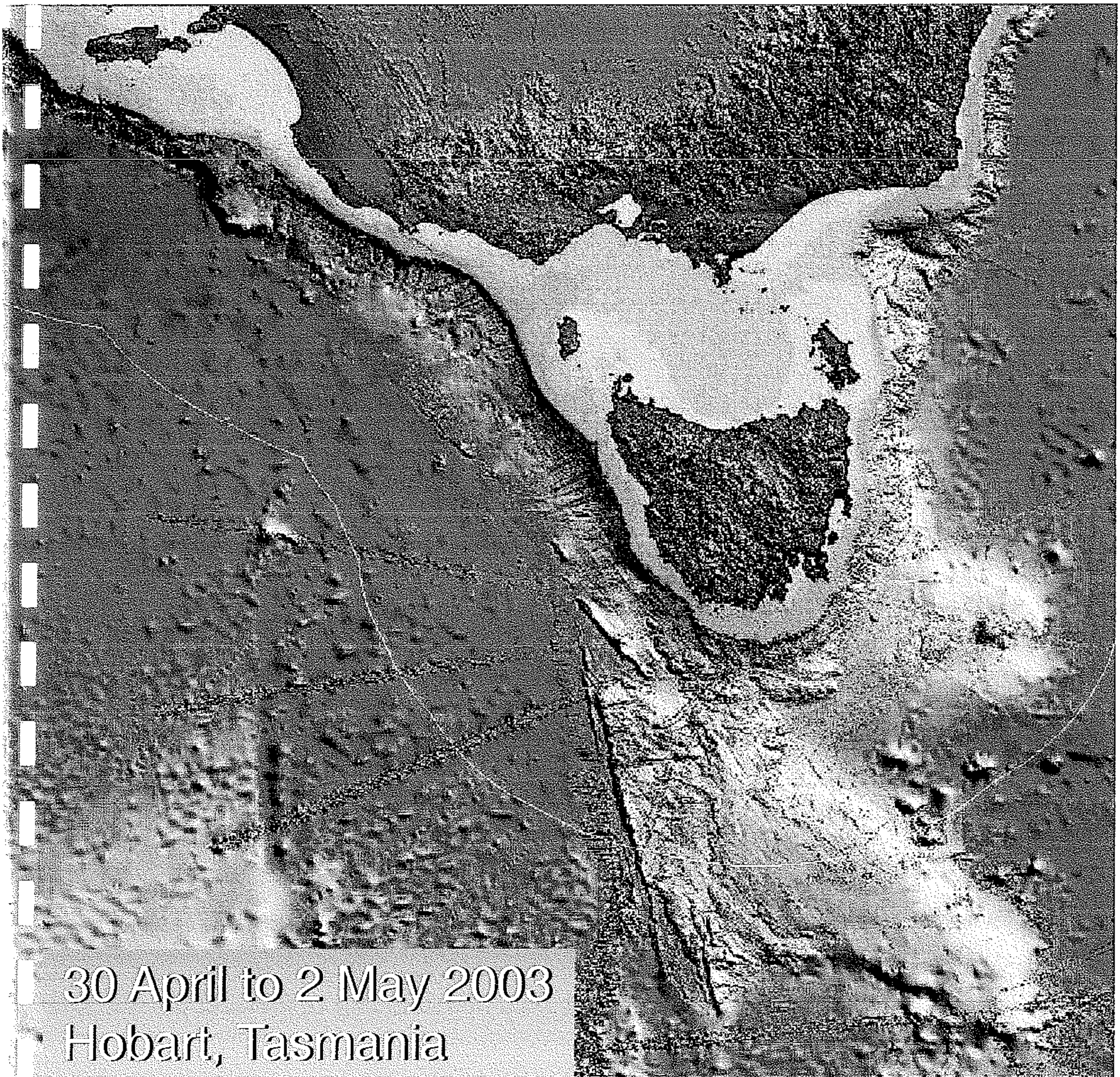
GEOHAB 2003

Geological Mapping of Habitats for Marine Resources and Management



Welcome to GeoHab 2003

Geological Mapping of Habitats for Marine Resources and Management

This year's conference is co-convened by
Peter Harris - Geoscience Australia
Alan Butler - CSIRO Marine Laboratories

We would like to thank our sponsors

GEOSCIENCE AUSTRALIA

Geoscience Australia

CSIRO MARINE RESEARCH

CSIRO Marine Laboratories

NATIONAL OCEANS OFFICE

National Oceans Office

Acknowledgments

Bruce Barker, Tim Ryan and Dave Cordell at CSIRO Marine Laboratories for oraganising the auditorium, 'tech support', email access, after hours building access and the poster room.
Linda Thomas at Geoscience Australia for webpage design, collection of monies and abstracts, printing of abstracts & name tags, organising conference dinner and morning & afternoon teas.
The National Oceans Office for organising the media coverage, the banner and the ice breaker evening.
Bill Gilmour from Thales GeoSoultions for sponsoring, and Bruce Barker from CSIRO for organising the post conference drinks.

GeoHab 2003 Timetable

Wednesday, 30 April 2003

	09.00 – 09.30	Registration		
	09.30 – 09.50	GeoHab Welcome	Kim Finney	Deputy Director, National Oceans Office
Session Chair: Peter Harris	09.50 – 10.10	Linking Fisheries to Benthic Habitats at Multiple Scales: Eastern Scotian Shelf Haddock (*Melanogrammus aeglefinus*)	John Anderson	Northwest Atlantic Fisheries Centre Department of Fisheries and Oceans Canada
Session Chair: Peter Harris	10.10 – 10.30	Interactions of fishing gears with seabed habitats on the deep continental shelf and slope off SE Australia	Alan Williams	CSIRO Division of Marine Research
	10.30 – 11.00	Morning Tea		
Session Chair: Terje Thorsnes	11.00 – 11.20	The Patchiness of Benthic Substrates, Measured Using the usSeabed Data Structure	Chris Jenkins	INSTAAR, University of Colorado
Session Chair: Terje Thorsnes	11.20 – 11.40	Marine DataView – an application for Visualising and Distributing Marine Seabed Data	Gordon Keith	CSIRO Division of Marine Research
Session Chair: Terje Thorsnes	11.40 – 12.00	Textural Image Analysis of Medium-to-deep-water backscatter mosaics of the seabed using artificial neural networks	Dietmar Muller	University of Sydney Institute of Marine Science (USIMS)
Session Chair: Terje Thorsnes	12.00 – 12.20	Marine Benthic Habitat Characterisation: The Need For A Standard	Gary Greene	Centre for Habitat Studies, Moss Landing Marine Laboratories
	12.20 – 14.00	Lunch		
Session Chair: Meredith Hall	14.00 – 14.20	SEAMAP Tasmania – the application of seabed habitat mapping for multiple marine resource management	Miles Lawler	Tasmanian Aquaculture and Fisheries Institute
Session Chair: Meredith Hall	14.20 – 14.40	The application of digital aerial photography to shallow water seabed mapping – How deep can you see?	Richard Mount	Tasmanian Aquaculture and Fisheries Institute
Session Chair: Meredith Hall	14.40 – 15.00	The Use of Side-Scan Sonar Terrain As A Surrogate for Habitat Mapping: Case Studies From Victorian Marine National Parks	Joseph Leach	Department of Geomatics, University of Melbourne
Session Chair: Meredith Hall	15.00 – 15.20	Addressing spatial uncertainty in seabed habitat mapping	Vanessa Halley	Tasmanian Aquaculture and Fisheries Institute
	15.20 – 16.00	Afternoon Tea		
	16.00 – 17.00	Discussion	Leader: Peter Harris	
	17.30 – 19.00	Ice Breaker Session	Lenna of Hobart	

Thursday, 1 May 2003

Session Chair: Brian Todd	09.00 – 09.20	Fossil Biodiversity Distribution as a Habitat Mapping Tool	Erin Arnold	Antarctic CRC
	09.20 – 09.40	Use of Foraminifera in Benthic Habitat Mapping of the Torres Strait – Gulf of Papua Region	Vicki Passlow	Geoscience Australia
	09.40 – 10.00	Biodiversity measures and surrogates: interpretation and uses of invertebrate samples from a multidisciplinary survey	Franziska Althaus	CSIRO Division of Marine Research
	10.00 – 10.20	Seabed Habitat Mapping in the Kent Group of Islands and its role in Marine Protection Area Planning	Alan Jordan	Tasmanian Aquaculture and Fisheries Institute
	10.20 – 11.00	Morning Tea		
Session Chair: Alan Butler	11.00 – 11.20	Application of Sidescan Sonar and Video for Assessing, Mapping and Visualising Distribution of Habitats and Benthic Biodiversity in Shallow Water	Andy Bickers	Marine Science Group, University of Western Australia
	11.20 – 11.40	Classification and Prediction of Marine Habitats: the use of rule based learning to optimise field research.	Katrina Baxter	University of Western Australia
	11.40 – 12.00	Benthic habitat of eastern Georges Bank, Gulf of Maine	Brian Todd	Geological Survey of Canada (Atlantic)
	12.00 – 12.40	How well do rapid assessment techniques and other surrogates reflect patterns in seabed biodiversity	Roland Pitcher	CSIRO Division of Marine Research
	12.40 – 14.00	Lunch		
Session Chair: Alan Stevenson	14.00 – 14.20	Seabed Structure and biota relationships – using surrogates obtained from acoustic, video and physical sampling	Rudy Kloser	CSIRO Division of Marine Research
	14.20 – 14.40	Applications of a hierarchical biodiversity classification framework for coastal and marine ecosystems	Vincent Lyne	CSIRO Division of Marine Research
	14.40 – 15.00	Classification of the Tasmanian Continental Shelf using multivariate analysis of wave and tide dynamics and physical sediment parameters	Rick Smith	Geoscience Australia
	15.00 – 15.30	Afternoon Tea		
	15.30 – 16.30	Discussion	Leader: Alan Butler	
	16.30 – 17.00	GeoHab Business Meeting		
	18.00 – 22.30	Conference Dinner Moorilla Estate	Brooke St Pier at 6pm	

Friday, 2 May 2003

Session Chair: Vaughn Barrie	09.40 – 10.00	Planning for the Conservation of Marine Biodiversity	John Roff	Acadia University Canada
	10.00 – 10.20	Visualisation for Management – from Egyptian papyrus maps to virtual reality	Terje Thorsnes	Geological Survey of Norway
	10.20 – 10.40	The sandbag nearshore coastal zone mapping project – a model for the future	Bill Gilmour	Thales Geosolutions (Pacific) Inc.
	10.40 – 11.00	Geology informing management – Experience in Australia's SE Marine Region	Meredith Hall	National Oceans Office
	11.00 – 11.30	Morning Tea		
Session Chair: Gary Greene	11.30 – 11.50	Geoscience and ocean management of Queen Charlotte Basin	Vaughn Barrie	Geological Survey of Canada
	11.50 – 12.10	Steering and applying marine science for Integrated Oceans Management – issues and current initiatives	Campbell Davies	National Oceans Office
	12.10 – 12.30	Tidally scoured shelf channels provide conduits for the existence of coral reef habitats in the northern Great Barrier Reef	Andrew Heap	Geoscience Australia
	12.30 – 12.50	A new map of geomorphic features on the Australian continental margin: application for regional marine planning	Peter Harris	Geoscience Australia
	12.50 – 14.00	Lunch		
	14.00 – 15.30	Discussion	Leader: Meredith Hall	
	15.30 – 16.00	Afternoon Tea		
	16.00 – 16.30	Wrap up session	Alan Butler Peter Harris	
	16.30	Poster Presentations		
	16.30	Post Conference Drinks	Hosted by Bill Gilmour	Thales Geosolutions

Saturday, 3 May 2003

9.00 – 17.00	Field Trip to Tasman Peninsula

Papers

Science to support Integrated Oceans Management of Australia's Oceans

Kim Finney, Deputy Director, National Oceans Office

The National Oceans is actively advancing implementation of Integrated Oceans Management for Australia's Oceans. The Office is responsible for leading the further development and implementation of Australia's Oceans Policy, including regional marine planning. Policy principles that guide the development of integrated oceans management include ecosystem-based management and integrated, outcome-based planning. Implementation of these planning and management principles requires a wide range of scientific information. This address will outline the ways in which scientific information is required – and is currently being used - to support Integrated Oceans Management. The challenges inherent in planning and managing with limited knowledge and limited resources will also be addressed.

Linking Fisheries to Benthic Habitats at Multiple Scales: Eastern Scotian Shelf Haddock (*Melanogrammus aeglefinus*)

By
John T. Anderson[1], J. E. Simon[2], D. C. Gordon[3] and P. C. Hurley[2]

[1]Northwest Atlantic Fisheries Centre
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland
Canada
A1C 5X1

[2]Department of Fisheries and Oceans
Marine Fish Division
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS
B2Y 4A2

[3]Department of Fisheries and Oceans
Environmental Sciences Division
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS
B2Y 4A2

Historical distributions of age one haddock on the eastern Scotian Shelf (NAFO Division 4W) were strongly density dependent consistent with direct dependence on benthic habitats. Distributions of ages 2 –5 haddock were weakly density dependent indicating weak to non-existent associations with benthic habitats. The spatial dimension and size of high likelihood areas of occurrence (≥ 75 %) for age one haddock changed with the scale of analysis. As bin size was reduced from 1342 km^2 (400 nm^2) to 755 km^2 (225 nm^2), to 336 km^2 (100 nm^2) to 84 km^2 (25 nm^2) the boundaries in preferred habitat shifted in location, became more fractal in nature and the total area increased is size. At 84 km^2 bin size approximately 61% of the study area had missing data making it impossible to determine the true nature and extent of high likelihood areas. Based on careful examination of the data, six 10 km x 10 km areas that represented preferred and non-preferred areas were selected on three banks of differing size for detailed study. High resolution acoustic surveys were carried out in these areas to determine small scale bathymetric structure. Preferred areas for juvenile haddock were always more rugged at smaller spatial scales than non-preferred areas, indicating that preferred habitats may be more complex. In addition, we observed a bank-scale dependency in surface structure where smaller banks were less rugged at smaller scales for the three banks sampled in this study. These results demonstrate preferred habitats of juvenile haddock occur at scales of 10 km, or less, and that there may be differences in preferred habitats as a function of bank size.

Interactions of fishing gears with seabed habitats on the deep continental shelf and slope off SE Australia

Alan Williams, Rudy Kloser, Nic Bax, Bruce Barker and Alan Butler

CSIRO Marine Research
Hobart

Benthic habitats of the deep continental shelf and slope (50 to 1500 m depth) off SE Australia are being surveyed for the first time in response to the needs of regional, ecosystem-based, marine management plans being developed under Australia's Oceans Policy. We surveyed and classified habitats at several sites, including some of the region's prime fishing grounds, using a toolkit that included multi-beam and single-beam acoustics, video cameras and physical samplers. Our results show that, at a resolution of 10s of km, this seascape can be visualised as a series of massive sediment flats ('soft-grounds') with 'hard-grounds' – predominantly limestone 'reefs', sandstone and granite bedrock, and steeply sloping claystone ridges – out-cropping in dispersed patches. At a finer scale resolution (km to m), structural features of hard-ground habitats attract several economically important fish species targeted by sectors of the local fishing fleet (trawl, gillnet, bottom longline, trap and dropline). In this paper we present a first assessment of the vulnerability of these hard-grounds to physical modification by fishing gears, with an emphasis on geological attributes of habitats: substratum composition, geomorphology and patch size. We define habitat vulnerability as its resistance to modification, its resilience, or capacity to recover once modification ceases, and the probability of modification occurring. We discuss these issues with respect to future needs for survey data and management of seabed habitat in this region.

THE PATCHINESS OF BENTHIC SUBSTRATES, MEASURED USING THE usSEABED DATA STRUCTURE.

Chris Jenkins,
INSTAAR, University of Colorado, Boulder CO 80302 USA
(chris.jenkins@colorado.edu)

A very large set of observational data now exists in the structure usSEABED which is compiled by the US Geological Survey, and The Universities of Colorado and Sydney using the dbSEABED software (see web pages). usSEABED holds over 300k attributed sites which are worked on using automated data mining techniques. A feature of the system is that it handles word-based descriptive data, which is extremely important for achieving useful data coverages and to represent biological aspects of the seabed. Data continues to be added and existing holdings are tested and cleaned as they build a national-scale, good-resolution mapping of seafloor sediment textures, compositions, physical properties and facies (including biofacies). usSEABED and its Australian, European and global counterparts are available for use by other researchers.

usSEABED is resolving seafloor facies variations on the order of 1km in many areas, and is a useful resource for statistical analysis of seafloor patchiness on kilometre scales. This analysis is of interest in seafloor mapping ventures, landscape ecology, naval acoustics, survey design and environmental biogeochemistry. We subjected 100 sites of relatively dense data coverage to geostatistical analysis (using GSLIB). The sites were nominated in a GIS (ArcView) as a point and radius, and represent environments from estuarine, through continental shelf to abyssal. An automated process now permits similar analysis to be carried out quickly in any areas where good collections of data exist.

The statistical results for the parameter phi grainsize showed that patchiness varies considerably from area to area. However, as a rule it is rather low (variance after 10km range ~1.2 phi) in inshore zones (<25m WD; except some estuaries), is at a maximum (~2.5phi) in the mid shelf (25-100m) and upper slope (250-1000m) zones, and is very low (~1 phi) in abyssal-bathyal environments. Except in the deepest regions, the range till variance plateaus is as little as ~5-10km. A variety of methods of analysis and visualization of the semi-variograms was examined.

Marine DataView – an application for visualising and distributing marine seabed data.

Gordon Keith, Jason Waring and Rudy Kloser
CSIRO Marine Research

Seabed observations come in a variety of georeferenced data sets including, acoustic, video, photographic and physical capture (sediments and biota) information. These data need to be quality checked, displayed and synthesized for a range of research, management and stakeholder uses. We concentrate here on the need of researchers to share, quality check and cross-reference the observational data in a timely manner. An associated need is the ability to distribute and view observational data without the need for extra software costs. A program "Marine DataView" was developed that represents the first step in addressing these needs.

DataView, written in Java, is a special purpose GIS system customised to our data and currently supports the following georeferenced data sets:

- Classified video clips of the seabed (not supported by commercial GIS systems),
- Bottom type indicies generated from single beam acoustics, including display of acoustic footprint,
- Survey information from legacy system data files,
- Background images generated from swath mapper acoustic data,
- Ship's operations and underway databases,
- Drop camera photographs and video frame grabs,
- Sediment samples with photographs and analyses.

DataView gets the majority of its data from database tables and has support for multiple data sources. Using Java technologies database tables can be stored in text files and written to CD in a format that is both human readable and database accessible. A demonstration of the software and its portability will be presented.

Textural image analysis of medium- to deep-water backscatter mosaics of the seabed using artificial neural networks

R. Dietmar Müller and Michael Hughes
University of Sydney Institute of Marine Science (USIMS)
The University of Sydney, NSW 2006
dietmar@es.usyd.edu.au, michaelh@mail.usyd.edu.au

Regional marine planning, conservation, management, engineering, and exploration issues require an ability to analyse seafloor geology and habitats based on remotely sensed multibeam images and a limited number of seafloor samples. Semi-automated image classification of medium- to deep-water images is particularly challenging, because of the scale differences involved in combining relatively low-resolution bathymetry and backscatter mosaics with point samples (cores, dredges) of the seafloor. Supervised image classification involves two steps: (1) the description of texture by a limited number of variables and (2) the generation of an algorithm that associates image textures with different seafloor types. We have experimented with this approach in the MatLab™ environment using 13kHz SIMRAD-EM12 backscatter images from the southeast Australian shelf (Fig. 1). Image resolution for this system is typically around 50-60 m. Our approach extracts grey-level run-length features, spatial grey-level dependence matrices and grey-level difference vectors from the image and uses these to identify hybrid feature vectors, which define different seafloor types. Sub-images measuring 32x32 pixels (~4x4 km) and centred on sample locations are used to train an artificial neural network to recognize the textural attributes and their variability for each class. With four classes we are able to train a neural network with accuracies of 97% (sandy ooze), 93% (clayey ooze), 84% (sand-gravel) and 88% (rock outcrop), based on 45 samples per class. The network is then tested with a second set of independent images with known seabed geology, resulting in accuracies of 95%, 93%, 82% and 86%, respectively. We find that the use of validation and regularisation techniques in neural network classification are important in producing a well-trained network that generalises well and is not "over-trained", meaning that image noise enters the training process. We also find that it is essential that backscatter intensity be corrected for grazing-angle. If it is not, then the mean intensity does not accurately recognise particular seafloor lithologies, thus reducing the network training success.

Marine Benthic Habitat Characterization: The Need For A Standard

H. Gary Greene, Joseph J. Bizzarro
Center for Habitat Studies, Moss Landing Marine Labs, Moss Landing, CA USA,
Victoria M. O'Connell and Cleo K. Brylinsky
Alaska Dept. Fish and Game, Sitka, Alaska USA, and
Mary M. Yoklavich
NOAA, National Marine Fisheries Service, Santa Cruz, CA USA

Marine benthic habitat characterization and mapping has continued to increase in effort and significance since last year's GeoHab meeting in Moss Landing, California. Many government organizations that manage ocean resources have progressed in defining habitats and developing standards for mapping seafloor and pelagic habitats. In addition, individual scientists have refined their habitat mapping schemes while others have published their work. However, a general disconnect still persists in the scientific community concerning what a standard mapping scheme should look like, and in some cases whether a standard that fits all is even possible. A critical lesson learned in the continuing dialogue on habitat mapping is that any standard developed needs to be flexible and easily adaptable to a researcher or agency's goals. Many organizations that manage fisheries are waiting for the scientific community to reach agreement in how habitats are to be mapped. Therefore, it is imperative that some type of standard be established and accepted by the working scientific community so that habitat types can be compared and contrasted across a wide spectrum of geographic scales.

We present a deep-water (sub-littoral) habitat scheme that is scale dependent, based on geomorphology, and addresses the three primary parameters of concern to fisheries managers: depth, substrate, and relief. Our operating philosophy in developing this scheme and attribute codes is that all seafloor areas should be mapped and characterized based on seafloor geology and morphology and independent of species-specific interests or associations. Resultant habitat maps are therefore applicable in a consistent manner to all demersal fishes or invertebrates that are of interest to researchers. We present a bottom-up scheme (substrate oriented) and coding system that can express the simplest or most complex seafloor condition and can be easily integrated into almost any habitat standard being considered by the contemporary marine habitat mapping community. This scheme is scale dependent progressing from large physiographic Mega- and Meso-habitat (tens of kilometers to tens of meters) types down to small Macro- and Micro-habitat (ten meters to centimeters) geomorphology and textural types. It is also technologically driven in that it reflects remotely sensed data sets and in situ observations that are obtained by modern technologies and methodologies. These data sets are typically the only information available in the deep sea that can be used for habitat mapping. For example, Mega- and Meso-habitats are usually remotely imaged with digital multibeam bathymetry and backscatter and side-scan sonar technologies, while Macro- and Micro-habitats are generally defined using remotely operated vehicles (ROVs) or occupied submersibles. In addition, seafloor conditions such as hardness (induration) and sediment or rock types are indicated. A list of modifiers is used to define parameters such as dynamic physical seafloor processes, biological attributes, texture, slope and rugosity. To illustrate this scheme, we are presently compiling a deep-water (>10 m) sub-littoral marine benthic habitat mapping atlas that will exhibit multibeam bathymetric and backscatter, side-scan sonar, seismic reflection profile, and photographic examples of the various habitats that can be mapped. An example of this atlas is presented.

SEAMAP Tasmania- the application of seabed habitat mapping for multiple marine resource management.

Miles Lawler, Alan Jordan and Vanessa Halley - Tasmanian Aquaculture and Fisheries Institute, University of Tasmania

Mapping of seabed habitats is being increasingly recognised as an important tool for both management of marine resources and for scientific study. In response to this, the Tasmanian Aquaculture and Fisheries Institute initiated the SEAMAP Tasmania project in 2000. The aim of this project is to map the estuarine, coastal and marine seabed habitats within the State Coastal Waters and make these widely available to government, industry and the community involved in research and planning issues such as Marine Protected Areas, marine farm development and fisheries assessment.
This paper will detail the methods employed in the SEAMAP Tasmania project for mapping in coastal areas. Firstly, detectable habitat boundaries from existing aerial photography are digitised into a GIS platform. These habitats, and those in deeper water, are extensively ground-truthed, with habitat boundaries logged in real-time using a single beam acoustic sounder coupled with extensive underwater video transects. This data is combined with the draft polygons from the aerial photography and used to construct maps of seabed habitat distribution. A hierarchical classification scheme is used to define habitat levels and decision rules used to ensure consistency in boundary definition.
This has proven to be a cost effective and practical method for habitat mapping where there is little patchiness in reef distribution or when habitats are mapped at a higher hierarchical level in the classification scheme. However, there are limitations to our approach in highly patchy habitats, which is a common feature of granite dominated reefs in north eastern Tasmania. While there is evidence that the geomorphology has little influence on the structuring of macroalgal communities, it has a major influence on the spatial structuring of habitats. Methods are now being refined to better characterise and map these patchy habitats down to the level of individual reef patches. This is an important issue when aiming to quantify the actual habitat area available to commercially important reef associated species. These refinements and future directions for inshore mapping will be discussed including development of shallow water acoustics and quantitative video surveys.
Finally, SEAMAP Tasmania has also developed and adopted several visualisation tools to disseminate data to stakeholders and managers including map series at variable scales, spatially referenced video and digital elevation models that include habitat distribution, available on CD-ROM and SEAMAP web site. A brief example of some of these outputs will be demonstrated.

The application of digital aerial photography to shallow water seabed mapping – How deep can you see?

Richard Mount - Tasmanian Aquaculture and Fisheries Institute and Centre for Spatial Information Studies, University of Tasmania

Aerial imagery is commonly used for mapping shallow seabed habitats. Typically, though, the imagery is originally acquired for other purposes and image quality is regularly poor over the water. There are a large number of interacting factors that influence the quality of imagery over shallow water by influencing water penetration, including the environmental conditions – such as water clarity, sun angles and water surface state – and spatial accuracy issues – such as suitable ground control. The issue of water clarity poses particular challenges in Tasmanian coastal waters that often have high plankton and sediment concentrations as well as reduced light penetration due to the presence of high levels of dark tannins from specific catchments.

This paper will detail aspects of ongoing research that aims to further develop efficient and cost-effective techniques for monitoring shallow marine vegetation – such as seagrass – by closely integrating aerial imagery with boat based field observations, including videography. To enable a complete assessment of individual beds, there is a need to assess the ability of aerial imagery to detect the deeper boundaries of the seagrass beds. As light is a limiting factor for seagrass growth, the location of the deeper edges of the beds are likely to be, at least partially, a response to the average light conditions.

Therefore, decreases in water quality in coastal waters are likely to result in a loss of habitat on the deeper boundary and regular assessment of this boundary through aerial photography could be a useful monitoring tool. However, changes in water quality also occur over the temporal scale of hours to days, which will influence the aerial image quality. The effect of water clarity on the ability to detect deeper seagrass boundaries will be examined from recent surveys conducted in coastal waters of southern Tasmania. These surveys also examined the use of digital imagery, which offers a number of advantages, including at the image processing stage of the work. Encouraging results from this ongoing research will be reported.

The Use Of Side-Scan Sonar Terrain As A Surrogate for Habitat Mapping: Case Studies From Victorian Marine National Parks.

Joseph H.J. Leach and Ralph Roob
Dept of Geomatics, University of Melbourne.

This paper describes the use of sub-tidal terrain, as mapped by side scan sonar, as a habitat indicator. The two case studies discussed are a mapping survey carried out over the Bunurong Coast, a section of coastline facing Bass Strait in South Eastern Australia and the site of the Bunurong Marine National Park, and a survey of the eastern portion of the Wilson's Promontory marine National Park.

The side-scan sonar used was a low cost, obstacle detection system (the Edgetech LC-100) and its use as a mapping tool presented significant difficulties. These difficulties meant that a complete side-scan coverage was not obtained in the Bunurong study. However, the study did succeed in using relatively low cost equipment to map the sea floor terrain in some detail. Areas of high and low profile reef, sandy bedforms, sand sheets and gravel and cobble covered floor were all mapped. Enough of the area was covered to allow interpolation of the observed terrain across the gaps. This terrain was interpreted as a surrogate for habitat since direct mapping of the habitat was not available. Acoustic classification data and drop video images were used to verify the side-scan terrain interpretations. There was broad agreement between the side-scan and both the video and sounder data, especially when the differences in interpretation due to data type are taken into account. The greater spatial coverage of the side-scan, however, allowed it to map some features, such as isolated sandy bedforms, that the other systems could not detect.

In a further study in the Wilson's Promontory Marine National Park, side-scan data was acquired over an area where detailed diver surveys of fish and invertebrate populations had been carried out. This gave the opportunity to test the effectiveness of side-scan terrain as an indicator of habitat and biodiversity and productivity. The hypothesis being that the more diverse the terrain the more productive and biodiverse the ecology. While this phase of the work is still in its early stages, the preliminary results support this hypothesis and lend support to the use of side-scan terrain as a habitat surrogate in the Bunurong study.

Addressing spatial uncertainty in seabed habitat mapping

Vanessa Halley, Miles Lawler and Alan Jordan - Tasmanian Aquaculture and Fisheries Institute, University of Tasmania

The Tasmanian Aquaculture and Fisheries Institute is currently mapping seabed habitats in State coastal waters (0-40 m) through a combination of aerial photography and field surveys using single-beam acoustic sounders, underwater video and sediment sampling. This project, titled SEAMAP Tasmania, is providing seabed habitat maps that are being used for a wide range of coastal research and planning issues such as Marine Protected Area development, environmental impact assessment, habitat monitoring, localised coastal developments and pollution and oil spill response assessment.

As SEAMAP data is sourced for a wide variety of applications, many of which require a capacity to detect change in habitat extent, it is essential that uncertainty within the spatial data is addressed and documented. While positional accuracy is well defined within seabed mapping literature, there has been less emphasis on defining spatial error in data sampling techniques, accuracy of labelling and methods of interpolation in seabed habitat mapping.

Well-designed data collection procedures help reduce observer bias, therefore minimising differences between operator or collection methods. Mapping can be conducted at various levels of resolution, which in turn is directly reflected by the detail described in the level of the hierarchical classification. Accuracy of labelling can be addressed by designing a clear and relevant classification system. The interpolation of points to polygons can also present sources of error so it is important that the techniques are made transparent and the methods replicable.

This paper addresses the sources of error that are inherent within seabed habitat mapping using the two techniques of single beam acoustics and videography to define habitat boundaries. First, the hierarchical classification structure that is the basis of mapping in the SEAMAP project will be described. The application of this to two key coastal ecotypes, vegetated unconsolidated and rocky reef will be examined and the decision rules used to define habitat boundaries will be discussed. Secondly, an adaptive sampling technique will be described and the methods used for the generation of polygons and the associated error involved in the interpolation of points discussed.

The error assessments within SEAMAP Tasmania allow for the datasets to be selected on their appropriateness for use and should assist coastal managers to recognise the limitations of the data, and assist in quantifying the extent of habitat change above that of mapping error. Error assessments also provide a clear insight into weaknesses in data collection and handling procedures so that they may be improved. Uncertainty measures are also valuable in documenting details in the dataset so that they may be sourced in the future and not be made redundant due to developments in technology or improvement in methodologies.

Fossil Biodiversity Distribution as a Habitat Mapping Tool

Erin C. Arnold and William R. Howard

Antarctic CRC
Private Bag 80
Hobart, Tasmania, Australia 7001

We have mapped biodiversity in Recent fossil planktonic foraminifera (shell-secreting protozoan microplankton) as a proxy for the persistent distribution of habitats in modern plankton ecosystems. This approach has the advantage of giving us a tool for comparing the geological record of ecosystem change to modern rates of change. In addition, recent surface sediments represent an integration of time, so that they represent the long-term character of the biome – an advantage for bioregionalisation efforts.

We have used three different metrics for biodiversity: species richness (simple number of species), and two measures that estimate the evenness versus dominance of particular taxa (Shannon index and "equitability.") The global diversity distribution shows that species number and Shannon diversity peak in the mid-latitudes, with intermediate values at the equator and minima at the poles. The diversity distribution is highly correlated to sea surface temperature (SST), consistent with niche partitioning hypotheses (e.g. Rutherford *et al.*, 1999). Equitability similarly shows polar minima but not an equatorial minimum. Differences among ocean basins may be explained by postdepositional processes such as carbonate dissolution, and physical oceanographic differences such as eastern boundary current upwelling. Differences among the three diversity indices suggest that aspects of biodiversity (species number and degree of dominance) may react independently to environmental conditions.

We have also used biodiversity as a measure of how ecosystems respond to climate change. Biodiversity in downcore sequences from the South Tasman Rise and Southern Indian Ocean were compared to variation in regional SST and global ice volume to determine ecosystem variation over the past 500,000 years – an interval marked by repeated climatic cycles. The rate and magnitude of ecosystem change is correlated with climate change, with the greatest diversity change occurring at the transitions between glacial and interglacial periods. Orbital periods associated with known climate forcing explain most of the biodiversity variability of the time series, suggesting that external climate forcing directly or indirectly dominated ecosystem change during the late Pleistocene. This temporal pattern implies plankton ecosystems are highly sensitive to rapid climate change, and may be expected to respond to future high-amplitude climate fluctuations. The patterns we observe in recent sediments are systematically related to physical and biological zonation in all ocean basins, and are correlated with ecological variations in the plankton (from net tows and sediment traps), suggesting the utility of the geological distribution of diversity is a useful tool for mapping and management of marine habitats.

Use of Foraminifera in Benthic Habitat Mapping of the Torres Strait – Gulf of Papua Region

Alix King, Vicki Passlow and Dylan Collins
Geoscience Australia

Three areas in the Torres Strait – Gulf of Papua region were selected for detailed study of sediments and benthic fossil biota. These areas form a transect across the shelf from the Fly River delta to the shelf edge, near the northern extremity of the Great Barrier Reef. Sediments range from muddy to gravelly carbonate sands. Deposition rates are low and relict content of sediments is often high.

The three areas show distinct differences in benthic foraminiferal assemblages as indicated by relative abundances at the order level, as well as distribution patterns of individual species. Dominant foraminiferal species within each area are also distinct. Given the high relict content in surface material across these sites, taphonomic features in selected taxa were documented and preservation scales developed. Taphonomic features indicate that abrasion is the main factor affecting preservation. A correlation between overall abundance and the numbers of fresh or relatively well-preserved specimens suggests that the use of taxa with an abundance greater than 5% gives valid assemblage data

Comparison between clusters of sites based on the most abundant foraminiferal species and environmental variables indicates that there is no one physical parameter which can be used to predict variations in foraminiferal assemblages. While the deltaic and outer shelf areas overlap in terms of water depths, mud content and gravel content they contain very distinct foraminiferal assemblages. Comparisons between these two clusters demonstrates the influence of seafloor morphology on foraminiferal faunas, while other clusters appear to be controlled more strongly by water depth or gravel content.

Biodiversity measures and surrogates: interpretation and uses of invertebrate samples from a multidisciplinary survey

F. Althaus; A. Williams; K. Gowlett-Holmes; D. Furlani; R. Kloser; A. Butler
CSIRO Marine Research

During a survey to develop and test a toolkit for mapping seabed habitats on the continental slope off SE Australia, our sled, rock dredge and trawl samplers of epibenthic invertebrates yielded 370 species and 74 higher level taxa representing an estimated 303 additional species. Ten community types were also scored in video imagery. The distribution of biodiversity forms a basis for area management, including the design of MPAs, and understanding it is a principal aim of habitat mapping. But what measures of biodiversity are achievable or suitable? Here we explore the possibilities in a data set that does not have species-level resolution for all taxa – a common situation in areas without a long history of study by taxonomists. Using a variety of taxonomic resolutions, and aggregated 'functional units' as surrogates for groups of taxa, we examine the utility of a range of univariate and multivariate metrics to describe biodiversity. Functional groupings are based on an organism's substratum preference, mobility and feeding mode. We pay attention to what is achievable given the limitations of taxonomic knowledge, and the resources available for at-sea sample collection and post-processing.

Seabed habitat mapping in the Kent Group of islands and its role in Marine Protected Area Planning

Alan Jordan, Vanessa Halley and Miles Lawler - Tasmanian Aquaculture and Fisheries Institute, University of Tasmania

Seabed habitat mapping is becoming an important component in the development Marine Protected Areas (MPA) in Tasmania and is essential in determining appropriate boundaries to ensure protected areas are comprehensive, adequate and representative in terms of biological diversity.

The Kent Group of islands situated in the middle of eastern Bass Strait, Australia were recently assessed for establishment of an MPA. To assist the process the spatial distribution of seabed habitat types in the Kent Group of islands were mapped out to the 3 nautical mile (Nm) limit. Habitat boundaries were logged in the field using a combination of single beam echosounders and video surveys of the seabed. The video was also used to identify the dominant macroalgae, seagrass and invertebrate species present. Habitats were defined at several hierarchical levels; the higher level categories being rock/consolidated substrate, unconsolidated vegetated and unconsolidated unvegetated substrate.

The Kent Group of islands has a diverse range of habitats reflecting the regions bathymetry, oceanography and geomorphology; including rocky reefs of varying exposure and depth, sheltered coves with seagrass, and extensive areas of sponge and sand habitat. Murray Pass is an area of particularly high habitat diversity due to the presence of deep water and strong currents providing a suitable environment for sponge habitat in depths >40 m.

While detailed biological studies of some assemblages have been conducted in the region, in general, the MPA planning assumes that the habitat categories mapped act as good surrogates for biological diversity. The mapping of habitat distributions is therefore important to ensure boundaries can be objectively derived in order to maximise the habitat diversity. However, limitations on the extent of video assessment often results in only the dominant algae, seagrass or invertebrates being described and unique features at the community, population or species level can be missed. In most cases finer-resolution mapping and detailed biological surveys are required if the protection of small-scale unique features is important to the overall objectives of the MPA. In many cases much of this data already exists from site specific studies but requires analysis within a GIS and MPA framework.

Overall, seabed habitat mapping in the Kent Group has generated a GIS capability to ensure representatives from all habitat categories are included in the MPA in an objective way. Often numerous alternative locations and boundaries exist and the habitat maps are intended to provide a basis with which to examine all potential options. The spatial information can also act as a GIS framework for more detailed community descriptions to be developed in the future as further resources become available to conduct finer-resolution seabed mapping and biological assessments. The techniques currently being developed to assist this more detailed assessment will be discussed.

Application of Sidescan Sonar and Video for Assessing, Mapping and Visualising Distribution of Habitats and Benthic Biodiversity in Shallow Water.

Andy Bickers
Ph.D. Student / Engineer
andyb@cyllene.uwa.edu.au
Marine Science Group,
School of Plant Biology, University of Western Australia,
Hackett Drive, Crawley, WA 6009.

Recent advances in technology now mean that high frequency sidescan sonar data can be accurately processed and georeferenced into digital mosaics quickly and efficiently.
These digital records are also very flexible and many approaches to image processing can be applied in order to segment the record into acoustically distinct regions representing areas of different substrate, relief or dominant organisms. Fully georeferenced towed video is then used to validate and classify the areas in terms of habitat, biodiversity or community structure. This video data can be supplemented by fine scale sampling by diver, ROV, sled or grab in areas selected from the sidescan record.
I will show that through a combination of these survey and analysis techniques, the texture and strength of the acoustic return of the sidescan record itself predicts aerial extent and boundaries of habitats which are surrogates for biodiversity and community structure.
I will also demonstrate that to maximise vessel utilisation and reduce costs, surveys of large areas can be designed to capture ecological boundaries and transitions without the necessity to provide 100% sidescan coverage. The survey design can stratified by analysis of satellite or aerial photography and integration of physical and oceanographic conditions.
The utility of the combined sidescan and towed video system with appropriate design is illustrated with examples of mapping of coastal benthic habitats from the Recherche Archipelago and Houtman Abrolhos, Western Australia. These results demonstrate how accurate and efficient seabed mapping can be performed in shallow water without large capital outlay and infrastructure and how clear maps and tools for management can be derived from the results.

Classification and Prediction of Marine Habitats: the use of rule based learning to optimise field research.

Katrina Baxter
Department of Geomatics, University of Melbourne.

Decision trees have been applied to classify marine habitat types within the Recherché Archipelago, Western Australia. Known for their ease of interpretation and abilities to handle both numeric and categorical variables, decision trees can include both biological and spatial variables to classify and predict ecological relationships. The results of the classification are graphically presented as a tree outlining a series of rules, in the form of if-then statements, by which classes or groups are defined.

Input variables such as depth, relief and substrate were used initially to classify and predict habitat types, using a video survey of 2700 locations. Accuracies of 80% were achieved when the model was applied separately to predict habitat types of locations withheld from the training phase of the model. Future modelling will include additional variables already collected, such as species presence/absence data, to improve the classification and assist in identifying surrogates that best define a particular habitat type. Spatial variables for each sample point, such as exposure, proximity to the nearest shoreline and distance across shelf will also be included. Relatively easily defined, spatial variables may act as effective surrogates for other physical variables (such as oceanography data and detailed bathymetry), which are often not available nor are easy or cost-effective to define at relevant scales across large areas.

A number of rules derived from the initial classification will be employed to target future field research in habitats or areas of interest using towed video, remotely sensed aerial and acoustic imagery. As it stands currently, the decision tree model can only make predictions about discrete points with known values. Although useful rules can be derived that help explain the importance of particular variables in defining habitat, the tree cannot predict habitat values beyond those points in a spatial context. The decision tree approach does however establish a methodology for future work incorporating variables with a spatial extent collected using Landsat and sidescan sonar. Given continuous data inputs for a given area, future work will evaluate the ability of rule-based classifiers, such as decision trees and genetic algorithms, to predict the probability of habitat occurrence spatially.

Benthic habitat of eastern Georges Bank, Gulf of Maine

Brian J. Todd, Vladimir E. Kostylev (Geological Survey of Canada Atlantic) and
Page C. Valentine (United States Geological Survey)

Canada and the United States share jurisdiction of Georges Bank, a 33,700 km^2 shoal forming the seaward boundary of the Gulf of Maine. Resource management on Georges Bank is the focus of scientific and public attention in both countries. For example, on species-rich gravel habitats of northern Georges Bank, fishing gear impact (scallop dredging) results in habitat degradation. Multibeam sonar bathymetric and backscatter information from the eastern (Canadian) portion of Georges Bank, supported by geophysical transects and geological samples, reveals a complex geomorphology and provides insight into geological processes during the last glacial maximum (~20,000 yr B.P.) and during deglacial time. Evidence suggests that only the northern edge of Georges Bank was overridden by glacial ice and that the whole bank was emergent to a present water depth of approximately 100 m at the end of the last glacial period. As post-glacial sea level rose, wave and current action during transgression reworked Georges Bank sediment, building the complex pattern of bedforms observed today. Mobile sand dominates on the shallowest part of eastern Georges Bank (< 70 m) but gravel is dominant elsewhere. Extensive sand wave fields, with sand wave heights exceeding 10 m, indicate that overall sediment transport is from northwest to southeast. Sea floor digital video, still photography and grab samples were used to describe benthic communities and the distribution of species occurring in various habitats. The two main environmental descriptors of benthic habitat are its stability and adversity. Each descriptor is a composite of a suite of environmental variables, including water depth, current strength, sediment grain size and food availability. Habitat was evaluated from video observations which suggested that the sea floor on the bank is a dynamic sedimentary environment where sand is introduced into gravel habitats by bedload transport initiated by tidal and storm wave currents. Habitat stability is reflected in life history traits of benthic species and necessitates an evaluation of the relative importance of natural and fishery-related disturbances.

How well do rapid assessment techniques and other surrogates reflect patterns in seabed biodiversity?

Pitcher, CR., Venables, W., Ellis, N., McLeod, I., Pantus, F., Austin, M., Wassenberg, T., Gordon, S., Smith, G.
CSIRO, Australia

The current lack of knowledge of biodiversity living on 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. Therefore rigorous and reliable baseline information is an imperative for management and conservation, including representative systems of protected areas. The cost of biological surveys is a major consideration and alternative, "rapid assessment" techniques, have been sought.

We report on an analysis of a previous series of seabed habitat and biodiversity surveys on a tropical shelf, as guidance to planned future surveys. Multiple survey devices were used, including: acoustics, towed video, epibenthic sled, prawn trawl and fish trawl. The biological sampling provided a detailed reference inventory of the distribution and abundance of the constituent biota. This biodiversity reference benchmark enabled rigorous testing of the performance of the "rapid assessment" techniques (video and acoustics) — how well did they reflect patterns in species biodiversity? Physical environmental covariates were also examined to test the utility of biophysical relationships as surrogates for unsampled biodiversity.

Applications of biodiversity inventory information were also addressed. We conclude that management applications such as risk-assessment, sustainable multiple-use, conservation planning, and performance evaluation, are ultimately dependent on adequate inventories of biotic distribution and abundance. Rapid assessment techniques and surrogates are supplementary — they can contribute to efficient designs for sampling biodiversity and may extend interpolation within sampled areas.

Seabed structure and biota relationships – using surrogates obtained from acoustic, video and physical sampling.

Rudy Kloser, Alan Williams and Alan Butler
CSIRO Marine Research

Mapping the form and nature of the seabed is a necessary requirement for understanding its ecological role for biological communities. We are developing a surrogate-based methodology to do this in response to the need to manage Australia's deep offshore seabed under Australia's Oceans Policy. Remote sensing surrogates of seafloor biotopes using visual and acoustic devices is attractive due to their collective properties: large sampling coverage per unit cost, non-destructive sampling and high spatial resolution. The necessary targeted physical sampling varies in quantity and quality depending on the taxonomic resolution required. A hierarchical classification framework can guide the sampling resolution needed at different spatial scales in relation to management needs. In this paper we outline our progress with the development of methods to map regions of seafloor in deep-water based around remote sensing. An acoustic multi-beam swath echosounder provided measures of seafloor morphology and substratum variability, a towed video camera provided measures of benthic biota and their multi-scale spatial relationships with seabed structure, and a simple benthic sled provided measures of benthic invertebrate biodiversity based on taxonomic and functional types, and samples of substrata. We discuss the relationship between acoustic, video and sled-measured variables and their limitations for mapping seabed biotopes in the deep ocean environment.

Applications of a hierarchical biodiversity classification framework for coastal and marine ecosystems

Vincent Lyne, Peter Last, Alan Williams, Mike Fuller, Keith Sainsbury, Bill Venables, Alan Butler, Rudy Kloser

CSIRO Marine Research

We describe preliminary applications of the habitat component of an ecosystem-based classification framework (Last et al, in prep), for assessing biodiversity and providing a framework for industrial and conservation management in the sea. Components of the framework comprise a parallel hierarchy of ecological units linked to units of a broader biophysical hierarchy, in a one-to-many relationship, via a set of ecological processes and characteristics that in concert determine the appropriate spatial units for ecological management. The spatial hierarchy of habitat-based units are used as the basis for identifying potential surrogates that are more easily measured than the ecological properties of their associated biota. These units can be used as the spatial basis for ecosystem management, with different scales, and different sets of scales, appropriate for addressing different management issues. We summarise our experience with example applications of a tropical multi-use environment, the North-West Shelf of Australia, and a temperate fisheries environment, the South-East shelf and slope of Australia. These examples illustrate the processes of selection and integration of informative physical, biological and geological data of various types and scales in deriving the hierarchical habitat units of relevance to ecological and management issues in those regions. Our intention is to further test and refine the classification through comparative national and international studies.

Classification of the Tasmanian Continental Shelf using multivariate analysis of wave and tide dynamics and physical sediment parameters.

R. Porter-Smith[1]*, P. T. Harris[1], A. Heap[1], O. Anderson[2], R. Coleman[3,4], D. Greenslade[5] and C.J. Jenkins[6]

[1]Geoscience Australia, GPO Box 252-80, Hobart, Tasmania 7001, Australia
[2]Kort & Matrikelstyrelsen, Geodetic Division, Rentemestervej 8, DK-2400 Copenhagen NV, Denmark
[3]Department of Surveying & Spatial Information Science, University of Tasmania, GPO Box 252-76, Hobart, Tasmania 7001, Australia.
[4]CSIRO, Division of Marine Research, GPO Box 1538, Hobart, Tasmania 7001 Australia
[5]Bureau of Meteorology Research Centre, Melbourne, Victoria 3001, Australia.
[6]Ocean Sciences Institute, Sydney University, NSW 2006, Australia.

Email r.smith@utas.edu.au

In 2001, *Geoscience Australia* and *CSIRO Marine research* jointly collaborated with the *National Oceans Office* to develop a regionalisation for the seafloor of the SE region of Australia. The result was a hierarchical bioregionalisation, based on geological and geomorphic features, oceanographic processes and biological data. Due to data limitations and the regional focus of the study, the assimilation and interpretation of data for the regionalisation was mainly qualitative and restricted to regions >200 m (i.e., beyond the continental shelf).

To compliment and extend the scope of this work, *Geoscience Australia* has developed a more-quantitative regionalisation on the Tasmanian continental shelf through multivariate analyses of wave and tide data, and sediment properties. Clustering techniques were applied in a GIS environment to investigate the feasibility of constructing an automated, quantitative regionalisation.

A major outcome has been the development of a framework founded on quantitative estimates of wave and tide processes, and sediment properties in constructing regionalisations. The quantitative treatment of physical data allows the efficient assimilation of large data sets whose relationship are complex and affords you greater accuracy in determining the boundaries and thus compliments non-quantitative regionalisations.

Planning for the Conservation of Marine biodiversity

John C. Roff
Acadia University, Canada

Marine protected areas (MPAs) in the North Atlantic have not been widely used, nor are they well deployed. Most existing MPAs have been developed as management tools for commercial species, and most offer little protection to habitats or non-commercial species. In collaboration with various government agencies and NGO's, including World Wildlife Fund Canada (WWF) and Conservation Law Foundation (CLF), I have been developing frameworks for the conservation of marine biodiversity. A central strategy to meet this goal is the development and implementation of a network of MPAs. Such a network should be ecologically-based and scientifically defensible, and should make use of the best existing information. To this end, as a case study, WWF with CLF is developing a draft framework for the Gulf of Maine and Scotian Shelf.
The main steps of this framework are:

Phase 1: Define SETS of high conservation value areas based on ecological criteria, including representative and distinctive areas
Phase 2: Define a functioning ecological network of candidate MPA's by incorporating criteria for connectivity and ecological integrity
Phase 3: Apply socio-economic and cultural criteria to choose among candidate sites to propose a network of candidate MPAs that meets ecological and economic goals.

Proposing a network of scientifically defensible protected areas requires working through these three phases. We are presently in the first phase of this process.
Phase 1 involves defining benthic and pelagic "seascapes" based on physical factors as a basis for representation. Phase 1 also involves defining distinctive areas based on both physical anomalies and areas that are important for focal species. We identify areas that best meet targets for both habitat representation and distinctive areas. These areas we are terming "areas of high conservation value."
Phase 2 will involve conducting a gap analysis to determine how the areas of high conservation value overlap (or don't overlap) with existing MPAs. It also involves applying rules of connectivity, replication and size requirements to identify possible networks of MPAs.
Phase 3 involves broadening out the process to stakeholders and interested parties to consider other socio-economic factors that will then be included in the methodology in an iterative approach. Only at this stage will a proposed network of candidate MPAs be identified

Visualisation for management - from Egyptian papyrus maps to virtual reality

Terje Thorsnes, Geological Survey of Norway, Norway

The art of visualising natural features for management is not new. When hunting for gold and other raw materials, the ancient Egyptians realised the need for visualing the geographic distribution of suitable rock types, with a brown greywacke being the favourite for sarcophaguses. This was done c. 1300 BC, and for some thousand years, the world did not really change much, event though some progress must be noted. It was not until the fall of the 20th Century when things started to roll. Computers evolved sufficiently to allow GIS systems to be operational, and to increase the efficiency of data acquisition and processing dramatically.

Presently, we have made progress in the art of visualisation, opening both our own eyes, and the eyes of other marine sciences and management for the intriguing subsurface world. A new understanding of processes and ecological interactions are some of the results. For management, an improved basis for decision-making has been achieved, but there is still a long way to go. Also in Norway, which likes to think of itself as pretty up-to-date with regard to coastal zone planning, the challenges are big. Much of the management is still based on paper, even though increasing amount of information is getting digitally available.

An interesting trend is the increasing awareness that central, heavily administrated databases run by one agency centralising a variety of data from different sciences and institutions apparently are suffering the same fate as the dinosaurs - they are becoming extinct. Like in the real world 60 million years ago, they are replaced by smaller, more intelligent and faster creatures - distributed databases managed by each institution, linked together by broadband connections, and together constituting virtual databases. This is also the basic philosophy of the MAREANO programme, a major mapping and database programme proposed by the Institute of Marine Research, the Geological Survey, and the Norwegian Hydrographic Service in the Norwegian and Barents Sea. Covering c. 135.000 km2, nearly 50% of the proposed budget (31.5 million US dollars) is dedicated to multibeam bathymetry and backscatter, because we consider a detailed terrain model linked with description of the basic physical features as a pre-requisite for a ecosystem based ocean management.

Being a programme with a clearly expressed multi-disciplinary approach, visualisation will be a key tool to bridge gaps between scientists, and between scientists and management. The main access will be through a web based GIS system, integrating all the data in 2D and describing the various aspects of the natural environment as they are at the time of data acquisition. All data will be free for public access, with a nominal charge for handling etc. Using the latest available commercial technology for web access, we feel that this should be rather up-to-date even in a global context.

But still there is a long way to go. While the challenge today is to get the data electronically to the desktop, and hopefully visualised in a manner that makes at least some sense to the planners and managers (provided that the right questions are asked in the first place, and the right methods are used), the future challenge is to provide a far better tool for management.

I think we need to start thinking of "intelligent" predictive models working in a 3D environment. As scientists - whether we are geologists, biologists, geophysisists, GIS experts, chemists or what ever - we should organise and utilise both our data and knowledge in a way that allows a non-expert to define a problem and get the information system to give an answer, integrating available information and presenting it in a visual way. To give an example from the Norwegian fjords - "what is the environmental impact of locating a fish farm with 3.000 tonnes annual production of salmon at location A". Given adequate information on topography, seabed sediments and other parameters, a future management information system should be able to predict in a quantitative way the consequences, and perhaps, give a recommendation for a better location.

GIS systems should develop into 3D, and allow the planner to explore and manipulate the real world by means of virtual reality - before making important decisions affecting an increasing number of conflicting stakeholders in the coastal and marine domains.

THE SANDAG NEARSHORE COASTAL ZONE MAPPING PROJECT – A MODEL FOR THE FUTURE

Bill Gilmour, Dr. Jerry Wilson - Thales Geosolutions (Pacific) Inc. and Jack Liebster - California State Coastal Conservancy

The California State Coastal Conservancy (Conservancy) and the San Diego Association of Governments (SANDAG) initiated the Inventory and Evaluation of Habitats and Other Environmental Resources in the San Diego Region's Nearshore Coastal Zone in 2000 as a valuable tool for marine resource conservation and management. The Nearshore Program is a cooperative, consensus-based effort involving state and federal resource and regulatory agencies including the National Marine Fisheries Service, California Department of Fish and Game, U.S. Fish and Wildlife Service, California Coastal Commission, and the U.S. Army Corps of Engineers, among others.

The Nearshore Program involved the establishment of a habitat classification system for the San Diego region, collection of existing marine resource and mapping data, survey and ground-truth of the nearshore coastal zone and synthesis of these data into a GIS database and web-based system for data dissemination.

The project would provide a comprehensive inventory of the marine habitats and associated communities within the nearshore marine environment of the San Diego region (from Dana Point south to the international border) that could potentially be impacted by beach nourishment activities. The data will be applicable for general resource management to address the needs of citizens, local governments, and state and federal resource managers.

The survey operations conducted by Thales Geosolutions (Pacific) Inc. mapped from the back beach to a depth of 20 fathoms (36 metres) MLLW and would provide both bathymetry and imagery of the seabed using a variety of sensors. Bathymetry was collected by multibeam echosounder and supplemented by existing LIDAR bathymeter data. The imagery was collected with Digital Multi Spectral Camera in the shallow water overlapping with multibeam acoustic backscatter imagery in the deeper water. Ground-truth operations involved towed underwater video and direct diving observations by marine ecologists.

The data is populated into an ESRI ArcGIS database which will be distributed via an ArcIMS website. Full digital spatial metadata to FDGC standards was included in the data deliverables.

The paper will present data in various software and imaging packages, to show the value of such a comprehensive dataset for a variety of planning and project initiatives, both now and in the future.

Geology informing management – Experience in Australia's South-east Marine Region

Hall, Meredith* and Davies, Campbell
National Oceans Office, GPO Box 2139, Hobart, Tasmania 7001
Meredith.Hall@oceans.gov.au

The National Oceans Office is responsible for leading the implementation of Australia's Oceans Policy, including regional marine planning. Planning for Australia's South-east Marine Region is well underway, and scientific information has been critical to progress to date. This presentation will discuss the multiple ways in which geological data and expert interpretation is informing planning and management, including bioregionalisation, representative marine protected areas, industry development, education and communication.

GEOSCIENCE AND OCEAN MANAGEMENT OF QUEEN CHARLOTTE BASIN

J. Vaughn Barrie[1], Kim W. Conway[1], Manfred Kruatter[2] and Alan Sinclair[3]

[1]Geological Survey of Canada, Institute of Ocean Sciences
[2] University of Stuttgart – Institute for Geology and Paleontology
[3]Pacific Biological Station, Department of Fisheries and Oceans

Queen Charlotte Basin is known to the world for two conflicting characteristics: 1) a world heritage site for its unique cultural and biological ecosystem and 2) its resource wealth in fisheries, potential hydrocarbons, wind power, and precious and industrial minerals. Government consideration of lifting the moratorium on hydrocarbon exploration in Queen Charlotte Basin and the proposal to develop marine wind farms has heightened the need for geoscience information for informed decision-making. The exploration and development of oil and gas, wind farms and placer and aggregate will inevitably be in conflict with traditional fisheries and will occur in an area that is subject to significant geohazards and the greatest seismicity in Canada. Of particular concern is the need to determine areas that should be restricted to resource development and areas that need full MPA protection. Consequently, habitat characterisation for Ocean Management of these competing resource industries and the protection of unique habitats is critical for the future ecological and economic health of the region.

For example, globally unique Hexactinellid sponges construct reefs on the western Canadian continental shelf. The reefs consist of four discrete complexes of mounds or bioherms and biostromes up to 20 m in height that discontinuously covering 700 km^2 of the basin in water depths of 165 – 240 m. The bioconstructions are built by a low diversity assemblage of three species of Hexactinosa, through sediment trapping and framework construction. Distribution of the sponge reefs is readily mapped by using a variety of remote acoustic methods including high-resolution seismic, sidescan sonar and a planned multibeam bathymetric survey. A recommendation to the Department of Fisheries and Oceans in Canada has been made to consider these areas as Marine Protected Areas. Further conflicts of habitat use may include the productive groundfish fishery that has a strong association to surficial geology.

To address these conflicts, a program has been developed between the different agencies of the federal government of Canada to provide the geoscientific knowledge necessary for effective decision-making on competing resource management issues in the Queen Charlotte Basin, and in particular, to map and delineate the benthic habitats for sustainable fisheries and provide knowledge for the establishment of Marine Protected Areas.

Steering and applying marine science for Integrated Oceans Management – issues and current initiatives

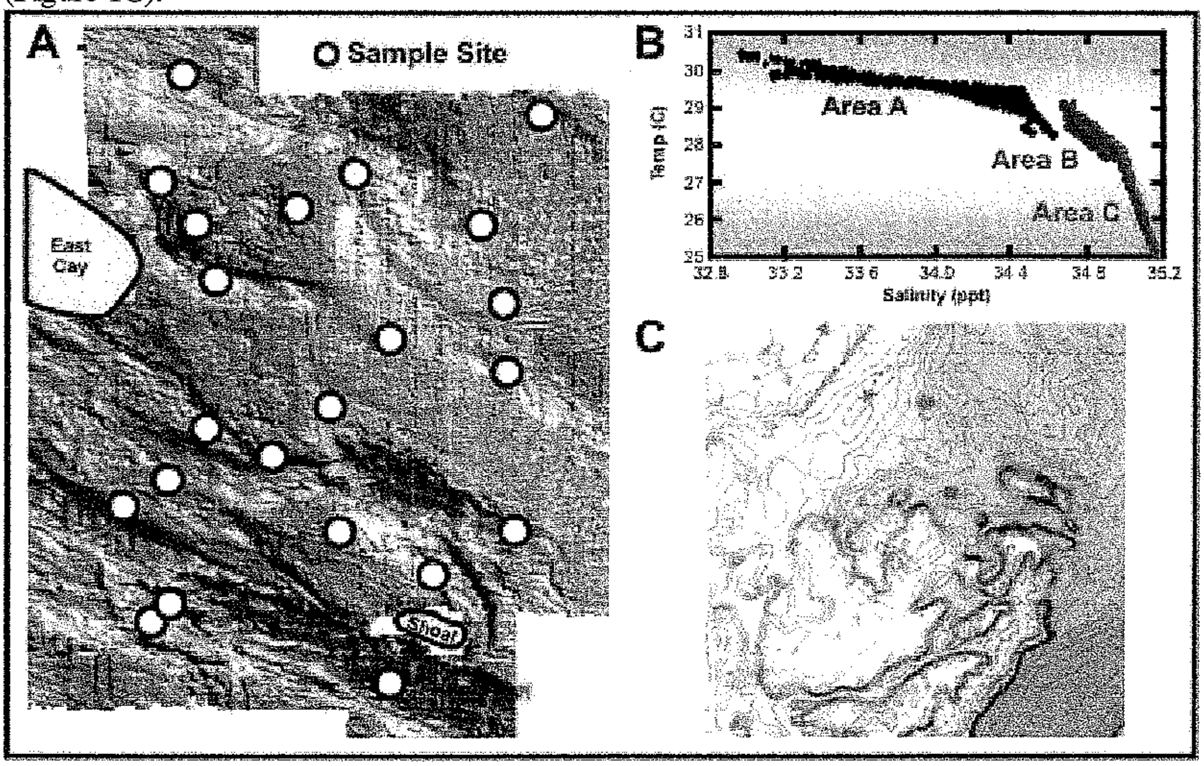
Davies, Campbell*; Finney, Kim and Deese, Heather
National Oceans Office, GPO Box 2139, Hobart, Tasmania 7001, Australia
Campbell.Davies@oceans.gov.au

The nature of the ocean presents myriad challenges for both marine science and integrated oceans management. Integrated Oceans Management requires extensive scientific input, but this input will always be limited by the extent of knowledge, available resources and timelines. Managers must work in close consultation with social and natural scientists to define – and refine – information requirements. These requirements for scientific input must be clearly articulated and inform coordinated, targeted research efforts which take full advantage of existing capacity (data, expertise, and infrastructure), and build future capacity. This presentation will highlight current initiatives which are improving our understanding of Australia's oceans and the application of that understanding in planning and management of human uses of the marine environment.

Tidally scoured shelf channels provide conduits for the existence of coral reef habitats in the northern Great Barrier Reef

Andrew D. Heap[1], Peter T. Harris[1], and Shipboard Party[2]
[1] Geoscience Australia, University of Tasmania, Hobart, AUSTRALIA
[2] Geoscience Australia, Canberra, AUSTRALIA

The Fly River, Gulf of Papua, is located in close proximity to the northern end of the Great Barrier Reef. The river annually discharges about 120 million tonnes of sediment, equal to that of all Australia's rivers combined. The export of sediment to the distal edge of the delta is believed to be a major control on the northern limit of the Great Barrier Reef. Using 240 kHz swath mapping and Chirp sonar, we discovered a series of channels extending for more than 80 km from eastern Torres Strait across the northern end of the Great Barrier Reef (Figure 1A). Some channels in the north are relict fluvial channels, containing lateral accretion surfaces in shallow sub-bottom profiles and incised channels that truncate underlying strata. Significantly, several over-deepened channels up to 220 m deep occur in the south. The channels, the deepest yet discovered on the Australian shelf, exhibit closed bathymetric contours and are floored with well-sorted carbonate gravelly sand. Tidal current modelling confirms that maximum bed stress occurred in the channels when sea level was approximately 40 m below its present position. The over-deepened channels appear, therefore, to be relict, having formed by tidal current scour during Pleistocene sea level low stands. Oceanographic data indicate that these channels are conduits for the up welling of colder, nutrient-laden water from the Coral Sea onto the shelf (Figure 1B). Tidal current scour, dispersal of Fly River terrigenous mud along the shelf, and the existence of the over-deepened channels have enabled coral reef habitats to exist at the present northern limit of the GBR at around latitude 9° S (Figure 1C).



A new map of geomorphic features on the Australian continental margin: application for regional marine planning.

Peter T. Harris, Andrew D. Heap, Vicki Passlow, Laura Sbaffi, Mellissa Fellows, Rick N. Porter-Smith, Cameron Buchanan and James Daniell

Petroleum and Marine Division, Geoscience Australia
GPO Box 378, Canberra ACT 2601

A new bathymetric database compiled for the Australian continental margin was used to map the distribution of major seabed geomorphic features within the 200 mile EEZ. The features included 20 categories recognised by the International Hydrographic Organisation (IHO) such as the shelf break, foot of slope, submarine canyons, seamounts, banks, trenches and plateaus. A separate category for bedforms (sandwaves and tidal sand banks) was also included. 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. The map of geomorphic features will be used in conjunction with other biological information to generate a bioregionalisation of the continental margin to provide a framework for ecosystem-based management of Australia's EEZ.

In this paper we present information on the procedures used to first interpret the separate geomorphic features and then group them into spatially distinct units, typically >100 km in extent. The bathymetric data set was grided at 250m and interpreted with reference to nautical charts and previously published work to derive a map of the distribution of geomorphic features. Mapping of features used 1:5,000,000 scale contour and shaded relief maps, and was carried out by hand. These maps were then scanned, georeferenced and digitised before being compiled into a single ARC-GIS layer. 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. In the southeast region of Australia, the identification and selection of "broad areas of interest" as possible candidates for marine protected areas, has been guided to a large degree by geomorphic information as this one of the few datasets with extensive coverage.

The British Geological Survey Offshore GIS and its application to marine habitat mapping.

Stevenson, A.G.[1], Graham, C.C.[1], Stewart, H.A.[1], Henni, P.O.[1], James, J.W.C.[2] and Cooper, R.[1]

[1]British Geological Survey, Murchison House, West Mains Road, Edinburgh, EH9 3LA, United Kingdom
[2]British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, United Kingdom

The British Geological Survey is part of the UK Natural Environment Research Council with responsibility for geological mapping of the UK land area and continental shelf and margins. A wide range of marine geological data have been acquired over the last 30 years including seismic and acoustics, sediment particle size, geochemistry and geotechnical data, leading to the publication of a series of thematic maps at 1:250,000 scale.

In recent years there has been increasing interest in the use of these maps and associated datasets in the development of marine habitat classifications. Digital data derived from bathymetry, seabed sediment, Quaternary geology and solid geology maps, and other data sources, have been used to develop the BGS Offshore GIS using ESRI ArcGIS 8.2.

A review of national and international habitat classification schemes has been carried out to assess which data and interpretations, presently held by the British Geological Survey, can be included in these classification systems. This assessment has mainly focussed on three classifications; the Marine and Estuarine Ecosystem and Habitat Classification (Allee et al., 2000); the European Nature Information System (EUNIS) habitat classification and the Deep-Water Marine Benthic Habitat Classification of Greene et al., which was presented at the GeoHab Conference in Monterey in 2002.

Work in progress will test the method of incorporating BGS data into existing classification schemes. Four GIS layers have been selected from the EUNIS and Deep-Water Marine Benthic Habitat classifications; two have been examined at a regional scale and two at a localised scale. These layers are Sublittoral Sediments (from the EUNIS classification), Megahabitat, Seafloor Slope and Geologic Unit (Deep-Water Marine Benthic Habitat Classification). The work will develop tools that will allow the BGS Offshore GIS to support any classification scheme implemented by legislation. The system will encompass both coastal and offshore areas.

ALLEE, R J, DETHIER, M, BROWN, D, FORD, R G, HOURIGAN, T F, MARAGOS, J, SCHOCH, C, SEALEY, K, TWILLEY, R, WEINSTEIN, M P, and YOKLAVICH, M. 2000. Marine and Estuarine Ecosystem and Habitat Classification. *NOAA Technical Memorandum*, NMFS-F/SPO-43.

GREENE, H G, YOKLAVICH, M M, O'CONNELL, V E, and JOSEPH, J. 2002. A GIS attribute Code for Deep-Water Marine Habitat Characterisation: Work in Progress. GEOHAB, 1st-3rd May 2002, *Agenda and Abstracts*, page 29.

Ecology of Hexactinellid Sponge Reefs on the Western Canadian Continental Shelf

Cook, S.E.[1], Reiswig, H.[1], Barrie, J.V.[2], Conway, K.W.[2] and Krautter, M.[3]
[1]University of Victoria, Victoria, Canada
[2]Geological Survey of Canada, Pacific Geoscience Centre, Sidney, Canada
[3]Institute for Geology and Paleontology, University of Stuttgart, Stuttgart, Germany

Globally unique siliceous sponge reefs occur on the western Canadian continental shelf and form extensive reef complexes in water depths between 160-240 m. The reefs discontinuously cover approximately 700 km^2 of B.C.'s continental shelf and form an important component of the shelf ecosystem. Analyses of underwater video and grab samples indicates that significant differences exist in the benthic fauna adjacent to and within the reefs. In many areas the reefs have been destroyed or damaged by otter trawl fishing gear used by the groundfish fishery. Closure of the groundfish fishery in these areas has been instituted but other seabed impacting fisheries, such as long lining and prawn, crab and fish trapping, continue. The reefs have been proposed as candidates for Marine Protected Area status not only because they are globally unique but also because the reefs may potentially play an important role in the shelf ecosystem. A nursery habitat function is suggested by the observation of large numbers of the juveniles of several commercially important rockfish species present in the reefs.

An important question that this project hopes to help address is the ecological linkages between the physical habitat formed by the reef sponges and species which use the reefs as habitat. These relationships will be examined through the bioclassification of underwater video to quantify abundance of living and dead sponge on the reef mounds as well as to identify and enumerate the many species of fish and invertebrates that utilise the reef habitat. These data will be integrated with geophysical data, such as sidescan sonar, high resolution seismic profiles and multibeam swath bathymetry, to more accurately map the living surface of the reefs and gain a better understanding of the complex reef community. This information will be available to allow appropriate resource management decisions to be made.