GEOHAB

Marine Geological Habitat Mapping

May 1st – 3rd 2002

Moss Landing Marine Laboratories
Moss Landing, California

Agenda and Abstracts

Contents

GeoHab 2002 Introductory Remarks

We welcome you to the third ad hoc international GEOHAB workshop and conference. This workshop is the outcome of a splinter group from the ICES Working Group on Marine Habitat Mapping where an informal GEOHAB Steering Committee was initiated. The first GEOHAB workshop originated from the ICES Working Group meeting held in Brugge, Belgium in 2000 and through the dedicated efforts of Thomas Noji was convened in Bergen, Norway in February 2001, as a workshop on Deep-Seabed Survey Technology. Under the direction of Brian Todd and Dick Pickrill this workshop was followed as a Special Session on Geological Habitat Mapping at the Geological Association of Canada's Annual Meeting held in St. Johns, Newfoundland in May 2001. At a GEOHAB Steering Committee meeting held in Halifax, Nova Scotia immediately following the St. Johns special session, it was decided that the third annual meeting should be held at Moss Landing, California USA.

The intent of this meeting, and of GEOHAB in general, is to inform scientists of new techniques and methodologies being used in geological mapping of aquatic benthic habitats and to investigate methods of presenting geology in a manner that is useful to a general cross-section of scientific disciplines, especially biologists. New thematic maps will be presented with the interest of feed back discussion from potential users. In regard to habitat characterization, several marine benthic habitat characterization schemes will be presented and we hope that some type of standardization of habitats will follow from these presentations. And finally, many case studies or various habitat maps will be displayed so that you will have the opportunity to visualize the manner in which habitats are being characterized today.

At this meeting 23 oral and 22 poster presentations will be delivered from scientists representing 8 different countries including Australia, Canada, Germany, Ireland, Norway, Portugal (Azores), United Kingdom and the United States. Presenters in attendance represent industry (2), academia (13), and various Government Organizations (25). A diverse spread of topics are presented and have been organized into 5 different sessions: A. Instrumentation, B. Techniques and Processing, C. Mapping Case Histories, D. Classification Schemes, and E. Applications and Policy.

We hope that you find this meeting informative and constructive. We welcome any and all constructive comments about the meeting and look forward to increased involvement by you in future activities.

H. Gary Greene
Brian Todd

Organizing Committee: the organizing committee for this conference consists of Brian Todd of the Geological Survey of Canada, Gary Greene and Joe Bizzarro of Moss Landing Marine Laboratories. The workshop coordinator is Isabelle Herbert of Moss Landing Marine Laboratories

The conference moderators are:
Session A and B
Waldo Wakefield – NOAA Northwest Fisheries Science Center, Newport, Oregon.
Ricardo Santos – Dept. of Oceanography & Fisheries, University of the Azores.

Session C and D
Peter Harris – Antarctic CRC and Geoscience Australia.
Mary Yoklavich – NOAA Southwest Fisheries Science Center, Santa Cruz.

Session E
Terje Thorsnes – Geological Survey of Norway.
Brian Todd – Geological Survey of Canada

Acknowledgements: the committee would like to express their thanks to the following sponsors for their support:
Moss Landing Marine Laboratories
Thales Geosolutions (Pacific) Inc., of San Diego, California
Triton Elics International of Watsonville, California.

They would also like to express their thanks to the following;

Director of Moss Landing Marine Laboratories, Dr Kenneth Coale and to the faculty and staff.

Barry Giles, Aldo DeRose and to Traci Prude for help with organization.

Especially they would like to thank the following graduate students; Janet Tilden, Steve Watt, Lee Murai, Holly Lopez and Mercedes Erdey for their assistance and Matt Levey for the logo design and technical support.

This workshop is in part supported by a grant from the National Seagrant Organization.

GeoHab 2002 – Agenda at a Glance

Wednesday May 1st 2002

9:00 am – 10:00 am	Coffee and registration. Poster set-up. Please complete and return a lunch order for Wednesday and Friday.
10:00 am – 10:05 am	Welcome by Kenneth Coale, Director Moss Landing Marine Laboratories
10:05 am – 10:15	Introduction, objectives and procedures – Gary Greene and Brian Todd
10:15 am – 12:30 pm	Session A – Instrumentation Session B – Techniques and Processing Moderated by Waldo Wakefield and Ricardo Santos
12:30 pm – 1:45 pm	Lunch at Moss Landing Marine Lab.
1:45 pm – 5:30 pm	Session C – Mapping Case Histories Session D – Classification Schemes Moderated by Peter Harris and Mary Yoklavich
6:00 pm – 8:00 pm	Reception.

Thursday May 2nd 2002

9:00 am – 12:30 pm	Session D – Classification Schemes continued Session E – Applications and Policy Moderated by Terje Thorsnes and Brian Todd
12:30 pm – 1.45 pm	Lunch (not provided)
1:45 – 4:00 pm	Informal working group meetings. Steering Committee meeting.
4:00 pm	Closing address and discussion of next meeting.
	Informal tour of Moss Landing Marine Lab. and Monterey Bay Aquarium Research Institute facilities.

Friday May 3rd 2002

9:00 am – 5:00 pm	Field trip to the Big Sur coast.

Detailed Session Agenda

Wednesday May 1st

9:00 am - 10:00 am Coffee and Registration and poster set-up

10:00 am – 10:05 am Welcome by Kenneth Coale, Director Moss Landing Marine Laboratories

10:05 am – 10:15 am Introduction, objectives and procedures by Gary Greene of Moss Landing Marine Laboratories and Brian Todd of the Canadian Geological Survey.

10:15 am Begin Session A

Session A - Instrumentation
Moderators Waldo Wakefield and Ricardo Santos

Multibeam Backscatter Comparisons: A Comprehensive Analysis of Comparative Systems and Manufacturers for Water Depths between 6.0 – 6000 meters. Lockhart, Doug, Saade, Edward and Gilmour, William.

Laser Line Scan Technology to Characterize Deepwater Habitats and Associated Organisms. Yoklavich, M., Grimes, C., Wakefield, Waldo W. and Greene, H.Gary.

Break for coffee – 15 minutes

Session B – Techniques and Processing
Moderators Waldo Wakefield and Ricardo Santos

Quantitative Seafloor Habitat Classification Using GIS Terrain Analysis: Effects of Data Density, Resolution and Scale. Iampietro, Pat and Kvitek, Rikk

Subfossil Assemblages in Sediments: a Possible Tool for Mapping Living Biota. Passlow, Vicki, O'Hara, Tim, Daniell, James J. and Beaman, Robin J.

SUSHIMAP – Survey Strategy and Methodology for Marine Habitat Mapping. Fossaa, Jan Helge, Alvsvaag, John, Thorsnes, Terje and Christensen, Ole

Seabed Biotope Surveys in Deep Water using Remote Sensing – Needs and Realities. Kloser, Rudy, Williams, Alan and Butler, Alan.

End Morning Session

Lunch 12.30 pm – 1.45 pm. Provided at Moss Landing Marine Lab.

Begin afternoon session

Session C – Mapping Case Histories
Moderators Peter Harris and Mary Yoklavich

Mapping the Geology of the Monterey Bay Area Seafloor at High Resolution and what it reveals of Shelf Benthic Habitats. Eittreim, Stephen L., Anima, Roberto J, and Edwards, Brian D.

Acoustic Mapping of Sponge Reefs in the Pacific Northwest. Conway, K.W., Barrie, J.V., Krautter, M. and Neuweiler, M.

The use of Geological Data in Developing a Framework for the Mapping of Marine Habitats on a National Scale in English Waters. James, J.W.C., Poulton, C., Philpott, S., Graham, C., Bee, E. and Jones, L.

Break for coffee – 15 minutes

MAREANO – a Proposed Integrated Study of the Mid-Norwegian Shelf and Slope – Focusing on Multibeam Technology, Geology, Habitat Mapping and Pollution. Thorsnes, Terje, Fossaa, Jan Helge and Olsen, Kjell.

Mapping Marine Benthic Habitat in the Gulf of Alaska: Biological Communities, Geological Habitat and Fishing Intensity. Heifetz, Jonathan, Courtney, Dean L., Fujioka, Jeffrey T., Greene, H. Gary, Malecha, Patrick and Stone, Robert P.

Mapping Seabed Habitat and Biodiversity for Ecological Risk Assessment and Conservation Planning. Pitcher, C.R., Venables, W., Pantus, F., Ellis, N., McLeod, I., Austin, M., Wassenberg, T., Skewes, T., Gordon, S. and Smith, G. (presented by Alan Butler)

Break for coffee - 15 minute

Session D – Classification Schemes
Moderators Peter Harris and Mary Yoklavich

Grasping the Thorny Issues of Marine Habitat Classification for Marine Habitat Mapping. Cogan, Christopher B. and Wright, Nancy.

A GIS Attribute Code for Marine Habitat Characterization: Work in Progress. Greene, H.Gary, Yoklavich, M.M., O'Connell,V.E., Bizzarro, Joseph J. and Wakefield, W.W.

End afternoon session.

6:00pm Reception sponsored by Thales Geosolutions (Pacific) Inc. This will provide an opportunity to view and discuss the poster presentations.

Thursday May 2nd

9:00 am Continue Session D – Classification Schemes
Moderators Terje Thorsnes and Brian Todd

Automated Seabed Classification for Habitat Assessment – Preliminary Results from Studies of Submerged Aquatic Vegetation in Puget Sound, WA. McGee, Richard, Tear, Lucinda M. and Bergersen, Douglas

A Regional Approach to Marine Sublittoral Habitat Classification: An Example for Northeastern North America. Valentine, Page C., Todd, Brian J. and Kostylev, Vladimir

Session E – Applications and Policy
Moderators Terje Thorsnes and Brian Todd.

Habitat Mapping of Sites of Conservation Importance (SCIs) around the Azores Islands for Management Purposes. Santos, Ricardo Serrao, Tempera, Fernando, Cardigos, Frederico and Salgado, Madalena

Small-Scale Analysis of Subtidal Fish Guilds and Associated Habitat Characteristics along Central California. Field, Jeffrey M., Yoklavich, Mary M., Cailliet, Gregor M., Bros, Shannon, de Marignac, Jean and Lea, Robert N.

The role of geoscience in the development of Australia's Southeast Regional Marine Plan. Harris, P.T., Heap, A.D., Passlow, V., Porter-Smith, R., Fellows, M. and Daniell, J.

Break for coffee – 15 minutes

Moving toward Ecosystem-based Management - an Interim Bioregionalisation for the Southeast Marine Region of Australia. Hall, Meredith, Davies, Campbell, Deese, Heather and Musso, Barbara.

Habitat Associations of Upper Slope Rockfishes (*Sebastes* spp.) and Co-occurring Demersal Fishes in the Headward part of Ascension Canyon California. Bizzarro, Joseph J., Field, Jeffrey M., Greene, H. Gary and Lea, Robert N.

Habitat Mapping with a Direct Application to Commercial Fisheries Management. O'Connell, V.M., Greene, H.Gary, Brylinsky, C., Bizzarro, Joseph J., Wakefield, W.W. and Carlile, D.

Mapping the Gulf of Maine: Building the Link between Marine Geology and Benthic Habitats to Improve Ocean Management. Todd, Brian J., Pickrill, Richard A., Valentine, Page C., Snow-Cotter, Susan and Noji, Thomas.

End technical sessions.

Lunch 12:30 pm – 1:45 pm. (not provided)

Begin afternoon session

1:45 pm – 4:00 pm	Informal working group meetings for participants who wish to get together and discuss their work. **Steering Committee meeting.**
4:00 pm	Closing address and discussion of next meeting.

Conference adjourned.

There will be informal tours of the Moss Landing Marine Laboratories facility and the Monterey Bay Aquarium Research Institute for anyone who is interested.

Free Evening.

Friday May 3rd

There will be a field trip to the Big Sur coast for those who wish to stay, entitled **"Geology and coastal habitats along a continental margin."** Led by Gary Greene, this trip will last approximately from 9 am to 5 pm and will include visits to Point Lobos, Garrapata Beach and Point Sur. There will be a small charge for lunch. Assemble in Moss Landing Marine Laboratories foyer at 9:00 am.

POSTER TITLES

Available to view Wednesday and Thursday with poster presentation session beginning 6:00 pm Wednesday May 1st. Letters refer to appropriate technical presentation session.

A1 Poster - Habitat Mapping in the Great Lakes – Use of SHOALS Lidar Data to Delineate Lake Trout Spawning Reefs. Barnes, Peter, Gardner, James, Fleischer, Guy and Lee, Kristen

B1 Poster – Fisheries habitat studies at Heceta Bank on the Oregon outer continental shelf: combining high-resolution sonar and seafloor investigations with GIS techniques. Wakefield, W. Waldo, Embley, Robert W., Tissot, Brian N., Yoklavich, M.M., Clemons, Julia E.R. and (in alphabetical order) Barss, William H., Bloeser, Jennifer, Bosley, Keith L., Hendler, Gordon L., Hixon, Mark A., Merle, Susan, Nasby, Nicole M., Noskov, Jackie Popp, Puniwai, Noelani, Reese, Douglas, Valdés, Ángel and Whitmire, Curt.

B2 Poster – Integration of high-resolution multibeam sonar imagery of the seafloor with direct observational data from occupied submersibles and ROVs to classify bottom types for habitat-based groundfish assessments at Heceta Bank, Oregon. Whitmire, Curt, Embley, Robert W., and (in alphabetical order) Clemons, Julia E.R., Merle, Susan, Puniwai, Noelani, Tissot, Brian N., Wakefield, W.Waldo and Yoklavich, Mary M.

B3 Poster – Development of techniques for mapping seabed biotopes in UK coastal waters – an integrated approach. Brown, Craig, Hewer, Alison, Meadows, Bill, Copper, Keith, Limpenny, David, Rees, Hubert and Vivian, Chris.

B4 Poster - Improved Mapping of Deep-Water Coral Ecosystems. By Grehan, Anthony J., Opderbecke, Jan, Unnithan, Vikram and Lane, Dave.

B5 Poster – The Effects of Habitat and Rugosity within a Benthic Kelp Forest Community. Sandoval, Eric and Greene, H.Gary.

B6 Poster - Reconnaissance Mapping of Seabed Characteristics of the Shallow Waters Surrounding the Majuro Atoll, Marshall Islands. Maher, Norman M.

C1 Poster - Acoustic seafloor mapping of Southeast Australia. Fellows, Melissa, Harris, Peter, Daniell, James and Heap, Andrew.

C2 Poster - Marine habitat mapping using multibeam backscatter data. Christensen, Ole, Karlsen, Arnfinn and Thorsnes, Terje.

C3 Poster – Deep reef habitats at the shelf edge in the Northeastern Gulf of Mexico – Scanlon, Kathryn M.

C4 Poster – Seafloor rocks and sediments of the continental shelf from Monterey Bay to Point Sur, California. Eittreim, Stephan L., Anima, Roberto J., Stevenson, Andrew J. and Wong, Florence L.

C5 Poster - Habitat mapping and Geology of Commercial Fishing Grounds in the Cape Ommeny – Hazy Island area of the Gulf of Alaska. O'Connell, V.E., Brylinski, C., Greene, H.Gary, and Bizzarro, Joseph J.

C6 Poster – Habitat mapping in the Transboundary region of Canada and the U.S: a new U.S. Canada Co-op. Greene, H.Gary, Barrie, J.V., Tilden, J.E., Lopez, H.L. and Fisher, Michael.

C7 Poster – Mapping of the Cowcod area of Southern California. Murai, Lee, Love, M., Yoklavich, Mary M., Greene, H.Gary and Bizzarro, Joseph J.

D1 Poster - Footprint: Issues of scale in acoustic seabed classification. Anderson, John T., Lang, Chris & Sutton, Vanessa.

D2 Poster - Development of mapping standards at the Geological Survey of Canada for marine bathymetry, geology and habitat maps. Todd, Brian J. and Shaw, John

D3 Poster - A unified hierarchical classification framework for coastal and marine habitats. Lyne, V., Last, Peter and Butler, Alan (presented by Dr Butler)

D4 Poster - Fisheries Habitat - Integrated Database Development for U.S. West Coast Groundfish and their Habitats. Goldfinger, Chris, Romsos, Chris, Milstein, Randall, Wakefield, Waldo and Lovelady, Suzanne

E1 Poster - European marine geoscience database projects – giving access to existing data collections. Stevenson, Alan.

E2 Poster - Mapping Irish Deep-Water Corals: a Necessary First Step towards their Conservation. By Grehan, Anthony J., Unnithan, Vikram and Olu - Le Roy, Karine.

E3 Poster – Habitat associations, distribution and abundance of Red Tree Coral *(Primnoa* spp.) and other sessile macroinvertebrates off Southeast Alaska. Bizzarro, Joseph J., Greene, H.G., Field, J., O'Connell, V.E. and Brylinski, C.

E4 Poster – Designating essential fish habitat (EFH) in Alaska: issues in consistency and efficiency when using geographical information systems (GIS). Reuter, Rebecca.

E5 Poster – Using multibeam bathymetry to investigate marine geology and potential marine reserves in the San Juan Islands, Washington, USA. Tilden, J. and Greene, H.G.

E6 Poster - Mapping Sedimentary Processes and Habitat Change in the nearshore area of Santa Cruz, California. Watt, S., Greene, H.G. and Foss, Brian.

E7 Poster – Reef fish – Habitat Associations in the Gulf of California. Levey, Matthew.

Oral Presentation Abstracts

(in order of presentation)

Multibeam Backscatter Comparisons: A Comprehensive Analysis of Comparative Systems and Manufacturers for Water Depths between 6.0 – 6000 meters.

Lockhart, Doug, Saade, Edward and Gilmour, William

Thales Geosolutions (Pacific) Inc., San Diego, CA

High-resolution multibeam bathymetric data are now routinely combined with multibeam generated "backscatter" data to support fisheries habitat and related studies worldwide. During the past several years, and in particular during the past 18 months, a variety of multibeam systems have been utilized to conduct these studies. Thales Geosolutions (Pacific), Inc. has conducted surveys using multibeam systems manufactured by both RESON and SIMRAD, operating at frequencies ranging from 12 – 200 KHz, in water depths ranging from 6.0 – 6,000 meters. The purpose of this discussion is to present examples of data products from these applications to better inform the Fisheries Habitat community on the capabilities and limitations of the various sensors at a variety of water depths and discrete frequencies. Data from a variety of worldwide locations are presented. An analysis of actual resolution will be provided as a function of frequency, water depth and vessel speed. In addition, the analysis of a controlled high-resolution side scan sonar vs multibeam backscatter comparison of a 10 sq km section of the seabed will be presented. It is hoped that the information provided herein will allow Fisheries Habitat scientists to better plan and predict the outcome of their studies, and to allow them to attain both the scientific and financial goals.

Laser Line Scan Technology to Characterize Deepwater Habitats and Associated Organisms

Yoklavich, Mary[1]; Grimes, Churchill[1], Wakefield, Waldo W.[2] and Greene, H.Gary[3]

[1] NOAA National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz Laboratory, CA
[2] NOAA National Marine Fisheries Service, Northwest Fisheries Science Center, Newport, OR
[3] Moss Landing Marine Laboratories, Moss Landing, CA

We conducted a 9-day field test of laser line scan imaging technology (LLS) to characterize and explore benthic habitats in and around the Big Creek Ecological Reserve (BCER) off the central California coast. We are determining the utility of LLS to assess the distribution and abundance of fish, megafaunal invertebrates, and habitats, and comparing LLS images with those acquired from side scan sonar and a remotely operated vehicle. We also are evaluating LLS ability to detect seafloor disturbance caused by fishing trawl gear. We surveyed an area about 2.6 km long and 0.4 km wide inside and directly outside BCER. With the laser we imaged isolated rock outcrops with patches of large *Metridium* sp. and dense groups of fishes, drift kelp, sea pens, salp chains, and sedentary benthic fishes (possibly California halibut, Pacific electric ray, ratfish, juvenile lingcod, etc.). The LLS system offers the advantage of imaging some of the biogenic components of habitat and describing their spatial relationships with detail that currently is not possible using acoustic techniques such as side scan and multibeam sonar. The LLS system also seemed to do an excellent job at imaging details of the low relief shelf sediments such as sand waves and ripples; evaluating these features in a broader context from a post-processed mosaic of the seafloor could help us understand coastal physical processes that influence dynamic benthic habitats. The development of LLS could improve our understanding of deep-water fish habitats.

Quantitative Seafloor Habitat Classification Using GIS Terrain Analysis: Effects of Data Density, Resolution and Scale

Iampietro, Pat and Kvitek, Rikk

Seafloor Mapping Lab., California State University Monterey Bay, Seaside, CA

There is a great need for accurate, comprehensive maps of seafloor habitat for use in fish stock assessment, marine protected area design, and other resource management pursuits. Recent advances in acoustic remote sensing technology have made it possible to obtain high-resolution (meter to sub-meter) digital elevation models (DEMs) of seafloor bathymetry that can rival or surpass those available for the terrestrial environment. This study attempts to use an algorithmic terrain analysis approach to efficiently, non-subjectively classify seafloor habitats according to quantifiable parameters such as slope, rugosity, and topographic position index (TPI). In addition, we explore the effects of original x,y,z and gridded data density on the results of these analyses, in order to provide insight into how inherent depth-dependent decreases in data density may affect this approach, and to assess the appropriateness of using historical, lower density bathymetric data. Finally, issues of scale with regard to rugosity and TPI are explored and their potential biological relevance discussed.

Subfossil Assemblages in Sediments: a Possible Tool for Mapping Living Biota

Passlow, Vicki[1], O'Hara, Tim[2], Daniell, James J.[1] and Beaman, Robin J.[3]

[1]Geoscience Australia, GPO Box 378, Canberra ACT 2601, Australia
[2]Museum Victoria, GPO Box 66E, Melbourne Vic. 30001 Australia
[3] University of Tasmania, GPO Box 252-76, Hobart Tas 7001, Australia

While the study of modern faunas has been used extensively as tool for the interpretation of fossil communities, there has been little investigation of the potential for subfossil data to be used as a tool for the prediction either of modern faunas or their links to geological parameters.

The material used in this work comes from a study of Bass Strait, carried out as a series of surveys in the period 1979-1983 (Wilson & Poore, 1987). Bass Strait forms a narrow seaway between mainland Australia and the island of Tasmania. The Bass Strait Study was aimed at the description of biological species in the area and remains the most comprehensive collection of marine invertebrates from the region. Sediment samples were also obtained as part of the original study, providing an opportunity to examine links between sediments and biota in the region.

On a general level, there are issues with the interpretation of subfossil data. Not all biota leave hard parts. Not all hard parts are readily preserved. In addition, post-mortem processes can affect the record of biota. Some of these limitations are evident in this study. Because of the nature of Bass Strait and its geology, many of the sediments are composed of a mix of recent and older, palimpsest material. While a high level of diversity is evident in the subfossil material, the biological data indicates that the greatest abundance occurs in groups which leave little or no fossil record.

Statistical analysis of the biota (O'Hara, 2002) showed little evidence of distribution patterns related to sediment at the scale of the study. At a more detailed level, the most abundant and potentially most useful of the subfossil groups appears to be bryozoans (lace corals). Bryozoans are one of the main sediment-producing organisms in the cool-water carbonate sediments of southern Australia. In the Bass Strait material distinct morphological types show distribution patterns which appear to be linked to sediment characteristics. The Bass Strait material suggests that the ability of the subfossil component to predict living fauna is a question both of scale and of the make-up of communities. On a more detailed level, bryozoa potentially provide data linking fauna and sediments. Sites to the east of Bass Strait, which have been studied more recently using a variety of techniques, including video and swath mapping, are providing an additional test of this approach.

References:

O'Hara, T., 2002. Benthic Assemblages of Bass Strait. Museum Victoria Report to Geoscience Australia. 39pp.

Wilson, R.S. & Poore, G.C.B. (1987). The Bass Strait Survey: biological sampling stations, 1979-1984. *Occasional Papers from the Museum of Victoria* 3: 1-14.

SUSHIMAP – Survey Strategy and Methodology for Marine Habitat Mapping.

Fossaa, Jan Helge[1], Alvsvaag, John[1], Thorsnes, Terje[2] and Christensen, Ole[3]

[1] Institute of Marine Research, Bergen, Norway
[2] Norwegian Geological Survey, Trondheim, Norway
[3] Norwegian University of Science and Technology

The project aims to develop a rapid, reliable and cost-efficient procedure for the mapping and monitoring of seabed habitats. The procedure integrates medium- and fine-scale data from visual and sediment-grab methods with large-scale bathymetric and backscatter data obtained by multibeam echo sounding. With the help of this procedure, SUSHIMAP will define a long-term plan for monitoring of marine habitats. Preliminary results from the sampling of fauna and seabed properties, as well as examples of integration and visualization of data and information from the multiple sources, are reported.

Seabed Biotope Surveys in Deep Water using Remote Sensing– Needs and Realities.

Kloser, Rudy, Williams, Alan and Butler, Alan

CSIRO Marine Research, Castray Esplanade, Hobart, Tasmania 7000 Australia.

This paper outlines a strategy for optimised deep seabed mapping using a combination of tools (multibeam and single beam acoustics, video, various direct samplers, and data from other sources). We focus on the management needs for seabed biotope mapping in the Australian context and its multi-disciplinary nature. We stress the habitat attributes relevant to the scale of impact of human activities and to the scale of management (not necessarily the same things), and we consider issues for monitoring using modern technology. The paper outlines the strengths and weaknesses of the equipment and methodologies employed so far. In particular, we give examples to highlight the realities of sampling and the need for caution with automated methods given current classification techniques for video and acoustics.

Mapping the Geology of the Monterey Bay Area Seafloor at High Resolution and what it reveals of Shelf Benthic Habitats.

Eittreim, Stephen L., Anima, Roberto J. and Edwards, Brian D.

U.S. Geological Survey, Menlo Park, CA 94025

Recently completed sonar mapping of the greater Monterey Bay offshore area by U.S. Geological Survey (USGS) scientists provides 100% sonar coverage for more than 100-km of the Continental Shelf from Año Nuevo to Pt Sur. Sonographs with one meter pixel resolution north of Monterey Canyon, and 2.5-m pixel resolution south of the Canyon, combined with seismic-reflection profiles and hundreds of seafloor samples, provide unprecedented detail for understanding seafloor characteristics that produce the physical traits of benthic habitats over this large area. Additional cooperative work between geologists and benthic biologists is needed to fully exploit this database.

North of Monterey Canyon, bedrock outcrops occur on parts of the inner and outer shelf, with a mid-shelf Holocene mud belt in between. This outcrop pattern is a product of the uplifting highlands of the Santa Cruz mountains, the 100-m sea level rise over the past 15,000 years, and the supply of sediment to the shelf from the three rivers entering Monterey Bay (San Lorenzo, Pajaro, and Salinas Rivers). The outcrops are generally elongated NW-SE, are produced by the outcrop of dipping beds that are resistant to erosion, and range from layered and blocky to rounded rubble piles. The sonographs, combined with high-resolution seismic-reflection profiles, reveal both the vertical and horizontal scales of outcrop as well as document the patchiness (or connectivity) of outcrop. Each of these three characteristics of seafloor geology can be crucial to the health of various benthic and demersal species.

These data sets include six areas of the continental shelf proposed by the State of California as Marine Protected Areas (MPAs) within the Monterey Bay National Marine Sanctuary. Three of the six proposed MPAs encompass outer-shelf substrate composed of varying amounts of modern fine-grained sediment, of low relief, layered-rock outcrops, of higher relief, and coarse rippled-sand deposits. Do geologic considerations support the selection of these locales as MPAs based on biologic data? The variation of bottom types observed throughout these inner-and outer-shelf environments, suggests a comparable diversity of biota over these regions.

Acoustic Mapping of Sponge Reefs in the Pacific Northwest

Conway, K.W. [1], Barrie, J.V.[1], Krautter, M.[2] and Neuweiler, M.[2]

[1] Pacific Division, Geological Survey of Canada
[2] University of Stuttgart, Germany, Institute of Geology and Paleontology

Recent mapping of siliceous sponge reefs on the continental shelf of western Canada has been accomplished by a variety of acoustic methods. The hexactinellid sponge reefs were first discovered during surveys employing sidescan sonar and sub-bottom profiling systems in the mid 1980's. High resolution, deep towed, single channel seismic (Huntec Deep-Tow), conventional hull mounted profilers (3.5 and 12 kHz) various sidescan sonar instruments (Klein, EGG and Simrad) and a multibeam swath bathymetry system (Simrad EM 1002) have all now been used to map sponge reef distribution. Four extensive sponge reef complexes, covering 700 km^2, have been identified in Queen Charlotte Basin (QCB) and one smaller reef complex has recently been discovered in the Georgia Basin (GB). The acoustic signature of these features, which can attain heights of 19 m in the QCB, is distinctive and readily identified. The reefs develop from the coalescence of small mud mounds that grow to form steep-sided bioherms and areally extensive biostromes, over millennia. The non-reflective acoustic properties of the reefs are mainly due to the massive clay matrix sediments, the framework of buried siliceous sponge skeletons, and the surface covering of living sponges. These characteristics provide a sharp acoustic contrast with the normally reflective and dense underlying relict glacial sediments, which are characterized by gravel to boulder size and glacial marine clays that have been iceberg scoured. At some sites sponge reefs with higher relative surface reflectivity are thought to be "dead" while in other areas sponge bioherms that have been subject to trawling by fishing vessels are readily mapped with sidescan sonar. Given that the frame building and reef forming Hexactinosan sponge species that create the reefs are found throughout the north Pacific it is possible that undiscovered sponge reefs exist on the deep continental shelves of Alaska and Russia.

The use of Geological Data in Developing a Framework for the Mapping of Marine Habitats on a National Scale in English waters.

James, J.W.C.[1], Poulton, C.[1], Philpott, S.[1], Graham, C.[2], Bee, E.[1] and Jones, L.[3]

[1] British Geological Survey, Keyworth, Nottingham, U.K.
[2] British Geological Survey, West Mains Road, Edinburgh, U.K.
[3] English Nature, Peterborough, U.K.

European legislation with regard to both marine and terrestrial habitats is producing a demand for facts and data so that national governments and conservation agencies can respond, in a constructive and informed manner, to their obligations under the legislation. Included within these are the designation of conservation areas and the mapping of specific marine habitats. These are for national coverage.

To meet the criteria for national coverage with English waters the only dataset available, apart from bathymetric charts, are 1:250,000 geological maps and survey data published and acquired by the British Geological Survey. The themes of these maps are seabed sediments, Quaternary Geology and Solid Geology. The seabed sediments map has been used as the main geological dataset in developing a framework for the mapping of marine habitats, with the Quaternary and Solid geology feeding complimentary data. A seabed features dataset has been created using ArcView as the GIS with attributed polygons linked to an Access database.

The sea bed features GIS is the primary dataset but this is complimented by a bio-feature dataset and bedform feature dataset based on criteria within the European Union Habitats Directive for mapping features such as sand banks, reefs, caves and gas escape features.

The project is a first step in meeting the demands of European legislation. It will require review when completed, in considering how far currently available data can be used to adequately map marine habitats in response to environmental and legislative pressure.

MAREANO – a Proposed Integrated Study of the Mid-Norwegian Shelf and Slope – Focusing on Multibeam Technology, Geology, Habitat Mapping and Pollution.

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An initiative is currently being taken by several Norwegian organizations to obtain funds to intensify ongoing investigations on marine sea-floor mapping off Norway. Led by the Geological Survey of Norway, the Institute of Marine Research and the Norwegian Hydrographic Service, planning during the last years has led to the inception of a large-scale mapping project entitled "MAREANO - Marine Areal Database for the Norwegian Sea". The proposed investigation area covers 270 000 km^2 of the shelf and deep sea off the central part of western Norway. If funded, the project period is planned to 2003-2007. It is a commercially important region for fisheries and the petroleum industry and includes the world's largest system of cold-water coral reefs. The aim of MAREANO is to collect new as well as historical data elucidating the physical, chemical and biological characteristics of the seabed along the mid-Norwegian shelf and parts of the deeper Norwegian Sea. The project shall produce a comprehesive database on seabed bathymetry, marine habitats, biological diversity and resources, mineralogical resources and geological features as well as habitat contamination. Stored in a GIS database, this information shall be available to environmental managers and interest groups as well as the fisheries, aquaculture and petroleum industries via a dedicated system on the Internet.

Mapping Marine Benthic Habitat in the Gulf of Alaska: Biological Communities, Geological Habitat and Fishing Intensity

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During summer 2001 multibeam, backscatter, and video data were collected on the Portlock Bank area of the central Gulf of Alaska in the vicinity of extensive bottom trawl and longline fisheries for groundfish. The objective of the study was to characterize bottom habitat in or near heavily fished grounds to understand whether habitats in current fishing grounds are vulnerable to ongoing fishing activities. The area mapped was about 1000 km^2 of the outer continental shelf and upper continental slope. Preliminary interpretations of multibeam and backscatter data indicate the presence of at least a dozen different benthic macro- or meso-habitats. The megahabitats of this area are distinctly the result of past glaciation with the glacial deposits presently being reworked and shaped into moderate (cm-m) relief features. Many submarine canyons notch the upper slope and provide steep relief with alternating mud-covered and consolidated sediment exposures. From the video data collected from the research submersible *Delta,* there was little evidence of trawling on the flatter grounds of the continental shelf where perhaps the relatively level bottom did not induce door gouging and there is a lack of boulders to be turned over or dragged. The most common sessile epifauna were crinoids, small non-burrowing sea anemones, glass sponges, stylasterid corals and two species of brittlestars. Occasional large boulders were located in depressions were the only anomaly in the otherwise flat seafloor. These depressions may have afforded some protection to fishing gear, as the glass sponges and stylasterid corals attached to these boulders were larger than were typically observed. In the fished areas of the upper slope, there was evidence of boulders turned over or dragged by trawling. The uneven bottom perhaps induced gouging by the trawl doors. The substrate was mostly small boulders, cobble, and gravel. Presently there does not appear to be much habitat in this habitat that can be damaged by trawl impacts. No large corals and very few large sponges were seen. Whether this is the result of past trawl activity is unclear.

Mapping Seabed Habitat & Biodiversity for Ecological Risk Assessment and Conservation Planning

Pitcher C.R., Venables, W., Pantus, F., Ellis, N., McLeod, I., Austin, M., Wassenberg, T.,Skewes, T., Gordon, S. and Smith, G.

(Paper to be presented by AJ Butler, CSIRO Marine Research, Hobart)

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The current lack of knowledge of biodiversity living on the open continental shelf seabeds makes conservation planning and management for sustainability in these areas a difficult and largely subjective task. Without this knowledge, it can also be difficult to justify management actions to stakeholders. It is therefore imperative that rigorous inventories of seabed biodiversity distribution & abundance are conducted to develop a reliable and effective baseline for conservation and management, including systems of highly protected areas (HPAs) justifiable on sound biological data. Selection of truly comprehensive, adequate and representative (CAR) candidate areas (CAs) is ultimately dependent on achieving such inventories, as is quantitative ecological risk assessment of human activities in the marine environment.

We report on progress with projects conducting habitat and biodiversity surveys on tropical shelf seabeds. Multiple survey devices are used, including: eg. acoustics, towed video, epibenthic sled, trawl. Biological sampling is necessary to deliver a sound scientific baseline and establish reference inventories of the constituent biota, using appropriate collections of voucher samples to authenticate species-level biodiversity. Having this baseline biodiversity reference enables rigorous testing of the performance of "rapid assessment" techniques (e.g., acoustics, video) – how well do they discriminate patterns in species biodiversity? Survey cost and amount of direct sampling is minimized by using environmental covariates and biophysical relationships to develop informed stratifications and predict biota in unsampled areas within strata. These approaches lead to the most efficient design for sampling a diversity of biotopes on the seabed, and combine state-of-the-art modelling to interpolate these data to habitats with the same biophysical characteristics.

Applications of this information include: identification of representative areas from which HPAs can be selected; assessment and performance review of marine reserve systems; identification of gaps in the coverage of biodiversity; development of indicators of the status of biodiversity in relation to sustainable/risk management of multiple-uses; and evaluation of alternative strategies for managing human use to deliver environmental goals.

Grasping the Thorny Issues of Marine Habitat Classification for Marine Habitat Mapping

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There are many issues of marine ecology that should be based upon a unified concept of habitat types and communities, and therefore, ecological classification. Whereas previous research relied on point data sources and available themes (e.g. fisheries catch data), we will increasingly require quantitative interdisciplinary descriptors of broad-based biodiversity. The classification of ecological habitat types is of fundamental importance to a suite of marine issues including the assessments of coastal zone management areas, marine protected areas (MPA's), environmental quality reports, environmental degradation analysis, toxic spill response planning, fisheries management, ocean aquaculture, and long-term ecosystem health issues such as El Niño and global warming. Each of these research topics considers marine habitat types and communities as fundamental elements of the ecosystem. If our conceptual model of these ecological units is in error, or if it varies implicitly within elements of multidisciplinary research, the products of our research are likely to be flawed, or at best inadequate.

In this paper we identify several existing habitat classification schemes, and discuss how each is specialized for particular goals. For each system the implicit and explicit classification system is explored to better understand how model bias can influence our perception of marine systems. We suggest methods to more closely integrate existing models, which will be needed if we are to provide researchers and applied management with a framework for habitat-type mapping and improved marine management.

Keywords: MPA, marine reserves, marine habitat classification, management areas, biodiversity, geographic information systems (GIS).

A GIS Attribute Code for Deep-Water Marine Habitat Characterization: Work in Progress

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Deep-water benthic habitat mapping is accelerating in scope and importance as remote sensing technologies, access to the seafloor, and concern for human impacts on fisheries and seafloor biota increase. With this increase in mapping effort and the use of GIS techniques, many different types of maps and various methods of habitat classification are being developed. To easily distinguish marine benthic habitats and to facilitate ease of use and queries with GIS and database programs, a habitat attribute code, based on the deep-water habitat characterization scheme developed by Greene et al. (1999), is presented. This scheme is hierarchical, can be used to compare and contrast marine benthic habitat types in a standard manner, and is divided into the following categories: System (marine benthic), Subsystem (based on physiography and depth), Class (based on seafloor morphology), Subclass (based on substratum texture and slope), and Modifiers (for bottom morphology, bottom deposition, bottom texture, physical processes, chemical processes, and biology). To reflect this classification in GIS and database programs, we have developed a two-part code. The following categories apply directly to habitat interpretations determined from remote sensing imagery (for mapping of study areas at the scale of 10s of km to 1 m): Megahabitat (based on physiography and size related, features larger than 10 km), Bottom Induration (based on substrate hardness), Meso/Macrohabitat (size-related, from 1 km to 1 m), Modifier (textural and lithologic relationship), Slope, and Seafloor complexity. Additional categories apply to smaller scale areas (10 m to cm) and are either determined from video, still photos, or direct observations: Macro/Microhabitat (size-related, from 10 m to cm), Modifiers (geologic and biologic), Slope, and Seafloor complexity. These categories can be used in conjunction to define a habitat across spatial scales or separately for comparisons between large and small-scale habitat types. Although the code appears complex, it is not necessary that all components be used and the code can be simplified and tailored for individual preferences. This scheme is a work in progress and we welcome input on how it can be improved and made more useful to a larger community of scientists, managers, and policy makers. A draft copy of the scheme and code with explanation is included as an appendix to this abstract volume for your use and comments.

Greene, H.G., Yoklavich, M.M., Starr, R.M., O'Connell, V.M., Wakefield, W.W., Sullivan, D.E., McRea, J.E., and Cailliet, G.M. 1999. A classification scheme for deep seafloor habitats. Oceanologica Acta. Vol. 22 (6): 663-678.

Automated Seabed Classification for Habitat Assessment– Preliminary Results from Studies of Submerged Aquatic Vegetation in Puget Sound, WA

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This presentation examines the preliminary results from an automated approach to seabed classification conducted for the purpose of habitat assessment. The area of study is a portion of Puget Sound, WA. Automated seabed classification was conducted on a mosaic of the sidescan sonar imagery acquired across the seabed. The classification scheme is based around a statistical analysis of a gray-level co-occurrence matrix. Boundaries of seabed types produced from the classification algorithms were analyzed in relation to the mosaicked imagery from which they were produced and in relation to other information describing the habitats of the survey area. Based on the results from this survey area we believe this sort of approach for analyzing seabed data can play an important role in habitat assessment but perhaps more importantly habitat monitoring.

A Regional Approach to Marine Sublittoral Habitat Classification: An Example for Northeastern North America

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Habitats can be defined as spatially recognizable areas where the physical, chemical, and biological environment is distinctly different from surrounding environments. Implicit in this definition is the question of scale. Conceivably, a habitat can be defined as narrowly or as broadly as the data and the purpose permit, and this flexibility of scale necessarily influences the development of habitat classification schemes.

Several recent habitat classification proposals have focused on a wide range of habitats that occur in European land and water environments;[1] United States marine and estuarine environments;[2] and worldwide deep (subtidal) sea floor environments.[3] These classifications define the marine sublittoral zone as lying below the intertidal zone and extending to the continental shelf edge at a water depth of approximately 200 m. The classification scheme proposed here is based on recent observations in the Gulf of Maine using multibeam and sidescan sonar surveys, video and photo transects, and sediment and biological sampling. The marine sublittoral in this region includes continental shelf basins that reach depths of approximately 400 m and submarine canyon heads that incise the continental shelf and reach depths of up to 800 m.

The goal of the proposed classification is to develop a practical method to characterize the marine sublittoral habitats of the northeastern North America region not just in terms of (1) their geological, biological, and oceanographic attributes, but also in terms of (2) the natural and anthropogenic processes that affect the habitats. The classification scheme is a four level hierarchy in which the three higher levels, *classes* (see table) and *subclasses* and *categories* (not shown), are applicable worldwide, while the lowest level (*attributes*, not shown), describes regional habitat characteristics. Classes 7 and 8 are included to address the growing importance of habitat information to the management of fisheries and environments. This approach to habitat classification is applicable also to regions outside of the Gulf of Maine.

Class 1 addresses the water depth and topographic setting of habitats in terms of photic/aphotic zones, depth intervals and physiographic features.
Class 2 addresses the movement and stability of seabed materials in terms of current type, strength, and frequency of movement.

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[1] EUNIS (European Nature Information System) Habitat Classification, Version 2.2, May, 2001: European Environment Agency (EEA), http://mrw.wallonie.be/dgrne/sibw/EUNIS/.
[2] Allee, R.J., and others, 2000, Marine and estuarine ecosystem and habitat classification: National Oceanic and Atmospheric Administration, NOAA Technical Memorandum NMFS-F/SPO-43, 43 p.
[3] Greene, H.G., and others, 1999, A classification scheme for deep seafloor habitats: Oceanologica Acta, v. 22, no. 6, p. 663-678.

Class 3 describes the texture and relative hardness of the seabed by using texture analysis and visual observations of seabed character.
Class 4 describes the physical and biological roughness of the seabed in terms of bedforms, shell deposits, burrows, epifauna, and gravel piles and other features smaller than those treated in Category 1.
Class 5 describes seabed chemistry in terms of carbon content and depth of oxidation, among others.
Class 6 addresses properties of water masses that affect habitats such as temperature, salinity, upwelling, and productivity, among others.
Class 7 describes the habitat in terms of faunal usage such as spawning, juvenile survival, and essential fish habitat, and in terms of human activities that affect the seabed.
Class 8 describes the recovery time of physical and biological characteristics of habitats from fishing and natural disturbances.
Class 9 enumerates the dominant and typical biological elements that characterize habitats.

The classification is expandable at all levels and into all regions and habitats. It serves as a template for a database, thus providing a convenient method for organizing and comparing habitat information. As new observations are made, new attributes can be added to the classification scheme. As regional classifications increase in complexity, it will be possible to compare habitats of different regions and to merge them if that proves useful.

CLASS
1 Water depth and topographic setting
2 Seabed dynamics and currents
3 Seabed texture and hardness
4 Seabed roughness and surface area
5 Seabed chemistry
6 Water column structure and productivity
7 Habitat usage
8 Habitat recovery from disturbance
9 Fauna and flora

Habitat Mapping of Sites of Conservation Importance (SCIs) around the Azores Islands for Management Purposes.

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The description of hydrothermal vents ecosystems is of interest both to ecological studies and nature conservation management of these unusual environments. In D. João de Castro offshore bank (Azores, Portugal), one of the sites designated as a Special Area for Conservation (Natura 2000 network), hydrothermal activity is a frequent feature between -13 and 45m deep. Under EU-MAST III project ASIMOV, several methods and technologies have been brought together to study the habitats and biological communities in the area. Side-scan, Doppler and echo-sounder units were used to draw geo-referenced 3-D maps that include the positioning, intensity and density of venting activity. The maps produced show that the venting activity concentrates in the northeastern part of the volcanic cone.

Imaging (photo and video) tools operated by UW-scooter-powered scuba divers have been employed to survey the bottom topography and identify conspicuous epibenthic species. The communities are mainly divided in three groups: sandy, rocky and rocky with venting activity. Sandy communities below –40 metres are species-poor. The rocky habitats between –20 to –45 metres are dominated by an algal mosaic of *Sargassum* sp., *Coralina* sp. and *Halopteris* sp. in the shallower area, and *Zonaria tournefortii* in the deeper zones. The communities on rocky substrata near vents are dominated by filamentous thermophyle bacteria and a dense mosaic of different algae (e.g., *Cladostephus spongiosus*, *Codium elisabethae* and *Padina pavonica*).

Water sampling along the water column allowed large-scale surveys of methane plumes (indicator of hydrothermal activity). The data collected with the later technique suggest the occurrence of hydrothermal activity at depths ranging between -150 and -250m. Hydrothermal fields at such depths are poorly known and D. João de Castro should be a suitable site for the development of future studies that make use of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs).

Small-Scale Analysis of Subtidal Fish Guilds and Associated Habitat Characteristics along Central California

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Recent declines in fish populations are prompting revisions and alterations to current fishery management policies. One alternative is the establishment of Marine Protected Areas (MPAs) to promote the recovery of fish stocks. However, before MPAs can be created, habitat associations of the fishes designated for protection need to be characterized to ensure that the ideal habitat can be included when MPAs are designated. Once the habitat associations of each species are known, remote sensing technology, such as side scan sonar, can be used to survey large-scale areas to identify potential habitat for MPAs.

In the Eastern Temperate Pacific, rockfishes (*Sebastes* spp.) are slow growing, have a late age-at-maturity and specific habitat affinities. These life history characteristics make them especially susceptible to fishing pressure and ideal candidates for protection through MPAs. To assess habitat associations of fishes within the Big Creek Ecological Reserve, Central California, we conducted submersible dives to identify habitat at the meter scale and to quantify fish populations. Multivariate statistical analysis revealed distinct habitat associations for several rockfish species. In addition, distinct seafloor features were identified as unique habitats at the meter scale.

The role of Geoscience in the Development of Australia's Southeast Regional Marine Plan.

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Ecosystem-based management via regional marine planning is a central policy principle of *Australia's Oceans Policy*, and the National Oceans Office is charged with putting regional marine planning into effect. An assessment of the geology and geomorphology of Australia's southeast region was carried out by Geoscience Australia in order to contribute to the derivation of a bioregionalisation that will provide a framework for ecosystem-based management of the region.

The bioregionalisation is a hierarchically structured system containing higher level 1 *Provinces* (>1,000 km in extent) and level 2 *Biomes* (several 100's km in extent), distinguished primarily based on the distribution of demersal fish species, but corroborated with data on tectonic elements, fault-lines and plate age. At the third level of this hierarchy are major meso-scale *geomorphological units* (~100 km in extent) characterised by similar geomorphology. A key point is that information at a lower level in the hierarchy was needed in order to locate higher level boundaries in each case (i.e. data mapped at the scale of level 3 was used to locate level 2 boundaries, etc.). Geological and modeled oceanographic data proved to be the only systematically collected (and therefore mappable) information available at levels 3 and 4 within the hierarchically structured system that we used.

The geomorphological units that we mapped on the slope and at abyssal depths were submarine canyons, saddles, plateau, continental blocks, seamounts, abyssal plains, oceanic ridges and troughs. Such units are typically about 100 km in extent. Geomorphological units are inferred to be associated with distinct biotic assemblages, which justifies their utilisation in the derivation of a bioregionalisation, although it is recognised that our reliance on purely physical data to map essentially biological units is a weakness in our analysis. A bathymetric data set grided at 250m was used with reference to previously published work to derive a map of the distribution of geomorphic units in the southeast region deeper than the continental shelf. The identification of individual submarine canyons was aided by using the results of a drainage analysis of the bathymetric model (including the 250m grid AUSLIG topographic map for Australia) carried out using ARCINFO. Patterns identified from the geological structure were corroborated by examining maps of crustal age, seabed sediment type, sedimentary basins, acoustic facies and modeled ocean current speed and direction (both mean and maximum). In some cases, the geomorphic units were further subdivided on the basis of patterns suggested by these corroborative data sets, particularly the acoustic facies maps.

Moving toward Ecosystem-based Management - an Interim Bioregionalisation for the Southeast Marine Region of Australia

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Under the United Nations Convention on the Law of the Sea, Australia has sovereign rights to explore, exploit, conserve and manage the natural resources within one of the largest Exclusive Economic Zones in the world. Australia's Oceans Policy provides a framework to fulfill our responsibilities of protection and ecologically sustainable management of our ocean jurisdictions. The National Oceans Office is responsible for leading the implementation of the policy through the development of Regional Marine Plans and coordination of other initiatives under the Policy. The first regional marine plan is being developed for the South-east Marine Region (SEMR), which includes three Large Marine Domains (Southeast, South Tasman Rise, Macquarie) and covers over 2 million square kilometres of Australia's Marine Jurisdiction. Policy principles that guide the development of regional marine plans include ecosystem-based management and outcome-based planning. This paper describes how these policy principles have guided the development of the Interim Bioregionalisation for the South-east Marine Region and a process for using the Bioregionalisation in development of ecologically based planning units for regional marine planning

Habitat Associations of Upper Slope Rockfishes (*Sebastes* spp.) and Co-occurring Demersal Fishes in the Headward part of Ascension Canyon California.

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Due to their typical life history patterns (slow growth, late age at maturity, extreme longevity) deep-water rockfishes (*Sebastes* spp.) are especially susceptible to overfishing, as evidenced by recent declines in most commercially targeted stocks. To establish effective Marine Protected Areas (MPAs), the interaction between fishes and their available habitats must be determined. Our objectives were to describe habitat associations for upper slope rockfishes and co-occurring fish species within the headward part of Ascension Canyon at both large (1 to 10s of kilometers) and small (10s to 100s of meters) scales. Geologic structure and lithology were investigated using high-resolution multibeam bathymetric and backscatter data. These data were interpreted to produce habitat maps of the study areas. Seafloor features and fish assemblages were then surveyed using the *Delta* submersible 50 meter intervals between 200 and 350 meters. Thirty-two ten minute transects were completed between two distinct, large-scale habitat types. At 200 and 250 meters, stripetail (*Sebastes saxicola*) and greenstriped (*S. elongatus*) rockfishes were the dominant fish species. At 300 and 350 meters, splitnose (*S. diploproa*) and shortspine thornyhead (*Sebastolobus alascanus*) were the most abundant rockfishes. Large and small-scale habitat associations of these and several other commercially important demersal fishes were also determined.

Habitat Mapping with a Direct Application to Commercial Fisheries Management

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The Alaska Department of Fish and Game (ADF&G) is using geophysical techniques to classify marine fish habitats for use in stock assessment of Demersal Shelf Rockfishes or DSR (Scorpaenidae: *Sebastes*). DSR are the target of an important shore-based fishery in the eastern Gulf of Alaska (330 mt allowable catch). These fishes are difficult to assess using traditional techniques as they are closely associated with complex rocky habitats. We have been using an occupied submersible to conduct line transects for estimating density of DSR since 1990. Biomass is derived as the product of estimated density (for all rocky habitats), the estimate of area of suitable habitat within the 200 m contour, and average weight of fish from port samples by management area. The greatest uncertainty in this approach is the estimate of rock habitat. Previously the estimate of area of suitable habitat was based solely on the habitat description from U.S. NOAA National Ocean Service navigation/bathymetric charts -- seafloor classification in these charts is very limited.

To improve our delineation of available habitat, we conducted a series of sidescan sonar surveys to identify areas of key habitat types in several important fishing grounds in Southeast Alaska. The first survey resulted in a large mosaic encompassing 563 km^2 of the seafloor off Kruzof Island, approximately one fourth of the estimated DSR habitat in the CSEO management area. The area is diverse in habitat, including areas of plutonic rock outcrop, boulders, gravel or pebble, and sand, plus an extended area of lava flows. These habitat characterizations have been groundtruthed with direct observations from a submersible. 304 km^2 of this area is classified as rocky.

We conducted a sidescan sonar survey on the Fairweather Ground in August of 1998. The area surveyed was 780 km^2 of seafloor, primarily on the western bank of Fairweather. In the area sidescanned, 452 km^2 was rocky. Although the area surveyed did not cover the entire Fairweather Ground, it is possible to compare techniques by evaluating the difference between the west bank polygon we thought was rock in 1998 (279 km^2 in this polygon) to the sidescan data that documents 218 km^2 of rock habitat within that polygon. The sidescan data in conjunction with NOS data, submersible dives, and logbook data were used to re-estimate rock habitat for the EYKT area, now estimated at 617 km^2.

Multibeam bathymetric and backscatter data were collected for a portion of the CSEO and SSEO sections in the summer of 2001. These data have not yet been fully analyzed

but preliminary review yields an estimate of 223 km^2 of rock habitat. To date we have mapped over 2000 square kilometers of seafloor. This represents 7% of the total habitat inside the 100 fm contour along the outer coast of Southeast. More importantly, we have mapped 980km^2 of rocky habitat, approximately 32% of what is estimated to occur. Ultimately, our ocean mapping efforts will provide a permanent record of the seafloor for use in the management of living resources within the region.

Mapping the Gulf of Maine: Building the Link between Marine Geology and Benthic Habitats to Improve Ocean Management.

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Multibeam sea floor mapping technologies have provided the capability to accurately, and cost effectively, image large areas of the seabed. This imagery provides base maps of sea floor topography and seabed reflectivity from which targeted surveys can be planned to characterize sea floor sediments and associated benthic communities. Integrated mapping programs have been developed to minimize ship survey time and to generate accurate maps.

Over the last decade extensive multidisciplinary surveys have been carried out in the Gulf of Maine on Stellwagen, Browns, German and Georges banks. Maps produced show bathymetry, surficial sediments and benthic communities. Scientific results have been published through normal peer review channels, but probably of far greater immediate impact has been the use of this knowledge by the commercial fishing industry and by fisheries managers. For example, associations between substrate type and benthic community composition have been used to generate precise maps of scallop habitat and to establish links between scallop abundance and substrate. For Browns Bank, four maps - shaded relief, backscatter intensity, surficial sediments and benthic habitat - have been exported to electronic charts and are now used in real time to guide offshore fishing effort. The environmental and economic benefits have been immediate, with reduced effort to achieve quotas, less bottom disturbance, and containment of fishing activity to known scallop grounds. Stock assessments and management practices have also been improved.

Other pilot projects in Atlantic Canada and the northeastern USA have demonstrated the value of integrated sea floor mapping in designating and managing marine protected areas (The Gully, Stellwagen Bank), in identifying offshore hazards such as landslides, in siting offshore structures, cables and pipelines, and in addressing environmental issues such as the routing of outfalls and disposal of dredge materials and mine tailings. To advance the application of these new tools and digital map products, an international scientific team is advocating the development of a mapping strategy to provide the foundation for sustainable ocean management in the Gulf of Maine for the 21st century.

Core agencies contributing to the development of this strategy include the Geological Survey of Canada, the United States Geological Survey, Fisheries and Oceans Canada and the National Oceanic and Atmospheric Administration, as well as strong participation from state and provincial agencies. Notably, there is also a strong interest by independent organizations such as the Gulf of Maine Council and the Sloan Foundation (Census of Marine Life) to see this initiative developed further.

Poster Abstracts

Habitat Mapping in the Great Lakes – Use of SHOALS Lidar Data to delineate Lake Trout Spawning Reefs.

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As part of the effort to restore native lake trout, six areas of offshore and coastal Lake Michigan habitat were mapped with SHOALS bathymetric lidar in late summer 2001. Decimeter elevation/bathymetric data referenced to IGLD85 datum were obtained on a 4 m grid over a total area of about 200 km^2 in water depths from 0 to 30 m. Shaded relief and color-coded depth images were developed within coarser regional gridded bathymetry and sub aerial DEM as a basis for maps and initial interpretation. Sparse substrate samples, underwater diver and useful but local video and camera observations supplement the morphologic information.

Three criteria are thought important to forming ideal lake trout spawning habitat. 1) Coarse substrate with voids; 2) "Clean" substrate (devoid of biologic growth and fine sediment); and 3) Adjacency to steep slopes with access to deeper water. Bedrock Devonian and Silurian carbonate rocks underlie most of the northwestern rim of the Michigan Basin and crop out at the coast and offshore, forming coarse substrate, and slopes. Overlying bedrock in many areas are glacial deposits including compacted clay tills and outwash gravel and boulders which also form void filled substrate as small (1-3km) ice lobe cobble and boulder moraines with outwash deposits. Post-glacial reworking appears minimal in depths greater than 10m. Sample and video observations suggest "cleanliness" may be compromised by invasive zebra mussel colonies, or algal growth. Laser waveform data is being analyzed for benthic albedo information which we hope will lead to an ability to assess both substrate texture and also substrate "cleanliness" and facilitate remote assessment of benthic habitat.

Fisheries Habitat Studies at Heceta Bank on the Oregon outer Continental Shelf: Combining High-resolution Sonar and Seafloor Investigations with GIS Techniques

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Since the late 1980s Heceta Bank, OR has been a primary focus of groundfish habitat investigations. The first phase (1987-90) used direct counts and observations from the submersible *Delta* to establish relationships between seafloor habitats and the abundance of demersal fishes and benthic invertebrates. A second phase of study was conducted after a comprehensive Simrad EM300 multibeam echosounder mapping effort was completed in 1998. The habitat and biologic data from the 1980's submersible dives were retrofitted onto the multibeam grid using GIS techniques, and then extrapolated to broader areas of the bank using the new imagery. The third phase of the study began in 2000 with the overall objective of conducting an *interdisciplinary* and *comprehensive* study of the marine habitats of this geological province, using state-of-the-art survey strategies, instrumentation, and data analysis. This poster presents an overview of the Heceta Bank Project, and includes results to date from the June 2000 and July 2001 cruises where the remotely-operated vehicle *ROPOS* and the two-person submersible *Delta* (year1) were used to explore the original sites surveyed during the first phase, and to complete extensive transects over portions of the Bank that were not surveyed previously. During the second field season, and between and during each ROPOS dive, biological oceanographers collected acoustic data with a three-frequency echosounder

(Simrad EK500) configured with down-looking 38, 120, and 200 kHz transducers mounted in a towed-body.

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Integration of High-Resolution Multibeam Sonar Imagery with Observational Data From Submersibles and ROVs to Clasify Bottom Types for Habitat-Based Groundfish Assessments at Heceta Bank, Oregon

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With the evolution of fishery science, methods for assessing fish stocks have greatly improved through the development of enhanced sampling equipment and techniques. Despite these improvements, the fishing industry and related management entities often criticize these methods for not yielding accurate and precise estimates of biomass. One possible alternative to traditional single-species assessments involves using the knowledge of important fish-habitat associations to inform a model design for conducting habitat-based community assessments.

One important preliminary step in performing such habitat-based assessments is to classify seafloor bottom types. The integration of data from high-resolution multibeam sonar imagery and geomorphologic data from direct observations enables the classification of bottom types at Heceta Bank - a shallow, rocky shoal off the central Oregon coast. This bottom-type classification is based on the premise that distinct signatures in sonar backscatter and bathymetry data are associated with distinct seafloor bottom types. Using a combination of previously developed and new GIS methods, imagery that depicts the locations of these bottom types on Heceta Bank is being created.

Future integration of other geomorphologic parameters will produce a more robust classification to serve as a framework for integrating observational data on fish densities. Our hope is that this classification will provide a context to support improved estimates

of abundances of various stocks of groundfish on a scale useful for regional stock assessments. Additionally, our methods for classifying seafloor bottom types could potentially serve as a model for other habitat-based community assessments.

Please visit project web site, "Habitat-Based Fisheries Studies: The Heceta Bank Project" http://newport.pmel.noaa.gov/heceta/index.htm

Development of Techniques for Mapping Seabed Biotopes in UK Coastal Waters – an Integrated Approach

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Recent advances in acoustic technologies are offering new insights and opportunities to explore and map seabed habitats. High-resolution biotope(i.e. physical habitats and their associated biological communities) maps of the seabed may assist in future site-specific environmental assessments of potential aggregate dredging areas and be of use in subsequent environmental monitoring activities. Thus, a three year programme of research was funded to investigate the utility of several acoustic remote sensing techniques, used in conjunction with biological sampling and underwater video surveys,to map seabed biotopes over regions of coarse substrate.

Four sites were selected in the eastern English Channel to develop the mapping techniques. The sites were chosen to offer a wide range of substrata of varying degrees of spatial complexity (sediment patchiness) in order to determine the capacity of the techniques to discriminate between neighbouring biotopes.

The example from the Hastings survey site works through the various stages in the mapping process.

Improved Mapping of Deep-Water Coral Ecosystems

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Marine scientists need more affordable, better coverage and greater capability remote survey and data processing systems for monitoring and enforcement of sustainable ecosystem policies.

This is certainly true for deep-water coral reef systems were acoustic mapping techniques (multi-beam and high frequency side-scan) appear insufficient to definitively distinguish corals without supplementary video or other high-resolution ground-truthing techniques. Typical ground-truthing video surveys produce 100's of hours of video, which require labour intensive scrutiny to extract even a part of the data contained.

The EU funded project AMASON will improve matters by researching, implementing and evaluating an inexpensive, modular, reconfigurable multi-sonar and video sensor system, with advanced data processing algorithms implemented within a geographic information system (GIS). The plug-and-play system will be readily deployable from ROV's, AUV's and towfish of opportunity. Data processing will be improved through the development of rapid object and region characterisation, classification and 3D shape reconstruction and will be carried out in large concurrent data sets from the video, small sidescan, parametric sub-bottom and multibeam bathymetric sonars. Fusion of feature and symbolic data will be used to improve confidence in detected events of scientific interest.

Here we present an integrated sample data set taken during IFREMER ROV investigations of deep-water corals in the Rockall Trough, west coast of Ireland, to highlight the problems facing improved mapping in coral areas both in terms of data acquisition and data fusion.

The Effects of Habitat and Rugosity within a Benthic Kelp Forest Community

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By understanding species/habitat associations, researchers can make predictions about a benthic community based on available habitat. Geophysical features are enduring and recurrent and can act as indicators of habitat and community types across a range of scales. The purpose of the proposed research is to test the hypothesis that previously unreported habitat classification and rugosity parameters affect the abundance and diversity of the benthic invertebrate and algal species within a kelp forest. This hypothesis will be tested by defining areas of low, medium and high rugosity within rocky habitat and comparing percent cover of the benthic invertebrate and algal species. The first phase of this study has been completed. Discrete habitats have been mapped using GIS and remote sensing techniques and general descriptions of discrete habitats have been used to examine the relationship between habitat characteristics and benthic community structure. Geologic structure, lithology and physiology in the nearshore environment of southern Monterey Bay have been mapped using multibeam and seismic data. Substratum rugosity was defined as the ratio of surface area divided by planar area. Using GIS, rocky reef habitat was further subdivided into high, medium and low rugosity strata. Qualitative surveys of the benthic invertebrate and algal species, suggest that rugosity can be used as a proxy for identifying benthic communities. In the second phase of the study, mean percent cover, species richness and abundance estimates will be tested for differences using a hierarchical designed ANOVA. The hierarchical design will be used to separate confounding scale and spatial differences among treatments. The results will provide important information to address the larger issue of benthic community variability within heterogeneous (rock) habitat strata and to further develop methods for rapid habitat and biological assessment.

Reconnaissance Mapping of Seabed Characteristics of the Shallow Waters Surrounding the Majuro Atoll, Marshall Islands.

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Satellite imagery from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor, launched by NASA in December 1999, is evaluated in this study for its suitability in mapping shallow water seabed characteristics of Majuro Atoll. The ASTER instrument, mounted aboard the *Terra* spacecraft is operated in a circular, near polar orbit at an altitude of 705 km. The orbit is sun-synchronous with a local time of 10:30 a. m. The repeat cycle is 16 days. ASTER scenes cover an area 60 km X 60 km with a spatial resolution of 15 meters and are available to researchers, via the internet, at no cost.

The visible (G= 0.52-0.60 μm, R= 0.63-0.69 μm) and near IR (0.76-0.86 μm) bands were combined and enhanced for spectral contrast using ERDAS Imagine software. Two scenes were mosaicked together in order to provide coverage of the entire atoll. The resulting image was co-registered with a 1:35,000 scale DMA nautical chart for bathymetric control.

Areas of high reflectance (unconsolidated coral sands), areas of low reflectance and sharp outlines (reefs or colonized hard ground), and mid-range areas of with soft outlines (possibly eel grass beds or fine sediment) could be differentiated from the image. Bottom types, or substrate habitats, were manually digitized using an ArcView habitat digitizer extension developed by NOAA.

The Majuro Atoll, located within the Marshall Islands and lying approximately 3700 km SW of the Hawaiian Islands at ~7°N, 171.2° E, was selected for this study in part because of concerns of the potential impacts on lagoonal habitats, of planned causeway construction that would connect the islets which make up the atoll, and restrict lagoonal circulation. Baseline habitat data will likely be collected prior to causeway construction and may serve as ground-truth data for this study. Plans are underway to survey the lagoonal waters using high-resolution multi-beam sonar. The satellite image derived basemap from this study, outlining shoal areas, may be useful in designing the multi-beam survey and mapping marine habitats.

ASTER imagery has a very high potential for use in reconnaissance mapping of coral reef distribution throughout tropical regions of the world due to its low cost and relatively high spatial resolution. However, similar mapping efforts would benefit considerably where ground-truth data is available to assist in more accurate classification.

Acoustic Seafloor Mapping of Southeast Australia

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Acoustic facies mapping of southeast Australia was undertaken, as one of several map layers, to understand the relationship between seabed geology and benthic habitat. The acoustic map layer generated was used in conjunction with other spatial data to determine seafloor morphology and sediment process as part of regional marine planning by the National Oceans Office. The data was generated by high frequency echo-sounders that record the acoustic response of surface sediments on continuous, paper based echograms. These were interpreted for echo-character, based on Damuth's (1980) classification scheme.

Acoustic facies mapping was the ideal method for regionally mapping a large area in a short period of time, using existing data. Damuth (1980) classified echo-character into three main categories; Type I (distinct), Type II (indistinct, prolonged) and Type III (indistinct, hyperbolae). The echo-characters recorded in southeast Australia were extremely variable, including all of those recognised by Damuth from other areas. Variations were a direct result of the underlying geological features, including sediment type, layering, structure and topography, which directly control benthic habitat.

Additional data sets such as sediment samples, swath imagery, and high-resolution bathymetry are needed to define the echo-types in terms of regional sedimentary process. While ground-truthing with seafloor samples in this area is yet to occur, comparisons were made with high-resolution bathymetry, swath imagery and the ground-truthing results from Whitmore & Belton (1997), Rollet et al (2001) and Damuth (1980). Types I and II were associated with sedimented areas. Sediments were predominantly oozes, with Type II's having more sand content. Type III's were associated with areas of rugged topography, with thin veneers of ooze. Bass Lake, a bathymetric low was defined by prolonged Type II echo-characters, surrounded by less prolonged Type I echo-characters. Canyons incising the continental slope were recognised by hyperbolic Type III echo-characters. Bass Canyon showed Type III, in incised valleys, Type I on the canyon floor with areas of Type II, possible debris flows. The Cascade Seamount similarly displayed steep slopes of Type III, the plateau of Type I and more prolonged Type II to the east, a possible debris flow.

Echo-characters were mapped at a higher resolution than other data sets available for marine regionalisation. Thus the acoustic facies were much higher in detail than the map of geomorphic units, interpreted from the bathymetry map. This has important implications when producing a bioregionalisation. For each scale of regionalisation, data are required to at least the next level lower; so for example to define provinces at scales of 100's to 1000 km, data is needed on a smaller spatial scale, of 10's to 100's km to ensure the boundaries are properly defined.

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Marine Habitat Mapping using Multibeam Backscatter Data

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Acquisition of multibeam backscatter is the fastest and most dense geophysical survey method of the seafloor. Algorithms used for environmental correction and interpretation of backscatter data are solely based on Lambert's Law, the understanding and development of the volume scattering has yet to be incorporated.

The large amount of data and the complexity of a backscatter dataset make the development of automatic interpretation software necessary. Two surveys were carried out, acquiring backscatter data to test the Triton interpretation software. A large-scale sampling and geotechnical program were performed to evaluate the results of the backscatter interpretation.

Remarkably good correlation was found between the backscatter interpretation and the sampling program within the initial survey area. The verification area showed a similar good correlation in the areas of coarser sediments. Problems with correlating the sampling result and the backscatter interpretation were experienced in the areas of softer sediments within the verification area. This could possibly be explained by volume scattering which is important in softer sediments.

Deep Reef Habitats at the Shelf Edge in the Northeastern Gulf of Mexico.

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The shelf-edge region in the northeastern Gulf of Mexico provides essential spawning and feeding habitats for numerous species of reef fish, including at least three groupers: gag (Mycteroperca microlepis), scamp (M. phenax), and red grouper (Epinephelus morio). These groupers are important to commercial and recreational fisheries, and all three species are now considered to be overfished. In June, 2000, two 100-square-mile areas, the Madison-Swanson Marine Protected Area (MPA) and the Steamboat Lumps MPA, were created and closed to all fishing for a period of 4 years to allow study of the effects of fishing on the shelf-edge biologic community and habitats. Cooperative studies involving the U.S. Geological Survey, Florida State University, and the National Marine Fisheries Service are underway to map the habitats and to understand the inter-relationships between the geology and the benthic community. In 1997, we mapped an unprotected area (Twin Ridges) and in 2000 began mapping the two new MPAs.

Recent sidescan-sonar surveys, high-resolution seismic-reflection profiles, sediment sampling, and bottom video, show that the shallow geology of these habitats has been shaped in part by the Quaternary sealevel history. We mapped high-relief rocky ledges in water depths of about 75 meters, some of which rise up to 15 meters above the surrounding seafloor. We believe that they mark a Pleistocene sea level stillstand. We also mapped high-relief pinnacles which appear to have been built on the remains of drowned patch reefs. These high-relief hardbottom areas are known to support spawning aggregations of gag and scamp groupers. Low-relief hardbottoms with evidence of sub aerial (?) dissolution, near the drowned paleoshoreline features provide habitat for red grouper. The red groupers appear to create and maintain the hardbottom habitat by sweeping areas clear of sediment to reveal the rugose rock surface below. Fine-grained sediments in the deeper parts of the MPAs and in nearby unprotected areas are pockmarked with small pits and burrows which are occupied by small shrimp and fishes such as bank sea bass (Centropristis ocyurus). Large (1-2 meter diameter) burrows may be made by tilefish (Lopholatilus chamaeleonticeps).

Our sidescan sonar data are processed and digitally mosaicked in near real time at sea, allowing efficient selection of sampling sites. The sidescan mosaics, sediment data, seafloor photographs, and geologic interpretations have been incorporated into ArcInfo GIS coverages, which are being made available for use of other scientists and resource managers.

Seafloor Rocks and Sediments of the Continental Shelf From Monterey Bay to Point Sur, California

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Acoustic swath mapping of the greater Monterey Bay area continental shelf from Point Año Nuevo to Point Sur reveals complex patterns of rock outcrops on the shelf, and coarse sand bodies that occur in distinct depressions on the inner and mid-shelves. This map portrays the seafloor components in a 36- by 48-inch map sheet at 1:100,000 scale. The digital database for the interpreted geology and other digital files, including the explanatory text, are available on the web for download.

Habitat Mapping and Geology of Commercial Fishing Grounds in the Cape Ommaney-Hazy Island Area of SE Alaska

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Preliminary interpretation of Reson SeaBat 8111 100 kHz digital multibeam bathymetric and backscatter data collected in the Cape Ommaney-Hazy Islands area, at the mouth of Chatham Strait, SE Alaska was undertaken to characterize demersal fish habitats. Since this area is commercially fished for yelloweye and other rockfish species, mapping of seafloor morphology and quantification of substrate types is necessary for use in stock assessment and management.

The study area lies within the Queen Charlotte-Fairweather fault system, a major transform system that separates the North America Plate from the Pacific Plate. The images we obtained reflect complex bedrock and sediment-covered seafloor structure resulting from the tectonic movement of faults within this system. This complexity is represented by major NW-SE trending en echelon faults with N-S and NE-SW conjugate faults and fractures. This is also an area where the Chatham Strait fault diverges northward from the Queen Charlotte-Fairweather fault zone. Faults within the transform fault system are easily identified from distinct linear bedrock scarps and linear scour depressions in areas of soft sediment seafloor.

We have preliminarily delineated 14 major habitat types comprised of soft, hard, and mixed substrate types. Soft seafloor types vary from mud to sand. Hard seafloor consists of deeply fractured and jointed plutonic rock, highly fractured, faulted and folded sedimentary rock, and pinnacles and boulders. Mixed seafloor types are comprised of fields and stringers of gravel, pebbles and boulders. Rockfish catch data show that yelloweye rockfish are concentrated along structurally complex bedrock exposures of high relief with high void to clast ratios.

In addition, we noticed that red tree coral (*Primnoa* spp.), which provide macro- and microhabitat (after Greene et al., 1999) for juvenile rockfishes, are associated with fault produced shatter ridges both in the Cape Ommaney and Cross Sound regions. This indicates that tectonic movement and fault-produced structure may play a major role in providing appropriate substrate for red tree coral attachment.

Habitat Mapping in the Transboundary region of Canada and the U.S: a new U.S. Canada Co-op

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The San Juan Islands (SJI) of northwestern Washington State, USA were carved into their present-day shape during the Pleistocene when glaciers advanced across the region and deeply cut the bedrock into valleys and grooves that are now fjords. These narrow fjords focus and strengthen tidal currents that scour the seafloor producing distinct strong current bedforms such as mega-sediment waves, dunes, ripples, scour depressions, troughs and channels, and sediment accumulation mounds and ridges. In many places, bedrock is exposed and has been scoured smooth by glaciation and current-driven abrasion. Ice- and current-scoured pinnacles and glacially deposited boulders (erratics) are scattered throughout the region.

Simrad multibeam EM 2001 bathymetric and backscatter data were collected by the Canadian Hydrographic Office in the Fall of 2001 in the Boundary Pass, northern Haro Strait, and northern San Juan Channel areas of the SJI as part of a joint U.S. (Moss Landing Marine Laboratories' Center for Habitat Studies) and Canadian (Geological Survey of Canada) seafloor mapping project. These data were merged with high-resolution bathymetric images collected in selected areas of the SJI during the Fall of 2000 for the purpose of assessing voluntary Marine Protected Areas (MPAs). From the shipboard data set, we interpreted 11 general habitat types that range from soft unconsolidated sediment, including many different bedform types, to hard bedrock outcrops consisting of differentially eroded sedimentary and meta-sedimentary rocks. Rock outcrops of differentially eroded sedimentary bedrock are considered the best habitat for rockfishes as these outcrops contain overhangs, caves, and crevices that can provide refuge for the fishes.

The intent of our work is to completely image the floor and walls of the SJI inland sea and to construct benthic habitat maps that can be used to better manage and conserve rockfishes and other biota. Under the U.S./Canadian Habitat Mapping Cooperative the Haro Strait, southern San Juan Channel, and northern San Juan Strait will be mapped in the fall of 2002.

Habitat Mapping of the Cowcod Conservation Areas, Southern California Borderland, USA

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The recent collapse of both recreational and commercial fisheries for cowcod prompted the Pacific Fisheries Management Council, together with the National Marine Fisheries Service and the state of California, to establish two Cowcod Conservation Areas (CCAs) in the Southern California Bight. These two areas, encompassing approximately 4,200 nm^2 and 100 nm^2, include key cowcod habitat along the Santa Rosa-Cortes and northern San Clemente Ridges and also the San Nicholas and Santa Barbara Islands. This area lies in a diverse and complex geologic setting comprised of basins filled with sediment and ridges generally of exposed bedrock locally covered with unconsolidated sediment. In order to distinguish habitat types for further assessment of cowcod abundance in these areas, we have compiled a seafloor data set comprised of marine geologic maps, seafloor sampling information, and a Reson 8101 100 kHz multibeam bathymetric survey in the shallow shelf areas of Santa Barbara Island for interpretation into habitat maps. The geologic maps were primarily constructed from interpreted seismic reflection profiles and modified to show true or assumed seafloor, or near seafloor, substrate types. This work illustrates the usefulness of marine geologic maps in "first-cut" habitat type delineation, especially in delineating hard from soft substrate types. Habitat types ranging from hard differentially eroded bedrock exposures to soft unconsolidated sediments were indentified. Complex detailed habitats were identified around Santa Barbara Island and on the Tanner-Cortes Bank. On Tanner-Cortes Bank irregular, highly rugose volcanic rock crops out in the shallow-water crests and is surrounded by well-developed erosional and depositional marine terraces and flow surfaces. The shallow shelf areas around Santa Barbara Island are comprised of hard volcanic rock outcrops and fairly well developed marine terraces. These habitat maps will be used to prioritize future high-resolution mapping efforts and to locate submersible dive sites for cowcod assessment surveys.

Footprint: Issues of Scale in Acoustic Seabed Classification

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Acoustic seabed classification is dependent on the ability of individual waveforms to represent different seabed types. Each acoustic ping striking the seabed will have a characteristic footprint area, primarily dependent on two variables: bottom depth and transducer beam width. What is the effective footprint area of an individual echo and how does this vary with depth? During acoustic surveys of the seabed, the overlap of successive footprint areas can vary considerably, depending on ping rate and vessel speed. What is the effect of sampling redundancy on acoustic seabed classification? Acoustic seabed classification typically involves combining several pings into a single classification process in order to reduce inherent variability in the acoustic seabed echoes. What is the effect of combining individual waveforms into aggregated units prior to classification? Seabed habitat can vary on the scale of meters. Our ability to resolve small-scale features of seabed habitats will depend on answers to these questions. We address these questions using theoretical and empirical approaches based on our recent work in the coastal waters of Newfoundland.

Development of Mapping Standards at the Geological Survey of Canada for Marine Bathymetry, Geology and Habitat Maps

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The recent development of new sea floor mapping tools centered on multibeam bathymetric technology has provided the first opportunity to map the sea floor continuously at high resolution, similar to the advantages offered by remote sensing onshore. Multibeam bathymetry, when integrated with other marine science data, provides an extensive database from which new interpreted geological, biological and engineering maps and related products are generated. These map products are essential to satisfy growing demands for integrated coastal management (ICM), defense and security concerns, and sustainable development of offshore renewable and non-renewable resources.

There exists (and should continue to be encouraged) a wide variety of options for multibeam data presentation, interpretation and dissemination. However, there are no Canadian (or global) standards for the production of multibeam bathymetric maps and interpretive digital map products. The purpose of this work is to:

- review map and data base options and user needs, and determine a range of appropriate standards and methodologies,
- apply the standards to demonstration projects in the coastal zone and on the continental shelf,
- produce a suite of map products that includes bathymetry, backscatter, surficial geology, and benthic habitat, and
- complete a report detailing the mapping techniques and recommending standards to be followed for future sea floor mapping in Canada.

The results of this mapping standards work will guide the future Canadian seabed mapping program and enable comparisons with techniques developed elsewhere in the worldwide community.

A Unified Hierarchical Classification Framework for Coastal and Marine Habitats

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Scientific description and practical management of resources generally demands a spatially stratified hierarchical system of habitat classification. Given such a system, research, and the utilisation, conservation, management and monitoring of resources, can be conducted in some equitable, or stratified, manner, at spatial and temporal scales appropriate to the task at hand. A single classification scheme is unlikely to meet all needs but a useful starting point is a conceptual classification framework that can be individually tailored to particular purposes (identifying information gaps, field sampling, modeling, monitoring, resource management). We put forward a unifying conceptual framework for treating coastal and marine habitats; the approach treats habitats and ecological attributes (e.g. community, population, species, genes) as complementary assessments of biodiversity which are linked by ecological processes. We describe here the habitat hierarchical component which proceeds to smaller scales in the order of the following major Levels: Province, Biome, Biogeomorphological, Primary Biotope, Secondary Biotope, Biological Facies, Micro Communities. Pragmatically based definitions of these Levels are presented and applied to the Australian coastal and marine environment. We summarise our experience with example applications illustrating the integration of physical, biological and geological information of various types and scales.

Keywords: Marine Habitats, Habitat Classification, Coastal Habitats, Marine Biodiversity, Habitat Scales, Habitat Types, Marine Provinces, Marin

Fisheries Habitat - Integrated Database Development for U.S. West Coast Groundfish and their Habitats

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The goal of this project is the creation and use of a comprehensive, helpful and easily accessible, multi-layer GIS database and associated web-site for groundfish habitat in the Pacific Northwest.

The most direct and immediate need for such a database is as a tool for use by fishery managers to support future marine fisheries management decisions. This information also relates directly to the consultation responsibilities of fishery management councils under the essential fish habitat provisions in federal law, and will serve as a resource for other agencies and entities in their decision processes. The database will provide marine researchers ready access to available information in order to establish and test hypotheses concerning marine habitat and resource distribution and change; limited data availability often constrains the questions that can be productively addressed. The database is a geologic, geophysical, and bathymetric system of data, metadata, and interpretive and derivative layers created from the raw data. The raw data sources include multi and single beam bathymetry, numerous sidescan sonar surveys, academic and oil industry rock, dredge and core samples, academic and oil industry seismic reflection data. These main data sources are augmented by auxiliary data from submersible observations, cable route surveys, cable burial video, trawl video, and others. These basic layers will be integrated into a bottom type classification, an iterative process that cannot be completely objective, but will include geologic interpretation of the data. Seismic reflection data for example, can be used to interpret rock outcrop, though the surface return in archived industry data cannot generally be used to distinguish other lithologies. Each interpretive layer will be tested against similar layers derived from other sources to iteratively converge on the best-fit classification. Derivative layers include slope, drainage, geologic structure and others. In areas of low data density, slope angle can be used as a crude predictor of rock outcrop, and will be combined with the data-based interpretive layers where no other data exist.

European Marine Geoscience Database Projects - giving access to existing Data Collections

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The scientific study of the marine environment and the sustainable development of resources are increasingly the subject of international co-operation. Research into marine habitats, climate change, pollution control, coastal development and commercial activities such as hydrocarbon exploitation, cable and pipeline surveys, marine aggregate extraction and siting of offshore structures such as wind farms, all require access to existing marine data resources. Until recently, many of these data resources were available only in widely dispersed research organisations and information centres, which focused mainly on national requirements. The need for collaborative initiatives which bring together these data resources has long been recognised, particularly in the USA where over 20 years ago a group of oceanographic research organisations got together to develop what is now the 'Index of Marine Geological Samples' giving access to sea-bed core data. The Index, hosted by the US National Geophysical Data Centre/ World Data Centre A for Marine Geology and Geophysics at Boulder Colorado, is supported by 19 organisations, 16 of which are from North America and 3 from Europe.

Over the last 30 years, the marine geology departments of the European geological surveys have acquired a vast data resource of seabed samples, cores and seismic survey information. In the late 1990's the geological surveys of the 14 maritime member states of the European Union participated in two proposals that aimed to address the issue of providing knowledge of existing seabed sample and core data. One proposal, the European Marine Sediment Information Network (EUMARSIN) proposed to compile metadata for all samples and cores held by the geological surveys in European seas. The other, EUROCORE, proposed to collect metadata for samples and cores from anywhere in the world, provided they were held by a European institution. During 1998, both proposals were accepted and funded by the Marine Science and Technology (MAST) programme of the Science, Research and Development Directorate General within the European Commission's Fourth Framework Programme.

The two projects were integrated to form the EU-SEASED Website (http://www.eu-seased.net) which makes use of a single Internet-access database presently holding information for over 220,000 sea-bed samples and cores from around the world, acquired by over 60 marine organisations from Europe. The searchable database provides information on the sample location, equipment type, sub-sample analyses, storage conditions and the organisation that should be contacted for access to the sample material and/or data. In addition to the metadatabase, the Website has an area for end-users to contribute feedback, a Newsletter with articles on the activities of the project partners and other marine organisations with interests in sea-floor sediments, and links to other marine

organisations and data centres, including the US Index of Marine Geological Samples. As such, the EU-SEASED Website aims to provide access to as wide a range of sea-floor geoscience data and information resources as possible.

The project participants plan to develop the metadatabase by including other valuable data resources and to expand the geographical coverage to include countries that are not members of the European Union. At the beginning of 2002, a new EC-funded project (EUROSEISMIC - European Marine Seismic Metadata and Information Centre) commenced, with the aim of compiling metadata for available seismic survey information held by the 15 data source holders who are participating in the project. This project will continue until December 2004 and initial estimates indicate that over 1.5 million line kilometres of seismic survey, including sonar, metadata will be contributed to the existing EU-SEASED system.

Mapping Irish Deep-Water Corals: a Necessary First Step towards their Conservation

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Deep-water coral reefs, formed principally by the framework constructing azooanthelate scleractinian, Lophelia pertusa, occur off the west coast of Ireland in water depths of 500 to 1200m. They are found in association with provinces (clusters) of spectacular carbonate mounds which rise between 10 and 300 m above the seafloor. These reefs are home to a rich associated invertebrate and fish fauna which until recently was very poorly described.

Pressures on the coral habitat are increasing with trawling in Norway estimated to have damaged 30 to 50% of known reefs and significantly impacted coral locations west of Scotland. Concerns over potential further damage to corals prompted a consortium of Irish and European scientists to begin a detailed EU funded environmental baseline study (ACES) of the coral ecosystem along the Atlantic Margin.

Last summer, an Irish-French-EU research mission CARACOLE (Carbonate Mound and Cold Coral Research) visited five deep-water coral locations in the Irish Porcupine Seabight and Rockall Trough. A total of 9 dives were conducted using the IFREMER remotely operated vehicle 'VICTOR'. High-resolution video and close-up digital stills taken with the ROV revealed the true extent and spectacular nature of the coral reef formations and the variability of the associated fauna between sites. Evidence of fishing activity was confined to imaging of static gears (gill/tangle nets) lost on the side of mounds. No evidence of trawl related damage to the corals was obtained even though accidental coral by-catch has previously been reported from deep-water trawl surveys in Irish waters.

European Union environmental regulations include the Habitats Directive, which provides the basis for protection of a priority list of species, and habitats through the creation of managed Special Areas of Conservation (SAC's). It is likely that Ireland will be required to designate a number of offshore SAC sites to protect Lophelia reefs in the near future. Analysis of CARACOLE data will provide the detailed habitat maps required to further the designation process, however, an important factor in choosing areas for conservation is the degree of representativeness of the site in terms of the entire distribution of the target species/habitat. The two-week CARACOLE mission enabled the detailed mapping of only a small number of mound locations in each mound province so that the degree of representativeness of the mapped corals areas remains unknown. The mound provinces cover several thousand square kilometres of seafloor, which makes

ROV mapping of the whole area prohibitively expensive and time consuming. Practical management of these areas will require production of maps using: new methodologies, e.g. identification of acoustic proxies for coral or the development of predictive models of mound coral cover; or new technologies, i.e. AUVs.

Habitat-Specific Distribution and Abundance of Red Tree Coral (*Primnoa* spp.) and other Sessile Macroinvertebrates off Southeastern Alaska

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Red tree coral (*Primnoa* spp.) and other sessile macroinvertebrates (i.e., vase sponges and anemones) provide high-relief habitat for several commercially important fishes and have been identified as habitat areas of particular concern (HAPC) by the North Pacific Fishery Management Council. *Primnoa* spp. exhibit extreme longevity, slow growth, and fragile, branching morphology. Red tree coral is susceptible to fishing disturbance and recovery from trawl damage appears to be quite slow. In order to conserve *Primnoa* and other sessile macroinvertebrate populations and determine their ecological relationships, their distributions must be mapped and their substrate affinities described. Using video data previously collected from a submersible during rockfish (*Sebastes* spp.) stock assessment surveys in the Eastern Gulf of Alaska, the distribution, abundance, and habitat associations of *Primnoa* and other sessile macroinvertebrates are being investigated from dives in depths between 130 and 220 meters. Using lasers set apart at a known distance, heights and trunk diameters of *Primnoa* spp. colonies can be estimated from video data and used to calculate ages for isolated colonies using the relationships described by Andrews *et al.* (in press). Additionally, this project demonstrates the ability to derive new information from a previously collected submersible data set, for a separate objective at little additional cost.

Designating Essential Fish Habitat (EFH) in Alaska: Issues in Consistency and Efficiency when using Geographical Information Systems (GIS)

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The NMFS Alaska Region is presently drafting an Environmental Impact Statement (EIS) to evaluate a reasonable range of alternatives to develop the mandatory Essential Fish Habitat (EFH) provisions. The process of updating habitat definitions and creating maps that describe EFH have led to basic questions about the standardization of map criteria. Although national EFH GIS standards are suggested, there are regional differences that will require specific standards for map criteria, such as projections, map features, and categories. Currently within the Alaska Region, research and GIS data are summarized by management areas (e.g., Gulf of Alaska, Bering Sea and Aleutian Islands), which share common features such as depth, but do not necessarily overlap between areas. For an Alaska Region project, such as the EFH EIS, an overall standard to make map production efficient is needed. Therefore, interpretation of the data sets and maps will be consistent. The standardization will assist fishery resource managers and allow NMFS to present visually how management decisions may appear in a geographic reference. This poster presents one way of resolving these issues.

Using Multibeam Bathymetry to Investigate Marine Geology and Potential Marine Reserves in the San Juan Islands, Washington, USA

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In the fall of 2000 Moss Landing Marine Laboratories surveyed five areas within the San Juan Archipelago (SJA) using a RESON 8101 multibeam bathymetric system. Both bathymetry and backscatter data were collected. This survey aimed to 1) investigate the marine geologic history of the SJA, and 2) identify habitats of declining bottomfish species such as rockfish (*Sebastes*), as part of a regional effort to create a system of marine reserves within the SJA. Previous scientific work identified these areas as potential reserves based upon biologic and physical oceanographic conditions. Two of the five survey sites were located within San Juan Channel, with one site situated at the narrow passage between San Juan Channel and the Strait of Juan de Fuca. Sites were also surveyed in southern Rosario and southern Haro Straits. Survey depths ranged from 3m along the rocky shorelines to 300m in Haro Strait.

Sun-shaded images produced from processed multibeam data revealed seafloor with numerous high relief bedrock outcrops among mainly reworked glacial sediments. A majority of the bedrock imaged appeared fractured and jointed, most likely due to a combination of ancient subduction processes and modern strike-slip movement. Evidence of glacial marine processes was widespread among the five sites. Northern San Juan Channel appears to have formed by glacial scouring, as seen by the characteristic U-shaped channel. In contrast, southern San Juan Channel most likely formed by movement along an ancient thrust fault. Crescent-shaped Lawson Reef in southern Rosario Strait represents a glacial marine deposit, possibly at the mouth of a sub-glacial stream. A combination of tectonic, glacial, and tidal processes shaped the seafloor through time within the SJA. The morphology of the seafloor, in turn, created physical habitats for many marine species, while also directly influencing circulation patterns within the islands. Areas of medium and high complexity identified using statistical analyses of slope data highlighted potential adult and juvenile bottomfish habitat. When combined with previously collected fisheries, physical oceanographic, and nearshore habitat GIS datasets, current voluntary no-take zones were evaluated and potential alternate marine reserves were outlined. Integration of such large datasets in compatible GIS formats allows for a comprehensive, regional perspective on marine reserve systems and other scientific and marine resource management issues.

Mapping Sedimentary Processes and Habitat Change in the Nearshore Area of Santa Cruz, California

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A harbor dredging experiment conducted in late March of 2001 along the beaches and nearshore of Santa Cruz, California consisting of three phases, Pre-Experiment, During-Experiment, and Post-Experiment was undertaken to determine depositional characteristics of fine grained sediment. In the Pre- and Post-Experimental phases of this experiment, high-resolution side-scan sonar and multibeam bathymetry data were collected to produce maps that define habitats, surface sediments and depth changes of the seafloor near the Santa Cruz Harbor. Offshore and beach sediment samples were collected three weeks prior to, and after, the experiment to analyze for changes in grain size and to provide physical evidence of seafloor substrate. Experimental monitoring consisted of daily beach and offshore sediment sampling.

Our sedimentological studies of dredge materials from the upper Santa Cruz Harbor, California suggest that sediment containing approximately 40% sand and 60% mud can be disposed in the surf zone without adversely affecting the quality of neighboring beaches or offshore rocky habitats while simultaneously replenishing sand to eroding beaches downcoast. A small amount of the mud-rich material (about 2300 m^3) was placed into the surf-zone during the winter of 2000-2001 to determine the retention of sands in the nearshore zone and the impact that fine-grain (mud) sediment may have on rocky habitats.

Reef fish – Habitat Associations in the Gulf of California

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How fishes associate with habitat has been the subject of much research, most focused on tropical coral reefs. There are differences in fish assemblages among geographic regions and types of reefs, so these results are limited to the habitat and region of interest. More research is needed on different types of reefs, in different regions, using the same methods. This study was conducted in the Parque Nacional Bahía de Loreto, located on the western-central Gulf of California, to determine how diversity and abundance of Gulf reef fishes differs among rocky habitats and among numerous habitat characteristics. Four habitat types were sampled, lava, large boulder, small boulder, and mixed. Diversity, abundance, and distribution of fish species were obtained during underwater stationary video surveys. Four habitat variables were measured, relief, rugosity, boulder diversity, and percentage cover. Assemblage and habitat data were analyzed using canonical correspondence analysis (CCA). Thirty-six transects were conducted. No differences in species richness, diversity, or fish abundance were found among the four habitat types. Fish are significantly associated with measured habitat variables. This work will continue with comparisons between rocky substrate and coral reefs.

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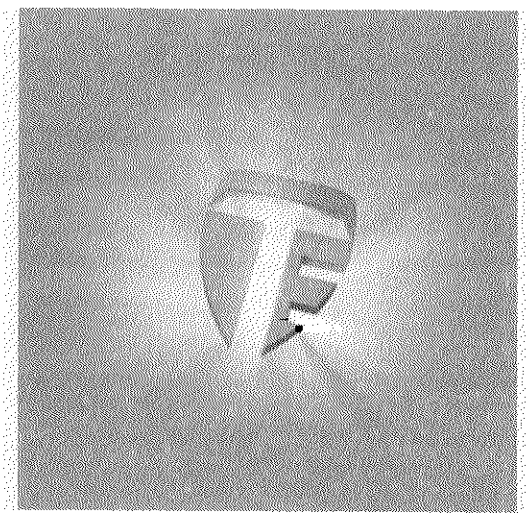
THALES



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