Preface

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Introduction

This volume reports upon the results of marine seabed mapping papers and posters presented at GeoHab conferences held between 2002 and 2006. GeoHab is a scientific organization conceived in Bergen, Norway in 2001 at a seabed survey technology workshop hosted by Thomas Noji, then at the Norwegian Institute of Marine Research. The Bergen workshop was followed by a special session on marine habitat mapping held at the 2001 Geological Association of Canada (GAC) conference in St. John's, Newfoundland, Canada. This GAC special session represents the first formal GeoHab conference. Therefore, it is fitting that the first published results of GeoHab conferences be issued as a Special Paper of the GAC. Following the St. John's meeting, GeoHab has convened conferences each year during the first week of May at Moss Landing, California, USA (2002), Hobart, Tasmania, Australia (2003), Galway, Ireland (2004), Sidney, British Columbia, Canada (2005), Edinburgh, Scotland, UK (2006) and Nouméa, New Caledonia (2007).

The objective of GeoHab is to provide an annual forum in which marine physical and biological scientists report upon the results of mapping and characterizing marine benthic habitats and engage in constructive dialog of mutual interest. The formation of GeoHab in 2001 was timely and constructive because of the emerging cross-disciplinary scientific field of marine benthic habitat mapping and characterization, an emergence primarily accelerated through the development of new technologies that allowed for complete and detailed imaging of the seafloor. Participation in GeoHab has increased substantially over the past years with the inclusion of managers and policy makers.

This book is divided into chapters; seafloor imaging and mapping technologies, seafloor mapping techniques, habitat classification schemes, marine habitat mapping case histories, seafloor disturbances, and marine policy. The papers presented in this volume represent the latest results in the field of marine benthic habitat mapping, characterization, and application. We hope that you find the assemblage of papers here useful, as it is our intent to contribute a work that can be used for general information and as a supplement to education wherever courses on marine mapping techniques and habitat characterization are being offered.

Modern Technologies

The four papers presented in this chapter address technologies that are emerging marine and coastal mapping tools. Detailed discussion of commonly-used tools such multibeam and sidescan sonar systems are not presented because they have been described in other publications and are referenced in many of the papers in the following chapters.

This chapter starts with a paper by Craig J. Brown entitled *Seafloor Imagery, Remote Sensing and Bathymetry: Acoustic Ground Discrimination Systems (AGDS)*, which describes the modification of single-beam echo sounders to determine seafloor geophysical properties to produce marine benthic habitat maps based on the principle that different substrates will display different acoustical signatures. The systems described measure properties of the returning echo or returning multiple echoes. The two systems specifically evaluated in this paper are RoxAnn™ and Quester Tangent Corporation (QTC™).

The second paper, *Satellite and Airborne Imagery Including Aerial Photography for Benthic Habitat Mapping* by Arnold Dekker, Richard Mount and Alan Jordan, assesses the capabilities and limitations of current airborne and satellite remote sensing techniques used for benthic habitat mapping and monitoring. The authors state that there is a "complex interaction between the often heterogeneous structure of the habitats and the classification approach taken". The paper addresses techniques for processing and interpretation of small-format and standard aerial photography using film and digital cameras and satellite and airborne digital mulispectral satellite sensors (*e.g.*, Landsat, Quickbird, IKONOS) and airborne hyperspectral sensors (*e.g.*, CASI™, HyMap™).

The third paper, *Canadian Imaging and Sampling Technology for Studying Benthic Habitat and Biological Communities* by D.C. Gordon Jr., D.L. McKeown, G. Steeves, W.P. Vass, K. Bentham and M. Chin-Yee, describes a suite of tools constructed at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, Canada, that has been used to image and sample the continental shelf seabed. These tools consist of *Towcam*, a towed camera sled that collects video and periodic still photos, *Campod*, an instrumented tripod with video and 35 mm still cameras attached, and *Videograb*, a hydraulically-operated device that photographs the seafloor prior to taking a sample. Descriptions of how these tools are used to characterize and map benthic habitats and biological communities over large areas are presented.

Concluding this chapter is a paper entitled *Automated Textural Image Analysis of Seabed Backscatter Mosaics: A Comparison of Four Methods* by R.D. Müller, S. Eagles, P. Hogarth and M. Hughes. The authors describe four different approaches to automatically analyze acoustic backscatter data for sediment and substrate identification. One method is based on the use of GeoAcoustic's software GeoTexture™ trained to use statistical methods for the generation of maps, while a second method uses the wavelet-domain utilizing Hidden Markov Models (HMM) and uses a Bayesian method for image segmentation. A neural network-based method, utilizing two different techniques for feature extraction, was used for the third and fourth approaches. One of these methods uses a space-domain based on grey-level run-length features compared to another method, which uses a Grey-Level Co-occurrence Iteration Algorithm (GLCIA). The four methods presented in this paper are compared and contrasted.

Mapping Techniques

This chapter presents five papers that describe various techniques used in mapping marine benthic habitats. The papers address unique technologies and focus on various methods used to map seafloor features.

The initial paper in this chapter, *Mosaics of Benthic Habitats using Laser Line Scan Technology*, addresses the use of Laser Line Scan (LLS) technology in producing images for habitat mapping. The authors, Mark R. Amend, Mary M. Yoklavich, Yuri Rzhanov, Churchill B. Grimes and W. Waldo Wakefield, consider LLS as an intermediate step between imaging habitats with remotely-sensed geophysical systems and *in situ* methods using video from Remotely Operated Vehicles (ROV) or submersibles. Although LLS has not gained wide acceptance as an economical mapping tool, primarily because of the limited number of systems available, these authors see potential in the future use of such systems, especially if improvements to data processing and geometric translation can be accomplished.

The paper, *A Rapid Method to Characterize Seabed Habitats and Associated Macro-organisms* by Tara J. Anderson, Guy R. Cochrane, Dale A. Roberts, Hank Chezar and Gerry Hatcher describes a new method by which the collection, processing and interrogation of abiotic and biotic seabed data can be rapidly accomplished to determine seabed habitat classifications. A small camera sled was used to ground-truth a sidescan sonar mosaic that was done in near real-time mode to produce habitat maps.

Ole Christensen, Oddvar Longva, Terje Thorsnes and Arnfinn Karlsen, in their paper *Marine Facies Mapping using Multibeam Backscatter*, compare mapping substrate types using an automatic classification method with a manual classification method on backscatter images. The comparison was done to determine cost and expediency in producing habitat maps. Documentation of facies types was done with a video-assisted grab sampler and free-fall penetrometer.

The fourth paper, *Exploratory Surveys of Seabed Habitats in Australia's Deep Ocean using Remote Sensing – Needs and Realities* by R.J. Kloser, A. Williams and A.J. Butler, presents an evaluation of the utility of mapping benthic terrain for management purposes at a scale of 1–10 km based on detailed multibeam sonar bathymetry and backscatter datasets. The maps these authors produced are segmented by depth, bathymetry-contrast, slope and backscatter; the maps are assessed for ecological significance by using video and physical samplers. The authors conclude that benthic terrains potentially could provide important surrogates for the distribution of general faunal groups.

The final paper in this chapter, *A Quantitative Approach for using Multibeam Sonar Data to Map Benthic Habitats*, by Curt E. Whitmire, Robert W. Embley, W. Waldo Wakefield, Susan G. Merle and Brian N. Tissot, addresses the use of multibeam sonar images and seabed characteristics observed from an ROV to map three major groundfish habitats on Heceta Bank, Oregon, USA. The bank consists of high-relief rock outcrop, boulder and cobble fields, and unconsolidated sediment (mud and sand). To refine these habitat types, the authors used spatial analysis tools within a Geographical Information System (GIS) to produce slope and topographic position indices to enhance the interpretation of the habitat types. Based on this work, the authors generated a "habitat prediction map".

Classification Schemes

Marine benthic habitat classification schemes have evolved considerably with the advancement of seafloor mapping technology. With the increasing production of habitat maps occurring today, a standard habitat classification scheme is being sought by the users of these maps. The authors of the seven papers comprising this chapter present various habitat-mapping schemes that are being used in Australia, England, Canada, and the USA. Both shallow-water and deep-water schemes are presented, along with various methods to produce different renditions of habitat types that may be useful to specific problems.

The first paper in this chapter, *Marine Classification, Mapping, and Biodiversity Analysis*, by Christopher B. Cogan and Thomas T. Noji, focuses on what the authors label "drifting terminology" and emphasizes the need for biodiversity assessment. They outline "how habitat classification systems and marine benthic habitat mapping are logical predecessors to measures of biodiversity". From the authors' perspective, they state that an important and useful research goal is "to measure and map marine biodiversity as a dynamic process while working with a variety of spatial scales and ecological indicators in an ecoregion context".

H. Gary Greene, Joseph J. Bizzarro, Victoria M. O'Connell and Cleo K. Brylinsky, in their paper *Construction of Digital Potential Marine Benthic Habitat Maps using a Coded Classification Scheme and its Application*, present a method that can be used in a GIS to attribute seafloor conditions as potential habitat types. The intent of the authors is to illustrate a mapping method that has been used for the past 15 years primarily to map groundfish habitats, but can be used for other types of habitat mapping as well. The habitat scheme was developed to facilitate reproducibility of habitat designations and comparisons of deep-water marine benthic habitats worldwide.

The third paper, *Addressing Spatial Uncertainty in Mapping Southern Australian Coastal Seabed Habitats* by Vanessa Halley and Alan Jordan, describes a process for attributing shallow water (<50 m deep) seabed habitats using a hierarchical classification system and a single-beam acoustic and aerial photographic dataset. The survey work was done offshore Tasmania and its design, along with attribution and cartographic decision rules used in the analyses of the data, are discussed in the paper. A spatial data model was applied to the results of the interpretation to minimize uncertainty; the need to assess and document the uncertainly is discussed.

In their paper, *Process-Driven Characterization and Mapping of Seabed Habitats*, Vladimir E. Kostylev and Charles G. Hannah demonstrate a method for creating seabed habitat maps using the habitat template approach to integrate multiple environmental fields of readily-available oceanographic data into a single map. The authors recognized that practical constraints on traditional geological, geophysical and biological observations, and on mapping of large extents of seabed, such as continental shelves, called for the development of new approaches to habitat characterization. Their mapping of the Scotian Shelf and Bay of Fundy on the Canadian Atlantic margin shows the distribution of habitats where organisms with particular life history traits are likely to flourish. Maps of this type enable the prediction of spatial patterns of benthic habitats and thus provide a framework for integrated management of ocean uses.

The paper, *A Framework for a Coastal/Marine Ecological Classification Standard (CMECS)* by Christopher J. Madden and D.H. Grossman, preceded and introduced by a Prologue, *An Introduction to a New Coastal Marine Ecological Classification Standard: The Emerging Conceptual Framework* by R.J. Alee, attempts to standardize marine and coastal habitat classification within the National Oceanographic Atmospheric and Administration (NOAA) of the USA as well as internationally. Madden and Grossman present a classification system that "provides a framework for organizing knowledge about coasts and oceans and their living systems". A hierarchical scheme is provided that can be used in the synthesis of data to evaluate and compare information across the national landscape and seascape. Thus, the Coastal/Marine Ecological Classification Standard (CMECS) presented by the authors can be applied to estuaries, coasts and oceans.

S.L. Philpott, J.W.C. James, C.V.L. Paulton, E.J. Bee, C. Graham and L. Jones contribute a paper entitled *The use of Geological Data in Developing a Framework for the Mapping of Marine Habitats on a National Scale in English Waters* that is "based on the premise that physiographic features, which include geology, sediment and morphology of the seabed, greatly influence the distribution and range of species and biological communities". Under the requirement of the European Union Habitats Directive, a GIS database was established with the primary layer designated seabed features; this layer shows the distribution of rock and sediment on the seafloor and this distribution can be used to influence the establishment of Special Areas of Conservation.

The final paper in this chapter is *Development of a Regional Seafloor Surficial Geologic Habitat Map for the Continental Margins of Oregon and Washington, USA* by Christopher G. Romos, Chris Goldfinger, Rondi Robison, Randall L. Milstein, Jason D. Chaytor and W. Waldo Wakefield. These authors use a refined form of "classical geologic interpretation techniques" to map regional physiographic and lithologic habitats of bottom dwelling (demersal) fishes. Based on the interpretations of marine geophysical and geological datasets, the authors construct surficial geologic habitat maps within a GIS. A unique method of assessing habitat mapping accuracy is presented using quality layers within a GIS that capture relative values of each dataset used in the mapping and ultimately distinguishes between "data-rich" and "data-poor" areas.

Case Histories

The nine papers of this chapter cover various habitat characterization studies, ranging from mapping benthic fisheries habitats to sponge reefs and corals, with the use of geophysical data, sediment samples and video. These studies report upon surveys done in temperate to high latitudes. Mapping case histories are significant in that they illustrate how diverse technologies and methods are used to map habitats specific to resource challenges such as declining fisheries, adverse impacts to habitats, and the establishment of Marine Protected Areas (MPA) to sustain or conserve living marine resources.

The first paper in this chapter, *Geophysical Variables as Predictors of Megabenthos Assemblages from the Northern Great Barrier Reef, Australia*, by R.J. Beaman and P.T. Harris, used multi-statistical analyses to evaluate the relationship between sediment, geomorphology, and the benthos. Using multibeam sonar data, the authors determined that geophysical variables of slope and gravel percentage were the best predictors for megabenthos assemblage patterns. A hierarchical habitat-mapping scheme to the Secondary Biotope and Biological Facies level was applied at a <10 m scale. The authors felt confident that geology, sediment and morphology could be used as predictors for benthos distribution, which then could be used for marine reserve selection.

Kim W. Conway, J. Vaughn Barrie and Manfred Krautter, in their paper *Complex Deep Shelf Habitat: Sponge Reefs in the Pacific Northwest*, present a case history on mapping siliceous (hexactinellid) sponge reefs that form distinct biological communities dominated by low-diversity assemblages of glass sponges. These reefs were mapped using high-resolution, deep-towed, single-channel seismic reflection profilers, conventional hull-mounted profilers, sidescan sonar, and multibeam swath bathymetry systems. The sponge reefs, which can attain a height of 21 m above the seafloor, have acoustic signatures that are distinctive and readily identifiable and this signature has been used to map reef distributions.

In the third paper, *The Offshore Edgecumbe Lava Field, Southeast Alaska: Geologic and Habitat Characterization of a Commercial Fishing Ground*, by H. Gary Greene, Victoria M. O'Connell, W. Waldo Wakefield and Cleo Brylinsky, a case study is presented on habitat characterization of a fisheries area where the target species are rockfishes. These authors describe the mapping of habitats using a towed sidescan sonar and swath interferometry bathymetry system. The fishing ground is comprised of lava flows, volcanic cones and plutonic rock outcrops that were clearly imaged in the geophysical data. To verify the habitat types and determine the abundance of fish in relationship to different substrate types, *in situ* observations and video transects were made using the manned submersible *Delta*. The information collected and mapped during this study is used directly to improve current fishery stock assessment.

The fourth paper, *Habitat Mapping of a Cold-water Coral Reef off Norway: A Comparison of Visual and Computer-assisted Methods to Interpret Sidescan Sonar Data* by V. Hühnerbach, Ph. Blondel, V.A.I. Huvenne and A. Freiwald, describes a high-resolution sidescan sonar study of deep-water *Lophelia pertusa* coral reef structures. These structures were observed *in situ* through underwater videos and with the use of the manned submersible *JAGO*. Interpretations of the sidescan sonar data resulted in the production of a "facies map that delineates different potential habitats within the coral reef environment, *e.g.*, live coral reef, dead and sediment-covered coral". In addition, a computer-assisted image analysis was undertaken to improve interpretation of the sidescan sonar data in an attempt to reveal patterns not visible to the human eye. These authors conclude that "visual and computer-assisted interpretations should be used as complimentary tools".

The following paper by I. McLeod, T.D. Skewes, S.R. Gordon and C.R. Pitcher, titled *A Method for Seabed Habitat Mapping: Integrating Acoustic Information with Biogeophysical Observations; Case Study – Scott Reef*, addresses characterization of seabed habitats through the use of digital echo-sounder data that were verified using towed video information. A hierarchical classification system was used to describe biological (epibenthos) and geological (substrate) characteristics. The authors used statistical indices, approximately equivalent to seabed roughness and hardness, to produce an acoustic index that was then interpolated to produce a seabed habitat map.

The sixth paper, *The use of Geophysical Survey Data in Fisheries Management: A Case History from Southeast Alaska* by Victoria O'Connell, Cleo Brylinsky and H. Gary Greene, addresses the management benefits of mapping seafloor habitats with the use of acoustical geophysical systems. Using sidescan sonar and multibeam sonar bathymetry and backscatter data, these authors mapped the distribution of rugged rock outcrops that are a key habitat for commercially-targeted yelloweye rockfish (*Sebastes rubberimus*). In the management of this species, the biomass is derived as a product of density, average weight, and area of habitat with density obtained by line-transects using the manned submersible *Delta*. These transects were also used to verify habitat types characterized with the geophysical data and areas of habitat derived from the habitat maps. Logbook information from the yelloweye rockfish fishery was also used to confirm prime habitats.

Alexandra L. Post, Laura Sbaffi, Vicki Passlow and Dylan C. Collins, in their paper *Benthic Foraminifera as Environmental Indicators in Torres Strait–Gulf of Papua*, describe a unique case study where benthic foraminifera appear to provide a detailed assessment of habitat types where the habitats are sedimentary deposits, both relict and modern. Using a multivariate technique, these authors analyzed relationships between environmental attributes and distributions of micro-biota and foraminiferal species. This technique indicated that factors such as percent carbonate mud, percent gravel, benthic productivity, temperature, salinity and grain size were important in addition to the relative abundances of various foraminiferal assemblages.

The eighth paper, *Mapping Marine Benthic Habitat in the Gulf of Alaska: Geological Habitat, Fish Distributions, and Fishing Intensity* by S. Kalei Shotwell, Jonathan Heifetz, Dean L. Courtney and H. Gary Greene, describes the construction of a habitat map using multibeam bathymetry and backscatter data that were correlated with various biological data including fish counts from manned submersible dives, independent bottom-trawl survey data, and commercial bottom-trawl fishery catch data. The occurrence and density of various fish species were calculated, which provided some general conclusions about fish species distribution over a range of habitat types. Fishing intensity by habitat type was examined using a density surface of the commercial fishing trawl hauls overlaid upon the habitat map.

The final paper of this chapter is by Les Watling and Carolyn Skinder, titled *Video Analysis of Megabenthos Assemblages in the Central Gulf of Maine*. Watling and Skinder report upon the use of submersible and ROV observations and video recordings to study the distribution of single species and ground-truth interpretations made using sidescan sonar and other non-visual devices. Using video and still photographs, patterns of megabenthos over a range of depths and substrate mixtures were developed. These authors concluded that "megabenthos assemblages in the Gulf of Maine appear to reflect the major habitat features delimited by substrate type and overlying water masses".

Seafloor Disturbances

This chapter addresses anthropogenic disturbances to the seafloor that may adversely impact marine benthic habitats. Three of the papers deal directly with marine aggregate extraction, one paper addresses the impacts of mobile fishing gear on continental shelf habitats, and the final paper is focused on the deposition and transport of dredged materials. Disturbances to the seafloor are becoming more of a concern because of the possibilities to alter and damage critical or principal habitats associated with living resources. Demand for offshore aggregate and sand is increasing worldwide because of the difficulty in finding readily extractable materials on land that can be obtained in an environmentally sustainable manner.

In the first paper in this chapter, *Marine Mining and Habitat* by J. Vaughn Barrie and Thomas M. Good, aggregate and sand mining along the west coast of Canada, which is unmonitored, is compared with marine mining practices in Japan and Europe, which are monitored. The authors recommend that an offshore habitat mapping protocol using new technologies should be established for Canada.

Thomas M. Good, J. Vaughn Barrie and Brian D. Bornhold, in their paper *Impact of Offshore Aggregate Extraction in the Prince Rupert Area of British Columbia, Canada*, used a towed Seabed Imaging and Mapping System (SIMS), sub-bottom seismic reflection profiles, sidescan sonar mosaics, helicopter overflights, and foot transects to observe and map disturbances associated with past shallow-water aggregate dredging in the Prince Rupert area of British Columbia, Canada. This dredging activity completely removed a tombolo and caused subsequent over-steepening of beaches.

The third paper, *Impacts of Bay Floor Disturbances on Benthic Habitats in San Francisco Bay* by H.G. Greene, T.L. Vallier, J.J. Bizzarro, Steve Watt and Bryan E. Dieter, uses disparate sets of multibeam sonar bathymetry, sidescan sonar and sediment sample data to assess bay floor disturbances by sand and aggregate extraction, navigation channel dredging, and ship movements. From a potential benthic habitat map, several natural and human-induced disturbed habitats were mapped. It was concluded that even though San Francisco Bay estuary's floor contains natural dynamic bedforms, aggregate extraction, bridge building, anchor drags, navigation channel dredging and past blasting of bedrock outcrops have altered and, in places, completely disturbed benthic habitats.

Les Watling's paper, *Visual Impacts of Mobile Fishing Gear on Continental Shelf Sedimentary Habitats*, describes the disturbance to the seafloor caused by fishing gear. Sediment-dwelling species are removed and species attached to cobbles and boulders are affected when these substrates are dragged along the bottom by mobile fishing gear. When classifying the benthic habitat in an area, it is important to understand the level of fishing activity in that area; disturbance due to fishing changes the range of biodiversity. Visual inspection of the seafloor yields clues to the level of mobile fishing gear disturbance, such as deep linear grooves in the sediment or boulders sitting on the sediment surface.

The last paper, *The Effects of Dredge Material Disposal on Marine Benthic Habitats of the Santa Cruz Bight, California* by Steve Watt and H. Gary Greene, deals with the concerns of harbour-dredged materials burying critical habitats. Mud dredged from a harbour was deposited in the nearshore area adjacent to a beach in an attempt to replenish the beach with sand. However, there was concern about the fine-grained content of spoil material settling out and covering kelp bed substrate. This study approaches the problem using multibeam sonar bathymetry and backscatter images and sediment sample data in a time-series analysis to document the transport and settlement of the sediment.

Marine Policy

The final chapter of this volume is directed to marine policy. The application of marine benthic habitat mapping and characterization initially began in the USA with the passage in Congress of the Magnuson-Stevens Fisheries Conservation and Management Act of 1996. Also in 1996, the Parliament of Canada passed the Oceans Act which laid out three principles – sustainable development, integrated management, and precautionary approach – to guide future development in Canada's three oceans. In Europe, Asia and in Oceania, various countries have recently established, or are considering, ocean policies. A worldwide increased intensity of exploiting marine living and non-living resources is pitting marine conservationists against commercial and recreational interests. The five papers that comprise this chapter address marine policies and management strategies in Australia, Canada, Europe and the United States.

The paper *Ocean Management of Queen Charlotte Basin, British Columbia, Canada* by J. Vaughn Barrie and Kim W. Conway focuses on the conflicts in managing an area where plentiful living and non-living resources exist and the pressure for exploiting these resources is increasing. The authors discuss the need to consider areas where resource extraction is allowed to take place and areas where MPAs should be established. The authors show that a broad approach, using ocean-mapping technology, is needed to provide the habitat and geoscientific knowledge necessary for effective decision-making when dealing with competing resource management issues.

The second paper, by Stephen L. Copps, Mary M. Yoklavich, Graeme Parkes, W. Waldo Wakefield, Allison Bailey, H. Gary Greene, Chris Goldfinger and Robert W. Burn entitled *Applying Marine Habitat Data to Fishery Management on the US West Coast: Initiating a Policy-Science Feedback Loop*, presents a method that allows scientific feedback into fisheries policy decisions that are based on marine benthic habitat characterizations. This approach was initiated from recent experience with implementing legal requirements to designate and protect Essential Fish Habitat (EFH) for groundfish off the west coast of the United States. Recent EFH maps, described in this paper, are based on a synthesis of data including multibeam sonar bathymetry, sidescan sonar, seismic reflection profiles, and seafloor bottom samples, as well as previously-published seafloor geologic maps.

The third paper, *Applications of Geophysical Information to the Design of a Representative System of Marine Protected Areas in Southeastern Australia* by Peter T. Harris, addresses Australia's management of the marine environment through the implementation of regional marine plans. Using abiotic geoscience information to characterize habitats, criteria for the establishment of MPA networks are being developed. The process starts with first drawing attention to Broad Areas of Interest (BAOI) that have the greatest diversity of geomorphic features and thus may have the highest biodiversity. Different seafloor geomorphic features were developed as proxies for habitats on the Australian continental slope and abyssal plain regions to support the selection of BAOI. The process presented in this paper demonstrates that GIS analysis of abiotic data can be a valuable and complementary tool for designing representative MPAs that meet biodiversity conservation objectives while minimizing socio-economic impacts.

R.A. Pickrill and V.E. Kostylev, in their paper *Habitat Mapping and National Seafloor Mapping Strategies in Canada*, report on the development of a national program to map Canada's offshore lands. This program is based on the concept that seafloor mapping can contribute to habitat characterization and environmental stewardship. The habitat-mapping strategy developed under this program produces outputs that incorporate five different approaches to mapping. In building toward a national mapping framework, the actual approach applied to an area is being driven by the "mapping scale, the ability to collect new data, environmental constraints, the time frame and stakeholder needs".

The final paper in this chapter, *European Marine Geoscience Database Projects – Giving Access to Existing Collections* by Alan G. Stevenson, and Terje Thorsnes, focuses on the benefits and outputs of a European multi-agency effort to produce a metadatabase that will be useful to researches around the world. This database consists of seabed samples, cores, and seismic and sonar survey information collected by fourteen maritime states' geological surveys of the European Union. "The objective of this paper is to describe the EU-SEASED metadatabase and to bring this important data resource to the attention of marine researchers in Europe and the rest of the world."

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