes in the coastal zone and on the continental shelf. Mar. Geophys. Res. **18**:607-629.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007/BF00313877

Hughes Clarke, J. 1994. Toward remote seafloor classification using the angular response of acoustic backscattering: A case study from multiple overlapping GLORIA data. IEEE J. Ocean Eng. **19**:112-127.

Keywords: underwater, classification, geology, acoustics, classification systems, sediment properties, side scan sonar, backscatter, ocean bottom

Abstract: While the average seafloor backscatter strength within a narrow range of grazing angles can be used as a first-order classification tool, this technique often fails to distinguish seafloors of known differing geological character. In order to resolve such ambiguities, it is necessary to examine the variation in backscatter strength as a function of grazing angle. For this purpose, a series of multiply overlapping GLORIA side scan sonar images (6.5 kHz) have been obtained in water depths ranging from 1000 to 2500 m. To constrain the placement of acoustic backscatter measurements and to measure the true impinging angle of the incident wave, the corresponding seafloor was simultaneously surveyed using the Seabeam multibeam system. As a result of the multiple overlap, the angular response of seafloor backscatter strength may be derived for regions much smaller than the swath width. By using the derived angular response of seafloor backscatter strength in regions for which sediment samples exist, an empirical seafloor classification scheme is proposed based on the shape, variance, and magnitude of the angular response. Because of the observed variability in the shape of the angular response with differing seafloor types, routine normalization of single-pass swath data to an equivalent single grazing angle image cannot be achieved. As a result, for the case of single-pass surveys, confident seafloor classification may only be possible for regions approaching the scale of the swath width.

Hutin, E., Y. Simard, and P. Archambault. 2005. Acoustic detection of a scallop bed from a single-beam echosounder in the St. Lawrence. ICES J. Mar. Sci.: Journal du Conseil **62**:966-983.

Keywords: acoustic ground discrimination, benthic biotopes, habitat mapping, QTC VIEW, remote sensing, scallop bed, seabed classification

Abstract: Single-beam seabed echoes combined with epi-macrobenthos photographs were used to remotely detect a scallop bed and characterize the specific acoustic signal of Iceland scallop (*Chlamys islandica*). A dense scallop bed was surveyed in 2002, with a QTC VIEW Series IV acoustic ground-discrimination system (AGDS) connected to a 38kHz, 7° split-beam SIMRAD EK60 scientific echosounder. In 2003, a 50kHz, 42° single-beam SUZUKI ES-2025 echosounder was connected to a QTC VIEW Series V AGDS. The QTC VIEW data were analysed with QTC IMPACT following the standard procedures and classified into acoustic classes. Several approaches were tested: unsupervised and supervised survey strategies directed to specific benthic communities. The SIMRAD EK60 seabed volume-backscattering strength (S_v) was submitted to a principal component analysis (PCA), before and after removal of a depth trend, and the scores on the first 10 principal components were classed by a K-means cluster analysis. The same seabed S_v data were submitted to stepwise discriminant analysis whose training data sets were defined with the ground-truth photographs using different groupings: biotope types, community types, and finally scallop-density classes. All the QTC AGDS approaches failed to reveal the scallop bed, community structures, or biotopes. The QTC classifications mimicked the bathymetry with a strong correlation of the acoustic classes with depth. The seabed S_v PCA+K-means approach presented similar depth-dependence, but, the PCA+K-means on the S_v residuals revealed the scallop bed. The discriminant analysis was the best solution for the scallop density with a general classification success rate of 75% and up to 91% for the highest density class. The S_v signature of the scallop bed is presented, and the most discriminant part of the acoustic signal is identified. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Huvenne, V. A. I., P. Blondel, and J. P. Henriet. 2002. Textural analyses of side scan sonar imagery from two mound provinces in the Porcupine Seabight. Mar. Geol. **189**:323-341.

Keywords: mounds, side scan sonar imagery, Porcupine Seabight, cold-water corals, image analysis, grey level co-occurrence, matrices

Abstract: Large mound structures have been discovered in the Porcupine Seabight (Northeast Atlantic) at a depth of 500-1200 m, associated with the growth of cold-water deep-sea coral species such as *Lophelia pertusa* (L.) or *Madrepora oculata* (L.). During the Training Through Research cruise in 1997, high-resolution OREtech sidescan sonar data were acquired over two provinces of these structures. This article focuses on the

presentation and quantitative interpretation of representative sections of these sidescan data from areas around the Belgica and Hovland mounds. Several image analysis tools were used, but texture analysis, based on grey level co-occurrence matrices, gave the best results. Entropy and homogeneity indices were calculated, and the resulting images made it possible to discriminate between different seabed features on a quantitative basis. Mounds, moats and background sediments could be delineated accurately, and the image textures could be linked to the actual seafloor appearance through core descriptions and deep-towed video data. A major difference was found in the acoustic returns from the two provinces studied: the Belgica province shows much rougher textures. This is due to an actual difference in seabed roughness, caused by a difference in bottom currents and sediment dynamics in the two areas. The combined effect of the northward-directed North Atlantic slope current and superimposed internal waves and tides appears to be much stronger in the Belgica province. The reported difference in current strength might well influence the growth of the deep-water coral species in both areas. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Huvenne, V. A. I., T. L. Le Bas, B. J. Murton, V. Huhnerbach, M. Cassidy, I. Rouse, A. Webb, D. White, L. Rolley, and M. T. Judge. 2009. RRS James Cook Cruise 35, 7-19 Jun 2009. Sidescan sonar mapping of the Whittard Canyon, Celtic Margin. National Oceanography Centre Southampton cruise report. Southhampton, UK.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://eprints.soton.ac.uk/69695/

Ierodiaconou, D., J. Monk, A. Rattray, L. Laurenson, and V. L. Versace. 2011. Comparison of automated classification techniques for predicting benthic biological communities using hydroacoustics and video observations. Cont. Shelf Res. **31**:S28-S38.

Keywords: benthic habitat mapping, towed video, multibeam echosounder, automated classification

Abstract: The effective management of our marine ecosystems requires the capability to identify, characterise and predict the distribution of benthic biological communities within the overall seascape architecture. The rapid expansion of seabed mapping studies has seen an increase in the application of automated classification techniques to efficiently map benthic habitats, and the need of techniques to assess confidence of model outputs. We use towed video observations and 11 seafloor complexity variables derived from multibeam echosounder (MBES) bathymetry and backscatter to predict the distribution of 8 dominant benthic biological communities in a 54km^2 site, off the central coast of Victoria, Australia. The same training and evaluation datasets were used

to compare the accuracies of a Maximum Likelihood Classifier (MLC) and two new generation decision tree methods, QUEST (Quick Unbiased Efficient Statistical Tree) and CRUISE (Classification Rule with Unbiased Interaction Selection and Estimation), for predicting dominant biological communities. The QUEST classifier produced significantly better results than CRUISE and MLC model runs, with an overall accuracy of 80% (Kappa 0.75). We found that the level of accuracy with the size of training set varies for different algorithms. The QUEST results generally increased in a linear fashion, CRUISE performed well with smaller training data sets, and MLC performed least favourably overall, generating anomalous results with changes to training size. We also demonstrate how predicted habitat maps can provide insights into habitat spatial complexity on the continental shelf. Significant variation between patch-size and habitat types and significant correlations between patch size and depth were also observed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Intelmann, S. S., J. D. Beaudoin, and G. R. Cochrane. Normalization and characterization of multibeam backscatter: Koitlah Point to Point of the Arches, Olympic Coast National Marine Sanctuary survey - HMPR-115-2004-03. NOAA Professional Paper NMFS.

Keywords: benthic, habitat mapping, sediment classification, multibeam backscatter normalization, textural analysis, Olympic Coast National Marine Sanctuary, essential fish habitat, groundtruthing, accuracy assessment

Abstract: Through a partnership between the National Oceanic and Atmospheric Administration's (NOAA) Office of Coast Survey (OCS), NOAA's National Marine Sanctuary Program (NMSP), and NOAA's Office of Marine and Aviation Operations (OMAO), high resolution bathymetry (HRB) was collected on various opportunistic occasions during the months of October from 2001-2004 in the Olympic Coast National Marine Sanctuary (OCNMS). These particular survey operations were conducted aboard the NOAA ship RAINIER using a variety of multibeam echosounders suitable for the various regions of the sanctuary that were surveyed. Backscatter was derived from the Reson shallow water multibeam echosounders using custom software developed by researchers at the University of New Brunswick (Fredericton, Canada), for an area in the OCNMS, near Cape Flattery from Koitlah Point to Point of the Arches, and mosaiced at 1-meter pixel resolution. This process of normalizing the backscatter imagery significantly reduced the post-processing validation efforts that are required for the characterization effort. Textural classification of the sonar imagery suggests that nearly 58 percent of the seafloor in this area is covered by soft substrates such as mud or silt, 19 percent of the area is comprised of mixed sediment including cobbles, pebbles, gravel and boulders mixed with soft substrate, and over 23 percent of the total area is characterized by hard, complex rocky bottom. Video from a towed camera sled, bathymetry data, sediment samples, and the backscatter have been integrated to describe geological and biological aspects of habitat. Polygon features have also been created and attributed with a hierarchical deep-water marine benthic classification

scheme (Greene et al. 1999). The data can be used with geographic information system (GIS) software for display, query, and analysis.

Intelmann, S. S., and G. R. Cochrane. Benthic Habitat Mapping in the Olympic Coast National Marine Sanctuary: Classification of Side Scan Sonar Data from Survey, HMPR-108-2002-01: Version I. Marine Sanctuaries Conservation Series, ONMS-06-01. Report, NOAA Professional Paper NMFS.

Abstract: In September 2002, side scan sonar was used to image a portion of the sea floor in the northern OCNMS and was mosaiced at 1-meter pixel resolution using 100 kHz data collected at 300-meter range scale. Video from a remotely-operated vehicle (ROV), bathymetry data, sedimentary samples, and sonar mapping have been integrated to describe geological and biological aspects of habitat and polygon features have been created and attributed with a hierarchical deep-water marine benthic classification scheme (Greene et al. 1999). The data can be used with geographic information system (GIS) software for display, query, and analysis. Textural analysis of the sonar images provided a relatively automated method for delineating substrate into three broad classes representing soft, mixed sediment, and hard bottom. Microhabitat and presence of certain biologic attributes were also populated into the polygon features, but strictly limited to areas where video groundtruthing occurred. Further groundtruthing work in specific areas would improve confidence in the classified habitat ma pp.

Intelmann, S. S., G. R. Cochrane, Brancato, and J. Hyland. 2007. Survey Report of NOAA Ship McArthur II Cruises AR-04-04, AR-05-05 and AR-06-03: Habitat Classification of Side Scan Sonar Imagery in Support of Deep-Sea Coral/Sponge Explorations at the Olympic Coast National Marine Sanctuary. NOAA Professional Paper NMFS.

Abstract: Habitat mapping and characterization has been defined as a high-priority management issue for the Olympic Coast National Marine Sanctuary (OCNMS), especially for poorly known deep-sea habitats that may be sensitive to anthropogenic disturbance. As a result, a team of scientists from OCNMS, National Centers for Coastal Ocean Science (NCCOS), and other partnering institutions initiated a series of surveys to assess the distribution of deep-sea coral/sponge assemblages within the sanctuary and to look for evidence of potential anthropogenic impacts in these critical habitats. Initial results indicated that remotely delineating areas of hard bottom substrate through acoustic sensing could be a useful tool to increase the efficiency and success of subsequent ROV-based surveys of the associated deep-sea fauna. Accordingly, side scan

sonar surveys were conducted in May 2004, June 2005, and April 2006 aboard the NOAA Ship *McArthur II* to: (1) obtain additional imagery of the seafloor for broader habitat-mapping coverage of sanctuary waters, and (2) help delineate suitable deep-sea coral/sponge habitat, in areas of both high and low commercial-fishing activities, to serve as sites for surveying-in more detail using an ROV on subsequent cruises. Several regions of the sea floor throughout the OCNMS were surveyed and mosaicked at 1-meter pixel resolution. Imagery from the side scan sonar mapping efforts was integrated with other complementary data from a towed camera sled, ROVs, sedimentary samples, and bathymetry records to describe geological and biological (where possible) aspects of habitat. Using a hierarchical deep-water marine benthic classification scheme (Greene et al. 1999), we created a preliminary map of various habitat polygon features for use in a geographical information system (GIS). This report provides a description of the mapping and groundtruthing efforts as well as results of the image classification procedure for each of the areas surveyed.

Jacobs, C. L. 2007. MV Franklin Cruise 0406, 14-23 Sep 2006. Habitat investigations on the West of Shetland continental slope. National Oceanography Centre, Southampton, UK.

Keywords: acoustic backscatter, bathymetric chart, cruise 0406 2006, EM1002, Franklin, West Shetland Slope, Wyville-Thomson Ridge, seafloor photography, iceberg plough-marks, multibeam bathymetry, seafloor mapping, sonar surveys, SEA4, SEA7

Abstract: The objectives of the MV Franklin 0406 cruise were to collect EM1002 multibeam bathymetry and backscatter data, carry out on-board processing and use interpreted mosaics to identify variations in seafloor geology and morphology. Using these interpretations as a guide to distinguish variations in benthic habitat, when required, additional high resolution side scan sonar transects would be run, and, in areas of special interest, seafloor photograph and video imagery collected. The aims were to (1) create high quality bathymetric maps of the survey areas; (2) create acoustic backscatter maps over the same areas; (3) when possible, define the extent of benthic habitats; (4) undertake photographic surveys of specific habitat areas to quantify the benthic ecology; (5) create high resolution bathymetric, backscatter and sonar maps of specific features as may be discovered, such as sponge reefs, carbonate mounds etc.; (6) complete, during the cruise, a preliminary interpretation of the above data. This was a highly successful cruise with almost all cruise objectives achieved. High resolution maps were made of the mid-slope channels to the west of the Shetland Isles and also the intersection of the Wyville-Thomson Ridge and UK Continental Shelf, a feature critical in physical oceanography and North Atlantic circulation studies, was imaged. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Jones, D. T., C. D. Wilson, A. De Robertis, C. N. Rooper, T. C. Weber, and J. L. Butler. 2012. Evaluation of rockfish abundance in untrawlable habitat: combining acoustic and complementary sampling tools. Fish. Bull., U.S. **110**:332-343.

Abstract: Rockfishes (*Sebastes* spp.) are an important component of North Pacific marine ecosystems and commercial fisheries. Because the rocky, high-relief substrate that rockfishes often inhabit is inaccessible to standard survey trawls, population abundance assessments for many rockfish species are difficult. As part of a large study to classify substrate and compare complementary sampling tools, we investigated the feasibility of using an acoustic survey in conjunction with a lowered stereo-video camera, a remotely operated vehicle, and a modified bottom trawl to estimate rockfish biomass in untrawlable habitat. The Snake-head Bank south of Kodiak Island, Alaska, was surveyed repeatedly over 4 days and nights. Dusky rockfish (S. *variabilis*), northern rockfish (S. *polyspinis*), and harlequin rockfish (S. *variegatus*) were the most abundant species observed on the bank. Backscatter attributed to rockfish were collected primarily near the seafloor at a mean height off the bottom of 1.5 m. Total rockfish backscatter and the height of backscatter off the bottom did not differ among survey passes or between night and day. Biomass estimates for the 41 square nautical-mile area surveyed on this small, predominantly untrawlable bank were 2350 metric tons (t) of dusky rockfish, 331 t of northern rockfish, and 137 t of harlequin rockfish. These biomass estimates are 5-60 times the density estimated for these rockfish species by a regularly conducted bottom trawl survey covering the bank and the surrounding shelf. This finding shows that bottom trawl surveys can underestimate the abundance of rockfishes in untrawlable areas and, therefore, may underestimate overall population abundance for these species.

Jones, G. E. and G. E. Glegg. 2004. Effective use of geophysical sensors for marine environmental assessment and habitat mapping. In: C. A. Brebbia, J. M. S. Perez, L. G. Andion, and Y. Villacampa (editors), Coastal Environment V: Incorporating Oil Spill Studies. **68**: 5-16.

Abstract: Given increased concern for sustainable management and its application to marine areas, the aim of this paper is to assess how best sublittoral marine habitats may be surveyed in order that the marine environment may be monitored, in compliance with the requirements of the scientific community, and that of the European Community, in both a cost effective and sustainable manner. Habitat surveys require information on the geomorphology and the biology of an area so that biotope units can be classified. A range of different survey approaches can be used for habitat identification all of which have both advantages and disadvantages. The final product usually results from a combination of at least two different approaches - for example, a remotely sensed side scan sonar image of the site with ground truthing in the form of

physical samples or video or still photography. This project aims to consider the use of the full range of survey and marine habitat mapping techniques and considers their cost effectiveness and their repeatability as part of a sustainable monitoring regime. It includes an assessment of work carried out within Plymouth Sound, a candidate Special Area of Conservation (cSAC), where a range of surveys using differing techniques and sensors has been undertaken in recent years.

Jung, M. S., H. S. Kim, and C. K. Park. 2007. Topographic analysis of bathymetry data acquired from the KR1 Area of Northeastern Pacific: Application of Wavelet-based Filter. Ocean and Polar Research **29**:303-310.

Keywords: wavelet analysis, bathymetric data, topography, 2-D filter, dominant orientation

Abstract: 2-D wavelet analysis is applied to bathymetric data from the KR1 area of Korea Deepsea Mining Area. The wavelet analysis is one of the quantitative methods to analyze the topography. The wavelet allows us to create filters to select for topography in a continuous variety of shapes, sizes, and orientation. The 2-D Linear B-spline filter, 100 BS and 100 NF, is convolved with bathymetric data to identify the location of abyssal hills and abyssal troughs in bathymetry. In addition, the 2-D derivative of Cubic B-spline filter, 60 BS and 60 NF, is applied to bathymetric data to find the slope of abyssal hill in bathymetry. These filters were rotated 5° counterclockwise from NS to match the dominant orientation of seafloor lineament. Both filters result in good match with abyssal hills, troughs, and slopes. This method can apply to fault, fold, and other lineament structures description with variable size. The result of application shows that wavelet analysis of bathymetric data could be used with fundamental data of geophysical analysis.

Keeton, J. A. and R. C. Searle. 1996. Analysis of Simrad EM12 multibeam bathymetry and acoustic backscatter data for seafloor mapping, exemplified at the Mid-Atlantic Ridge at 45°N. Mar. Geophys. Res. **18**:663-688.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2FBF00313880

Kendall, M. S., O. P. Jensen, C. Alexander, D. Field, G. McFall, R. Bohne, and M. E. Monaco. 2005. Benthic mapping using sonar, video transects, and an innovativeapproach to accuracy assessment: A characterization of bottom features in the Georgia Bight. J. Coast. Res. **21**:1154-1165.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Kenny, A. J., I. Cato, M. Desprez, G. Fader, R. T. E. Schuttenhelm, and J. Side. 2003. An overview of seabed-mapping technologies in the context of marine habitat classification. ICES J. Mar. Sci. **60**:411-418.

Keywords: seabed-mapping technologies, swath system, single-beam system

Abstract: A wide range of seabed-mapping technologies is reviewed in respect to their effectiveness in discriminating benthic habitats at different spatial scales. Of the seabed attributes considered important in controlling the benthic community of marine sands and gravel, sediment grain size, porosity or shear strength, and sediment dynamics were highlighted as the most important. Whilst no one mapping system can quantify all these attributes at the same time, some may be estimated by skilful interpretation of the remotely sensed data. For example, seabed processes or features, such as bedform migration, scour, slope failure, and gas venting are readily detectable by many of the mapping systems, and these characteristics in turn can be used to assist a habitat classification (and monitoring) of the seabed. We tabulate the relationship between 'rapid' continental shelf sedimentological processes, the seabed attributes affecting these processes, and the most suitable mapping system to employ for their detection at different spatial scales. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Kenyon, N. H., I. Klaucke, J. Millington, and M. K. Ivanov. 2002. Sandy submarine canyon-mouth lobes on the western margin of Corsica and Sardinia, Mediterranean Sea. Mar. Geol. **184**:69-84.

Keywords: Mediterranean Sea, submarine canyon, canyon-mouth lobe, side-scan sonar, sand turbidite

Abstract: Long-range, low-resolution and deep-towed, high-resolution side-scan sonar records, high-resolution seismic profiles and core samples were used to study the relatively small canyon fed turbidite systems west of Corsica and Sardinia. The margin west of Corsica is dissected by deep (up to 1500 m), straight canyons that have steep axial gradients (10° slopes are common) and that extend from land to sea without a break in gradient. The submarine canyon axes are readily mapped by their stronger acoustic backscatter. The axes have scour holes and trains of gravel or pebble waves. Canyoned slopes have widespread, shallow sediment failures. Five separate depositional lobes are recognised, extending beyond the canyon mouths. Deep-towed, high-resolution seismic profiles across part of one lobe show stacked sedimentary sheets, a few tens of kilometres wide. Cores from these sheets contain coarse to medium sand beds that are up to 3 m thick, with some mud clasts in the middle of the beds and up to

3% clay in the sand matrix. A drape of nannofossil ooze on top of cores indicates that the main activity through the canyons is at times of low sea level. The lobes tend to appear as weak backscatter, with fringes of a braid-like pattern of stronger backscatter. The reasons for this acoustic pattern are not fully understood, though in general the sand bodies are found where backscatter is relatively weak. The size of the canyon-mouth lobes is proportional to the size of the subaerial drainage basins. The limited sediment supply accounts for the absence of a well-developed submarine ramp despite the sand-dominated input from multiple sources. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Kilbourne, K.H., M. E. Field, J. V. Gardner, and C. J. Jenkins. 1999. Evaluating benthic fish habitats on the continental shelf and slope of the Southern California Bight: Design and use of a benthic character database. In: Proceedings of the 2000 Ocean Sciences Meeting. **80**:49.

Keywords: stock assessment, sediment texture, habitat, resource management, fishery management, backscatter

Abstract: Recent concern over the sustainability of commercial and sport fisheries has increased the need for physical descriptions of benthic fish habitats. Physical descriptions are useful for quantifying available habitat, and they provide a basis upon which fisheries managers can make informed decisions. One important physical aspect of benthic habitat is the character of the seafloor, *e.g.*, the abundance of rock outcrops and the distribution of sediment textures. We have developed a benthic character database for the continental slope and shelf of the western United States and Southern Canada. This database provides a foundation for mapping benthic habitats and for a wide variety of other studies. The database system is designed to maximize the amount and variety of data in two ways. First, the system has the ability to standardize the format of almost any type of existing, geographically referenced, quantifiable data (average grainsize, percent carbon, sorting coefficients, etc.). Second, verbal descriptions of the sediment are converted by fuzzy logic algorithms into semi-quantitative values to extend the data coverage. Currently, we use the database to investigate correlations between sediment characteristics and the distribution of demersal fish and other benthic organisms in the Southern California Bight. To accomplish this, biologic data from otter trawls and other benthic surveys are compared with sediment characteristics. Using the distribuion of species and the distribuion of benthic characteristics, facies are determined with factor analyses (Q-mode analysis with a verimax rotation) and a GIS (ArcView). Other potential applications of the database include analyses of physical shelf processes, cruise planning, and interpretation of multibeam and side scan backscatter maps. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Kingon, K. 2010. Locating and mapping reef fish habitat on a tight budget. p.536b *In* Proceedings of the Gulf and Caribbean Fisheries Institute. San Juan, Puerto Rico.

Abstract: Unlike the terrestrial environment where comprehensive maps are readily available, maps of the ocean are scarce and usually lack the detail required to identify benthic habitats. A relatively inexpensive, commercially available product may help marine researchers overcome this obstacle. This system, distributed by Humminbird for fishermen, records side scan imagery, bathymetry data, and GPS coordinates simultaneously and costs under $2000. The Humminbird system reveals geologic features and habitat types as well as schools of fishes and other large marine animals. The main advantages of this particular system are the side scan component and the ability to record all the imagery, maps, and coordinates on to a SD card. The recorded data can be downloaded to a computer, converted into a more usable format and then incorporated into ArcGIS to create georeferenced habitat maps. Using the Humminbird, I mapped several artificial reefs and hardbottom sites in the northeastern Gulf of Mexico and verified the imagery with dive surveys. The mapping methods were improved as the study progressed and ideally consist of recording one parallel transect at a time by starting the recording at the beginning of each transect and stopping it at the end. This greatly reduces the amount of post-processing and makes the imagery easier to manage. Relatively small ledges, rocks, and reef balls can be identified and accurately mapped using this approach. The Humminbird system has great potential and should benefit future reef fish research and provide essential maps for effective-ly implementing ecosystem based management.

Kloser, R. J., N. J. Bax, T. Ryan, A. Williams, and B. A. Barker. 2001. Remote sensing of seabed types in the Australian South East Fishery: development and application of normal incident acoustic techniques and associated 'ground truthing'. Mar. Freshw. Res. **52**:475-489.

Abstract: Calibrated acoustic backscattering measurements using 12, 38 and 120 kHz were collected over depths of 30-230 m, together with benthic epi- and in-fauna, sediments, photographs and video data. Each acoustic ping was envelope detected and digitized by echo sounder to include both the first and second echoes, and specifically designed software removed signal biases. A reference set of distinct habitat types at different depths was established and a simple classification of the seabed combined both biological and geological significance. The simple acoustic indices could discriminate three of these at a single frequency. This demonstrates that the acoustic indices are not directly related to specific seabed properties but to a combination of seabed hardness and roughness attributes at a particular sampling frequency. The

methods described can be transferred to higher resolution swath mapping acoustic sampling devices such as digital side-scan sonars and multibeam echo sounders.

Link: http://www.publish.csiro.au/nid/126/paper/MF99181.htm

Kloser, R. J., J. D. Penrose, and A. J. Butler. 2010. Multi-beam backscatter measurements used to infer seabed habitats. Cont. Shelf Res. **30**:1772-1782.

Keywords: Australia, biotopes, epifauna, backscatter, video, multi-beam

Abstract: Backscatter from multi-beam sonar (MBS) was used to discriminate ecologically relevant seabed characteristics based on 62 reference sites sampled with georeferenced video, sediment grab and rock dredge between 50 and 500m water depth. A simple biotope characteristic of soft (unconsolidated) and hard (consolidated) was used to compare the acoustic backscatter data with the data on mega-epifauna and substrate type obtained from video and physical sampling. Substrate type of homogeneous reference sites was predicted by matching the backscatter incidence angle profile (0-70A) to that of a seabed scattering model. Referencing the seabed backscatter to a consistent incidence angle (40A) gave a metric with high spatial resolution (2.4-20m), which minimised errors of range, incident angle and beam compensation. This simple metric provided a consistent approach to analyse and interpret the data and was strongly correlated with substrate type and faunal functional groups. The high resolution backscatter metric was a closer match to the small spatial scale of seabed patch lengths observed by video (50% <50m). The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Kloser R.J., A. Williams, and A. Butler. Exploratory Surveys of Seabed Habitats in Australia's Deep Ocean using Remote Sensing—Needs and Realities In: Todd BJ, Greene HG, editors. Mapping the seafloor for habitat characterization: Geological Association of Canada, Special Paper; Geological Association of Canada, Special Paper. **472007**: 93–110.

Keywords: acoustic equipment, benthic environment, remote sensing equipment, bathymetric data, classification, ecosystem management, environmental monitoring, backscatter, continental slope, seafloor mapping, multibeam sonar

Abstract: This paper considers the management needs for mapping seabed biotopes in the Australian context. We note that the task is multi-disciplinary and that natural regions need to be identified on a range of hierarchically nested scales for different planning and management purposes. Advances in remote acoustic and video technology has led to new ways of carrying out exploratory surveys of seabed biotopes in deep water (> 50 m). We combined fine-scale bathymetry and backscatter from multibeam acoustic swath mappers with targeted and georeferenced biophysical, geophysical and

visual sampling to classify areas at a variety of spatial scales. Our methodology provides a framework for optimising the collection, interpretation and integration of acoustic, visual and physical data in future surveys. Because it would be prohibitively expensive to map the extremely large Australian marine jurisdiction, surveys will need to be targeted in areas of highest management need. These include hot spots for biodiversity as well as points where anthropogenic impacts are high, for example at continental slope canyons and seamounts. We provide examples of biotopes (habitats) relevant to the scale of impact of human activities and to the scale of management (not necessarily the same things), and consider some realities for monitoring using modern technology - as well as the need for caution with automated methods given current limitations.

Kostylev, V. E., R. C. Courtney, G. Robert, and B. J. Todd. 2003. Stock evaluation of giant scallop (*Placopecten magellanicus*) using high-resolution acoustics for seabed mapping. Fish. Res. **60**:479-492.

Keywords: multibeam backscatter, scallops, *Placopecten magellanicus*, habitat, benthos, mapping

Abstract: Survey designs in use for the evaluation of sea scallop stocks do not consider the variability of sediment type, despite strong evidence of its importance for the recruitment and survival of scallops on the sea floor. This study examines the distribution of scallops on Browns Bank, Scotian Shelf, at two test sites, in comparison to sea floor sediment distribution, with particular attention to the effects of small-scale sediment variability on the abundance of the commercially exploited scallop. Important links between scallop abundance, sediment type and habitat structure are described. Scallops are strongly associated with gravel lag deposits, which are readily distinguishable from sand-covered terrain through the use of multibeam backscatter data. There exists a highly significant correlation between scallop survey catch rates and backscatter intensity which can be used for the prediction of scallop stock abundance. Developments in underwater acoustics enable for more precise sea floor mapping and contribute to better estimates of scallop abundance. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Kostylev, V. E., B. J. Todd, G. B. J. Fader, R. C. Courtney, G. D. M. Cameron, and R. A. Pickrill. 2001. Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. Mar. Ecol. Prog. Ser. **219**:121-137.

Keywords: habitat mapping, benthos, multibeam, sediment, Scotian Shelf

Abstract: This study presents results of a new approach for sea floor habitat mapping based on an integrated analysis of multibeam bathymetric data, associated geoscientific information, and benthos data from Browns Bank on the southwestern Scotian Shelf, off the Canadian Atlantic coast. Based on sea floor sediment maps and statistical analysis of

megabenthos determined from photographs, 6 habitats and corresponding associations of benthos were derived and mapped. The habitats are distinguished primarily on the basis of sediment type and water depth. Additional factors are sea floor geomorphology, habitat complexity, and relative current strength. A Browns Bank benthic habitat map is developed as a conceptual model summarizing the understanding of the bank ecology. This study highlights the utility of multibeam bathymetric sonar for interpretation of sea floor sediments and for extrapolating benthic habitat characteristics across large areas of sea floor.

Kostylev, V. E., B. J. Todd, O. Longva, and P. C. Valentine. 2005. Characterization of benthic habitat on northeastern Georges Bank, Canada. In. B. W. Barnes and J. P. Thomas, editors. Benthic Habitats and the Effects of Fishing. **41**:141-152.

Keywords: habitat template theory, mapping, habitat, niche, resouce management

Abstract: Seafloor habitats of the Canadian part of Georges Bank were assessed and mapped following the habitat template theory (Southwood 1988). The approach considers the primary selective forces (habitat disturbance and adversity of the environment) that have shaped the existing communities of benthic species and that have defined the life history traits of species found in different habitats. The disturbance axis of the template is modeled based on the information on sediment, currents, and bathymetry. The adversity axis is modeled based on chlorophyll concentration, bottom water temperature, salinity, and seasonal variability in temperature. A preliminary sediment map needed for assessment of the natural disturbance rate was developed from high-resolution multibeam backscatter groundtruthed with archive and current sediment sample data. The distribution of megabenthos assemblages identified from underwater photography was found to follow gradients in disturbance and adversity on the bank. We suggest that application of the habitat template theory is useful for ocean managers in defining areas that are more or less likely to suffer from adverse human impacts. If natural rates of habitat disturbance are high. then risk of harmful habitat alteration and degradation is lower than in naturally stable areas. Similarly, if the natural adversity of the environment is high, then adding additional stressors will further reduce the scope for growth of organisms, which makes natural populations in adverse environments less likely to recover than populations in benign environments.

Krüger, J. C., and T. R. Healy. 2006. Mapping the Morphology of a Dredged Ebb Tidal Delta, Tauranga Harbour, New Zealand. J. Coast. Res. **22**:720-727.

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Link: http://www.jstor.org/stable/4300326?seq=1#page_scan_tab_contents

Lamarche, G., X. Lurton, A. L. Verdier, and J. M. Augustin. 2011. Quantitative characterisation of seafloor substrate and bedforms using advanced processing of multibeam backscatter--Application to Cook Strait, New Zealand. Cont. Shelf Res. **31**:S93-S109.

Abstract: A comprehensive EM300 multibeam echo-sounder dataset acquired from Cook Strait, New Zealand, is used to develop a regional-scale objective characterisation of the seafloor. Sediment samples and high-resolution seismic data are used for ground-truthing. SonarScopeA registered software is used to process the data, including signal corrections from sensor bias, specular reflection compensation and speckle noise filtering aiming at attenuating the effects of recording equipment, seafloor topography, and water column. The processing is completed by correlating a quantitative description (the Generic Seafloor Acoustic Backscatter--GSAB model) with the backscatter data. The calibrated Backscattering Strength (BS) is used to provide information on the physical characteristics of the seafloor. The imagery obtained from the BS statistical compensation is used for qualitative interpretation only; it helps characterizing sediment facies variations as well as geological and topographic features such as sediment waves and erosional bedforms, otherwise not recognised with the same level of detail using conventional surveying. The physical BS angular response is a good indicator of the sediment grain size and provides a first-order interpretation of the substrate composition. BS angular response for eight reference areas in the Narrows Basin are selected and parameterised using the GSAB model, and BS angular profiles for gravelly, sandy, and muddy seafloors are used as references for inferring the grain size in the reference areas. We propose to use the calibrated BS at 45° incidence angle (BS45) and the Specular-To-Oblique Contrast (STOC) as main global descriptors of the seafloor type. These two parameters enable global backscatter studies by opposition to compensated imagery whose intensity is not comparable from one zone to the other. The results obtained highlight the interest of BS measurements for seafloor remote sensing in a context of habitat-mapping applications. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Lathrop, R. G., M. Cole, N. Senyk, and B. Butman. 2006. Seafloor habitat mapping of the New York Bight incorporating sidescan sonar data. Estuar. Coast. Shelf Sci. **68**:221-230.

Abstract: The efficacy of using sidescan sonar imagery, image classification algorithms and geographic information system (GIS) techniques to characterize the seafloor bottom of the New York Bight were assessed. The resulting seafloor bottom type map was compared with fish trawl survey data to determine whether there were any discernable habitat associations. An unsupervised classification with 20 spectral classes was

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produced using the sidescan sonar imagery, bathymetry and secondarily derived spatial heterogeneity to characterize homogenous regions within the study area. The spectral classes, geologic interpretations of the study region, bathymetry and a bottom landform index were used to produce a seafloor bottom type map of 9 different bottom types. Examination of sediment sample data by bottom type indicated that each bottom type class had a distinct composition of sediments. Analysis of adult summer flounder, *Paralichthys dentatus*, and adult silver hake, Merluccius bilinearis, presence/absence data from trawl surveys did not show evidence of strong associations between the species distributions and seafloor bottom type. However, the absence of strong habitat associations may be more attributable to the coarse scale and geographic uncertainty of the trawl sampling data than conclusive evidence that no habitat associations exist for these two species. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Limpenny, D. S., S. E. Boyd, W. J. Meadows, and H. L. Rees. 2002. The utility of side scan sonar techniques in the assessment of anthropogenic disturbance at aggregate extraction sites. In: Proceedings of the Theme Session on the Use the Integration of Acoustic and Optimal Survey Techniques and Marie Biological Data for the Purpose of Seabed Classification. **4**:1-20.

Keywords: habitat mapping, sidescan sonar, aggregate extraction

Abstract: Marine benthic habitats are vulnerable to the influence of a wide range of anthropogenic activities (*e.g.* aggregate extraction, dredged material disposal and trawling). Recent developments in seabed mapping techniques offer the potential to radically alter approaches to monitoring the impacts of such activities. In this paper we report on an integrated mapping approach, using geophysical and faunal sampling techniques, in order to assess the impacts of marine aggregate extraction at the seabed.

Studies at two aggregate extraction sites in the southern North Sea utilised sidescan sonar and single beam bathymetry to produce maps of the distribution of sediment types and associated natural and anthropogenic features. These acoustic maps were used as an exploratory tool to facilitate the generation of effective site-specific sampling designs and for locating representative reference sites against which changes at impacted locations may be compared in the longer-term. The longevity of the physical impacts of dredging activity at the seabed were also assessed.

The employment of geophysical techniques to map the extent, magnitude and persistence of the effects on the seabed arising from marine aggregate is fundamental for the interpretation of wider cause and effect relationships. The outcome of recent survey work is presented, together with a generic strategy for generating habitat maps.

Lo Iacono, C., E. Gracia, S. Diez, G. Bozzano, X. Moreno, J. Danobeitia, and B. Alonso. 2008. Seafloor characterization and backscatter variability of the Almeria Margín (Alboran Sea, SW Mediterranean) based on high-resolution acoustic data. Mar. Geol. **250**:1-18.

Abstract: An acoustic study of the Almeria Margin (eastern Alboran Sea, SW Mediterranean) was carried out by means of an integrated dataset, comprising deep-towed TOBI sidescan sonar, swath-bathymetry, TOPAS high-resolution seismics and sediment gravity cores. The Almeria Margin is a complex system dominated by volcanic and tectonic features shaped by recent sedimentary processes, in which a regional hemipelagic sedimentation is intercalated by sporadic gravitative events. The aim of this work is twofold. The first objective is to recognize the sedimentary and tectonic features that shape the Almeria Margin. The main morpho-sedimentary and morpho-structural elements observed are: the Almeria canyon/channel Turbidite System, the Dalias Tributary Valley System, landslides, active faults and folds and volcanic banks. The second aim is to explore and quantify the surface and subsurface seafloor parameters that characterize the backscatter of the study area. Sedimentary, geomorphological and biological elements that play a role in the acoustic signature of the Almeria Margin were detected. Nevertheless, it should be noted that seafloor acoustic backscatter is also affected by geometrical and instrumental factors. Despite the wide variability of the environments studied, a low average acoustic backscatter reflects a diffused draping of hemipelagic sedimentation in the area. Higher backscatter values were observed at the top of some volcanic banks, along the Almeria canyon, and in the shallower sector of the Dalias tributary valley system. The influence of subseafloor properties in the acoustic signature of the area was revealed by backscatter-grain size correlations, which were carried out for different depth intervals in sediment cores collected in the Almeria Turbidite System. A poor relationship was found between backscatter and superficial silty sediments of the area, whereas a higher correlation resulted in the upper 50 cm. The presence of subsurface turbidites in the cores associated with the higher backscatter values suggests volume interface scattering of these sandy layers as a controlling factor of the acoustic signature obtained in the Almeria Margin. On the other hand, in rough settings such as the ones observed in the Dalias Tributary Valley System, topographic relief of up to 1-1.5 m strongly interacted with the TOBI acoustic pulse. This suggests that large-scale roughness is an additional parameter that characterizes the acoustic strength of the area. Extremely high reflective patches distributed along some of the volcanic banks (Chella and Pollux Banks) for depths ranging from 230 to 470 m coincide with areas where carbonate cold water coral mounds develop. In the TOBI images, coral facies reach the maximum value of acoustic backscatter, which is probably related to the rough morphology of coral ecosystems. The position of coral mounds in the banks suggests that the occurrence of strong bottom currents and reduced sedimentary inputs are environmental factors that favour their settling and development in the Almeria Margin. The citations and abstracts are from Aquatic

Lockhart, D., R. J. Pawlowski, and E. J. Saade. 2005. Advances in processing and collecting multibeam echosounder data for seabed habitat mapping. In: B. W. Barnes and J. P. Thomas, editors. Benthic Habitats and the Effects of Fishing. **41**:179-182.

Keywords: backscatter, multibeam, snippets

Abstract: Backscatter data from Reson multibeam echo sounders (MBES) can be captured as a single time series for each beam footprint. Referred to as snippets, this data has a few advantages over MBES pseudo side scan and, in some cases, true side scan data. Snippets can be precisely co-registered to the bathymetric surface using the fact that the snippet and sounding are from the same place. This process implicitly corrects the snippet position for water column refraction. The resulting mosaic has improved signal to noise qualities as a result of precise positioning. Other advantages include increased resolution, automated mosaic assembly and potential for automated image classification. Data products generated from snippet processing are useful for habitat classification.

Lomnicky, J. and R. McConnaughey. 2008. Integrating charting and acoustic habitat research: NOAA hydrographers and fishery biologists collaborate on multi-mission projects in Alaska. Sea Technol. **49**:10-15.

Keywords: Alaska, stock assessment, fishery biologists, habitat, marine fisheries, legislation, environment management, fishery surveys, fishery management, fishery resources

Summary: The National Marine Fisheries Service (NMFS) is the National Oceanic and Atmospheric Administration (NOAA) line office responsible for managing the fishery resources of the United States according to mandates in the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). The MSFCMA and associated legislation emphasize the maintenance of a healthy ecosystem and dictate management of sustainable and economically viable fisheries. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Lucieer, V. and G. Lamarche. 2011. Unsupervised fuzzy classification and object-based image analysis of multibeam data to map deep water substrates, Cook Strait, New Zealand. Cont. Shelf Res. **31**:1236-1247.

Keywords: segmentation, backscatter, bathymetry, habitat mapping, fuzzy-c-means

Abstract: A comprehensive 32kHz multibeam bathymetry and backscatter survey of Cook Strait, New Zealand (500km^2), is used to generate a regional substrate classification map over a wide range of water depths, seafloor substrates and geological landforms using an automated mapping method based on the textural image analysis of backscatter data. Full processing of the backscatter is required in order to obtain an image with a strongly attenuated specular reflection. Image segmentation of the merged backscatter and bathymetry layers is constrained using shape, compactness, and texture measures. The number of classes and their spatial distribution are statistically identified by employing an unsupervised fuzzy-c-means (FCM) clustering algorithm to sediment samples, independent of the backscatter data. Classification is achieved from the overlay of the FCM result onto a segmented image and attributing segments with the FCM class. Four classes are identified and uncertainty in class attribution is quantified by a confusion index layer. Validation of the classification map is done by comparing the results with the sediment and structural maps. Backscatter (BS) strength angular profiles are used to show acoustic class separation. The method takes us one step further in combining multibeam data with physical seabed data in a complementary analysis to seek correlations between datasets using object-based image analysis and unsupervised classification. Texture within these identified classes is then examined for correlation with typical backscatter angular responses for mud, sand and gravel. The results show a first order correlation between each of the classes and both the sedimentary properties and the geomorphological map. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

MacDonald, A. 2009. Advancements in area-based imagery processing: An integrated geocoder delivers a streamlined workflow and new capabilities. Hydro International **13**:20-23.

Abstract: For many years the focus has been on collecting and processing the first bottom return of multi-beam sonars. However, the acoustic backscatter acquired by multi-beam sonars, as well as side-scan sonars, also carries important information about the sea floor and its physical properties. This information provides valuable data to aid in sea-floor classification and important auxiliary information for a bathymetric survey. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Mackey, S. D. and D. L. Liebenthal. 2005. Mapping changes in Great Lakes Nearshore substrate distributions. J. Great Lakes Res. **31**:75-89.

Abstract: Nearshore substrate characteristics such as texture (grain size) and composition, available surface area, pattern, distribution, and relative stability are critical parameters that determine how biological organisms (and communities) utilize those substrates during different life stages. Geo-referenced sidescan-sonar data are used in combination with traditional sampling techniques and Geographic Information System (GIS) technologies to map substrate contacts and aquatic habitat distributions within Great Lakes nearshore areas. New methods are developed that includes area change analysis and cen-troid analysis to quantitatively assess net change in substrate area and evaluate relative substrate stability. An Area Change Ratio (ACR) can be calculated for individual substrate polygons (patch analysis) or groups of substrate polygons (area analysis) of the same substrate type. Areas of relative stability are represented by ACR values near zero. Areas of moderate stability are represented by values ranging between 0.2 and 0.5 and highly unstable areas are represented by values of 0.5 or greater. Substrate centroids or "centers of mass" are also calculated and can be used to quantitatively integrate change in substrate area and the location of individual substrate polygons or groups of polygons within a survey area. Comparison of centroid movement provides a quantitative measure of the magnitude and direction of change in substrate area through time. These techniques address many of the spatial and temporal limitations associated with more traditional approaches, e.g., shore-normal profiling, detailed bathymetric surveys, and repetitive sampling of bottom materials, and yet can be combined with these traditional approaches to develop a more detailed understanding of nearshore habitat distribution and stability. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Magorrian, B. H., M. Service, and W. Clarke. 1995. An acoustic bottom classification survey of Strangford Lough, Northern Ireland. J. Mar. Biol. Assoc. UK. **75**:987-992.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link:
http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=4372256

Malzone, C., M. Wilson, and P. Iampietro. 2006. Advances in the evaluation of acoustic beamformed backscatter data for fisheries applications. J. Acoust. Soc. Am. **120**:3018.

Keywords: echosounders, avoidance reactions, backscatter, data storage

Abstract: Single-beam echosounders are well-established tools for fisheries research. However, single-beam echosounder geometry is limited to a very small ensonification volume located within a 3 to 15° cone directly beneath the vessel. Recent advances in multibeam echosounder technology provide the option to collect backscatter and water-column data during an IHO order 1 hydrographic survey. Such comprehensive

data sets are valuable for scientific and management purposes since they expand the volume in which water-column data are collected, and they provide as well a potential method to link the biology to the habitat. However, water-column information collected with multibeam echosounders poses several challenges, including increased data storage requirements, a need for data decimation, and survey methodology considerations. In this paper, concurrently acquired backscatter data from a split-beam scientific echosounder and multibeam echosounder are analyzed for relative abundance, spatial distribution, and avoidance behavior of pelagic organisms, primarily the market squid Loligo opalescens and various finfish. Aspects of the data sets are then explored, compared, and contrasted. Proposed solutions to some of the challenges posed by multibeam sonar water-column analysis are then reviewed and placed within an overall framework for fisheries applications. Copyright 2006, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/120/5/10.1121/1.4787083

Mayer, L. A. 2006. Frontiers in seafloor mapping and visualization. Mar. Geophys. Res. **27**:7-17.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs11001-005-0267-x

McConnaughey, R. A. and K. R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. **57**:2410-2419.

Keywords: Bering Sea, *Pleuronectes asper*, sediments, food availability, *Pleuronectidae, Reinhardtius hippoglossoides, Atheresthes stomias*, feeding behavior, sediment properties, mud, sand, population density, food organisms, *Hippoglossoides elassodon, Pleuronectes quadrituberculatus, Lepidopsetta*, marine environment, marine, substrate preferences, marine fish

Abstract: Spatially explicit relationships between pleuronectid flatfish abundance and surficial sediments in the eastern Bering Sea were investigated using published sediment descriptions and trawl survey data (1982–1994). Flatfish food habits were also examined because sediment properties are known to affect the distribution and abundance of benthic prey. For six species, we compared sediment textures in areas of highest and lowest abundance (kilograms per hectare). Sand predominated in areas of high yellowfin sole (*Pleuronectes asper*) (YFS) (p << 0.001) and rock sole (*Lepidopsetta* spp.) (RS) (p << 0.001) abundance, while mixed sand and mud was most common in areas of lowest abundance. In contrast, mixed sand and mud predominated in areas preferred by flathead sole (Hippoglossoides elassodon) (FHS) (p << 0.001), Alaska plaice (*Pleuronectes quadrituberculatus*)(AP)(p = 0.002), and arrowtooth flounder (*Atheresthesstomias*) (ATF) (p = 0.004), with more diverse substrates in low-density

areas. Areas of high and low Greenland turbot (*Reinhardtius hippoglossoides*)(GT)(p = 0.845) abundance had similar sediment textures (primarily mixed sand and mud). Species with highly restricted diets (AP) or piscivores with weak sediment associations (GT, ATF) had relatively inflexible food habits, whereas YFS, RS, and FHS food habits varied considerably with sediment type. Our findings suggest that benthic-feeding pleuronectids prefer certain sediment textures because of adaptive differences in prey availability.

McGonigle, C., C. Brown, R. Quinn, and J. Grabowski. 2009. Evaluation of image-based multibeam sonar backscatter classification for benthic habitat discrimination and mapping at Stanton Banks, UK. Estuar. Coast. Shelf Sci. **81**:423-437.

Abstract: In recent years, efforts have increased to develop quantitative, computer-directed methods for segmentation of multibeam (MBES) backscatter data. This study utilises MBES backscatter data acquired at Stanton Banks (UK) and subsequently processed through the QTC-Multiview software environment in a bid to evaluate the program's ability to perform unsupervised classification. Statistical comparison with ground-truth data (grab, stills and video) enabled cross validation of acoustic segmentation and biological assemblages observed at the site. 132 unspecified variables were extracted from user-specified rectangular patches of the backscatter image, reduced to three vectors by PCA, then clustered and classified by the software. Multivariate analyses of ground-truth data were conducted on 75 stills images and 51 grab samples. Video footage coincident with the stills was divided into 30s segments and coded by dominant substrate and species. Cross tabulation determined the interrelationship between software classifications, multivariate analysis of the biological assemblages and coded video segments. Multiview optimally identified 19 classes using the automated clustering engine. These were revised to 6 habitats *a posteriori*, using combined analysis of ground-truth data and Multiview data products. These habitats broadly correspond to major physiographic provinces within the region. Multivariate statistical analysis reveals low levels of assemblage similarity (<35%) for samples occurring within Multiview classes, irrespective of the mode of acquisition. Coded video data is more spatially appropriate than the other methods of ground-truthing investigated, although it is less well suited to the extraction of truly quantitative data. Multivariate analysis indicates assemblages within physiographically distinct Multiview classes have a low degree of biological similarity, supporting the notion that abiotic proxies may be contraindicative of benthic assemblage variations. QTC-Multiview performs well as a mechanism for computer-assisted segmentation of MBES backscatter imagery into acoustic provinces; however a degree of caution is required prior to ascribing ecological significance to these classifications. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

McGonigle, C., C. J. Brown, and R. Quinn. 2010. Insonification orientation and its relevance for image-based classification of multibeam backscatter. ICES J. Mar. Sci. **67**:1010-1023.

Abstract: The use of multibeam echosounders (MBES) for mapping benthic habitat has gained widespread acceptability. Multibeam backscatter imagery provides an objective tool for scientists and managers to chronicle the extent and condition of the benthic resource. However, there are no standardized methods describing how best to process backscatter data to derive meaningful segmentations, although several acquisition parameters have been identified as having the capacity to affect the classification result. This research attempts to determine how the orientation at which a feature is insonified can affect classification outcome using commercially available software (QTC-Multiview), and to evaluate this significance related to vessel speed as a proxy for data density. A complex 2-km^2 area of Stanton Banks, UK, was selected as the test site for the study. The area was insonified using a Kongsberg Simrad EM1002 MBES at perpendicularly opposing orientations, at two different vessel speeds within the same 24-h period. The classifications displayed 53% (k = 0.396) similarity at 4 m s^{-1} and 49% (k = 0.342) at 2 m s^{-1} from opposing orientations. Common orientations at different speeds were 68% (k = 0.583) similar (east-west) and 53% (k = 0.384; north-south). Most of the variation was in topographically complex areas, which coincided with shallow depths (<60 m). Meteorological and oceanographic conditions at the time the data were collected were evaluated as having had the potential to influence the outcome of the classifications. Interpretation of the results suggests that the orientation at which insonification occurs has a greater ability to influence the classification result than vessel speed using an image-based technique. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

McGonigle, C., C. J. Brown, and R. Quinn. 2010. Operational Parameters, Data Density and Benthic Ecology: Considerations for Image-Based Classification of Multibeam Backscatter. Marine Geodesy **33**:16-38.

Abstract: Efforts to develop a procedurally robust method for automated classification of multibeam backscatter have taken a variety of approaches *(e.g.,* image-based, textural, angular range analysis). For image-based classification, little research has focused on the roles of operational parameters of vessel and sonar system in affecting the final classification. Repeat multibeam surveys (2005 and 2006) conducted at the same area with different sounding densities were classified using QTC-Multiview. Comparison of class areas revealed 78% agreement between classifications derived

from the two surveys. Cross-tabulation of ground truth video and class demonstrate 71% agreement in the low-density survey and 77% for the high-density. Differences between classifications are primarily attributed to variation in along track data density, errors in the compensation process, and/or insufficient quality control of the input data. Natural change detection at the scales observed was determined not to be practically discernable from the errors associated with the classification process.

Link:

McGonigle, C., J. H. Grabowski, C. J. Brown, T. C. Weber, and R. Quinn. 2011. Detection of deep water benthic macroalgae using image-based classification techniques on multibeam backscatter at Cashes Ledge, Gulf of Maine, USA. Est. Coast. Shelf Sci. **91**:87-101.

Abstract: Benthic macroalgae form an important part of temperate marine ecosystems, exhibiting a complex three-dimensional character which represents a vital foraging and spawning ground for many juvenile fish species. In this research, image-based techniques for classification of multibeam backscatter are explored for the detection of benthic macroalgae at Cashes Ledge in the Gulf of Maine, USA. Two classifications were performed using QTC-Multiview, differentiated by application of a threshold filter, and macroalgal signatures were independently extracted from the raw sonar datagrams in Matlab. All classifications were validated by comparison with video ground-truth data. The unfiltered classification shows a high degree of complexity in the shallowest areas within the study site; the filtered demonstrates markedly less variation by depth. The unfiltered classification shows a positive agreement with the video ground-truth data; 82.6% of observations recording *Laminaria sp.*, 39.1% of *Agarum cribrosum* and 100.0% (n = 3) of mixed macroalgae occur within the same acoustically distinct group of classes. These are discrete from the 8.1% recorded agreement with absences and nulls (>40 m) of macrophytes (n = 32) from a total of 86 ground-truth locations. The results of the water column data extraction (WCDE) show similar success, accurately predicting 78.3% of *Laminaria sp.* and 30.4% of *A. cribrosum* observations. The unfiltered classes which showed agreement with the ground-truth data were then compared to the WCDE results. Comparison of surface areas reveals the overall percentage agreement is relatively constant with depth (67.0-70.0%), with Kappa coefficient increasing from k = 0.17-0.35 as depth (and surface area) increases. The results have demonstrated that both methods were more effective at detecting the presence of *Laminaria sp.* (82.6-77.3%) than *Agarum cribrosum*, (66.6-30.4%), and that the efficiency of prediction decreased with depth. Canopy volume derived from the WCDE analysis was between 1.21×10^6 m^3 at <24 m water depth, 1.82×10^6 m^3 at <30 m and 2.45×10^6 m^3 at <40 m. These results suggest that the presence of benthic macrophytes has a significant capacity to affect image-based classification of acoustic data, and highlights the fact that multibeam backscatter and image-based classification have significant potential for benthic macroalgal research. This is beneficial to help refine segmentations of

substrates, adding valuable contextual information about biological characteristics of infaunal and epifaunal benthic communities.

McHugh, C. M. G., W. B. F. Ryan, S. Eittreim, and D. Reed. 1998. The influence of the San Gregorio fault on the morphology of Monterey Canyon. Mar. Geol. **146**:63-91.

Keywords: San Gregorio fault, Monterey Canyon, mass-wasting, brachiopods, chemosynthetic communities

Abstract: A side-scan sonar survey was conducted of Monterey Canyon and the San Gregorio fault zone, off shore of Monterey Bay. The acoustic character and morphology of the sonar images, enhanced by SeaBeam bathymetry, show the path of the San Gregorio fault zone across the shelf, upper slope, and Monterey Canyon. High backscatter linear features a few kilometers long and 100 to 200 m wide delineate the sea-floor expression of the fault zone on the shelf. Previous studies have shown that brachiopod pavements and carbonate crusts are the source of the lineations backscatter. In Monterey Canyon, the fault zone occurs where the path of the canyon makes a sharp bend from WNW to SSW (1800 m). Here, the fault is marked by NW-SE-trending, high reflectivity lineations that cross the canyon floor between 1850 m and 1900 m. The lineations can be traced to ridges on the northwestern canyon wall where they have similar to 15 m of relief. Above the low-relief ridges, bowl-shaped features have been excavated on the canyon wall contributing to the widening of the canyon. We suggest that shear along the San Gregorio fault has led to the formation of the low-relief ridges near the canyon wall and that carbonate crusts, as along the shelf, may be the source of the high backscatter features on the canyon floor. The path of the fault zone across the upper slope is marked by elongated tributary canyons with high backscatter floors and `U'-shaped cross-sectional profiles. Linear features and stepped scarps suggestive of recent crustal movement and mass-wasting, occur on the walls and floors of these canyons. Three magnitude-4 earthquakes have occurred within the last 30 years in the vicinity of the canyons that may have contributed to the observed features. As shown by others, motion along the fault zone has juxtaposed diverse lithologies that outcrop on the canyon walls. Gully morphology and the canyon's drainage patterns have been influenced by the substrate into which the gullies have formed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

McRea, J. E., Jr., H. G. Greene, V. M. O'Connell, and W. W. Wakefield. 1999. Mapping marine habitats with high resolution side scan sonar. Oceano. Acta **22**:679-686.

Keywords: habitat, megahabitat, mesohabitat, side scan, mapping

Abstract: The application of marine geophysics and GIS techniques to the characterization of benthic habitats has increased the ability of fisheries managers to assess distribution and habitat types beyond common practices. We report upon a 150 kHz sidescan sonar survey offshore of Kruzof Island, Alaska undertaken to characterize rockfish (*Sebastes*) habitat. Using GIS, MapGrafix and Map Factory we determined the percentage of seafloor cover that exists in our survey area. Bathymetry in the study area was determined with sidescan interferometry. All XYZ data were gridded using Surfer and plotted in shaded relief, bathymetric contour, and 3-dimensional formats. Contoured bathymetry was used as an overlay in MapGrafix. Small sub-areas were extracted from the bathymetric data for closer study, and gridded in Surfer. Areas of the mosaic where backscatter patterns were not distinct were verified with hand samples and video collected with the submersible Delta. The use of submersibles for verification of interpreted lithologies and surface textures enables a high degree of accuracy for the interpretations. Lithotypes were lumped into larger groups based on morphology and fish associations with different morphologies verified using the submersible. The accuracy of digital maps from high-resolution sidescan sonar data allows a close quantification of the areal extents of these important features, directing the application of management strategies to critical areas. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Micallef, A., T. P. Le Bas, V. A. I. Huvenne, P. Blondel, V. Huehnerbach, and A. Deidun. 2012. A multi-method approach for benthic habitat mapping of shallow coastal areas with high-resolution multibeam data. Cont. Shelf Res. **39-40**:14-26.

Abstract: The coastal waters of the Maltese Islands, central Mediterranean Sea, sustain a diversity of marine habitats and support a wide range of human activities. The islands' shallow waters are characterised by a paucity of hydrographic and marine geo-environmental data, which is problematic in view of the requirements of the Maltese Islands to assess the state of their coastal waters by 2012 as part of the EU Marine Strategy Directive. Multibeam echosounder (MBES) systems are today recognised as one of the most effective tools to map the seafloor, although the quantitative characterisation of MBES data for seafloor and habitat mapping is still an underdeveloped field. The purpose of this study is to outline a semi-automated, Geographic Information System-based methodology to map the distribution of habitats in shallow coastal waters using high-resolution MBES data. What distinguishes our methodology from those proposed in previous studies is the combination of a suite of geomorphometric and textural analytical techniques to map specific types of seafloor morphologies and compositions; the selection of the techniques is based on identifying which geophysical parameter would be influenced by the seabed type under consideration.We tested our approach in a 28km^2 area of Maltese coastal waters. Three

data sets were collected from this study area: (i) MBES bathymetry and backscatter data; (ii) Remotely Operated Vehicle imagery and (iii) photographs and sediment samples from dive surveys. The seabed was classified into five elementary morphological zones and features - flat and sloping zones, crests, depressions and breaks of slope - using morphometric derivatives, the Bathymetric Position Index and geomorphometric mapping. Segmentation of the study area into seagrass-covered and unvegetated seafloor was based on roughness estimation. Further subdivision of these classes into the four predominant types of composition - medium sand, maeerl associated with sand and gravel, seagrass settled on sand and gravel, and seagrass settled on bedrock - was carried out through supervised classifications of morphometric derivatives of the bathymetry and textural indices of backscatter, based on information from training stations. The resulting morphologic and seabed composition maps were combined to plot the distribution of the predominant habitats in the coastal waters offshore NE Malta, some of which are of high conservation value. Ground-truthing of the habitat map using ROV imagery and dive observations confirms that our approach produces a simplified and accurate representation of seafloor habitats while using all the information available within the MBES data sets. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Mitchell, N. C. and J. E. Hughes Clarke. 1994. Classification of seafloor geology using multibeam sonar data from the Scotian Shelf. Mar. Geol. **121**:143-160.

Keywords: bathymetry, backscatter, sediment

Abstract: We describe a method for classifying multibeam sonar data, and illustrate the method using data collected with a Simrad EM1000 sonar on the Scotian Shelf, Canada. The method involves comparing various attributes of the bathymetry and backscatter with typical examples of specified seafloor types and computing their statistical degree of similarity. Sediment ponds are identified as areas of low echo amplitude and low topographic gradient and curvature. Ridges and troughs are identified by fitting a paraboloid to patches of the bathymetry. Once the sediments, ridges and troughs are located, we are able to use the database to extract orientations and other characteristics of these features. For example, the orientation of the topography can be computed from the paraboloid surface, and rose diagrams of the ridge and trough orientations reflect the fabric of up-turned Cambro-Ordovician sedimentary beds outcropping in this area. The unconsolidated sediments ponded within small basins have low topographic gradients with consistent tilts towards the southeast (mean 133°), which we interpret as due to offshore transport of Holocene sediments, possibly in response to storms. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Mitchell, N. C. and M. L. Somers. 1989. Quantitative backscatter measurements with a long-range side-scan sonar. IEEE J. Ocean Eng. **14**:368-374.

Abstract: It is shown that useful relative backscatter strengths can be calculated from GLORIA long-range side-scan sonar data using a simple acoustic model. The calculation was performed on GLORIA side-scan sonar data collected during 1987 in the southern Indian Ocean. GEOSECS hydrographic information was used to access the effects of refraction (ray bending and aspherical spreading signal losses). Sea Beam bathymetry was used to correct the effective insonified area and compute the grazing angle. A major difficulty in performing this calculation over the terrain chosen (mid-ocean ridge topography) was one of adjusting navigation so that small features in Sea Beam and GLORIA data matched. Preliminary results show a 10-dB falloff in backscatter strength with decreasing grazing angle (10°-40°) at 6.5 kHz over what must presumably be a rough surface (extruded basalts and breccias)

Monk, J., D. Ierodiaconou, V. L. Versace, A. Bellgrove, E. Harvey, A. Rattray, L. Laurenson, and G. P. Quinn. 2010. Habitat suitability for marine fishes using presence-only modelling and multibeam sonar. Mar. Ecol. Prog. Ser. **420**:157-174.

Abstract: Improved access to multibeam sonar and underwater video technology is enabling scientists to use spatially-explicit, predictive modelling to improve our understanding of marine ecosystems. With the growing number of modelling approaches available, knowledge of the relative performance of different models in the marine environment is required. Habitat suitability of 5 demersal fish taxa in Discovery Bay, south-east Australia, were modelled using 10 presence-only algorithms: BIOCLIM, DOMAIN, ENFA (distance geometric mean [GM], distance harmonic mean [HM], median [M], area-adjusted median [Ma], median + extremum [Me], area-adjusted median + extremum [Mae] and minimum distance [Min]), and MAXENT. Model performance was assessed using kappa and area under curve (AUC) of the receiver operator characteristic. The influence of spatial range (area of occupancy) and environmental niches (marginality and tolerance) on modelling performance were also tested. MAXENT generally performed best, followed by ENFA-GM and -HM, DOMAIN, BIOCLIM, ENFA-M, -Min, -Ma, -Mae and -Me algorithms. Fish with clearly definable niches (i.e. high marginality) were most accurately modelled. Generally, Euclidean distance to nearest reef, HSI-b (backscatter), rugosity and maximum curvature were the most important variables in determining suitable habitat for the 5 demersal fish taxa investigated. This comparative study encourages ongoing use of presence-only approaches, particularly MAXENT, in modelling suitable habitat for demersal marine fishes.

Mueller, R. and S. Eagles. 2007. Mapping seabed geology by ground-truthed textural image/neural network classification of acoustic backscatter mosaics. Math Geol. **39**:575-592.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs11004-007-9113-9

Nasby-Lucas, N. M., B. W. Embley, M. A. Hixon, S. G. Merle, B. N. Tissot, and D. J. Wright. 2002. Integration of submersible transect data and high-resolution multibeam sonar imagery for a habitat-based groundfish assessment of Heceta Bank, Oregon. Fish. Bull., U.S. **100**:739-751.

Keywords: habitat, transects, stock assesment, groundfish, GIS, sonar

Abstract: In the face of dramatic declines in groundfish populations and a lack of sufficient stock assessment information, a need has arisen for new methods of assessing groundfish populations. We describe the integration of seafloor transect data gathered by a manned submersible with high-resolution sonar imagery to produce a habitat-based stock assessment system for groundfish. The data sets used in this study were collected from Heceta Bank, Oregon, and were derived from 42 submersible dives (1988-90) and a multibeam sonar survey (1998). The submersible habitat survey investigated seafloor topography and groundfish abundance along 30-minute transects over six predetermined stations and found a statistical relationship between habitat variability and groundfish distribution and abundance. These transects were analyzed in a geographic information system (GIS) by using dynamic segmentation to display changes in habitat along the transects. We used the submersible data to extrapolate fish abundance within uniform habitat patches over broad areas of the bank by means of a habitat classification based on the sonar imagery. After applying a navigation correction to the submersible-based habitat segments, a good correlation with major boundaries on the backscatter and topographic boundaries on the imagery were apparent. Extrapolation of the extent of uniform habitats was made in the vicinity of the dive stations and a preliminary stock assessment of several species of demersal fish was calculated. Such a habitat-based approach will allow researchers to characterize marine communities over large areas of the seafloor.

Nelson, C. H., D. C. Twichell, W. C. Schwab, H. J. Lee, and N. H. Kenyon. 1992. Upper Pleistocene turbidite sand beds and chaotic silt beds in the channelized, distal, outer-fan lobes of the Mississippi fan. Geology **20**:693-696.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Nitsche, F. O., R. Bell, S. M. Carbotte, W. B. F. Ryan, and R. Flood. 2004. Process-related classification of acoustic data from the Hudson River Estuary. Mar. Geol. **209**:131-145.

Abstract: Acoustic surveying provides valuable information on the distribution of sedimentary environments in subaqueous settings. Frequently, differences in acoustic backscatter strength are used to distinguish sedimentary environments on the basis of their grain size composition. Here, we are presenting acoustic backscatter data from the Haverstraw Bay section of the Hudson River Estuary that has been mapped using sidescan, sub-bottom profiling, and multibeam bathymetry as part of the Benthic Mapping Project of the Hudson River Estuary Program, funded by New York State. In addition, hundreds of gravity cores, and grab samples provide ground truth for a classification of the river bottom into discrete substrate types. Analyses of sedimentary environments reveal patterns in backscatter strength beyond those that can be related to the sediment grain size distribution alone. An integrated interpretation of sidescan, sub-bottom profiling, and high-resolution bathymetry data indicates that the backscatter pattern can be attributed to spatial variations in the modern depositional environments which cause differences in bottom roughness and sediment compaction. Based on an integrated interpretation of the acoustic and sample data sets, we distinguished eight different sedimentary classes. Many of the classes can be linked to dynamic processes including contemporary deposition, erosion, and sediment migration in sand waves. The results provide a better understanding of the dynamic processes of the Hudson River Estuary and improve the interpretation of the acoustic backscatter data from fine grained sedimentary environments. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Orpin, A. R. and V. E. Kostylev. 2006. Towards a statistically valid method of textural sea floor characterization of benthic habitats. Mar. Geol. **225**:209-222.

Abstract: Multibeam bathymetric sonar technology and benthic habitat research require the systematic characterization of the seafloor, necessitating reliable and accurate sea floor descriptors in combination with a robust means to statistically assess descriptor associations. Historically, geoscientific sea floor characterisation involves identifying the spatial extent and relationship of geological units, broadly following litho- or chronostratigraphic criteria, but these conventions may not be meaningful biologically because they incorporate temporal elements that stem from a geochronological qualifier. Textural properties of geological facies are typically given in

terms of distribution-dependent statistics, which have been shown to be inappropriate with multimodal marine sediments, such as on glaciated shelves. As habitat classification is aimed at boundary definition, the boundaries between groups in such cases could be arbitrary, or based on very subtle differences, or noise (e.g., sampling bias). This study uses an independent statistical approach pioneered by Calinski and Harabasz (C-H) which offers significant advantages in determining the appropriate number of groups that might exist in any sample population. Used in conjunction with a multivariate extension to information-entropy, grain size populations can be clustered into statistically validated groups. This study utilizes a 30-yr legacy of 4-class grain size data collected from the Scotian Shelf, Canadian Atlantic continental margin, we show that a traditional stratigraphic approach does not provide clear discrimination between basic textural types, and hence, basic benthic habitats. Considerable improvements in textural zonation are obtained using a combination of information entropy-clustering and C-H technique. Two high resolution, 32-class particle-size data sets yield a solution where no obvious textural groups exist, contrary to published field-based studies. Comparison of sediment grab samples to bottom photographs from other shelf sites show that photos capture (sample) a wider range of textural variability, particularly the coarsest-gravel component that is sometimes absent from grabs, and therefore, classification from photos creates more groups. This study emphasizes that data resolution and sea-floor sampling strategies should be intimately linked, and to fully unravel high-resolution textural data might require in excess of a four order of magnitude increase in the number of bottom sediment samples. Therefore, data should be collected at the highest practical resolution but be reduced to a resolution meaningful for mstatistical analysis, in accordance with the total sample population. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Pace, N. G. and H. Gao. 1988. Swathe seabed classification. IEEE J. Ocean Eng. **13**:83-90.

Keywords: backscatter, oceanographic techniques, oceanography, probability, sonar

Abstract: The degrees to which different seabed types may be discriminated using features of the power spectrum of the signals backscattered from the seabed, in a side-scan mode, is evaluated. The statistics derived from the data sample considered suggest that the probability of correctly classifying the six seabed types (sand, mud, clay, gravel, stones, rock) is in excess of 97 percent using the spectral features that are defined.

Pandian, P. K., J. P. Ruscoe, M. Shields, J. C. Side, R. E. Harris, S. A. Kerr, and C. R. Bullen. 2009. Seabed habitat mapping techniques: an overview of the performance of various systems. Mediterranean Marine Science **10**:29-43.

Keywords: seabed habitat mapping, acoustic techniques, remote sensing

Abstract: Seabed mapping has become vital for effective management of marine resources. An important role in moving towards ecosystem based management is played by the defining and understanding of the relationships among marine habitat characteristics, species distribution and human activities. Mapping seabed characteristics by means of remote acoustic sensing, using seabed seismic profiling, sidescan sonar, or echo-sounder based classification systems, is becoming of increasing importance. This paper gives a brief overview, of existing marine habitat mapping technologies and their recent developments. In single-beam echo-sounders, using multiple frequencies will be useful in classifying the seabed. It must be observed that the resolution of a sidescan sonar with narrower along-track beam width and higher range sampling rates will be better than a multi-beam echo-sounder, although the specifications of the newer systems are much improved. Airborne LIDAR bathymetry is very useful for shallow water seabed mapping, particularly in challenging rocky areas vulnerable for ship-based mapping operations. Seabed maps are essential in any case for siting of bottom mounted energy devices. The utmost care should be taken at all stages of the classification process, such as input data, control of interfering factors, seabed acoustic attributes, classification methods and ground-truth observations. The results of seabed mapping depend mostly on instrument stability, settings, algorithms adopted, environmental factors and survey methods. It is essential that seabed maps undergo frequent updation and improvement over time due to technological advances.

Parnum, I. M., A. N. Gavrilov, P. J. W. Siwabessy, and A. J. Duncan. 2006. Analysis of high-frequency multibeam backscatter statistics from different seafloor habitats. In: Proceedings of the Eighth Eurpean Conference on Underwater Acoustics. Carvociro, Portugal. 775-780.

Abstract: Acoustic backscatter imagery depicts morphological and physical characteristics of the seabed surface. However, statistical characteristics of acoustic backscatter from the seabed measured with high-frequency narrow-beam multibeam sonar systems are highly dependent on incident angle and the insonified area, which appears in particular in more variable or noisy returns at near-nadir angles. Although multibeam backscatter images need to be compensated for angular dependence, the angular statistical characteristics need to be retained as informative parameters for seafloor characterisation. As part of the Coastal Water Habitat Mapping (CWHM) project of the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, methods for processing andanalysis of multibeam backscatter data for seafloor characterisation are being developed. Results presented here were obtained from Reson Seabat 8125 multibeam sonar data collected around the Recherche Archipelago in Western Australia. The data represent different types of the seabed cover, including sand, rhodolith and bedrock. Statistical characteristics of backscatter intensity derived from these different seabed types at different angles of incidence are investigated along with the effects of compensating the backscatter strength for angular

dependence with a newly developed algorithm. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Pearce, S. K. and J. S. Bird. 2013. Sharpening side scan sonar images for shallow-water target and habitat classification with a vertically stacked array. IEEE J. Ocean Eng. **38**:455-469.

Keywords: array signal processing, geophysical image processing, image classification, interference suppression, object detection, oceanographic techniques, sonar arrays, sonar imaging

Abstract: Side scan imagery is commonly used to provide a 2-D real-time "look" at the seafloor in high resolution. In shallow-water environments, however, interference from surface scattering and from multipath signals may deteriorate the quality of the side scan images to the point where target detection and classification are no longer achievable. This paper investigates the extent to which this interference may be suppressed by a small array which employs across-track beamforming. A side scan array utilizing a vertical stack of six receive elements was constructed, and is shown to be effective at providing a clear view of the seafloor when surface and multipath interference is present. A theoretical analysis examines the relative path strengths of the received signals for different across-track beam patterns, and examines how these signals are affected when beamforming is applied on transmit and/or receive. Shadow contrast reduction caused by the along-track beamwidth is also considered for different along-track beam patterns and different target widths. A simulator was created to illustrate the impact of interference contributing to the received signal, and to show how the received signal is affected when beamforming is applied. The across-track beam patterns of the experimental array were measured, and these data are used to enhance the theoretical and simulated predictions of received signal strength. Experimental data are also presented in which a side scan image, heavily contaminated by interference, is significantly improved using across-track beamforming. It is concluded that a vertically stacked multielement side scan sonar which employs across-track beamforming on receive is a valuable tool for suppressing the multipath and surface interference which arise in shallow-water surveys.

Phillips, N. W., D. A. Gettleson, and K. D. Spring. 1990. Benthic biological studies of the Southwest Florida Shelf. Am. Zool. **30**:65-75.

Keywords: geophysical sampling, visual sampling, side scan sonar, oil, habitat mapping

Abstract: Between 1980 and 1987, the US Dept of the Interior funded a series of benthic studies of the continental shelf off southwestern Florida to gather environmental data in order to make decisions about offshore oil leasing. An overview of that research, including habitat mapping and benthic station sampling, is presented. The citations and

Pickrill, R. A. and B. J. Todd. 2003. The multiple roles of acoustic mapping in integrated ocean management, Canadian Atlantic continental margin. Ocean Coastal Manage. **46**:601-614.

Keywords: coastal zone management, high resolution mapping, multibeam

Abstract: Coastal and ocean environments worldwide are coming under increasing pressure from resource development. In some cases, integrated coastal zone management programs have been successfully adopted. However, with the collapse of offshore fisheries and competition among industries for use of the seabed, many maritime countries are recognizing that more data are needed to support the sustainable management of offshore resources. Developments in multibeam mapping technology, in concert with traditional geoscience survey techniques, now provide the capability to image the sea floor in high resolution. Examples from the Canadian Atlantic continental margin are used to demonstrate the application of high-resolution sea floor mapping techniques to develop data bases and maps; these maps are fundamental information for the future management of offshore resources. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Pinn, E. H., and M. R. Robertson. 2003. Effect of track spacing and data interpolation on the interpretation of benthic community distributions derived from RoxAnn[TM] acoustic surveys. ICES J. Mar. Sci. **60**:1288-1297.

Keywords: data interpolation, geographical information system, habitat type, image analysis, macrofauna, RoxAnn[TM]

Abstract: A 150 mile^2 (388 km^2) area in the South Minch on the Scottish west coast was surveyed acoustically using the seabed discrimination system RoxAnn[TM]. This site was chosen from BGS seabed sediment maps because of the wide variety of substratum types present within a relatively small area. The work presented here investigates different combinations of survey track spacing in relation to interpolation of acoustic data for mapping benthic biodiversity. Three different survey track spacings (4, 2 and 1 km) and three pixel sizes (1000, 500 and 250 m) were utilised. The results indicated considerable variations in the fine scale variations of the substratum maps produced and their accuracy in relation to ground truth data. Depending on the track spacing and level of interpolation utilised, the survey site could be considered relatively important under the UK Biodiversity Action Plan in terms of priority habitat types present or completely insignificant. These variations have serious implications for the use of this technology in site identification, conservation and management. The citations and

Piper, J. E., K. W. Commander, E. I. Thorsos, and K. L. Williams. 2002. Detection of buried targets using a synthetic aperture sonar. IEEE J. Ocean Eng. **27**:495-504.

Keywords: backscatter, buried object detection, sonar detection, sonar target recognition, synthetic aperture sonar

Abstract: This paper presents observations of buried target detections made using a 20-kHz synthetic aperture sonar. At grazing angles below the critical angle, surprisingly high signal-to-noise detections were made of cylindrical targets buried at depths of 15 and 50 cm. During a separate set of measurements, buried spheres were clearly seen at steep grazing angles, but were generally not seen below the critical angle. Since scattering from wave-generated sand ripples may contribute to detections at grazing angles below the critical angle, the information available on the ripple fields is discussed and used in acoustic backscatter simulations for the buried spheres. Lack of information on the ripple height precludes a definitive explanation for the absence of buried sphere detections at subcritical grazing angles.

Poppe, L. J., S. D. Ackerman, D. S. Foster, D. S. Blackwood, S. Williams, M. S. Moser, H. F. Stewart, and K. A. Glomb. 2007. Sea-Floor character and sedimentary processes of Great Round Shoal Channel, Offshore Massachusetts. Open-file Report. U.S. Geological Survey.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://pubs.er.usgs.gov/publication/ofr20071138

Poppe, L. J., K. Y. McMullen, D. S. Foster, D. S. Blackwood, S. J. Williams, S. D. Ackerman, M. S. Moser, and K. A. Glomb. 2010. Geological interpretation of the sea floor Offshore of Edgartown, Massachusetts. Open-file Report. U.S. Geological Survey.

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Poppe, L. J., S. D. Ackerman, S. J. Williams, M. S. Moser, H. F. Stewart, and K. A. Glomb. 2008. Sedimentary environments and processes of Great Round Shoal Channel, Offshore Massachusetts. **1138**.

Keywords: depressions, sediment transport, shoals, channels, sedimentation, sand waves, erosion, sedimentary structures, multibeam, side scan sonar

Abstract: Multibeam and side scan sonar data cover 39.9 sq. km of Great Round Shoal Channel, the main passage through shoals at the eastern entrance to Nantucket Sound. These data and verification stations show seabed composition and terrain, provide information on transport and habitat, and are part of a framework for research and management activities along the Massachusetts inner-shelf. Processes of erosion and non-deposition prevail at the western channel entrance, off the southeastern tip of Great Round Shoal, and across the eastern study area. High-energy environments there prevent Holocene deposition and erode finer grained sediments, exposing glacial drift and leaving coarse lag deposits. These conditions are especially apparent off the tip of the shoal where large scour depressions have formed. Elsewhere, sand waves dominate in areas characterized by coarse bedload transport. Barchanoid sand waves, common near the channel axis where Holocene sediments are thinner, align into elongate fields with bedforms that progressively widen and increase in amplitude and complexity eastward. Transverse sand waves with slip faces generally oriented eastward dominate along channel edges where sediment supply is greater. Barchanoid sand wave orientation and transverse sand wave and obstacle mark asymmetry show net transport is predominantly eastward and out of Nantucket Sound. Dataset comparisons with existing charts show the shoal tip has propagated over 0.6 km southeastward since 1954. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Prada, M., J. Rivera, D. Oulette, Y. Leon, J. Mateo, Z. Zapata, and E. Gomez. 2008. Strengthen Caribbean MPA's personnel in ecosystem based management by enhancing skills in use of marine acoustics for habitat mapping and fish detection. p. 671. *In* Proceedings of the Gulf and Caribbean Fisheries Institute. Gulf and Caribbean Fisheries Institute, c/o Harbor Branch Oceanographic Institution, Fort Pierce, FL.

Keywords: marine acoustics, habitat mapping, fish biomass, bathymetry, functional networking

Abstract: Increasing demand for tourist activities in Bahia de las Aguilas, Jaragua National Park requires conservation polices and management actions, but these must be based on sound technical information. To facilitate this, a collaborative Caribbean MPA habitat mapping group joined resources and expertise during a 10-day practical course, involving 14 MPA personnel from five countries. The goals were to enhance skills in the use of marine acoustics for mapping within reef environments, and use this technology to generate maps within key areas of Jaragua National Park. For mapping, the R/V Mago de Mar was outfitted with the following acoustic transducers: 300-kHz Marine Sonic Technology side scan sonar, 200-kHz Lowrance Model LCX110c fathometer and a 120-kHz split-beam 6° Hydroacoustic Technology, Inc. transceiver (model 244). Using these, approximately 1,000 ha of the seafloor adjacent to Bahia de las Aguilas, Cuenvanjo and Bucan Ye were mapped for benthic habitat, bathymetry and fish biomass. Final products

from this work included two habitat maps of 1:1000, four bathymetric 3-D models and several transverse sections, detailed tables and maps locating sites with fish aggregations. With CONANP support, all products and reports are accessible through the internet (http://pyucatan.conanp.gob.mx/sss3.htm). The combination of field work and conceptual training, especially in hydroacoustics, broadened participant's experiences and opened new possibilities for ecosystem-based management. The development of this project demonstrates how functional MPA networking is essential to overcome funding and logistical limitations as well as the importance to have trained personnel working together towards common goals.

Preston, J. M., A. C. Christney, W. T. Collins, R. A. McConnaughey, and S. Syrjala. 2004. Considerations in large-scale acoustic seabed characterization for mapping benthic habitats. In: Proceedings of the Theme Session on the Acoustic Seabed Classification - Applications in Fisheries Science and Ecosystem Studies. **13**: 2-4.

Keywords: acoustic seabed classification, seabed characterization, benthic habitat, hydro-acoustic, remote sensing

Abstract: In 1999, NMFS Alaska and QTC collected about 18,000 line miles of seabed acoustic data at 38 and 120 kHz from the eastern Bering Sea. With four million echoes at each frequency, this data set permitted thorough explorations of some practical considerations that influence every acoustic seabed classification. Our unsupervised classification involved an objective determination of the optimal number of classes for each of the pre-classification methods we explored, allowing useful comparisons among methods. Stacking, one of the pre-classification steps, is the process of averaging sequential echoes to allow sediment information to express itself in spite of ping-to-ping variability. With stacks of fifty pings, feature spaces had more detail and better defined clusters, thus more classes in unsupervised classification, compared to stacks of five pings. Classification by echo shape requires resampling to compensate for depth changes. While effective, resampling changes the apparent roughness and the amount of detail submitted to the feature-generating algorithms. Depth and stack size affect spatial resolution; the scale of the survey and the sharpness of sediment boundaries guide the surveyor's choice of spatial resolution. Even such a huge data set is a sampling of the sea bottom, and further sub-sampling simplified feature spaces further, reducing the optimal number of classes. The two frequencies differed in beam width and sediment penetration, thus gave complimentary information. The influences of each of these preclassification methods and other considerations will be presented, as maps of acoustic diversity and with statistical comparisons, accompanied by preliminary correlations with fish census data.

Preston, J. M., A. C. Christney, W. T. Collins, and R. A. McConnaughey. 2005. Quantitative measures of acoustic diversity to support benthic habitat characterization. In: B. W. Barnes and J. P. Thomas, editors. Benthic Habitats and the Effects of Fishing. 209.

Abstract: The fundamental dataset produced by an acoustic classification system is a representation of the acoustic diversity of the sediments in the survey area. Each acoustic record, from a ping, a stack of pings, or a section of a sonar image, is transformed to a feature vector, typically in two or three dimensions. Features may be from spectral analysis or from integration of parts of an echo envelope. Rather than classifying sediments with just these few features, it is often more useful and adaptable to generate many features and use multivariate statistical techniques to select the linear combinations that capture most of the variance in the dataset. Classification can then be done by dividing the records into groups based on the values of the most important, typically three, principal components. A difficult step in this classification process is estimation of the appropriate number of clusters. Motivated by the need for an automated seabed classification process that is both objective and adaptable to a wide variety of survey applications, this paper describes objective methods for choosing the number of clusters, based on information theory. Actual classifications provide insights into acoustic diversity, which can be used as a proxy for change in sediment characteristics including the influence of benthos. QTC IMPACT^{TM} calculated 166 features from each stack of a very large set of echoes from the Bering Sea. An optimum classification scheme, using the three most important principal components, was identified, based on K-means clustering guided by finding minima using information theory techniques.

Quattrini, A. M., S. W. Ross, M. C. T. Carlson, and M. S. Nizinski. 2012. Megafaunal-habitat associations at a deep-sea coral mound off North Carolina, USA. Mar. Biol. **159**:1079-1094.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs00227-012-1888-7

Raineault, N. A., A. C. Trembanis, and D. C. Miller. 2012. Mapping Benthic Habitats in Delaware Bay and the Coastal Atlantic: Acoustic techniques provide greater coverage and high resolution in complex, shallow-water environments. Estuaries and Coasts **35**:682-699.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs12237-011-9457-8

Ramsay, P. J. and W. R. Miller. 2002. Multibeam bathymetric survey defines coelacanth habitat. Hydro International **6**:57-59.

Keywords: multibeam, bathymetry, canyon

Abstract: Marine GeoSolutions (Pty) Ltd was contracted by the National Research Foundation (NRF) of South Africa to undertake a multibeam bathymetric survey of the northern KwaZulu-Natal submarine canyon system to define potential coelacanth habitats for the SA Coelacanth Conservation and Genome Resource Programme. Five survey blocks were defined to include all the known submarine canyons in the area. The survey blocks were systematically surveyed to develop a series of colour-draped bathymetric maps and three-dimensional models of the canyons. These maps were then used to provide information for potential submersible dive sites and produce the basal layer of a marine GIS (Geographical Information System). The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Rattray, A., D. Ierodiaconou, L. Laurenson, S. Burq, and M. Reston. 2009. Hydro-acoustic remote sensing of benthic biological communities on the shallow South East Australian continental shelf. Estuar. Coast. Shelf Sci. **84**:237-245.

Keywords: habitat mapping, decision tree classification, backscatter, bathymetry

Abstract: Information regarding the composition and extent of benthic habitats on the South East Australian continental shelf is limited. In this habitat mapping study, multibeam echosounder (MBES) data are integrated with precisely geo-referenced video ground-truth data to quantify benthic biotic communities at Cape Nelson, Victoria, Australia. Using an automated decision tree classification approach, 5 representative biotic groups defined from video analysis were related to hydro-acoustically derived variables in the Cape Nelson survey area. Using a combination of multibeam bathymetry, backscatter and derivative products produced highest overall accuracy (87%) and kappa statistic (0.83). This study demonstrates that decision tree classifiers are capable of integrating variable data types for mapping distributions of benthic biological assemblages, which are important in maintaining biodiversity and other system services in the marine environment. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Riegl, B. M. and S. J. Purkis. 2005. Detection of shallow subtidal corals from IKONOS satellite and QTC View (50, 200 kHz) single-beam sonar data (Arabian Gulf; Dubai, UAE). Remote Sens. Environ. **95**:96-114.

Keywords: IKONOS, QTC view, optic-acoustic comparison, habitat mapping, coral reef, Arabian Gulf

Abstract: We compared the results of seafloor classifications with special emphasis on detecting coral versus non-coral areas that were obtained from a 4x4-m pixel-resolution multispectral IKONOS satellite image and two acoustic surveys using a QTC View Series 5 system on 50 and 200 kHz signal frequency. A detailed radiative transfer model was obtained by *in situ* measurement of optical parameters that then allowed calibration of the IKONOS image against in situ optical measurements and a series of ground-truthing points. Eight benthic classes were distinguished optically with an overall accuracy of 69% and a Tau index T of 65. The classification of the IKONOS image allowed discrimination of three different coral assemblages (dense live, dense dead, sparse), which were confirmed by ground-truthing. Data evaluation of the acoustic surveys involved culling of datapoints with <90% confidence and <30% probability, two QTC- provided statistics, and the deletion of data classes without clear spatial patterns (visualized by single-class trackplots). The deletion of these ubiquitous classes was necessary in order to obtain any clearly interpretable spatial pattern of echo classes after the surveys were resampled to a regular grid and areas between the lines interpolated using a nearest neighbor algorithm. The 50 kHz acoustic seafloor classification was able to determine two classes (unconsolidated sand versus hardground) but was not able to determine corals. The 200 kHz survey determined high rugosity (=corals and sand ripples) versus low rugosity (=flat areas) but was not able to determine consolidated and unconsolidated sediments. Classes were extrapolated to the entire grid and polygons obtained from the two surveys were combined to provide maps containing four classes (rugose hardground=coral, flat hardground=rock, rugose softground=ripples and algae, flat softground=bare sand). Compared with the classification map derived from the IKONOS image, they were 66% accurate (T=59) when the most highly processed data (only selected classes, >90% accuracy and >30% probability) were used, and 60% accurate (T=53) when less processed data (selcted classes only, all data) were used. Accuracy against ground-truthing points of the most highly processed dataset was 56% (T=46). These results indicate that results from optical and acoustic surveys have some degree of commonality. Therefore, there is a potential to produce maps outlining coral areas from optical remote-sensing in shallow areas and acoustic methods in adjacent deeper areas beyond optical resolution with the limitation that acoustic maps will resolve fewer habitat classes and have lower accuracy. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Rivera, J. A., M. C. Prada, J. L. Arsenault, G. Moody, and N. Benoit. 2005. Detection of fish spawning aggregations from reef habitats mapped with high resolution side scan sonar imagery. p. 431-434. *In* Proceedings of the Fifty Six Annual Gulf and Caribbean Fisheries Institute. Fort Pierce, Florida.

Keywords: remote detection of fish, side scan sonar, coral reef fishery

Abstract: As part of a multibeam and side scan sonar (SSS) benthic survey of the Marine Conservation District (MCD) south of St. Thomas, USVI and the seasonal closed areas in St. Croix; Lang Bank for red hind (*Epinephelus guttatus*) and the mutton Snapper (*Lutjanus analis*) area, a summary of all fish aggregations and benthic habitats encountered in the SSS imagery was accomplished. The survey covered a total of 18 km^2 throughout the federal jurisdiction fishery management areas. The complementary set of 28 habitat classification digital maps covered a total of 5,462.3 ha, with the MCDW accounting for 45% of that area, MCDE with 26%, LB with 17% and MS with the remaining 13%. With the exception of MS, corals and gorgonians on consolidated habitats were significantly more abundant than submerged aquatic vegetation (SAV) on unconsolidated sediments or unconsolidated sediments. Both MCDW and the MCDE were the areas having continuous coral habitat as the most abundant consolidated habitat, accounting for 41% and 43%, respectively. LB and MS areas had their consolidated habitats constituted predominantly by gorgonian plain habitat with 95% and 83%, respectively. Coral limestone habitat was more abundant than coral patch habitat and it was found near to the shelf break in MS, MCDW and MCDE. There was minimal coverage for those habitats types at LB. The acquired imagery had high spatial resolution (0.15 m) and allowed the detection of different fish aggregation types. The largest FA densities were located at MCDW and MCDE over coral communities that occupied up to 70% of the bottom cover. USO's densities were similar among locations and occurred primarily over sand and shelf edge areas. FA's school size was significantly smaller at MS than the other three locations (MCDW, MCDE, LB). This study shows the advantages of utilizing SSS in determining fish distributions and density.

Roberts, J. M., C. J. Brown, D. Long, and C. R. Bates. 2005. Acoustic mapping using a multibeam echosounder reveals cold-water coral reefs and surrounding habitats. Coral Reefs **24**:654-669.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2Fs00338-005-0049-6

Robinson, K. A., K. Ramsay, C. Lindenbaum, N. Frost, J. Moore, A. P. Wright, and D. Petrey. 2011. Predicting the distribution of seabed biotopes in the southern Irish Sea. Cont. Shelf Res. **31**:S120-S131.

Keywords: marine, benthic, habitat mapping, modelling, irish sea

Abstract: Habitat maps are becoming increasingly important for marine management in the United Kingdom, though fully ground-truthed acoustic datasets are only available for a limited number of areas. In order to address this information gap in the short term, the HABMAP (HABitat MAPping for conservation and management of the southern Irish Sea) project was set up to develop a predictive modelling tool that would enable the

distribution of benthic biotopes to be mapped in areas of the southern Irish Sea where survey data is currently absent. The project collated physical and biological datasets in a Geographic Information System (GIS), and used these to develop a multi-parameter rule-based model to predict biological community type. Maps were produced for individual biotopes, and a confidence assessment method was developed to highlight areas where predicted distributions were likely to be more or less accurate. The maps were validated using survey data collected both as part of the HABMAP project and by other organisations. The maps arising from the project are intended to act as a guide for marine scientists, and have the potential to be used in a variety of activities including conservation management and marine spatial planning. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Rodrigo, C. 2006. Seabed characterization and classification in Puerto Montt Bay using multibeam bathymetry and backscatter data. Investigaciones marinas **34**:83-94.

Keywords: multibeam bathymetry, backscatter data, marine sediments, submarine topography, Puerto Montt, Chile.

Abstract: A high resolution multibeam bathymetric survey was carried out in Puerto Montt Bay, Chile. Moreover, intensity data derived from acoustic signals reflected by the sea bottom was gathered using the same sonar system; the ratio was calculated between emitted and backscattered energy. The resulting topographic model shows a soft coastal platform and an abrupt slope. There are small submarine channels in the slope zone and a main channel in the central bay zone that could be related to the depression associated with the Tenglo channel. These channels act as conduits for the sediment transport from shallow to deep waters. The backscatter information was used in order to classify seabed sediments, subsequently confirmed by analyzing sediment samples from the respective sites. Coarse sediments feature higher intensities or backscatter signals than fine sediments. Muddy sands generally prevail in the investigation area. However, coarse material tends to concentrate in shallow waters and fine material in deep sectors. Sediment transport in the interior and the mouths of Tenglo channel in strongly influenced by tide currents. This does not hold for material transport occurring on the slope and in the deeper parts of the bay, where other mechanisms, such as turbity currents, are more important. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Original Abstract: Se efectuo un levantamiento batimetrico de alta resolucion con sonar multihaz en la bahia de Puerto Montt,Chile. Ademas se obtuvo, con el mismo sistema de sonar, datos de intensidad de las senales acusticas reflejadas sobre el fondo del mar y se calculo la razon entre la energia acustica emitida y la recibida en los transductores (backscatter o retrodispersion acustica). El modelo topografico resultante presento una suave plataforma costera y una vertiente submarina abrupta. Existen pequenos canales

submarinos en la zona de la vertiente y en la zona central de la bahia hay un canal principal que puede ser relacionado con la depresion que da origen al canal Tenglo. Estos canales han servido de conducto para el transporte de sedimentos desde el sector somero al profundo. La informacion de backscatter se utilizo para clasificar los sedimentos del fondo apoyado con los resultados de muestras de sedimentos. Se encontro que los sedimentos mas gruesos tienen mayor intensidad o fuerza de backscatter que los finos. En la bahia redominan las arenas fangosas, pero los materiales mas gruesos tienden a concentrarse en sectores someros y los mas finos en sectores profundos. En el interior y en las bocas del canal Tenglo, el transporte de sedimentos es fuertemente influenciado por las corrientes de marea, no asi el transporte de materiales sobre las vertientes submarinas y el area mas profunda de la bahia, donde otros mecanismos, como corrientes de turbidez, tendrian mas importancia.

Rooper, C. N. and M. Zimmermann. 2007. A bottom-up methodology for integrating underwater video and acoustic mapping for seafloor substrate classification. Cont. Shelf Res. **27**:947-957.

Abstract: A method that links acoustic mapping data to underwater video observations of seafloor substrate is described for use in defining fish habitat. Three study areas in the Aleutian Islands were acoustically mapped using sidescan and multibeam sonar. The sidescan sonar data were used to compute average reflectivity (hardness) and seafloor complexity. The multibeam depth data were used to determine local slope, rugosity (seafloor roughness) and relative height. Underwater video was collected from three to four transects in each of the three study areas. The underwater video was used to classify the seafloor into nine observed primary and secondary substrate classes. A statistical relationship between the observed (video) and the remotely sensed (acoustic) seafloor characteristics was estimated using a classification tree. The best classification tree utilized rugosity, reflectivity and complexity data and produced misclassification rates of less than 25% overall. Mean grain size of sediment samples was not strongly related to the acoustic data. Error rates were highest for those substrate classes with the smallest number of data points. The results highlight the need for adequate sample sizes and coverage of all potential substrate types when groundtruthing acoustic maps. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Ryan, W. B. F. and R. D. Flood. 1996. Side-looking sonar backscatter response at dual frequencies. Mar. Geophys. Res. **18**:689-705.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2FBF00313881

Sampson, D. 2009. Mapping to management in Massachusetts. In: Proceedings of the Gulf of Maine symposium— Advancing ecosystem research for the future of the Gulf. **295**:133.

Keywords: environmental conditions, seafloor mapping, tidal currents, environment management, fishery management, sonar imagery, potential resources, resource management, marine environment, environmental monitoring

Abstract: The Massachusetts Oceans Act of 2008 requires the Secretary of the Executive Office of Energy and Environmental Affairs (EEA) to develop a comprehensive ocean management plan by Dec. 31, 2009. The plan is largely an exercise in four-dimensional zoning, and, as such, is highly reliant on spatial data. A key component of these spatial data are seafloor mapping data from the United States Geological Survey (USGS) who have to date mapped 35% of Commonwealth waters. The USGS data provide high resolution bathymetry, sidescan sonar mosaics, depth to bedrock measurements, and geologic interpretations and were examined for their potential use in deriving maps of sediment, habitat resources, and suitable locations for human uses, including alternative energy generating sites, infrastructure (pipelines, cables), and sand extraction for beach nourishment. Despite the presence of this rich data source, some emergent management needs called for information that could not be easily extracted from the USGS data: most prominently, a synoptic map of seafloor sediment. As work on the management plan has evolved, our understanding of data and information needs has commensurately evolved to reveal the need for additional data products. Amongst these are statewide merged bathymetry, modeled tidal currents, and perhaps most importantly, a seafloor/water column geophysical "habitat" map. Such a habitat map would allow managers and scientists to begin habitat suitability modeling for species of interest, diversity, and patch metrics to better identify areas of unique conditions (representing particular habitat) that should be exempted from some or all potential ocean/seafloor uses. The draft ocean management plan contains a proposed Science Framework identifying prioritized scientific/data acquisition needs in the next five years, which includes development of such data products. Reproduced with the permission of Her Majesty the Queen in Right of Canada, 2015.

Sautter, L. R. and M. S. Harris. 2008. Undergraduates at sea and in the laboratory conducting habitat mapping using multibeam and side scan sonar. In: Proceedings of the American Geophysical Union.

Keywords: post-secondary education, teaching methods, river channels, seafloor morphology, geology, geophysics, continental shelf and slope processes

Abstract: During the last five years, undergraduate students at the College of Charleston have had numerous opportunities to take part in the college's Transect Program and sail aboard research vessels on 2-5 day cruises to study the continental shelf. The program's

purpose is to train students in oceanographic research while developing a long-term information geodatabase to characterize and monitor essential fish habitats, and to map seafloor geomorphology. During these cruises students take the lead to conduct a variety of research investigations which include hydrographic surveys of the seafloor using side scan sonar, multibeam bathymetry, and video collected using a remotely operated vehicle and during SCUBA dives. Following the data collection cruises, students have enrolled in semester-long research courses to analyze data and document results through poster and oral presentations. More than 60 students have taken part in at least one of 6 programs. In the past two years, the NOAA Ship NANCY FOSTER has provided invaluable sea time to conduct multibeam surveys of the mid- and outer continental shelf off Charleston, so that the 22 participating Transect students have focused their work on seafloor mapping, and have become trained in state-of-the art CARIS multibeam and side scan sonar processing software. Most of these students have presented their results at professional meetings, and manuscripts are currently in preparation. Students have had numerous post-program opportunities to conduct further research at sea and in the lab. They have collaborated with NOAA scientists and other investigators, conducting bathymetry data processing and analysis from other regions. Most recently, two program graduates worked with University of Washington investigators to map sites for the Ocean Observatory Initiative Regional Scale Nodes. Several students have been contracted or hired as hydrographic survey technicians, while others have gone to graduate school to continue their work using these invaluable skills learned as undergraduates. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Scanlon, K. M. and D. G. Masson. 1992. Fe-Mn nodule field indicated by GLORIA, north of the Puerto Rico trench. Geo-Mar. Lett. **12**:208-213.

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Link: http://link.springer.com/article/10.1007%2FBF02091840

Scheirer, D. S., D. J. Fornari, S. E. Humphris, and S. Lerner. 2000. High-resolution seafloor mapping using the DSL-120 sonar system: Quantitative assessment of side scan and phase-bathymetry data from the Lucky Strike segment of the Mid-Atlantic Ridge. Mar. Geophys. Res. **21**:121-142.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1023%2FA%3A1004701429848

Schimel, A. C. G., T. R. Healy, D. Johnson, and D. Immenga. 2010. Quantitative experimental comparison of single-beam, sidescan, and multibeam benthic habitat maps. ICES J. Mar. Sci. **67**:1766-1779.

Keywords: accuracy, average of mutual information (AMI), contingency matrix, Cramér's V, Goodman–Kruskal's lambda, kappa statistic, Theil's uncertainty coefficient

Abstract: Map comparison is a relatively uncommon practice in acoustic seabed classification to date, contrary to the field of land remote sensing, where it has been developed extensively over recent decades. The aim here is to illustrate the benefits of map comparison in the underwater realm with a case study of three maps independently describing the seabed habitats of the Te Matuku Marine Reserve (Hauraki Gulf, New Zealand). The maps are obtained from a QTC View classification of a single-beam echosounder (SBES) dataset, manual segmentation of a sidescan sonar (SSS) mosaic, and automatic classification of a backscatter dataset from a multibeam echosounder (MBES). The maps are compared using pixel-to-pixel similarity measures derived from the literature in land remote sensing. All measures agree in presenting the MBES and SSS maps as the most similar, and the SBES and SSS maps as the least similar. The results are discussed with reference to the potential of MBES backscatter as an alternative to SSS mosaic for imagery segmentation and to the potential of joint SBES-SSS survey for improved habitat mapping. Other applications of map-similarity measures in acoustic classification of the seabed are suggested. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Schimel, A. C., D. Johnson, T. Healy, P. J. McComb, B. Beamsley, and D. Immenga. 2008. Potential influence of shells on multibeam backscatter imagery within the Te Matuku Marine Reserve, New Zealand, J. Acoust. Soc. Am. **123**: 3212.

Keywords: backscatter, bathymetry, seafloor mapping, surveying, shells

Abstract: - To develop a simple EM3000 backscatter processing code and assess its quality.
- To investigate the relationship between shell fragment distribution and multibeam backscatter over a specific regionof the Te Matuku marine reserve.
- To assess the potential detection of shells and shell fragment distribution using an EM3000 echosounder. Copyright 2008, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/123/5/10.1121/1.2933391

Schimel, A. C. G., T. R. Healy, P. McComb, and D. Immenga. 2010. Comparison of a Self-Processed EM3000 Multibeam Echosounder Dataset with a QTC View Habitat Mapping and a Sidescan Sonar Imagery, Tamaki Strait, New Zealand. J. Coast. Res.:714-725.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Schultz, A. L., H. A. Malcolm, D. J. Bucher, M. Linklater, and S. D. A. Smith. 2014. Depth and medium-scale spatial processes influence fish assemblage structure of unconsolidated habitats in a subtropical marine park: e96798. PLoS ONE **9**:e96798.

Keywords: marine protected areas, multivariate regression, backscatter, bathymetric variation, rugosity

Abstract: Where biological datasets are spatially limited, abiotic surrogates have been advocated to inform objective planning for Marine Protected Areas. However, this approach assumes close correlation between abiotic and biotic patterns. The Solitary Islands Marine Park, northern NSW, Australia, currently uses a habitat classification system (HCS) to assist with planning, but this is based only on data for reefs. We used Baited Remote Underwater Videos (BRUVs) to survey fish assemblages of unconsolidated substrata at different depths, distances from shore, and across an along-shore spatial scale of 10s of km (2 transects) to examine how well the HCS works for this dominant habitat. We used multivariate regression modelling to examine the importance of these, and other environmental factors (backscatter intensity, fine-scale bathymetric variation and rugosity), in structuring fish assemblages. There were significant differences in fish assemblages across depths, distance from shore, and over the medium spatial scale of the study: together, these factors generated the optimum model in multivariate regression. However, marginal tests suggested that backscatter intensity, which itself is a surrogate for sediment type and hardness, might also influence fish assemblages and needs further investigation. Species richness was significantly different across all factors: however, total MaxN only differed significantly between locations. This study demonstrates that the pre-existing abiotic HCS only partially represents the range of fish assemblages of unconsolidated habitats in the region.

Serpetti, N., M. Heath, E. Armstrong, and U. Witte. 2011. Blending single beam RoxAnn and multi-beam swathe QTC hydro-acoustic discrimination techniques for the Stonehaven area, Scotland, UK. J. Sea Res. **65**:442-455.

Keywords: sediment acoustic classification, RoxAnn© System, QTC-Multiview System, ground truthing survey, seabed mapping, Scotland, UK

Abstract: Surface properties of the seabed in a 180km^2 area of coastal waters (14-57m depth) off northeast Scotland were mapped by hydro-acoustic discrimination using single and multi-beam echosounders linked to signal processing systems (RoxAnn for

the single beam, and Questor Tangent Corporation (QTC) Multiview for the multibeam). Subsequently, two ground truthing surveys were carried out, using grab and TV sampling. The RoxAnn and QTC-Multiview outputs showed strong similarity in their classifications of seabed types. Classifications generated by QTC-Multiview were used to supervise those based on seabed roughness and hardness indices produced by the RoxAnn system and thereby develop a 'blended' map based on both systems. The resulting hydro-acoustic classes agreed well with a cluster analysis of data on sediment grain sizes from the grab sampling, and indicated that the area could be described by distinct regions of surface texture and surficial sediments ranging from muddy sand to boulders and rock.

Shaw, K. B., C. L. Walker, S. C. Lingsch, F. A. Bowles, and P. Fleischer. 1990. Investigations of digital image analysis and enhancements of GLORIA acoustic imagery. Naval Ocean Research and Development Activity, Report 247.

Keywords: image enhancement, automated cartography, digital records, acoustic imagery, mapping, defence craft, underwater exploration, bottom topography, image processing

Abstract: The U.S. Navy is interested in improving underwater mapping and interpretation technologies for bottom and subbottom segmentation and classification, as well as feature extraction and identification of potential hazards. These refinements would greatly enhance the capability of Navy sensors and systems to distinguish and identify underwater objects and the geological structure of the bottom and subbottom. The Naval Ocean Research and Development Activity was tasked to analyze imagery from the U.S. Geological Survey's Exclusive Economic Zone Survey Experiment. Digitally mosaicked GLORIA (Geological Long-Range Inclined Asdic) acoustic imagery were analyzed as a zeroth-order model for the acoustic imagery sensor, TAMU2, developed by Texas A&M University. Multiple image analysis techniques, as well as several image enhancement techniques, were applied to the data set. This report describes the systems, the experiment, and the methods used to analyze the GLORIA data. Geological interpretations are also provided.

Shumchenia, E. J. 2010. Benthic habitat mapping and assessment using organism-sediment relationships. Masters. University of Phode Island. **71**:1-200.

Keywords: habitat, biotic, abiotic, sediment relationships, mapping

Abstract: The study of organism-sediment relationships involves characterizing a suite of biological and geological features that control the spatial and temporal patterns of the benthic landscape and the response of these ecosystems to natural and anthropogenic disturbance. Acknowledging this variability is essential for effective

monitoring and management of all marine ecosystems, but especially coastal environments where anthropogenic stresses tend to dominate. This dissertation examines organism-sediment relationships to support habitat mapping and assessment in Greenwich Bay, a shallow sub-embayment within Narragansett Bay, Rhode Island, USA. Sediment profile imagery (SPI) played a prominent role in linking sediments, organisms and water quality in these studies. In the first chapter, we found that burrow structures and the apparent redox potential discontinuity (aRPD), or oxidized layer of surface sediment visible in SPI were the strongest surrogates for water quality over multiple assessment windows and dissolved oxygen thresholds. Therefore, the use of SPI widens the spatial extent of water quality monitoring efforts by reflecting the near-term water quality of sites where it is impractical to deploy multiple probes. In the second chapter, SPI is used in combination with traditional grab samples and acoustics to integrate biotic (benthic biological communities) and abiotic (sediment types, depositional environments) data to create accurate and useful habitat maps. Relationships between the biology and geology were preserved when maps were created using a linkage tree based on significant associations between macrofauna abundance and percent sand, backscatter standard deviation and bathymetry. In the third chapter, water quality and biological habitat data were combined to characterize the effects of a major change in wind-driven circulation on hypoxia prevalence and benthic communities. Persistent hypoxia and weak exchange with Narragansett Bay promoted the dominance of opportunistic species in enclosed parts of the study area. Periodic hypoxia and intermittent exchange followed by normoxia and increased flushing allowed tube-building amphipods (*Ampelisca abdita*) to reach mat densities at the mouth of the bay. The horizontal and vertical transport of water was important to the structure of benthic communities by influencing water column structure, nutrient and organic matter transport and deposition, and larval delivery.

Snellen, M., D. G. Simons, and R. Riethmueller. 2008. High frequency scattering measurements for mussel bed characterisation. J. Acoust. Soc. Am. **123**:5251-5256.

Abstract: Several approaches exist towards seafloor classification using high-frequency backscattering measurements. The classification approach taken in this paper is a model-based classification employing backscatter data measured by a multibeam-echosounder (MBES) system. The method discriminates between sediments in the most optimal way by applying the Bayes decision rule for multiple hypotheses, implicitly accounting for the backscatter strength ping-to-ping variability. The-method's applicability for seafloor classification has been demonstrated by using 300 kHz MBES data collected in the Cleaver-Bank area (North Sea). The area is well-known from a geological point of view due to extensive sampling campaigns and is characterized by a wide variety of seafloor types. Here we apply the classification method to MBES data acquired in the Oosterschelde estuary (the Netherlands) which is known to contain mussel culture spots. Also recordings using a video camera towed close to the seafloor

and core measurements have been taken. From the video recordings estimates of mussel coverage as a function of position were derived. Analysis of the MBES results shows that they clearly reveal the presence of the mussel beds, indicating the usefulness of acoustic classification for habitat mapping. A comparison between MBES analysis results, video recordings and sample analysis will be presented. Copyright 2008, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/123/5/10.1121/1.2934852

Stanton, T. K. and D. Chu. 2004. On the acoustic diffraction by the edges of benthic shells. J. Acoust. Soc. Am. **116**:239-244.

Keywords: shells, backscatter, incidence

Abstract: Recent laboratory measurements of acoustic backscattering by individual benthic shells have isolated the edge-diffracted echo from echoes due to the surface of the main body of the shell. The data indicate that the echo near broadside incidence is generally the strongest for all orientations and is due principally to the surface of the main body. At angles well away from broadside, the echo levels are lower and are due primarily to the diffraction from the edge of the shell. The decrease in echo levels from broadside incidence to well off broadside is shown to be reasonably consistent with the decrease in acoustic backscattering from normal incidence to well off normal incidence by a shell-covered seafloor. The results suggest the importance of the edge of the shell in off-normal-incidence backscattering by a shell-covered seafloor. Furthermore, when considering bistatic diffraction by edges, there are implications that the edge of the shell (lying on the seafloor) can cause significant scattering in many directions, including at subcritical angles. Copyright 2004, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/116/1/10.1121/1.1675813

Stephens, D., and M. Diesing. 2014. A Comparison of Supervised Classification Methods for the Prediction of Substrate Type Using Multibeam Acoustic and Legacy Grain-Size Data. PLoS ONE **9**:e93950.

Keywords: bathymetry, acoustic backscatter, multibeam, supervised classification

Abstract: Detailed seabed substrate maps are increasingly in demand for effective planning and management of marine ecosystems and resources. It has become common to use remotely sensed multibeam echosounder data in the form of bathymetry and acoustic backscatter in conjunction with ground-truth sampling data to inform the mapping of seabed substrates. Whilst, until recently, such data sets have typically been classified by expert interpretation, it is now obvious that more objective, faster and repeatable methods of seabed classification are required. This study compares the

performances of a range of supervised classification techniques for predicting substrate type from multibeam echosounder data. The study area is located in the North Sea, off the north-east coast of England. A total of 258 ground-truth samples were classified into four substrate classes. Multibeam bathymetry and backscatter data, and a range of secondary features derived from these datasets were used in this study. Six supervised classification techniques were tested: Classification Trees, Support Vector Machines, k-Nearest Neighbour, Neural Networks, Random Forest and Naive Bayes. Each classifier was trained multiple times using different input features, including i) the two primary features of bathymetry and backscatter, ii) a subset of the features chosen by a feature selection process and iii) all of the input features. The predictive performances of the models were validated using a separate test set of ground-truth samples. The statistical significance of model performances relative to a simple baseline model (Nearest Neighbour predictions on bathymetry and backscatter) were tested to assess the benefits of using more sophisticated approaches. The best performing models were tree based methods and Naive Bayes which achieved accuracies of around 0.8 and kappa coefficients of up to 0.5 on the test set. The models that used all input features didn't generally perform well, highlighting the need for some means of feature selection.

Sternlicht, D. D. and C. P. de Moustier. 2003. Remote sensing of sediment characteristics by optimized echo-envelope matching. J. Acoust. Soc. Am. **114**:2727-2743.

Keywords: echosounders, remote sensing, acoustics, sediment properties, mean grain size

Abstract: A sediment geoacoustic parameter estimation technique is described which compares bottom returns, measured by a calibrated monostatic sonar oriented within 15° of vertical and having a 10° -21° beamwidth, with an echo envelope model based on high-frequency (10-100 kHz) incoherent backscatter theory and sediment properties such as: mean grain size, strength, and exponent of the power law characterizing the interface roughness energy density spectrum, and volume scattering coefficient. An average echo envelope matching procedure iterates on the reflection coefficient to match the peak echo amplitude and separate coarse from fine-grain sediments, followed by a global optimization using a combination of simulated annealing and downhill simplex searches over mean grain size, interface roughness spectral strength, and sediment volume scattering coefficient. Error analyses using Monte Carlo simulations validate this optimization procedure. Moderate frequencies (33 kHz) and orientations normal with the interface are best suited for this application. Distinction between sands and fine-grain sediments is demonstrated based on acoustic estimation of mean grain size alone. The creation of feature vectors from estimates of mean grain size and interface roughness spectral strength shows promise for intraclass separation of silt and clay. The correlation between estimated parameters is consistent with what is observed *in situ*. Copyright 2003, reproduced with permission from Acoustical Society of America.

Storlazzi, C. D., T. A. Fregoso, N. E. Golden, and D. P. Finlayson. 2011. Sediment dynamics and the burial and exhumation of bedrock reefs along an emergent coastline as elucidated by repetitive sonar surveys: Northern Monterey Bay, CA. Mar. Geol. **289**:46-59.

Keywords: bedrock, sediment, reef, burial, exhumation, inner shelf

Abstract: Two high-resolution bathymetric and acoustic backscatter sonar surveys were conducted along the energetic emergent inner shelf of northern Monterey Bay, CA, USA, in the fall of 2005 and the spring of 2006 to determine the impact of winter storm waves, beach erosion, and river floods on biologically-important siliclastic bedrock reef habitats. The surveys extended from water depths of 4m to 22m and covered an area of 3.14km^2, 45.8% of which was bedrock, gravel, and coarse-grained sand and 54.2% was fine-grained sand. Our analyses of the bathymetric and acoustic backscatter data demonstrates that during the 6months between surveys, 11.4% of the study area was buried by fine-grained sand while erosion resulted in the exposure of bedrock or coarse-grained sand over 26.5% of the study area. The probability of burial decreased with increasing water depth and rugosity; the probability of exhumation increased with increasing wave-induced near-bed shear stress, seabed slope and rugosity. Much of the detected change was at the boundary between bedrock and unconsolidated sediment due to sedimentation and erosion burying or exhuming bedrock, respectively. In a number of cases, however, the change in seabed character was apparently due to changes in sediment grain size when scour exposed what appeared to be an underlying coarser-grained lag or the burial of coarser-grained sand and gravel by fine-grained sand. These findings suggest that, in some places, (a) burial and exhumation of nearshore bedrock reefs along rocky, energetic inner shelves occurs over seasonal timescales and appears related to intrinsic factors such as seabed morphology and extrinsic factors such as wave forces, and (b) single acoustic surveys typically employed for geologic characterization and/or habitat mapping may not adequately characterize the geomorphologic and sedimentologic nature of these types of environments that typify most of the Pacific Ocean and up to 50% of the world's coastlines. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Summers-Morris, E., P. Iampietro, and R. Kvitek. 2004. Geographic Information Systems (GIS) analysis of high-resolution multibeam bathymetry and remotely operated vehicle data to model rockfish habitat preference. J. Acoust. Soc. Am. **116**:2486-2486.

Keywords: multibeam, video, rockfish, habitat, ROV

Abstract: Management of declining rockfish stocks requires effective tools capable of providing accurate stock assessments of near-shore, high-relief habitat. Multibeam bathymetry, when analyzed with GIS landscape analysis tools, can create models which

can identify preferred habitat based on species-specific parameters. For this study, high-resolution multibeam data of the Del Monte shale beds in Monterey Bay, California were analyzed in GIS for slope, rugosity, and relative topographic position to assess rockfish (*Sebastes* spp.) habitat preference. Video transects collected by a remotely operated vehicle (ROV) provided habitat ground-truth and fish distribution data. A series of habitat suitability models was created in GIS by combining different suitability factors from multibeam-derived grids: slope, rugosity, topographic position index (TPI), and depth. Distance to preferred categories for each parameter were determined for eight rockfish species. Of these, distance to peak features identified by TPI50 proved the most effective means of modeling fish distribution, successfully predicting an average of 80% of the eight rockfish species. Using fish distribution information, stock estimates were calculated for the study area. By combining GIS landscape analysis tools with multibeam bathymetry and ROV video data, we have created a predictive tool that can locate areas of most suitable habitat given rockfish-specific parameters. Copyright 2004, reproduced with permission from Acoustical Society of America.

Link: http://scitation.aip.org/content/asa/journal/jasa/116/4/10.1121/1.4784927

Sutherland, T. F., J. Galloway, R. Loschiavo, C. D. Levings, and R. Hare. 2007. Calibration techniques and sampling resolution requirements for groundtruthing multibeam acoustic backscatter (EM3000) and QTC VIEW™ classification technology. Estuar. Coast. Shelf Sci. **75**:447-458.

Keywords: acoustic survey, multibeam backscatter, QTC VIEW™, sediment porosity, groundtruthing, sulfur, aquaculture

Abstract: Both acoustic and sediment surveys were carried out in the Broughton Archipelago, British Columbia, in order to map a former aquaculture site and calibrate acoustic surveys with georeferenced sediment properties. The acoustic surveys included EM3000 Multibeam (including backscatter) and QTC VIEW™ (Series IV) technologies, while the geotechnical survey entailed Van Veen grab sampling of surface sediments and associated analyses. The two acoustic technologies were consistent in their ability to identify distinct regions of seafloor characterized by rock outcrops, consolidated substrates, or gel-mud depositional fields. Both multibeam backscatter data and QTC VIEW™ number-coded classifications were extracted across a range of circular areas located at each georeferenced sampling station (radii: 2, 3, 4, 5, 8, 12, 16, 20m). Statistical correlations were observed between backscatter and certain geotechnical properties, such as sediment porosity, sediment grain size fractions (<2km, silt content), and particulate sulfur concentration. The areal resolution of backscatter extraction was explored in terms of determining a sensitive calibration technique between backscatter and sediment properties. In general the highest r^2 values between backscatter and sediment variables were observed across extraction radii between 8 and 20m. Such groundtruthing techniques could be used to interpolate seafloor characteristics between sampling stations and provide a steering tool for sampling designs associated

Talukdar, K. K. and R. C. Tyce. 1992. Relation of sea beam echo peak statistics to the character of bottom topography. Geo-Mar. Lett. **12**:200-207.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://link.springer.com/article/10.1007%2FBF02091839

Taylor, R., N. Vine, A. York, S. Lerner, and D. Hart. 2008. Evolution of a benthic imaging system from a towed camera to an automated habitat characterization system. Woods Hole Oceanographic Institution, Department of Applied Ocean Physics and Engineering, Woods Hole, Massachusetts. Report. 1-7.

Keywords: stock assessment, cameras, mapping, fishery surveys, species richness, population density, acoustic data, HabCam

Abstract: We have an operational and practical digital imaging system that delivers high resolution overlapping still images to a computer system on the bridge of a commercial scallop fishing vessel for immediate viewing, storage, and onboard image processing. This system produces 100 nautical mile long optical transects of benthic taxa, communities, and associated substrate each day. It is intended to provide fisheries managers with accurate scallop population density estimates and habitat characterization. We call the instrument HabCam for habitat mapping camera system. Joint ship operations with NOAA vessels conducting annual scallop surveys has allowed for nearly direct comparison between estimates of scallop abundance by survey dredge and the HabCam imaging system. For 47 transects conducted jointly during 2007, dredge efficiency ranged from 10 to 80% with a mean of 40% (SD 23.9%) depending on area, substrate, tow direction relative to current, and mean distance between the dredge tow track and the HabCam imaging track. Integration of synoptically collected acoustical (675 kHz sidescan, 175 kHz synthetic aperture side scan and 300 kHz multibeam) and optical imaging has allowed for direct registration and comparison of sampling modalities, ground truthing of acoustical data, and extrapolation of information gained at small scale (1m) but high spatial resolution (1 mm) with optics to large scale (>200 m) acoustical data sets. What was initially developed as a scallop survey tool has become an instrument system capable of providing information on habitat characterization, estimates of megafauna abundance, biodiversity, and species richness. A project called the Northeast Bentho-pelagic Observatory (NEBO) is using HabCam to evaluate these ecological parameters at sentinel study sites to document mechanistically how and why benthic community composition is changing over time. A key element in the development of HabCam as a tool for habitat characterization is the

Teixeira, J. B., A. S. Martins, H. T. Pinheiro, N. A. Secchin, R. Leao de Moura, and A. C. Bastos. 2013. Traditional Ecological Knowledge and the mapping of benthic marine habitats. J. Environ. Manage. **115**:241-250.

Keywords: fisheries management, participatory geography information, systems, seabed mapping, sidescan sonar, marine protected areas

Abstract: Traditional Ecological Knowledge (TEK) is the empirically accumulated knowledge of local communities whose livelihoods depend directly on natural resources. TEK has a considerable potential as a reliable, rapid and low cost information source. However, its use for decision making in environmental management is frequently challenged due to the lack of scientific validation and the multiple and poorly understood biases deriving from measurement and analytical errors, as well as from political, cultural and religious sources. During the planning stage of a Marine Protected Area (MPA) in Southeastern Brazil we assessed fisherfolk TEK regarding seabed features, comparing it with results from a conventional oceanographic assessment. TEK was acquired and synthesized during a survey involving 19 fishing villages and a consensus analysis that minimized variation among individual fisherfolks and communities. The oceanographic survey included high resolution benthic habitat mapping tools such as sidescan sonar and ground-truthing with SCUBA near the interfaces of benthic features identified by fisherfolk. Nearly 3000 km^2 of seafloor were mapped by local fisherfolk as "gravel", "sand", "mud" and "reef structures", while side-scan sonar surveys covered approximately 360 km with an average 400 m swath. Analyses of overlap and proximity showed that TEK is relatively cost-effective and accurate for large-scale benthic surveys, especially as a starting point for planning oceanographic surveys. Moreover, including TEK in the planning stage of MPAs may increase communities' participation and understanding of the costs and benefits of the new access and fishing effort regulations. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Todd, B. J. and V. E. Kostylev. 2011. Surficial geology and benthic habitat of the German Bank seabed, Scotian Shelf, Canada. Cont. Shelf Res. **31**:S54-S68.

Keywords: German Bank, Scotian Shelf, surficial geology, habitat mapping, 42°59'N to 43°41'N, 65°28'W to 66°47'W

Abstract: To provide the scientific context for management of a newly opened scallop fishing ground, surficial geology and benthic habitats were mapped on German Bank on the southern Scotian Shelf off Atlantic Canada. To provide a seamless regional dataset, multibeam sonar surveys covered 5320km^2 of the bank in water depths of 30-250m and

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provided 5m horizontal resolution bathymetry and backscatter strength. Geoscience data included high-resolution geophysical profiles (seismic reflection and sidescan sonar) and seabed sediment samples. Geological interpretation revealed that bedrock is exposed at the seafloor on much of German Bank and is overlain in places by glacial and postglacial sediment. Biological data included seafloor video transects and photographs from which 127 taxa of visible megabenthos were identified. Trawl bycatch data were obtained from government annual research surveys. Statistical analysis of these two datasets and a suite of oceanographic environmental variables demonstrated that significantly different fauna exist on bedrock, glacial sediment and postglacial sediment. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Trusel, L. D., G. R. Cochran, L. L. Etherington, R. D. Powell, and L. A. Mayer. 2010. Marine benthic habitat mapping of Muir Inlet, Glacier Bay National Park and Preserve, Alaska with an evaluation of the coastal and marine ecological clissification standard III. Open-file Report. U.S. Geological Survey.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

Link: http://pubs.usgs.gov/sim/3122/

Tyce, R. C. 1977. Quantitative acoustics near the sea floor. California. Univ., San Diego. Scripps Institution of Oceanography, Marine Physical Lab. Report 6.

Keywords: acoustic reflection, attenuation, computer displays, oceans, real time systems, reflectivity, sea floor, sea surface, surface topography, three dimensional displays

Abstract: For more than a decade, the Deep-Tow group of the Marine Physical Laboratory has been developing acoustic systems for near-bottom geophysical studies of the deep sea floor. A major aim of this work has been the detailed measurement of those properties of the sea floor which affect acoustic propagation. Such properties include the slope of the bottom, the acoustic reflectivity of the sea floor and of buried interfaces, and the attenuation of sound in marine sediments. The extreme lateral variability of such properties in the deep ocean makes near-bottom measurements important. This need has resulted in the development of narrow-beam altimeters for accurate depth and slope determination, a computerized seismic profiling system for measurement of sea floor reflectivity and attenuation at 4 kHz, and computerized side-scan sonar systems for acoustic backscatter and bottom slope determinations. These systems were designed to provide real-time processing and displays of acquired data. This paper discusses the development and application of these systems, and the results that illustrate the extreme variability of sea floor acoustic properties which have been observed by these systems.

Valentine, P. C., G. R. Cochrane, and K. M. Scanlon. 2003. Mapping the seabed and habitats in National Marine Sanctuaries - Examples from the East, Gulf and West Coasts. Mar. Technol. Soc. J. **37**:10-17.

Abstract: The National Marine Sanctuary System requires seabed and habitat maps to serve as a basis for managing sanctuary resources and for conducting research. NOAA, the agency that manages the sanctuaries, and the USGS have conducted mapping projects in three sanctuaries (Stellwagen Bank NMS, Flower Garden Banks NMS, and Channel Islands NMS) with an emphasis on collaboration of geologists and biologists from the two agencies and from academic institutions. Mapping of seabed habitats is a developing field that requires the integration of geologic and biologic studies and the use of swath imaging techniques such as multibeam and sidescan sonar. Major products of swath mapping are shaded-relief topographic imagery which shows seabed features in great detail, and backscatter imagery which provides an indication of the types of materials that constitute the seabed. Sea floor images provide an excellent basis for conducting the groundtruthing studies (using video, photo, and sampling techniques) that are required to collect the data necessary for making meaningful interpretative maps of the seabed. The compilation of interpretive maps showing seabed environments and habitats also requires the development of a sea floor classification system that will be a basis for comparing, managing, and researching characteristic areas of the seabed. Seabed maps of the sanctuaries are proving useful for management and research decisions that address commercial and recreational fishing, habitat disturbance, engineering projects, tourism, and cultural resources. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

van der Kooij, J., S. Kupschus, and B. E. Scott. 2011. Delineating the habitat of demersal fish assemblages with acoustic seabed technologies. ICES J. Mar. Sci.: Journal du Conseil **68**:1973-1985.

Abstract: Habitats influence species distribution and, although the seabed is an important habitat factor for demersal species, traditional sampling methods often provide no practical solution to investigating the seabed over large areas. The ability of a multivariate method that utilizes single-beam acoustic seabed data combined with species composition data to define demersal fish habitats was tested. The best model explained 19.4% of the variance observed in the species data and was robust between

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years. Ten biotopes were identified, each containing species that, either alone or in combination with others, were indicative of that biotope. Using unclassified acoustic seabed data as explanatory variables, discrepancies between the numbers of acoustically distinct classes and species assemblages, as previously reported in the literature, were avoided, while utilizing their relationship with community structure. The study focused on the relationship between simultaneously recorded species composition and seabed data from fishing stations, but because continuous acoustic data along the survey tracks were available between stations, the model could be used to predict the spatial extent of the biotopes. Although the method was developed with the eventual aim of providing a meaningful foundation to the spatial management of mixed fisheries, it could also contribute to applications in spatial planning. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

van Overmeeren, R., J. Craeymeersch, J. van Dalfsen, F. Fey, S. van Heteren, and E. Meesters. 2009. Acoustic habitat and shellfish mapping and monitoring in shallow coastal water - Sidescan sonar experiences in The Netherlands. Estuar. Coast. Shelf Sci. **85**:437-448.

Keywords: sidescan sonar, acoustic imaging, acoustic monitoring, seabed habitats, shellfish, (sub)littoral zone

Abstract: Sidescan sonar has been applied in a number of shallow water environments along the Dutch coast to map and monitor shellfish and seabed habitats. The littoral setting of these surveys may hamper data acquisition flying the towfish in zones of turbulence and waves, but also offers valuable opportunities for understanding, interpreting and validating sidescan sonar images because of the ability to ground-truth during low water periods, enabling easy identification and validation. Acoustical images of some of the mussel banks on the tidal flats of the Wadden Sea, recorded at high tide, show a marked resemblance with optical Google Earth images of the same banks. These sonar images may thus serve as 'acoustic type signatures' for the interpretation of sonar patterns recorded in deeper water where ground-truthing is more difficult and more expensive. Similarly, acoustic type signatures of (Japanese) oyster banks were obtained in the estuaries in the southwest of the Netherlands. Automated acoustic pattern recognition of different habitats and acoustical estimation of faunal cover and density are possible applications of sidescan sonar. Both require that the backscattering observed on the sidescan sonar images is directly caused by the biological component of the seafloor. Filtering offers a simple and effective pre-processing technique to separate the faunal signals from linear trends such as emanating from wave ripples or the central tracks of the towfish. Acoustically estimating the faunal density is approached by in-situ counting peaks in backscattering in unit squares. These counts must be calibrated by ground-truthing. Ground-truthing on littoral mussel banks in the Wadden Sea has been carried out by measuring their cover along lines during low tide. Due to its capacity of yielding full-cover, high resolution images of large surfaces, sidescan sonar proves to be an excellent, cost-effective tool for quantitative time-lapse monitoring of habitats. The

van Rein, H., C. J. Brown, R. Quinn, J. Breen, and D. Schoeman. 2011. An evaluation of acoustic seabed classification techniques for marine biotope monitoring over broad-scales (> 1 km^2) and meso-scales (10 m^2-1 km^2). Est. Coast. Shelf Sci. **93**:336-349.

Keywords: sonar, seabed, mapping, monitoring, biotopes, seagrass, kelp, scale

Abstract: Acoustic seabed classification is a useful tool for monitoring marine benthic habitats over broad-scales (>1 km^2) and meso-scales (10 m2-1 km^2). Its utility in this context was evaluated using two approaches: by describing natural changes in the temporal distribution of marine biotopes across the broad-scale (4 km^2), and by attempting to detect specific experimentally-induced changes to kelp-dominated biotopes across the meso-scale (100 m^2). For the first approach, acoustic backscatter mosaics were constructed using sidescan sonar and multibeam echosounder data collected from Church Bay (Rathlin Island, Northern Ireland) in 1999, 2008 and 2009. The mosaics were manually segmented into acoustic facies, which were ground-truthed using a drop-video camera. Biotopes were classified from the video by multivariate exploratory analysis and cross-tabulated with the acoustic facies, showing a positive correlation. These results were integrated with bathymetric data to map the distribution of seven unique biotopes in Church Bay. Kappa analysis showed the biotope distribution was highly similar between the biotope maps, possibly due to the stability of bedforms shaped by the tidal regime around Rathlin Island. The greatest biotope change in this approach was represented by seasonal and annual changes in the growth of the seagrass, Zostera marina. In the second approach, sidescan sonar data were collected before and after the removal of 100 m^2 of kelp from three sites. Comparison of the data revealed no differences between the high-resolution backscatter imagery. It is concluded that acoustic seabed classification can be used to monitor change over broad- and meso-scales but not necessarily for all biotopes; its success depends on the type of acoustic system employed and the biological characteristics of the target biotope. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Vandermeulen, H. 2007. Drop and towed camera systems for ground-truthing high frequency sidescan in shallow waters. Can. Tech. Rep. Fish. Aquat. Sci. **2687**:1-18.

Keywords: camera, sidescan sonar, ground truth

Abstract: The specifications and design of a drop and towed video camera system are described for shallow water use. The drop camera is a downward looking 'quadrat' camera useful for quantifying objects seen in the frame. The towed camera offers rapid 'transect' views of the bottom useful for describing habitat classes. All video is

georeferenced to dGPS specifications (sub-meter precision) and stored as digital video clips in ArcGIS projects which include camera tracks (towed camera) and point locations (drop camera). Both camera systems are used to ground truth high frequency sidescan images (800 kHz, 30m swath).

Original Abstract: Le document decrit les specifications et la conception de systemes de videocameras larguee et remorquee en eaux peu profondes. La camera larguee est une camera a detection plongeante utilisee pour quantifier les objets affiches sur les images. La camera remorquee fournit des vues transversales rapides du fond servant a decrire les classes d'habitat. Toute la video est georeferencee par rapport aux specifications du DGPS (precision submetrique) et stockee sous forme de videoclips numeriques dans le cadre de projets ArcGIS comprenant des trajectoires de camera (camera remorquee) et des emplacements ponctuels (camera larguee). Les deux systemes de camera permettent d'etablir la realite de terrain correspondant a des images obtenues par balayage lateral a haute frequence (800 kHz, couloir de 30 m). Reproduced with the permission of Her Majesty the Queen in Right of Canada, 2015.

Vandermeulen, H. 2011. An echosounder system ground-truthed by towfish data: A method to map larger nearshore areas. Can. Tech. Rep. Fish. Aquat. Sci. 2958:1- 21.

Keywords: single beam, video, sidescan sonar, echo sounder, habitat

Abstract: The specifications and design of an echosounder system are described for shallow water use. A BioSonics, Inc. DT-X digital echosounder with 210 and 430 kHz single beam transducers was custom fitted to a 22' research vessel with a unique transducer cage. The echosounder system can be run at 4 knots, offering rapid coverage of large areas of the bottom. Towfish transects (video and sidescan) are used to ground-truth the echosounder data, creating benthic habitat classes and maps. All positional data is collected at dGPS specifications (sub-meter precision).

Original Abstract: Les specifications et la conception d'un systeme echo-sondeur destine a une utilisation en eux peu profondes sont decrites. Un echo-sondeur numerique DT-X de BioSonics Inc. muni de transducteurs a faisceau unique de 210 kHz et 430 kHz a ete specialement installe sur un batiment de recherche de 22 pi au moyen d'une cage de transducteurs unique. Le systeme peut etre utilise a une vitesse de 4 noeuds, ce qui permet de couvrir rapidement de grandes etendues du fond. Des images de section provenant d'un corps remorque (video et balayage lateral) servent a valider les donnees de l'echo-sondeur a l'egard de la realite du terrain, ce qui permet de creer des classes et des cartes d'habitats benthiques. Toutes les donnees de positionnement sont recueillies en qualite DGPS (precision submetrique). Reproduced with the permission of Her Majesty the Queen in Right of Canada, 2015.

Vandermeulen, H. 2011. Mapping the nearshore using a unique towfish. Can. Tech. Rep. Fish. Aquat. Sci. 2959: 1-18.

Abstract: The specifications and design of a towfish system are described for shallow water use. The towfish contains a color video camera, high frequency sidescan and positioning transponder. The towfish offers rapid 'transect' views of the bottom useful for describing habitat classes. The towfish is unique in that the video acts as a ground truth for the sidescan imagery in real time. The transponder on the towfish interacts with a transceiver mounted to the vessel hull to produce positional data to dGPS specifications (sub-meter precision). All video is georeferenced and stored as digital video clips in MapInfo GIS projects which also include towfish tracks and high frequency sidescan images (330 kHz, 30 m swath). The GIS projects can be used to generate habitat maps.

Original Abstract: Les specifications et la conception d'un systeme de corps remorque destine a une utilisation en eaux peu profondes sont decrites. Le corps contient une camera video couleur, un sonar a balayage lateral haute frequence et un transpondeur de positionnement. Il permet d'obtenir rapidement des vues de du fond qui sont utiles pour decrire les classes d'habitats. Le corps remorque est unique en ce que les images video servent a valider l'imagerie a balayage lateral en temps reel a l'egard de la realite du terrain. Le transpondeur du corps remorque interagit avec un emetteur-recepteur monte sur la coque du batiment pour produire des donnees de positionnement de qualite DGPS (precision submetrique). Toutes les images video sont georeferencees et stockees sous forme de sequences video dans des projets de SIG MapInfo, qui contiennent egalement les trajectoires du corps et les images a balayage lateral haute frequence (330 kHz, couloir de 30 m). Le projet de SIG peut servir a generer des cartes d'habitat. Reproduced with the permission of Her Majesty the Queen in Right of Canada, 2015.

Volgin, A. V. and J. M. Woodside. 1996. Side scan sonar images of mud volcanoes from the Mediterranean Ridge: Possible causes of variations in backscatter intensity. Mar. Geol. **132**:39-53.

Abstract: A survey of a large field of mud diapirs on the Mediterranean Ridge south of Crete was carried out using both OKEAN (9.5kHz) and MAK-1M (30kHz) sidescan sonar systems during Leg-2 of the Third Training Through Research cruise of R/V Gelendzhik in June and July, 1993. High backscatter intensities were recorded by both systems to different degrees over the mud diapirs and their immediate surroundings. Causes of variations in the backscatter intensity are considered to be the spatial distribution of mud breccia associated with the mud domes (both the burial depth of the mud breccia beneath hemipelagic drape and its areal extent) and its physical properties, along with

contributions from seafloor roughness and the topography of the mud domes. Significant sources of volume scattering of the sidescan sonar sound signal are considered to be mud breccia inhomogeneities represented by millimetric/centimetric clasts of various lithologies and free gas bubbles distributed through the mud matrix. A good general relationship is established between these sources and the observed backscatter variations through analysis of ground truth data from core samples, with 5kHz deep-tow subbottom profiler records and seafloor video observations as well as the sidescan sonar records; but a fully quantitative assessment of this relationship would require acoustic modelling and additional ground truth data. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

von Szalay, P. G. and R. A. McConnaughey. 2002. The effect of slope and vessel speed on the performance of a single beam acoustic seabed classification system. Fish. Res. Amsterdam **56**:99-112.

Keywords: QTC VIEW, acoustic seabed classification, bottom types, bottom slope, vessel speed

Abstract: Although the emergence of an acoustic single beam seabed classification system appears promising as a cost-effective tool to acquire information about bottom types, some limitations of this technology with respect to vessel speed and rough terrain have been identified. To further refine this technology, we examined the QTC View system to determine if it would work in an area such as the Gulf of Alaska, which is characterized by deep water, steep slopes, heterogeneous substrate. Studies were undertaken to evaluate the operational limits with respect to vessel speed and bottom slope. Results indicate that speeds between 3 and 12kn have no significant effect on classification performance, but bottom slopes exceeding approximately 5-8° appear to cause a complete breakdown in classification accuracy. The potential of trawl-mounted sonar systems, currently under evaluation, as a potential solution to expanded range of operation over bottom slopes is discussed. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

von Szalay, P. G. and D. A. Somerton. 2009. A comparison of acoustic backscatter between a trawling and a free-running vessel for eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Fish. Res. (Amsterdam) **96**:223-229.

Keywords: fish reactions, trawling, free-running, bottom trawl surveys, acoustic backscatter

Abstract: High-quality acoustic backscatter is continuously collected with Simrad ES-60 echosounders during the annual eastern Bering Sea (EBS) bottom trawl survey. Scientists at the Alaska Fisheries Science Center are examining the potential of

combining the acoustic backscatter data collected between trawl stations with the trawl catch data to improve the precision of the survey index of walleye pollock (*Theragra chalcogramma*) abundance. A previous study we conducted [von Szalay, P.G., Somerton, D.A., Kotwicki, S., 2007. Correlating trawl and acoustic data in the eastern Bering Sea: a first step toward improving biomass estimates of walleye pollock (*Theragra chalcogramma)* and Pacific cod (*Gadus macrocephalus*)? Fish. Res. 86, 77-83.] showed a high correlation between walleye pollock trawl catches and simultaneously collected acoustic backscatter; in this study, we compared walleye pollock acoustic backscatter collected while trawling at 3 knots with that of a free-running vessel traveling at 10 knots. Acoustic data were collected by two vessels during the 2006 and 2007 EBS bottom trawl surveys in a pair-wise fashion at 134 trawl stations. The free-running transects were conducted either immediately before or immediately after the trawl hauls and were parallel to the trawl paths but offset by approximately 250m. The pollock acoustic backscatter was significantly greater for the trawling vessel in both the layer below the headrope and in the layer above the headrope, and was independent of the order in which the trawling and free-running transects were performed. A comparison of the seabed echo between trawling and free-running did not show a significant difference, suggesting that the discrepancy in the pollock backscatter is due to differences in fish behavior and not to differences in vessel attitude between the two operational modes. The higher backscatter values associated with trawling may be due to reactions of fish within a school that produce a coordinated swimming response, which has the potential to increase the average target strength. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Weber, T. C., C. Rooper, J. Butler, D. Jones, and C. Wilson. 2013. Seabed classification for trawlability determined with a multibeam echo sounder on Snakehead Bank in the Gulf of Alaska. Fish. Bull., U.S. **111**:68-77.

Keywords: trawlable, variability, backscatter, video, multibeam

Abstract: Rockfishes (*Sebastes* spp.) tend to aggregate near rocky, cobble, or generally rugged areas that are difficult to survey with bottom trawls, and evidence indicates that assemblages of rockfish species may differ between areas accessible to trawling and those areas that are not. Consequently, it is important to determine grounds that are trawlable or untrawlable so that the areas where trawl survey results should be applied are accurately identified. To this end, we used multibeam echosounder data to generate metrics that describe the seafloor: backscatter strength at normal and oblique incidence angles, the variation of the angle-dependent backscatter strength within 10° of normal incidence, the scintillation of the acoustic intensity scattered from the seafloor, and the seafloor rugosity. We used these metrics to develop a binary classification scheme to estimate where the seafloor is expected to be trawlable. The multi-beam echosounder data were verified through analyses of video and still images collected with a stereo drop camera and a remotely operated vehicle in a study at Snakehead Bank, similar to

100 km south of Kodiak Island in the Gulf of Alaska. Comparisons of different combinations of metrics derived from the multibeam data indicated that the oblique-incidence backscatter strength was the most accurate estimator of trawlability at Snakehead Bank and that the addition of other metrics provided only marginal improvements. If successful on a wider scale in the Gulf of Alaska, this acoustic remote-sensing technique, or a similar one, could help improve the accuracy of rock-fish stock assessments.

Wever, T. F., H. M. Fiedler, G. Fechner, F. Abegg, and I. H. Stender. 1997. Side-scan and acoustic subbottom characterization of the sea floor near the Dry Tortugas, Florida. Geo-Mar. Lett. **17**:246-252.

Keywords and abstract are not provided as requested by Springer Publishing. Please visit the link below for the keywords and abstract.

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Whitmire, C. E., W. W. Wakefield, R. W. Embley, S. G. Merle, and B. N. Tissot. 2004. A Quantitative Approach for using Multibeam Sonar Data to Map Benthic Habitats. Journal of the Acoustical Society of America **116**:2486.

Keywords: acoustical properties, backscattering, cameras, reflectivity, remotely operated underwater vehicles

Abstract: Dramatic declines in abundance of several demersal species of fish off the US west coast have resulted in their designation as "overfished" (*i.e.,* <25% of unfished biomass). The causes of those declines are not clearly understood, and there are only limited abundance data for many other demersal species. One challenge in designing a systematic survey for these species is that many of them associate with heterogeneous seabeds of varying relief. In many areas, the rugged seabed topography precludes sampling by conventional survey techniques (*e.g.*, bottom trawl). For this reason, direct count surveys using submersibles and Remotely Operated Vehicles (ROVs) have been used to enumerate demersal fishes in situ. However, enumeration is limited to a narrow swath of seafloor visible from submersibles or ROVs, and there is often no spatial context to extrapolate density estimates to larger geographic areas. To facilitate such extrapolations, seabed characteristics observed from an ROV were analyzed in the context of multibeam sonar data to map three benthic habitats on a large rocky bank off the central Oregon coast known as Heceta Bank. Because sediment texture (*e.g.*, boulders) and topographic relief (*e.g.*, rock outcrops) have been shown to correlate with demersal fish distributions, habitat classes were optimized for a biological component of interest (i.e., groundfish). The observed seabed characteristics were extrapolated over the extent of a multibeam sonar survey using backscatter and quantitative parameters derived from high-resolution bathymetric imagery. The resultant map predicts the

extents of Rock Outcrop (high vertical relief), Boulder/Cobble (high acoustic reflectivity) and Mud/Sand (unconsolidated).

Williams, A., R. Moser, and B. Barker. 2004. Mapping, understanding and managing fishery habitat: a case study of the commercial pink ling (*Genypterus blacodes: Ophidiidae*) off SE Australia. In Proceedings of the International Council for the Exploration of the Sea, Copenhagen, Denmark.

Keywords: stock assessment, seafloor mapping, habitat, classification, cameras, submarine canyons, fishery management, ecological distribution, multibeam

Abstract: Benthic habitats of the upper continental slope seabed (similar to 200-700 m depth) off SE Australia are being surveyed for the first time using multi-beam acoustics, video cameras and physical samplers. Research is presently focused on developing multi-scale mapping methods to support the needs of regional, ecosystem-based, marine management plans being developed under Australia's Oceans Policy. Early survey results show immediate application to one aspect of this integrated planning structure: the understanding and management of 'fishery habitat'. A survey of the Big Horseshoe submarine canyon - one of the region's prime fishing grounds - demonstrated the multi-scale association of the commercial pink ling with benthic habitats. In this paper we provide a visualization of these associations using terrain maps generated by multibeam acoustics, together with video images and physical samples, and set in the context of a hierarchical habitat classification framework. Within this framework, benthic habitats are discussed in relation to their ecological role for pink ling, their use by commercial fishers as 'trawl' and 'non-trawl' fishing grounds, the impacts resulting from fishing, and the integration and interpretation of this information for spatial management of fishing effort.

Wilson, M. F. J., B. O'Conneli, C. Brown, J. C. Guinan, and A. J. Grehan. 2007. Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope. Mar. Geod. **30**:3-35.

Keywords: multibeam bathymetry, terrain analysis, scale, habitat suitability modelling, continental slope

Abstract: Multibeam surveys can provide detailed bathymetry data for the continental slope from which quantitative descriptors of the seabed terrain (*e.g.,* slope) may be obtained. We illustrate the value of these descriptors for benthic habitat mapping, and highlight the advantages of multiscale analysis. We examine the application of these descriptors as predictor variables for species distribution models, which are particularly valuable in the deep sea where opportunities to directly survey the benthic fauna remain limited. Our initial models are encouraging and suggest that wider adoption of these methods may assist the delivery of ecologically relevant information to marine resource managers.

Link: http://www.tandfonline.com/doi/full/10.1080/01490410701295962

Woodside, J. M. and A. V. Volgin. 1996. Brine pools associated with Mediterranean Ridge mud diapirs: An interpretation of echo-free patches in deep tow side scan sonar data. Mar. Geol. **132**:55-61.

Keywords: diapirs, side scan sonar, brines, backscatter, grazing angle

Abstract: MAK-1M deep tow sidescan sonar surveys have revealed two echo-free patches in an area of mud diapirs on the Mediterranean Ridge. The unusual shape of these patches and absence of returned signal can be explained more easily by the presence of brine pools rather than as a topography effect. The high acoustic impedance contrast at the interface between brine and seawater, a result of the salinity contrast there causing a relatively high contrast in sound velocity and water density, acts as a screen preventing sidescan sonar sound signal at low grazing angles from reaching the seafloor. Sound is reflected and refracted away from the sonar towfish without any backscatter. The inferred brine pools appear to be associated with faults recognized on sonographs and subbottom profiler records. This first observation of brine pools related to mud volcanoes and mud diapirs suggests that salt is present in areas of mud diapirism, possibly playing a role in that process, or at least that the brines and mud may share flow paths within the Mediterranean Ridge. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Wu, S., J. Guo, and H. Tokuyama. 2005. Sedimentary processes in Zenisu deep-sea channel revealed by side-scan imagery. Chin. J. Oceanol. Limnol. **23**:368-375.

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Yeung, C., and R. A. McConnaughey. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES J. Mar. Sci. **65**:242-254.

Keywords: acoustic backscatter, benthic invertebrates, Bering Sea, groundfish, habitat, trawl survey

Abstract: Environmental variables that are ecologically relevant and easily measured over large areas are useful for modelling species distributions and habitats. Continuous acoustic, sonar-backscatter data convey information about physical properties of the seabed, and hence could be a valuable addition to that suite of

variables. We tested the potential utility of acoustic backscatter for improving habitat models of marine species using data from a pilot sidescan-sonar survey. Raw digital-backscatter data were processed with QTC SIDEVIEW and CLAMS software. Resultant acoustic variables - - Q - values (Q1, Q2, and Q3), representing the first three principal components of the data derived from image analysis of backscatter echoes, and a complexity metric (compx) measuring the variance of Q-values in a geographic area--were used in multiple linear regression to model individual species abundance from bottom-trawl survey data. Habitat models for flathead sole (*Hippoglossoides elassodori),* Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), red king crab (*Paralithodes camtschaticus*), basket star (*Gorgonocephalus eucnemis*), and sponges (*Porifera*) included acoustic variables as significant predictors. For these six taxa, full models explained 67-86% of variability in abundance, with 9-54% of that total contributed by the acoustic predictors, suggesting that acoustic data could advance habitat research for some bottom-associated marine species. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Yoklavich, M. M., H. G. Greene, G. M. Cailliet, D. E. Sullivan, R. N. Lea, and M. S. Love. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: an example of a natural refuge. Fish. Bull., U.S. **98**:625-641.

Keywords: habitat, rockfish, bathymetric, side-scan sonar, video, species composition, species abundance

Abstract: A multidisciplinary assessment of benthic rockfishes (genus *Sebastes*) and associated habitats in deep water was conducted in Soquel Submarine Canyon, Monterey Bay, California. Rock habitats at depths to 300 m were identified by using bathymetric and side-scan sonar imaging, verified by visual observations from a manned submersible, mapped and quantified. Species composition, abundance, size, and habitat specificity of fishes were determined by using a video camera and parallel laser system along transects made by a submersible. We counted 6208 nonschooling fishes representing at least 52 species from 83 10-min strip transects that covered an estimated 33,754 m^2. Rockfishes represented 77% of the total number of individuals, and included a minimum of 24 species. Six distinct habitat guilds of fishes were manifest from habitat-based clustering analysis: small species were associated with mud and cobble substrata of low relief, and larger species of rockfishes were associated with high-relief structures such as vertical rock walls, ridges, and boulder fields. There was remarkable concordance between some of the guilds identified in Soquel Canyon and the results of other habitat-specific assessments of fishes along the west coast of the United States from central California to Alaska. These generalities are valuable in predicting community structure and evaluating changes to that structure, as well as in applying small-scale species-habitat relationships to broader-scale fishery resource surveys. Additionally, establishment of these groups is critical when incorporating the

concept of essential fish habitat (EFH), and negative impacts to it, into the management of fisheries in relatively deep water, as required by the Sustainable Fisheries Act of 1996. High numbers of large rockfishes (e.g. *Sebastes chlorostictus*, S. *levis*, S. *rosenbblatti*, and S. *ruberrimus*) were locally associated with rock ledges, caves, and overhangs at sites having little or no evidence of fishing activity. Abundance and size of several species were lower at fished than at unfished sites. We suggest that rock outcrops of high relief interspersed with mud in deep water of narrow submarine canyons are less accessible to fishing activities and thereby can provide natural refuge for economically important fishes, as exemplified in Soquel Canyon.

Young, M. A., P. J. Iampietro, R. G. Kvitek, and C. D. Garza. 2010. Multivariate bathymetry-derived generalized linear model accurately predicts rockfish distribution on Cordell Bank, California, USA. Mar. Ecol. Prog. Ser. **415**:247-261.

Keywords: ecosystem-based management, rockfish, groundfish, GLMs, marine protected area, fishery management

Abstract: Accurate efficient estimation of actual and potential species distribution is a critical requirement for effective ecosystem-based management and marine protected area design. In this study we tested the applicability of a terrestrial landscape modeling technique in a marine environment for predicting the distribution of ecologically and economically important groundfish, using 3 species of rockfish at Cordell Bank National Marine Sanctuary (CBNMS) as a model system. Autoclassification of multibeam bathymetry along with georeferenced submersible video transect data of the seafloor and demersal fishes were used to model the abundance and distribution of rockfish. Generalized linear models (GLMs) were created using habitat classification analyses of high-resolution (3 m) digital elevation models combined with fish presence/absence observations. Model accuracy was assessed using a reserved subset of the observation data. The resulting probability of occurrence models generated at 3 m resolution for the entire 120 km^2 study area proved reliable in predicting the distribution of all the species. The accuracies of the models for *Sebastes rosaceus, S. flavidus* and *S. elongatus* were 96, 92 and 92%, respectively. The probability of occurrence of S. flavidus and S. rosaceus was highest in the high relief rocky areas and lowest in the low relief, soft sediment areas. The model for S. elongatus had an opposite pattern, with the highest predicted probability of occurrence taking place in the low relief, soft sediment areas and a lower probability of occurrence in the rocky areas. These results indicate that site-specific and species-specific algorithmic habitat classification applied to high-resolution bathymetry data can be used to accurately extrapolate the results from *in situ* video surveys of demersal fishes across broad areas of habitat. The citations and abstracts are from Aquatic Sciences and Fisheries Abstracts (ASFA) and are provided with permission of ProQuest LLC. Further reproduction is prohibited.

Young, M. A., R. G. Kvitek, P. J. Iampietro, C. D. Garza, R. Maillet, and R. T. Hanlon. 2011. Seafloor mapping and landscape ecology analyses used to monitor variations in

spawning site preference and benthic egg mop abundance for the California market squid (*Doryteuthis opalescens*). J. Exp. Mar. Biol. Ecol. **407**:226-233.

Keywords: ecosystem based management, marine protected areas, no-take zones, reproduction, sidescan sonar, squid fishery

Abstract: The California squid fishery is concentrated largely on nearshore squid spawning aggregations. Because of this practice a central concern for sustainable squid fisheries in California is to determine whether reproductive activities and subsequent egg laying occur at rates that are sufficient to support harvestable populations of this sub-annual species. Using high-resolution data collected via acoustic mapping methodology, we estimated a 99% decrease in egg mops abundance from 2005 to 2007. Sidescan sonar images from detailed benthic mapping suggest that although squids prefer a sandy substrate as their primary egg mop habitat, the depths across which egg mops were distributed differed significantly between surveys and spatial distribution of egg mops varied across years on this large spawning ground. Our results suggest that sidescan sonar surveys could serve as an important tool used to aid sustainable management of the California market squid fishery through the monitoring, designation and adaptive management of seasonally variable no-take spawning zones and can help in developing stock assessments of this commercially important species.

Zhou, X., and Y. Chen. 2004. Seafloor sediment classification based on multibeam sonar data. Geo-Spatial Information Science Quarterly/Diqiu Kongjian Xinxi Kexue Xuebao **7**:290-296.

Keywords: seafloor classification, multibeam sonar, backscattering strength, sonar images

Abstract: The multibeam sonars can provide hydrographic quality depth data as well as hold the potential to provide calibrated measurements of the seafloor acoustic backscattering strength. There has been much interest in utilizing backscatters and images from multibeam sonar for seabed type identification and most results are obtained. This paper has presented a focused review of several main methods and recent developments of sea-floor classification utilizing multibeam sonar data or/and images. These are including the power spectral analysis methods, the texture analysis, traditional Bayesian classification theory and the most active neural network approaches.

Link: http://www.tandfonline.com/doi/abs/10.1007/BF02828555

Zitter, T. A. C., C. Huguen, and J. M. Woodside. 2005. Geology of mud volcanoes in the eastern Mediterranean from combined side scan sonar and submersible surveys. Deep-Sea Res. (Part I, Oceanographic Research Papers) **52**:457-475.

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310   GUTHRIE, C. M. III, HV. T. NGUYEN, and J. R. GUYON. 2016. Genetic stock composition analysis of the Chinook salmon bycatch from the 2014 Bering Sea walleye pollock (Gadus chalcogrammus) trawl fishery, 25 p. NTIS No. PB2016-101397.

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