GeoHab 2007

Marine Benthic Habitats of the Pacific and Other Oceans: Status, Use, and Management

An International Conference
Hosted by the Government of New Caledonia,
in conjunction with
The Circum Pacific Council and the South Pacific Applied Geoscience Commission

2-6 May 2007, Institute for Research & Development (IRD)
Noumea, New Caledonia

ABSTRACTS

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CONFERENCE PROGRAMME			
	Theme	**Title**	Presenter
Day 1	Registration	08.00 (Registration will also be available Tues. 1st May 3.00PM to 5.00PM)	
Wed 2nd May			
08.30-09.00	Conference Opening Session		
9.00 to 10.30	Shelf and Sea Floors	The multidisciplinary ZoNéCo programme: an integrated, decision-making tool to assess potential deep-sea, mega-scale habitats within New Caledonia's EEZ	Yves Lafoy
	Session 1 5 Papers	A practical morpho-dynamic framework for mapping seafloor environment for the purpose of seabed management in Canadian EEZ.	Vladimir Kostylev
		Quantitative Analysis of Backscatter Data and Automatic Segmentation of Seafloor Physical Properties in Cook Strait, New Zealand	Alan Orphin for Geoffroy Lamarche
		"Charting the Yasawa Platform" Complex morphology and structure with a marine habitat of potentially significant diversity is revealed for the first time in the Fiji Islands	Robert Smith
		Seabed Biodiversity of the Continental Shelf of the Great Barrier Reef Region.	Nic Bax
10.30 -11.00	Break		
11.00-13.00	Shelf and Sea Floors contd.	Benthic habitat mapping in coastal waters of south-east Australia	Daniel Ierodiaconou,
	Session 2 6 Papers	Application of swath acoustics to map seabed habitats on the continental shelf of New South Wales, Australia	Alan Jordan
		Spatial Analysis of Multiscale Seascapes on Oceanic Island Flanks	Jens C. Krüger
		Discovery, characterization, and mapping of chemosynthetic habitat along the active East Coast margin of New Zealand	Alan Orpin
		Seafloor habitat characterization on the Aleutian Ridge, Alaska	Jennifer Reynolds
		Benthic Habitat Variation over Tidal Ridges	Thaienne van Dijk
12.30-13.30	Lunch		

Wed 2nd May	**Combined Technology-Case Studies**		
Afternoon			
13.30-15.30	Session 3 5 Papers	Comparative water residence times of Tarawa lagoon post and pre causeway construction: a hydrodynamic modeling approach.	Herve Damlamian
		Evaluation of a wide swath bathymetry system, CUBE modelling, and 3D data visualization for habitat mapping	Peter Davies
		Repeating high-resolution sidescan and multibeam surveys – possible implications for long-term habitat monitoring	Veit Huhnerbach
		Seabed classification using acoustic backscatter data and artificial neural networks	Ivor Marsh / Colin Brown
		The nature of Tuvalu's vulnerability to flooding and inundation revealed by historical reconstruction for 108 years	Hiroya Yamano
15.30-16.00	Break		
16.00-17.30	*Combined Technology-Case studies contd.*	Characterising marine habitats in a gravel-lag environment: integration and use of high resolution seismic in the Eastern English Channel Marine Habitat Map study	Angela Morando
	Session 4 5 Papers	Modeling acoustic backscatter as a tool for seabed classification	Jiashun Yu
		Mapping Sargassum beds of New Caledonian South West Lagoon: merging shipborne acoustic and optical satellite data improves mapping accuracy.	Guillaume Dirberg
		Aggregate Assessment in Majuro Lagoon, Marshall Islands.	Salesh Kumar
		Evaluation of automated backscatter classification for benthic geology and habitat discrimination on Georges Bank, Canada.	Craig Brown
18.30	Welcome Function	Sponsored by Government of New Caledonia	

Day 2			
Thurs 3rd May			
08.45	Opening Remarks	Mary Power	
9.00-10.30	Management Applications and Frameworks	The deepwater marine protected area network off southeastern Australia: a signpost to the information needed from benthic habitat mapping	Alan Williams
	Session 1 4 Papers	Securing WA's Marine Futures: "A Collaborative Project Revealing our Ocean's Hidden Depths" An investment of the Natural Heritage Trust	Paul Kennedy
		Global ocean conservation priorities for benthic ecosystems identified by GIS analysis of multiple spatial data layers.	Peter Harris
		Pacific Islands Regional Ocean Policy: - Establishing the boundaries for national implementation	Mary Power
10.00-10.30	Break		
11.00-12.30	Management Applications and Frameworks contd.	The implementation of Marine Landscape concept in the Baltic Sea region	Anu Reijonen
	Session 2 5 Papers	Regionalisations of the Australian coastal and marine environment: A geophysical	Rick Smith
		Integrating Science and Management – A Case Study from the North European Arctic Oceans	Terja Thorsnes
		Using 'seascapes' to help predict Australia's benthic marine habitat diversity	Andrew Heap
		A Decision Support System supporting regulatory and management processes in the Sustainable Exploitation of Marine Aggregates	Yassine Lassoued
12.30-13.30	Lunch		

Thurs 3rd May Afternoon			
13.30-15.30	Seamounts	Location of seamounts in the Western and Central Pacific Ocean (WCPO): screening and cross-checking of existing datasets.	Valerie Allain
	Session 3A 3 Papers	Mapping the Graveyard “seamounts”: multiple techniques for multiple objectives	Malcolm R. Clark
		High-resolution spatial variability in the megafauna of a deep-water active Samoan volcanic seamount related to habitat	Daniel Jones
	Bio-physical Processes	Remote sensing investigations into sediment bioturbation on the Oman continental margin	Colin Jacobs
	Session 3B4 Papers	The biogeochemical role of Pacific Island shallow and intertidal soft bottom environments.	Arthur Webb
		Effects of eutrophication, ice scouring and invasive species on macroalgal communities in the northern Baltic Sea.	Helen Orav-Kotta
		Benthic Habitat and Biodiversity	Nic Bax
15.30-16.00	Break		
16.00-17.30	*Fisheries*	Optimizing non-extractive bottomfish sampling strategies using GIS and multibeam data	Michael Parke
	Session 4 3 Papers	The distribution of marine biotopes and signs of fisheries impact in the south-western Barents Sea - Results from the first MAREANO cruises	Pal Buhl-Mortensen
		Sea scallop habitat in the Gulf of Maine	Brian Todd

Day 3			
Friday 4th May	Coral Reef and Seagrass		
08.45	Opening	The status of the Millennium Coral Reef Mapping for Pacific Ocean Islands	Serge Andrefouet
9.00-10.30	*Habitat Mapping and Characterisation*	High resolution optical remote sensing for a Reefscape Ecology perspective of the Amirantes Ridge, Seychelles	Sarah Hamylton
	Session 1 3 Papers	A Matter of Scale and Other Things: The Ultimate Convergence of Multidisciplinary Mapping of Habitats	Gary Greene
10.30-11.00	Break	Mapping Benthic Habitats on Fijian Coral Reefs: Integrating Field and Remote Sensing Approaches	Chris Roelfsema
11.00-12.30	*Habitat Mapping and Characterisation contd.*	Modeling and Mapping Coral Reef Habitats Transitions: an Integrated Remote Sensing and Artificial Intelligence Approach.	Julie Scopélitis
	Session 2 4 Papers	Mapping depth and benthic habitats of a remote coral reef using a semi-analytical inversion/optimization approach and Quickbird data	Magnus Wettle
		Integrating Satellite Image Data and Photo-Transects: Mapping Benthic Cover Types to Coral Reef Habitat Zones	Stuart Phinn
12.30-13.30	Lunch		
Afternoon		Coral health monitoring – linking remote sensing and coral colour methodologies	Ian Leiper
13.30-15.30	*Monitoring*	Seagrass-Watch: mapping and monitoring seagrass habitats in the Pacific Islands	Len McKenzie
	Session 3 5 Papers	Linking spatio-temporal variability of benthic communities to abiotic environment: where and when to sample?	Jonne Kotta
		Mapping, Monitoring and Assessing Seagrass Habitats in Tropical Australia	Michael Rasheed
		Seagrass monitoring by underwater videography: disturbance regimes, sampling design, and statistical power	Stewart Schultz
16.00-17.00	Closing Session		
	Closing Function		

POSTERS	
• Habitat Classification and Mapping Product Development as a Tool to Support the Coastal Management Community	Becky Allee
• Development of a classification scheme for shallow water marine benthic communities for planning and management of marine protected areas in Western Australia	Kevin Bancroft
• Cold seep habitats: use of a new towed camera array to explore and map chemosynthetic benthic communities on the east coast margin of New Zealand	David Bowden
• Seabed diversity of Keppel Bay, a macrotidal shallow-water embayment in the southern Great Barrier Reef	Brendan Brooke
• Volcanic Features as Important Fisheries Habitats in Alaska – The Attraction of Negative Relief	Cleo Brylinsky
• Faunal Associations with Carbonate Mounds and Cold Seeps in Hecate Strait, British Columbia, Canada	Sarah Cook
• Mapping of cold-water coral habitats in the Minch, NW Scotland	Veit Hüehnerbach
• Habitat Mapping and Continental Margin Ecosystems (COMARGE)	Alan Hughes
• Image texture analysis of shallow-water sidescan sonar and multibeam backscatter data: comparability and compatibility	Veerle Huvenne
• A multidisciplinary investigation of the Wyville-Thomson Ridge and the European Continental Shelf intersection	Colin Jacobs
• Morphometric characterisation of rocky reefs using swath acoustic bathymetry	V Lucieer
• Benthic Habitat Inventory and Mapping in NE Baltic Sea	George Martin
• Predicting the distribution of seagrass in a complex archipelago area using habitat modelling techniques; how to find eelgrass (Zostera marina L.) among 30 000 islands?	Anna-Leena Nöjd
• Mapping Techniques for Evaluating a Potential Aggregate Site in Tarawa Lagoon, Kiribati	Ashishika Sharma
• Mapping and typologies of mangroves of New Caledonia	Sabrina Vrily
• The MAREANO project: integrated geological, biological and habitat mapping in the Barents Sea, Norway	Margaret Wislon
• Nearshore Habitat Mapping: Wellington South Coast Marine Reserve	I.C. Wright

ABSTRACTS

Wednesday 2nd May

SESSION 1

The multidisciplinary ZoNéCo programme: an integrated, decision-making tool to assess potential deep-sea, mega-scale habitats within New Caledonia's EEZ

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Since 1993 New Caledonia has launched the ZoNéCo programme (for "Zone économique de Nouvelle-Calédonie") in order to open new avenues for both EEZ governance and economic development.

This multi-disciplinary, on-going programme is divided into three phases:
- the first phase aims at producing a base map of the ocean floor and includes the analysis of earlier data on the subject ;
- the second phase seeks to identify the mineral and biological resources, and to describe the environment in which they are found ;
- the third phase consists in the assessment of the economic development potential associated with such resources.

The ZoNéCo programme calls upon many scientific disciplines such as, swath-mapping and seabed imaging, gravity, magnetism, seismic, physical oceanography, satellite remote sensing, phytoplankton biology, fisheries science, and habitat.
From a deep water fisheries point of view, habitat is defined as the physical seafloor condition (e.g. rock, sand, or mud) that allows for sustainability of a targeted species. Distribution and exploitation of resources are mainly linked to: (1) the morphology and depth of the bottom; (2) the nature of the substratum.

Because most of the benthic habitats are defined by their geology, depth, chemistry, and by and other attributes such as, temperature, nutrients, and currents, multidisciplinary techniques are critical in determining habitat structure and lithology.

Between 1993 and 2004, nine surveys have investigated deep sea, mega-scale habitats. Six seafloor mapping, geophysics and physical oceanography cruises were conducted aboard Ifremer's R/V L'Atalante, followed by three related exploratory fishing surveys in order to survey potential sites of interest for fishery resources. Those nine surveys have swath-mapped and imaged (down to water depths of 2,500 m.) an area of about 500,000 sq. km, i.e. about 35% of New Caledonia's EEZ.

In addition to the offshore surveys, the ZoNéCo Programme has, since 1999, been focusing on :

- the understanding of the relationship between Tuna resources and the marine environment variability;
- the use of remote sensing data for Habitat mapping;
- the use of an ecosystemic approach on coastal reef fisheries, to understand relationships between the fishing resource and the fishing communities;
- investigating the Southwestern Lagoon through surveys deploying the Institute for Research and Development / IRD's Acoustic Ground Discrimination System (AGDS).

Main results and outcomes of the deep-water surveys

Over the last 14 years, the multidisciplinary results of the current ZoNéCo programme have led to an improvement in the knowledge of the marine environment that surrounds New Caledonia.

¤ In terms of deep-sea, mega-scale potential habitats, seafloor-type interpretation of the five swath-mapping surveys has enabled:

- - better understanding of the relationship between Living resources (Marine Biodiversity & Fisheries) and Marine Geology;
- - definition of appropriate fishing strategies, with trawling surveys planned on low-reflectivity, flat-topped, shallow areas with smooth slopes;
- - optimization of the fishing grounds exploitation, by using appropriate sampling tools to reduce equipment loss and maximize the gear efficiency.

However, sampling surveys (fishing and dredging cruises) still need to be conducted to ground-truth the newly discovered potential non-living and living resource targets.

¤ In terms of living resource assessment, the three exploratory surveys revealed potentially exploitable species of fish (red snappers, alfonsino (Beryx splendens), black bream (Eumegistus illustris)) and prawns.

In order to formulate a sound resource management policy, specimens of alfonsino were kept for later genetic studies aimed at establishing whether they belong to a single or to several stocks.

Trawl attempts failed to bring back any specimens of orange roughy (Hoplostethus atlanticus), despite the fact that this species is abundant in the New Zealand part of the Norfolk Ridge.

¤ In terms of resource management, the study of samples of commercially exploitable species collected during the programme, particularly alfonsino, has greatly improved the knowledge of the biological parameters (growth rates, reproduction, mortality, etc, ...) required for formulating sound resource management guidelines and policy. Commercial fishing inventories can be thus conducted that could lead to the establishment of a fishing and aquaculture monitoring facility.

¤ Regarding Physical oceanography, measurements obtained, together with satellite-observed sea-level altimetry data, make it possible to study the seasonal and inter-annual variability of climate and rainfall conditions throughout the region, and in New Caledonia in particular.

The unveiled, large (200 km in diameter), deep, counter-clockwise gyre (reaching down to 700 m depth) may play a major role in the dissemination of the larvae and juveniles of species of commercial interest. Moreover, the occurrence of an upwelling along the Southwest coast of New is likely to have an influence on the distribution of marine species of commercial interest.

¤ Finally, regarding the governance of both living and non-living resources of New Caledonia's EEZ, ZoNéCo's multidisciplinary data, classified and recorded into specific and topic-oriented data bases, can be cross-cut to generate specific "products" or "decision-making" maps (i.e. integrated maps obtained after compilation of swath bathymetry, acoustic imagery, physical oceanography and geophysical data).

The production of these integrated maps mainly aims at:

- matching the needs of various professionals (fishermen, geologists, oceanographers, planning authorities),
- improving the governance of the 1,400,000 sq. km-wide EEZ of New Caledonia, together with its associated non-living and living resources.

A practical morpho-dynamic framework for mapping seafloor environment for the purpose of seabed management in Canadian EEZ.

Vladimir E. Kostylev and John Shaw

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In recent years some of the largest advances in science have taken place at the intersection between formerly separate disciplines. Habitat mapping - at the intersection between marine ecology, marine geology and physical oceanography - has come to prominence as a necessary tool for ocean management. Habitat mapping recognizes that the physical nature of the sea floor, i.e., surficial geology, is critical to understanding the distribution of marine biological resources that economically sustain coastal communities in Canada. In 2006 Natural Resources Canada commenced a 4-year project to address these questions, with an emphasis on establishing a national perspective of the geo-environment and habitats on Canadian continental shelves. The goal of the project is to describe broadscale patterns in seabed habitat structure and processes in Canadian waters, their impacts on seabed life, and relevance to major issues under Ocean Action Plan. The emphasis is on understanding how geological controls on benthic habitat vary through time, and on the assessment of the relative importance of physical factors at different spatial scales. The unifying idea of the project is to interpret and map emergent, rather than apparent, properties of Canadian seabed habitats based on the integration of knowledge of geologic, oceanographic and ecological patterns and processes on different spatial and temporal scales. The project accommodates a variety of interdisciplinary issues important for Ocean Management, crucial for achieving balance between resource exploitation and preservation of unique seabed habitats.

Quantitative Analysis of Backscatter Data and Automatic Segmentation of Seafloor Physical Properties in Cook Strait, New Zealand

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Echo-sounder backscatter intensity is a relative measure of the sound-scattering by the seafloor. Backscatter strength is a function of the seafloor substrate and roughness, i.e. it is associated to both sediment grain size , porosity, and small scale topography. Quantification of the backscattered signal can potentially provide a means to remotely characterize the nature of the seafloor and generate regional-scale maps of geological and possibly biological significance.

Our work focuses on the Cook Strait region, central New Zealand, where a wealth of EM300 multibeam bathymetry and backscatter data (~ 30 kHz) are available, augmented by an extensive geological database (seafloor photographs, sediment and rock samples, and high-resolution seismic profiles). This provides an excellent opportunity to ground truth and quantify the backscatter signal.

The processing of the backscatter signal, which aim is to remove the effects of the recording equipment, seafloor topography, and the water column, is undertaken using the newly implemented SonarScope software, developed by Ifremer. The processing includes sonar image mosaicing, signal calibration and compensation, speckle noise filtering, image segmentation and image textural analysis. The backscatter is processed at an enhanced resolution of 5 or 10 m grid depending on water depth. Backscatter profiles have been extracted from the raw data carefully accounting for the angular dependence which is readily available from the co-registered multibeam bathymetry data.

The analysis of the backscatter data resulted in the identification of local geological, sedimentological, topographic, and possibly biological features otherwise not recognised with conventional surveying. Angular backscatter laws have been systematicaly extracted for characteristic areas, documenting the variety of geological facies in this extremely tectonically and sedimentologically active region. This catalogue will form a generic reference for future investigation at other areas. Examples of detailed analysis of local features include: 1) High reflectivity areas at the top of the continental slope associated with rough micro-topography and carbonate concretions originating from relict cold seeps; 2) Low reflectivity associated with the tops of sand waves and ridges in central Cook Strait, an unprecedented counter-intuitive result; 3) Complex reflectivity patterns associated with active fault scarp which emphasises the potential of backscatter data in submarine seismic hazard studies; 4) Reflectivity in canyons that varies along the continental slope and provides an indication of transported material and activity; and, 5) New statistical compensation of the backscatter data from the Haungaroa volcano allows a proof-of-concept biodiversity mapping exercise. The method utilised ecological theory to predict biodiversity from a knowledge of seabed substrate heterogeneity. The latter could be derived from the segmentation of the backscatter data, now that acquisition artefacts are properly compensated and attenuated. This technique will be of importance for other large-scale mapping initiatives, such as Cook Strait.

"Charting the Yasawa Platform"
Complex morphology and structure with a marine habitat of potentially significant diversity is revealed for the first time in the Fiji Islands

Robert Smith (SOPAC)

Felix Maharaj (Fiji Hydrographic Unit)

The Yasawa Islands platform and its plate tectonic significance has long been the subject of study to unravel its geological evolution. However, until now, much of this shelf platform marking the western boundary of the Fiji platform has never been mapped.

Previous resource surveys were limited to geophysical hydrocarbon surveys undertaken in the early 70s with great difficulty experienced in navigating the shelf waters due to the inadequate coverage of existing charts of the area. Kilometre-long streamers would find uncharted shoals. The occasional reconnaissance surveys by organizations interested in the fisheries potential of the shelf were also not very exhaustive.

Today a large portion of the vessel traffic in the Yasawa and Mamanuca Islands are operated by the tourism industry using modern GPS navigation systems against backdrops of highly inaccurate chart data that has datum incompatibilities and that are certainly not consistent with current mapping standards. The "F – 5", a chart released by the Fiji Hydrographic Department in 1986, is the only available chart for the Yasawa Islands and clearly indicates how much of the area remains uncharted. Viwa Island, the most western island in the group, lies on the western edge of the platform and outside the western boundary of the chart.

With limited resources to survey an area of 4,000 km2 to optimum standards, the Fiji Hydrographic Department sought the assistance of SOPAC for the use of their multibeam mapping system, a RESON 8101. The principal objective of the programme was to produce a new chart for the Yasawa and Mamanuca group of islands. In 2005 four months of survey work was completed; and in 2006 another month. This collaborative effort resulted in the acquisition of 5500 line kilometres of multibeam, sidescan and backscatter data covering an area of approximately 1600 km^2.

The benefits of this combined mapping exercise are just beginning to unfold along with the almost magical landscape of the Yasawa platform heretofore hidden even from remote imaging satellite sensors. The very complex seafloor morphology with numerous patch reefs, drowned barrier reef systems, a network of structurally controlled valleys and channels, fault scarps, fault-controlled basins dramatic fore reef slopes with 500 m scarps have now yielded their secrets. Offshore submarine canyon development is surprisingly limited. With such a complex morphology, a complex hydrodynamic flow regime is likely to exist across the platform, hence a considerable diversity in the marine biodiversity can be expected.

One such habitat explored in this dataset is home to a diverse group of fishes commonly referred to as bottom fish that are found on the fore-reef slopes, pinnacles and seamounts at depths between 100 – 500 m and is highly prized for the quality of its flesh.

Technically the survey was very challenging with excellent lessons learnt about what can be achieved on a shoestring budget – but that is a different story on its own. Apart from producing a new chart for the Yasawa waters, the same dataset can further exploration into the natural resource potential of the area in fisheries, habitats, coral research and exploring climate change and sea-level rise impacts and implications.

Seabed Biodiversity of the Continental Shelf of the Great Barrier Reef Region.

Pitcher, Roland[1], Peter Doherty[2], John Hooper[3], Peter Arnold[3] & Neil Gribble4

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Until recently, little was known about the distribution, abundance and diversity of habitats and biota of the deeper shelf seabed between the coral reefs of the Great Barrier Reef (GBR) Marine Park. From 2003 to 2006, the GBR Seabed Biodiversity Project has been mapping these habitats and sampling their biodiversity along the length and breadth of the region.

The Project is now producing comprehensive inventories & maps, developing risk indicators with respect to fisheries sustainability, and assessing the status of biological assemblages. This information is assisting managers to conserve important habitats and rare biodiversity, and to ensure that fisheries within the Park are ecologically sustainable.

The scale of the project is large (>200,000 km^2; >1385 sampling sites) and can be achieved only by applying multi-disciplinary skills to acquire the many different data types and describe the diversity of habitats and biota. This was achieved by multiple investigators from several collaborating agencies, with funding support from CRC Reef, FRDC and the National Oceans Office.

Methods include analysis of bio-physical relationships between the physical environment and species and assemblages (eg. large scale datasets such as satellite remote sensing, oceanographic model output, sediments, bathymetry and acoustics), as well as human disturbance, as a basis for biodiversity characterization, prediction and mapping.

Progress and results from fieldwork, biological identifications and analyses will be presented. In particular we will present results on the degree to which biophysical variables can be used to predict the distribution of biodiversity and habitats.

SESSION 2

Benthic habitat mapping in coastal waters of south-east Australia

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The Victorian Marine Mapping Project will improve knowledge on the location, spatial distribution, condition and extent of marine habitats and associated biodiversity in Victorian State waters. This information will guide informed decision making, enable priority setting, and assist in targeted natural resource management planning. This project entails benthic habitat mapping over 500 square kilometers of Victorian State waters using multibeam sonar, towed video and image classification techniques. Information collected includes seafloor topography, seafloor softness and hardness (reflectivity), and information on geology and benthic flora and fauna assemblages collectively comprising habitat. Computerized semi-automated classification techniques are also being developed to provide a cost effective approach to rapid mapping and assessment of coastal habitats.

Habitat mapping is important for understanding and communicating the distribution of natural values within the marine environment. The coastal fringe of Victoria encompasses a rich and diverse ecosystem representative of coastal waters of South-east Australia. To date, extensive knowledge of these systems is limited due to the lack of available data. Knowledge of the distribution and extent of habitat is required to target management activities most effectively, and provide the basis to monitor and report on their status in the future.

Application of swath acoustics to map seabed habitats on the continental shelf of New South Wales, Australia

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The mapping and spatial analysis of subtidal seabed habitats and benthic assemblages in the marine environment is being increasingly used to further advance spatial management and monitoring of the seabed. Developments in swath acoustic technology has allowed a considerable increase in the area of the seafloor to be mapped at increasing resolution. An interferometric sidescan sonar that collects geo-referenced depth and sidescan backscatter data has been recently employed in coastal waters off New South Wales, Australia to generate high resolution bathymetric and backscatter mosaics of the seafloor. This key tool is combined with more traditional aerial photography, underwater video surveys and Geographical Information System (GIS) analysis to create a number of spatial products used to derive digital elevation models, seabed habitat maps and data on macro-benthic floral and faunal assemblages.

The detailed bathymetry has revealed large variations in structural complexity of reef habitats, with the morphology of the seafloor examined using parameters of slope and rugosity. The spatial distribution of seabed habitats are digitised as a vector layer using a combination of the bathymetry and backscatter and hill-shading ollusks s e techniques. The backscatter has also revealed significant structuring of unconsolidated habitats (primarily sand) at the scale of 100's of metres, influenced primarily by the presence of sand waves and variations in particle size and shell content. Further ground-truthing using video and sediment grabs are allowing these habitats to be mapped at a lower hierarchical level improving our understanding of the spatial distribution of soft-sediment assemblages on the continental shelf. Continued video analysis of rocky reef habitat is also providing information on the extent and zonation of sessile assemblages over large geographic scales.

Around 400 sq/km of the NSW continental shelf has been mapped during the first two years of the program, primarily targeted at nearshore and offshore rocky reef habitats within NSW Marine Parks in the Tweed-Moreton, Manning Shelf and Batemans Shelf bioregions. Mapping of seabed habitats is an essential component of Marine Park planning and is particularly important for the process of developing zoning options to ensure representative habitats are included with the highly protected Sanctuary Zones. Zoning plans have recently been ollusks for two new marine parks in NSW covering almost 2000 sq/km, and the use of the habitat maps in the zoning process will be discussed.

Protocols are being developed to integrate and display spatial data from the range of remote sensing techniques, including map series at variable scales, spatially referenced video and detailed metadata. The current mapping methods employed in the project will be presented and future research areas, such as the use of digital still photography to improve taxonomic resolution and quantification of morphological structure of sessile fauna and flora will be outlined.

Spatial Analysis of Multiscale Seascapes on Oceanic Island Flanks

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The most common parameter that is used for benthic habitat mapping is depth. The volume of bathymetric data available in the Pacific region has increased significantly in recent times, with contributions from space, air, and water-based systems, and the dissemination of data through web-based portals. The quality as well as temporal and spatial resolution (both vertical and horizontal) of these data varies greatly as a function of sensor capabilities, initial survey requirements and post-processing efforts. Outputs remain compatible however, as data are commonly distributed as points with depth attributes. Identifying sources and merging multiple datasets for a particular area is becoming increasingly viable and beneficial, as there is a general paucity of bathymetric data within Pacific Island Countries. While creating a continuous raster surface of seafloor topography is a valuable exercise, it requires aggregating, interpolating and edgematching of the original datasets. This presents challenges for subsequent benthic mapping as features are often degraded and quantitative methods of surface analysis rely on scale-dependent morphometric variables such as slope angle.

This study explores spatial analysis techniques using recently acquired multibeam echosounder data from a variety of Pacific Ocean island settings. The resolution of a multibeam echosounder system generally decreases with water depth and distance from the nadir. This has significant implications when mapping the steep slopes (average of 20-25º) of oceanic islands, as resultant grid spacing ranges from 5 m in the nearshore to more than 100 m over abyssal plains. As the resolution of the seafloor data decreases, so does the complexity of the methods that can be used to ollusks s e and classify potential benthic habitats. The resultant morphological interpretation is generally limited to scale-independent meso and megascale features such as crests, depressions, and thalweg areas.

Discovery, characterization, and mapping of chemosynthetic habitat along the active East Coast margin of New Zealand

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New Zealand and American institutes studying the water chemistry and biodiversity of chemosynthetic habitats discovered numerous new cold seep sites along the East Coast margin of New Zealand during research cruises in October and November 2006 ("Cook Strait Methane", RENEWZ I – NEW ZEEPS, funded by NOAA and NIWA). Here, oblique convergent tectonics has led to the development of a thick accretionary wedge of deformed tertiary mudstones. Forty years of historical geophysical and fisheries surveys built a library of "unusual phenomena". This was not fully realized until the nineties as potential evidence of cold seeps. A land-mark study by Lewis and Marshall (1996) compiled the occurrences of seep-related fossils and carbonate concretions collected from dredges and fouled in fishing nets, together with geophysical evidence of suspect seep sites and flares. One of these sites off the Wairarapa has provided NIWA researchers with time-series data that showed persistent methane-enrichment above a flare since September 2005. In isolation these discoveries were somewhat serendipitous in nature, but collectively established a compelling case for cold seeps environments along this region of New Zealand.

Localities published by Lewis & Marshall (1996) formed the framework for the most recent research cruise aimed specifically at precisely locating seep sites and undertaking in situ visual investigations and sampling. Once on location a systematic series of surveys were undertaken to provide increasingly tighter control on the precise occurrence, dimension and geomorphology of the site. In the absence of multibeam bathymetry, regional surveys using an EM300 were initiated to provide adequate coverage (hundredsof ollusks s square). In partnership with multibeam binned at 25 m, backscatter imagery was used to identify unusual seafloor (typically a strong intensity return) and authigenic carbonate hard-grounds and chemosynthetic shell hash, characteristic of cold seep sites globally. In some cases, sites were smaller than the resolution afforded by standard backscatter analysis. The broad-scale base map data was refined by two echo sounders operated using a series of 1-2 km long figure-of-eight passes over any suspect sites: (1) an ES60 38 kHz echo sounder (primarily for fisheries acoustics) to image the water column above any seep flares and pin-point the seep site; and, (2) a 3.5 kHz sounder to characterize seafloor and sub-seafloor strata, which in most cases clearly identified aureoles of carbonate cementation and hummocky microtopography tens of centimeters to 2

m in scale. Experience showed that the water column soundings were very good at pin-pointing discrete targets while the 3.5 kHz sounder provided excellent spatial control of the seep extent. Once the centre of the seep had been ascertained, a deployment sequence was initiated for instruments lowered off the ship. An HPR 21-32.5 kHz acoustic navigation system was attached to all deployments and the position of the gear was calculated and plotted in real-time over the multibeam data using specifically designed geospatially software (OFOP© v. 3.0.2a, Greinert 2006). These data were also broadcast to the bridge to ensure both scientific and ship's crews were working together. A series of orthogonal tows followed using a new Deep-Towed Imaging System (DTIS) that recorded high-definition digital video and digital stills. Real-time video footage was relayed to the ship and synchronous sea floor observations were annotated on-the-fly using geospatial software. These data also formed the framework for subsequent quantitative analysis back in the laboratory, detailing faunal assemblage relationships with geomorphology. After 4-8 tows a library of sea floor observations were compiled and reviewed before precision coring, CTD water sampling, grabs or epibenthic sleds were deployed.

The key ingredient to the success of this approach was the continual refinement of observational data within a geospatial environment. The end result was a seafloor, water chemistry, and faunal sampling routine that could isolate targets to within 30 m at 1000 m water depth in the absence of a ROV or dynamic positioning system.

Lewis, K.B, Marshall, B.A. 1996. Seep faunas and other indicators of methane-rich dewatering on New Zealand convergent margins. New Zealand Journal of Geology and Geophysics 39, 181-200.

Greinert, J. (2006). Ocean Floor Observation Protocol (OFOP©) Version 3.0.2a. JG-Production, Days Bay, New Zealand.

Seafloor habitat characterization on the Aleutian Ridge, Alaska

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The Aleutian Ridge extends 1600 km westward from the Alaska Peninsula, and forms the physiographic boundary between the North Pacific Ocean and the Bering Sea. Trawl surveys and fishing bycatch reports indicate that the central and western parts of the Aleutian Ridge may have the highest abundance and species diversity of deep corals in the world. The intersection of deep coral abundance with a high level of fishing activity drives a need for information on the distribution and characteristics of the deep coral, for effective ecosystem management.

The research reported here is part of an multidisciplinary study to identify habitat associations of deep coral and sponges, and to determine the distribution of these habitats. The ultimate goal is to construct a predictive model for the distribution of deep coral and sponge species on a regional scale. This predictive approach is practical because the habitat characteristics of the Aleutian Ridge seafloor vary systematically with the geology and oceanography. Representative areas contain specific assemblages of habitats in relatively predictable patterns. The approach is to characterize representative areas, using new high-resolution sonar mapping and visual groundtruth/sampling, and then extrapolate the regional distribution of those types of areas using existing hydrographic charts and regional geology. While this approach cannot pinpoint the locations of local habitats in areas that have not been mapped at high resolution, it can predict the occurrence and abundance of those types of habitats (habitat assemblages) in new areas. Combining this predicted habitat map with habitat associations of deep coral and sponge species will produce a predicted map of the deep coral and sponge distribution.

The study focuses on a 500km section of the Central Aleutian Ridge, from 50m to 3000m water depth. Based on variations in the regional geology, oceanography, coral bycatch data, and fishing pressure, seventeen sites were chosen as representative of seafloor in the region. Bathymetry and backscatter surveys were conducted with Reson SeaBat 8111 (100 kHz) and Reson SeaBat 8150 (24 kHz) multibeam echosounders. Visual observations and sampling were accomplished with the manned submersible Delta and the deep-diving ROV Jason II. The biological aspects of the study are underway by our colleagues at NOAA's Alaska Fisheries Science Center (Jon Heifetz, Robert Stone) and the Alaska Department of Fish & Game (Doug Woodby). This presentation focuses on the interpretation and habitat classification of the multibeam data, in the context of the regional geology.

Aleutian Ridge forms the forearc and volcanic arc of the Aleutian subduction zone. The crest of the ridge is an eroded, submerged platform, with a chain of islands and active volcanoes along the north edge. The north and south flanks of the ridge face different water masses and current regimes, have different rock substrates, and have distinct patterns of sedimentation and erosion. Along the north flank, the volcanoes act as major sources of detritus, and seafloor characteristics vary with proximity to the active and inactive volcanoes. Submarine volcanic cones also form distinctive habitats. South of the islands, the summit platform has extensive outcrops of volcanic and sedimentary bedrock. Toward the south flank, sediment cover increases with depth and distance from the islands, producing a predictable sequence of outcrops, sedimented shelf with sediment waves, sediment deposition on the upper slope, and a zone of mass wasting located at mid-slope. The Aleutian ridge is also tectonically active, and the south flank within the study region is cut by extensional faults and a deep rift canyon that exposes fresh bedrock, providing substrate for corals. The regional distribution of these general seafloor characteristics is combined with the high-resolution surveys of representative areas, to predict the abundance and distribution of local-scale deep coral habitats across the region.

BENTHIC HABITAT VARIATION OVER TIDAL RIDGES

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Marine habitat mapping reveals that benthic habitats vary on continental shelves in relation to the distance to the coast and to offshore morphology. Tidal ridges are expected to accommodate different benthic habitats, which are important to both benthic and pelagic organisms. Some of these ridges are nominated to become marine protected areas, but are also attractive for their marine aggregates and may be designated in part as mining areas. Improving our insight in the benthic habitat variation over tidal ridges and our understanding of the relationship between ecology and abiotic factors, are therefore important not only from a scientific point of view, but also for assessing ecological values and their preservation in the management and use of shallow continental seas. Here, we aim to present the habitat variability within two sites with tidal ridges in the southern North Sea.

Acoustic facies mapping is a spatially continuous method and was carried out at the Brown Bank and Thornton Bank, two tidal ridges of 28 and 12 m height difference respectively. The diagnostic value of facies was validated with seabed samples, obtained using a cylindrical box corer. The selection of sampling locations was based on morphological data and on the acoustic facies of just collected multibeam and sidescan sonar data.

Preliminary results show that the contrasting acoustic facies on sonograms represent differences in geomorphology, sediment grain size and/or macrobenthos (Figure). Expected biological facies are not always corroborated by information from ground truthing. A preliminary classification reveals a general zonation over both tidal ridges in which the sandy tops accommodate poor benthic communities and the adjacent slopes and swales are characterized by rich communities of higher density and diversity.

The tops of the tidal ridges display fine to medium well-sorted and unbioturbated sand and low benthos densities (26-156 ind/m2) with very low diversities (2-6 species per sample). Cluster analysis and multi-dimensional scaling indicate that 4 out of 5 crest samples presently analyzed form a separate cluster, although similarity among these samples is not large. Very coarse sea bed sediments (up to cobbles) occur in the swales to the east of the ridges and biotubated sandy sediments and sand on clay in the swales to the west of the ridges. All swales have rich communities with densities of >1000 ind/m2 up to 4000 ind/m2 and diversities of 16-28 species per sample. The dominant species within these communities differ among samples. On the slopes, the average benthos density is 614 ind/m2 and diversity is also intermediate.

Both the cluster analysis and the multi-dimensional scaling plot display clear differences between the two areas, for example the near-absence of ollusks at the Thornton Bank, although some annelid worms and crustacean species are common in both areas. The small similarity between samples and the dissimilarity between the two sites may be explained by the large sediment variability and distance between samples both within and between the sites.

As a next step, the effect of the Quaternary geology on facies and benthos communities will be investigated. Also, the analysis of the remaining samples will allow us to test the relationship between sand wave mobility and benthos (e.g. stabilizers/destabilizers).

This study contributes to the understanding of spatial habitat variability and to the improvement of marine habitat mapping techniques, and may be used in the hypothesis-testing of controls on habitat changes in time. Outcomes of this research will help policy makers to manage continental seas in a sustainable manner.

SESSION 3

Comparative water residence times of Tarawa lagoon post and pre causeway construction: a hydrodynamic modeling approach.

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During the second half of the 20th century, causeways linking the separate islets of South Tarawa were constructed. Early photographic evidence suggest this was occurring in an ad hock manner from before 1940 (local dry wall construction), through to the early 1980's when the Bariki / Betio causeway was completed. The impact of the closure of these ocean passages over lagoon water residence times and therefore water quality is unknown. However, the issue of declining water quality within the lagoon is a frequently cited by the Government of Kiribati and broader Tarawa community.

A two dimensional hydrodynamic baseline model was created using MIKE 21 software and once calibrated, this tool was used to calculate spatially-dependant water residence times within the lagoon. The water residence time was defined as the time taken by a water or tracer parcel to leave the domain of interest. Water residence times in turn are a useful tool when considered in terms of inputs, water quality and ecological maintenance of the lagoon ecosystem.

Due to the shallow enclosed nature of the lagoon, water circulation was predominantly regulated by tidal fluctuations over the open western barrier reef and single deeper channel. However, the contribution of flow through the remaining open inter-tidal channels of North Tarawa was also successfully simulated by locating sources in each channel. These flow rates were in turn calibrated using in situ channel flow data collected over a tidal cycle.

Using the calibrated model the closed channels of South Tarawa were removed and the model was run again and allowed to simulate flow through the former inter-tidal channels. It is recognized that this simulation scenario cannot be calibrated or compared to real data (since no channels remain open) and it is likely that due to the different orientation of South Tarawa, wave setup and tidal flow would be different to that measured in North Tarawa. However, we are confident that such simulations present one of the best opportunities to understand the role that causeway construction has in changing water residence time in Tarawa lagoon.

Evaluation of a wide swath bathymetry system, CUBE modelling, and 3D data visualization for habitat mapping

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Geoswath is a shallow water swath bathymetry system designed to provide wide coverage in shallow water depths. Fledermaus is a suite of software designed for the processing and modelling of bathymetry data, and the 3D visualisation of any point or bitmap data. The combined capabilities of these two tools provide an accurate and efficient means of developing digital elevation models of the seabed and providing visualisations used to assist the process of mapping seabed habitats.

The Department of Environment and Conservation, New South Wales has been operating a Geoswath 125 kHz system for 2 years to collect bathymetry and backscatter information for habitat classification in coastal waters. The information is used to assist management of coastal ecological resources and selection of marine protected areas. The project has mapped some 400 km2 to date with a further 250 km2 planned for the next year.

This paper examines in detail a subset of the NSW dataset, which has been mapped with the Geoswath and groundtruthed with sediment sampling, and underwater towed video. Batch filtering and correction of the raw soundings was accomplished with the Geoacoustics software GS+ and Geotexture. The data XYZ data were then imported to the Fledermaus suite for CUBE modelling and final data validation. This methodology allows large volumes of data to be processed very efficiently. The backscatter data were processed with the Geotexture software into a mosaic and draped over the bathymetry in Fledermaus.

Analysis of the acoustic backscatter and 3D bathymetric model enables reliable seafloor classification to at least three habitat classes from acoustic data alone but further division from seabed morphology is possible. Towed video data is needed to discriminate certain seafloor habitats and to provide data on bbenrhic assemblages. Incorporating all data into the 3D visualization environment of Fledermaus allows subtle relationships between different data types to be easily analysed and understood. The Fledermaus software suite has the additional advantage of being an effective marketing medium for presenting results of habitat studies, either in the form of movies generated from the software or as Scene files of complex data assemblages.

The error budgets of the system and the error analysis from ground truthing will be presented. Improvements to data quality and presentation by through use of the Fledermaus product will be assessed. In our opinion the Geoswath / Fledermaus system provides a suitable option as a fairly low-cost system for shallow water habitat mapping. Advantages and limitations of the combined system plus software will be discussed.

Repeating high-resolution sidescan and multibeam surveys – possible implications for long-term habitat monitoring

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During RV Pelagia cruise 250 in the Minch (NW Scotland) in summer 2006, a total of four survey lines of high-resolution deep-towed sidescan sonar (325 kHz) and hull-mounted multibeam (30 kHz) were concurrently run over cold-water coral mounds, bedrock and smooth sediment. Two of the tracks each were chosen to run over the same area of seafloor in two different directions (WNW-ESE and NNW-SSE) to see the impact of different ensonification direction on the acoustic backscatter. Extensive ground-truthing complemented the identification of the different facies/potential habitats.

The two acoustic data sets of sidescan and multibeam backscatter were processed to similar resolution, using radiometric and geometric corrections, with the in-house NOCS software suite PRISM. Subsets from the backscatter imagery were then analysed with the University of Bath software TexAn using Grey Level Co-occurrence Matrices (GLCMs) to calculate entropy and homogeneity indices in moving windows across the imagery. Entropy quantifies the amount of local chaos or organisation within an image, whereas homogeneity describes the amount of similarities/ dissimilarities in a chosen neighbourhood around each pixel.

The objective of the study is not only to distinguish between different seabed facies (coral, bedrock, background sediment etc.), using texture analysis, but also to assess the quality of repeated hydro-acoustic surveys over the same terrain in almost identical oceanographic conditions. Our aim is to find out if potential changes in the acoustic data correspond to real changes of the seabed environment, or if they are due to acoustic noise of the equipment and the oceanographic conditions surrounding the habitats.

Seabed classification using acoustic backscatter data and artificial neural networks

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The MESH (Mapping European Seabed Habitats) programme is an international marine habitat mapping programme whose aim is to produce seabed habitat maps for the seas around north-west Europe. As part of the development of predictive tools for habitat mapping, we have focused on Simrad EM1002 95kHz multibeam backscatter data acquired by RV Celtic Voyager in several shallow-water (<100m) locations offshore Ireland. In order to prepare backscatter mosaics for seabed classification, we have worked with individual beam data logged in Simrad format datagrams. Artifacts associated with data acquisition, including nadir striping, were corrected and beam footprint backscatter data were mosaiced and classified using artificial neural networks.

Unsupervised classifications to delineate acoustically similar seabed types were carried out employing variants of neural network models (Kohonen competitive, self-organising feature map and learning vector quantisation). On a validation data set, the Kohonen competitive network and the self-organising feature map networks out-performed the most commonly utilised statistical classifier, the migrating means (ISODATA) algorithm. Classic Haralick textural features were also computed from the original backscatter mosaic using grey level co-occurrence matrices. Our results indicate that neural network seabed classifications based on these features can be unnecessarily complicated and, on the basis of Occam's Principle, may be inappropriate in the absence of ground truthing.

These results suggest that Haralick features may be more useful in supervised classifications. These were carried out using a back propagation neural network and a maximum likelihood classification algorithm using ground truthing information collected from 22 sampling stations covering an area of ~140 km2. The resultant classifications using the two methods are comparable but it would be possible to improve the accuracy of the predictions if a systematic ground truth sampling programme were undertaken.

The paper concludes with a discussion on the limitations of working with mosaics of backscatter data and outlines an inversion scheme for backscatter ping data to improve seabed classification.

The nature of Tuvalu's vulnerability to flooding and inundation revealed by historical reconstruction for 108 years

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Reef islands formed on coral atolls are small, low, and flat, with elevations of only a few meters, and thus they are highly vulnerable to elevated sea levels caused by extreme events and global warming. This vulnerability was evidenced recently on Fongafale Islet, the capital of Tuvalu, as it flooded during recent accelerated spring high tides that might have been related to accelerated sea levels due to global warming. An island's vulnerability to sea level rise may be determined by many factors, not only environmental but also economic and social. This study used data that spanned 108 years, in order to reconstruct changes in topography, land use/cover, population and distribution of buildings. Results indicate that the vulnerability of Fongafale Islet relates to its original landform: the central part of the island was formerly dominated by swampland that flooded at high tides. Population migration and centralisation to Fongafale Islet from the 1970s following independence of Tuvalu and Kiribati, along with a decline in overseas mining and limited options for paid employment, led to expansion of building areas into the original swampland and the ensuing vulnerability. Our results clearly demonstrate that examination of global environmental issues should be based on characteristics specific to the region of interest, and strongly indicate the need to specify these characteristics using historical reconstruction in order to understand the nature of the area's vulnerability and confront global environmental changes.

SESSION 4

Characterising marine habitats in a gravel-lag environment: integration and use of high resolution seismic in the Eastern English Channel Marine Habitat Map study

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The Eastern English Channel Marine Habitat Map study is a multidisciplinary project aimed to characterize marine habitats in an area with potential marine aggregate resources and to provide baseline data for future assessment of the impact of dredging in a regional context.

The project was carried out over three years and it covered an area of 5000 sq km. A geophysical survey programme was designed and undertaken to provide a grid of multibeam and sidescan sonar corridors up to 500 m wide with a single boomer sub-bottom line in the centre of each corridor. Thirty three corridors up to a maximum length of 120 km were completed

Following an initial interpretation of the geophysical data a sampling strategy was planned for a ground truthing survey to collect the biological data. Following two successful surveys a total of 224 Hammon Grabs and 72 Beam trawls were collected along with 58 Video camera sledge tows and 13 drop-camera deployments for photographic and video observations.

The geophysical data were processed, interpreted and cross-correlated with supervised not automated methodologies and they were used to identify the physical character of the sea bed. The geophysical techniques used had different grades of resolution and they were all fundamental and complementary for the creation of a three-dimensional framework and to create maps of physical character of seabed.

The principal aggregate resources are within an area dominantly of sandy gravel at the seabed and underlain by a series palaeo-channels incised into bedrock. These are adjacent to extensive areas of exposed rock or rock covered by a thin veneer of gravel. The study has indicated a general grain-size gradient from cobbles in the west to sandy gravel in the east becoming sandy in the far east of the study area.

The presence of this extensive gravelly deposit suggests that palaeo-morphodynamic processes were responsible for their formation in the English Channel, since present day marine processes are not conducive to transport or deposition of gravelly sediment. Video evidence suggests some of the gravel has been derived in-situ from the underlying bedrock.
Visual characterization of gravel lithology based on video-image analysis has allowed the identification of distinct lithologies within the gravels and provided evidence for some distinctive habitats being associated with particular types of gravel.

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Modeling acoustic backscatter as a tool for seabed classification

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A wave theory model providing reliable modelling of rough seabed scatting has been used to investigate the characteristics of multibeam acoustic swath backscatter data. The modelling is performed on a user-provided two-dimensional model of the seabed specifying its roughness and the acoustic properties across the ocean/sea-floor interface and produces backscatter amplitudes as a two-dimensional function with respect to angles, synthetics of a ping record in multibeam survey.

We use a stochastic process to characterise the observed seabed roughness, which is known to be very variable. To keep model parameters to a minimum we use only two parameters to describe the roughness, including the roughness amplitudes and correlation length – properties that are indicative of lithologies and sedimentary processes. These allow us to generate seabed models for a range of seabed bottom types that have been formed from a variety of geomorphic processes.

A suite of canonical models are used to study amplitude variation of the synthetic data over a broad range of seafloor reflection coefficients and roughness scales (> 1 mm). We will present synthetic angular response for different model parameters, such as water depth, seabed dips and roughness, and survey system parameters, such as sonar frequency and beam width. Our synthetic modelling code now opens the door to improved discrimination of seabed geometry, roughness and lithology. In addition, the synthetic backscatter curves are the starting point for efficient inversion and classification of seafloor physical properties.

Mapping Sargassum beds of New Caledonian South West Lagoon: merging shipborne acoustic and optical satellite data improves mapping accuracy.

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Mining of sand and gravel from beaches to provide a source of aggregate material for construction purposes is a major activity in the Pacific Island Countries. This contributes significantly towards beach and coastal erosion in an atoll environment such as Majuro. Seabed mapping in dredgeable areas can help avoid the problem of unsustainable beach mining by identifying alternate offshore sources of aggregate material.

High-resolution mapping, sediment sampling, and seismic profiling of the atoll were carried out in July 2006. Two multibeam echosounder systems were used to obtain bathymetry and backscatter in shallow (<300 m) and deep waters (10-2000 m), covering an area of 450 km2. Boomer seismic profiles were collected at three separate locations in the lagoon. Seventy-one sediment samples were collected at pre-determined locations in the lagoon.

The sediment samples were used to ground-truth the multibeam and seismic data. This geophysical information was supplemented with satellite imagery and LIDAR bathymetry, where available, and used to delineate seabed features and assess the volume of available aggregate. The preliminary results indicate that multibeam bathymetry together with backscatter can be used for site-specific maps of geological significance, which are also useful in defining potential habitats.

Aggregate Assessment in Majuro Lagoon, Marshall Islands.

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Mining of sand and gravel from beaches to provide a source of aggregate material for construction purposes is a major activity in the Pacific Island Countries. This contributes significantly towards beach and coastal erosion in an atoll environment such as Majuro. Seabed mapping in dredgeable areas can help avoid the problem of unsustainable beach mining by identifying alternate offshore sources of aggregate material.

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Evaluation of automated backscatter classification for benthic geology and habitat discrimination on Georges Bank, Canada.

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Developments in acoustic survey techniques, in particular multibeam sonar, have revolutionised the way we are able to image, map and understand the seabed environment. It is now cost effective to image large areas of the seafloor using these techniques, and the information from such surveys provides base line data from which thematic maps of the seabed environment, including maps of benthic geology and habitats, can be derived when interpreted in conjunction with in-situ ground-truthing data. Traditional methods for the interpretation of acoustic backscatter rely on experienced interpretation by eye of grey-scale images produced from the data. However, interpretation of data can be extremely subjective, and new developments in automated backscatter classification software offer an objective method of segmentation of acoustic backscatter data into acoustically similar regions. In 2006 a large multibeam sonar data set from Georges Bank, Canada, was classified using the backscatter classification software, QTC Multiview. Data from 7900 km2 of seabed were classified and results were compared with 190 ground-truthing stations to assess the performance of the classification for geological and habitat discrimination. The relationship between backscatter metrics derived from the classification software and benthic geological and biological characteristics were explored using statistical methods. Preliminary results suggest that automated backscatter classification may aid interpretation of multibeam sonar data for the production of geological and habitat maps.

Thursday 3rd May

SESSION 1

The deepwater marine protected area network off southeastern Australia: a signpost to the information needed from benthic habitat mapping

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Benthic habitat mapping is being used to segment Australia's offshore seabed into multi-scale 'bioregions'. These bioregions underpin a developing national network of marine protected areas (MPAs) for conserving Australia's marine biodiversity in deep water (approximately >50 m depth). The first part of the national network is in place off southeastern Australia, providing the opportunity both to review its conservation gains and the role of benthic habitat mapping in its development. We conclude that the process has been successful in capturing an extremely large area of seabed that contains many areas of important biodiversity. However, there is the potential to improve the process as the network is extended to other regions around Australia. Here we discuss the data required to understand benthic habitats as surrogates for the distribution of sessile benthic megafauna at intermediate spatial levels of Australia's hierarchical bioregional framework. Our examples focus on two classes of geomorphic features with characteristic and vulnerable biodiversity – submarine canyons and seamounts – that have proved important in the southeast Australian context and are increasingly the focus for international and high seas conservation planning. In particular, we ask 'what is the appropriate scale at which to represent biodiversity for conservation management?'

Securing WA's Marine Futures: "A Collaborative Project Revealing our Ocean's Hidden Depths" An investment of the Natural Heritage Trust

Paul Kennedy

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Marine Futures is a $4.2 million investment by the Australian and West Australian Governments through the Natural Heritage Trust (NHT). The project is developing an increased understanding of Western Australia's marine environment between Kalbarri and Eucla.

The collaborative project is based upon partnerships between Regional Natural Resource Management (NRM) Councils, the Australian and West Australian Governments, university researchers (the University of Western Australia) and industry (primarily Fugro).

Upon its completion in June 2008, *Marine Futures* will produce the first comprehensive cross-regional assessments and maps of key South-Western Australian marine habitats. This will be achieved by using state-of-the-art technology, and will provide information on the distribution and extent of the diverse habitats and the organisms associated with them.

The outputs from Marine Futures will form the basis for identifying key marine indicators and supporting Regional NRM Councils in establishing targets for maintaining the quality marine ecosystems.

In summary, the Marine Futures project is one of the most exciting and ambitious marine-focused NHT funded projects in Australia to date. If you would like more information on the *Marine Futures* project, please email marinefutures@uwa.edu.au.

Global ocean conservation priorities for benthic ecosystems identified by GIS analysis of multiple spatial data layers.

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At the 5th World Parks Congress held in Durban, South Africa in 2003, a ten-year strategy was set forth to promote the development of a global representative system of marine protected areas (the HSMPA; Gjerde, 2003). In the ten-year strategy, specific mention is made of "developing and making available scientific research relevant to the development of a global representative system of MPA networks". The terms "representative" and "network" have special meaning in such an enterprise. To be "representative", the MPA network should contain areas that reasonably reflect the biotic diversity of the marine ecosystems from which they derive, which in this case is the entire high seas area. The term "network" alludes to issues of connectivity and complementarity. The conservation significance of any habitat depends upon a range of factors, but chief among these are its relative uniqueness and occurrence on the earth. In other words, a global frame of reference is required. In order to design a global representative system of MPAs that aims to conserve the biodiversity of the oceans, a map is needed that conveys information that is relevant to the distribution of biodiversity. Previous attempts have been made to classify the pelagic ocean environments but not the benthic environment. The aim of this paper is to investigate means of creating a global map of benthic habitats.

At first appearance, the task of collating the available information on habitats, connectivity, and biodiversity for the global ocean seems insurmountable. However, there are existing spatial representations of environments and ecosystems that provide useful starting places. First, a global map of seafloor geomorphology identifies the spatial distribution of broad-scale benthic habitats. Second, this map can be subdivided by seascapes derived through multivariate analysis of global data sets of seabed bathymetry, sediment thickness, primary production and ocean currents. The integrated geomorphology/seascapes map complements existing pelagic classification schemes and identifies spatial heterogeneity of habitats that we suggest has direct applications for the design of a global network of representative MPAs.

Pacific Islands Regional Ocean Policy: — *Establishing the boundaries for national implementation*

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The Pacific Islands Regional Ocean Policy (PIROP) was approved by Pacific Island Forum leaders in 2002, the Prime Ministers of Prime Ministers of Cook Islands, Federated States of Micronesia, Fiji, Guam, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, New Zealand and Australia.

The Policy, the first of its kind in terms of a regionalized approach to ocean management, underscores the importance of the ocean to the Pacific Small Island Developing States and their people. The PIROP is intended to serve as an overarching framework within which the various actions affecting oceans and coasts in the region can be viewed to assess progress towards achievements of outcomes desired by the region. The associated Pacific Islands Regional Ocean Policy Framework for Integrated Strategic Action (PIROP-ISA) sets forth both broad initiatives and more specific actions that are needed to implement the Regional Ocean Policy.

Implementation at the National level faces many challenges. The tyranny of small (land) size and real and relative geographic isolation and limited human and financial resources generates major challenges for these SIDS, that would in fact be more accurately be described as “large ocean states”, having as they do essential stewardship for a significant component of the worlds largest ocean mass and its living and non living resources, including the last significant remaining healthy stocks of migratory finfish, a resource of global significance. [Oceanic fisheries (primarily for tuna) are undertaken by about 1,300 fishing vessels from 21 countries, one-third of which are based in the Pacific islands and employ 6-8 per cent of the labour force. The catch value from the region’s oceanic fisheries is estimated at around US$2 billion[1] in the western and central Pacific Ocean]. The non-living resources promise even greater economic potential in the future.

One of the greatest challenges facing these countries is that of establishing full legal sovereignty over their Exclusive Economic Zones and potential Extended Shelf Areas. Although most of the countries and territories have declared a 200 nautical mile Exclusive Economic Zone (EEZ), most are still in the process of delimiting these. Currently, there are forty five shared boundaries of which only fourteen have actually been negotiated and / or ratified. In respect of extended continental shelf under Article 76 of UNCLOS, seven Pacific Island countries with grounds for a potential

[1]At prices in regional ports.

claim have yet to prepare their submissions within the timeline of May 2009. SOPAC, the Pacific Applied Geoscience Commission, has supported some of its member countries to complete desktop studies, which is an important step toward assessing the strength of a coastal States potential toward an extended continental shelf.
A Strategy to progress this has recently been developed during a high level dialogue. Accessing the technological, legal and financial resource to pursue this will be a major challenge in the coming years and will rely heavily on the generosity of Pacific Rim neighbors and other development partners such as the European Commission and individual EU members who are currently engaged in the region on a bi-lateral basis.

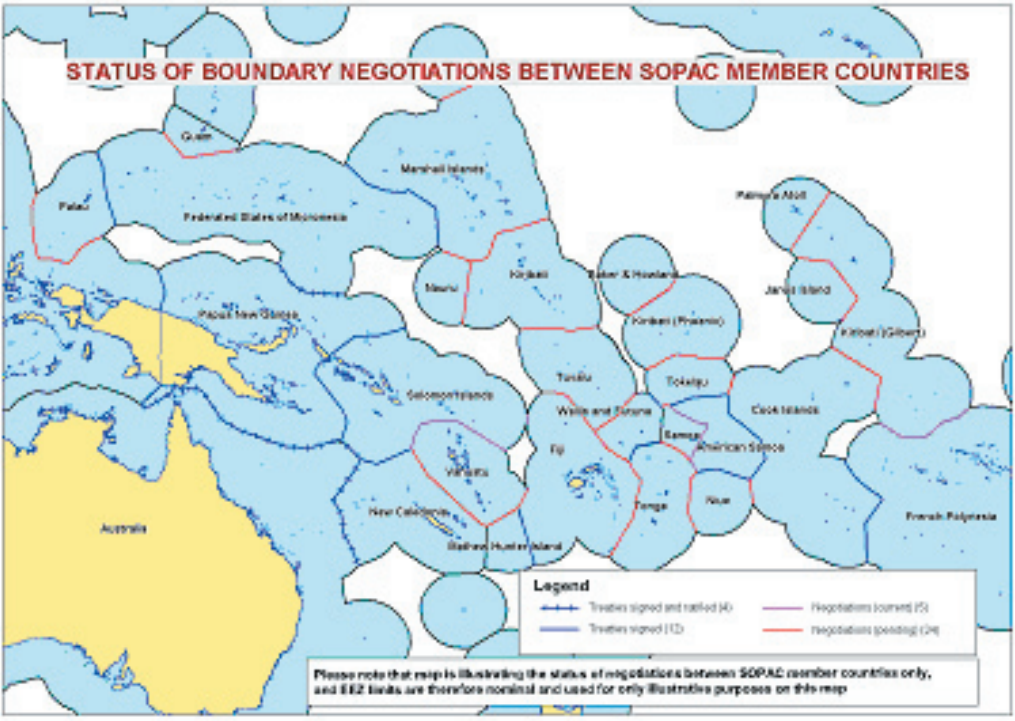

Figure: Status of Shared Maritime Boundary Negotiations between SOPAC member countries.

SESSION 2

The implementation of Marine Landscape concept in the Baltic Sea region

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The marine environment is deteriorating rapidly in many marine areas due to increased human activities like marine traffic, coastal development and land/sea -based pollution sources. The Baltic Sea, one of the world largest brackish water areas, has been under anthropogenic influence for centuries and the use of marine resources has intensified during the last decades. The lack of transnational marine spatial planning and information-based management has resulted in degradation of the marine ecosystem (e.g. eutrophication, intensified erosion, oil emissions). Massive constructions like harbours and the North European Gas Pipeline (NEGP) from Russia to Germany through the Baltic Sea require an efficient transnational approach to management. With the expansion of the European Union (EU) the Baltic Sea has become the largest inland marine region in the EU. This has highlighted the need of common management strategy for the Baltic Sea (included to the proposed European Commission (2005) Marine Strategy).

BALANCE (http://www.balance-eu.org/) is a EU co-funded (INTERREG IIIB) project that aims to establish an ecosystem-based approach to sustainable management for the Baltic Sea. There are 19 partners and 7 subcontractors from 10 countries around the Baltic (Denmark, Finland, Sweden, Germany, Poland, Lithuania, Latvia, Estonia, Norway and U.S.A). The project will provide key information and spatial planning tools for stakeholders and environmental as well as non-governmental agencies. One of these tools is a marine landscape map of the Baltic Sea and Kattegat. The marine landscape concept is a broad classification of the marine environment based on geophysical and hydrographical features. It is a cost effective method to describe marine areas where biological data is often sparse. Roff and Taylor (2000) developed concept to predict species assemblages in Canadian territorial waters. The method has also been applied in the North-western Atlantic through MESH, in the UK trough the Irish Sea Pilot Project (Golding et al. 2004) and UKSeaMap (Connor et al. 2006). The marine landscape has now also been applied to the Baltic Sea where it will form the basis for inter alia a broadscale assessment of the ecological coherence and the representativity of the MPA network in the entire Baltic Sea and Kattegat.

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Regionalisations of the Australian coastal and marine environment: A geophysical perspective

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In recent years benthic regionalisations for the Australian continental shelf have been developed using a hierarchical framework and quantitative estimates of geological, geomorphic features, oceanographic processes and biological data. Over the years methodologies have progressed from a Delphic approach to one that is quantitatively driven and therefore statistically robust. Methodologies and techniques are constantly being refined. The regionalisation process has largely been confined to investigate the hierarchical structure from a regional or mesoscale perspective and these pieced together to reflect a continental wide scale picture. Political pressure and disparity of available or relevant data have constrained the regionalisations.

The current higher level structure was determined largely from the distribution of Australia's fish species which are used as a surrogate for paleohistoric evolutionary processes that define contemporary marine and coastal ecological systems. An age old problem that recurs in debates on regionalisations is the one on the relative importance of biology, geology and oceanography in defining regional structures. We investigate in this work the geophysical approach to determining the higher level structuring of Australia's coastal and marine regions. Our aim is to compare the results of this approach with the existing biological regionalisations in order to understand the relative roles of the biogeophysical components in shaping Australia's ecological regions.

The high-level geophysical province structure is being investigated by examining the complexity of the coastline and its relationship to crustal elements of the Australian continental platform. The complexity of the coastline was calculated using fractal analysis and the results compared to various mappings of geophysical variables that control coastline formation and structure – such as tides, waves and currents. Our intention is to carry out similar analyses for the lower level so-called "biomic" structure by investigating depth based changes in geophysical properties.

Our expectation is that there will be similarities and differences in the structures obtained by the respective biophysical and geophysical approaches. It is only from such comparative studies that constructive quantitative approaches can be developed for robust regionalisations of the coastal and marine systems.

INTEGRATING SCIENCE AND MANAGEMENT – A CASE STORY FROM THE NORTH EUROPEAN ARCTIC OCEANS

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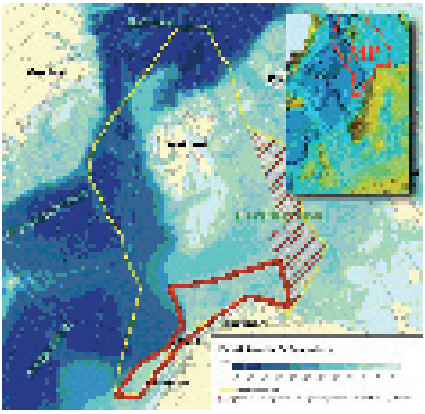
The Lofoten-Barents Sea region is an area where the expectations for exploitable hydrocarbon resources are high. Particular interest is focussed off Lofoten, which is also important for several fish stocks, particularly cod. Rich and vulnerable ecosystems, including cold water coral reefs and sponge communities occur in the same area.

In order to ensure a sustainable development of the Barents Sea, the Norwegian government has initiated an ambitious management process (Management Plan – MP), aiming at a holistic ecosystem based approach. The total area covered is 1.400.000 km2. This process has identified severe knowledge gaps regarding some of the ecosystems. In order to fill the knowledge gaps regarding benthic ecosystems, a major multidisciplinary (oceanography, geology, biology, chemistry) seabed and ecosystem mapping program (MAREANO) has been granted for the period 2005-2010. The program has a budget of 250 million NOK, covering “only” 140.000 km2. MAREANO will provide an important part of the knowledge base on which decisions regarding future development will be based. Important products include databases showing where the most vulnerable ecosystems occur, important habitats, and the environmental state prior to large scale industry development. These databases shall be available by 2010, when the Norwegian authorities will decide upon the future development of the oil industry in the Lofoten-Barents Sea region.



Overview map of the area covered by the Management Plan (MP - yellow outline), and the MAREANO area (red outline). Inset map – mid and North Europe with the MP area outlined in red.

The program started late in 2005, with multibeam bathymetry mapping on Tromsøflaket, one of the particularly vulnerable areas identified by the EIAs. Based on terrain models and acoustic interpretation of the backscatter from the multibeam bathymetry mapping, a number of targets were identified, representing a broad scatter of seabed sediments, habitats and ecosystems. These ranged from gravelly ground, heavily incised by iceberg plough marks, via sandy areas, to muddy areas with a very high intensity of pockmarks. During 2006, these targets were surveyed, with towed video equipment, grab for biological sampling, and multicorer for geological and chemical sampling. The results have been integrated to 5 types of geological

seabed maps, with maps addressing habitats, biodiversity, ecosystems and production coming in 2007. In addition, databases of pollution in sediments is under construction, addressing both heavy metals and organic compounds, including “new” substances as brominated flame retardants and PFOS.

The European Union (EU) is currently working on its Marine Strategy, with strong focus on sustainable development of the European waters on all scales. The approach chosen by the Norwegian government, with a dedicated program focussing on integrated mapping and studies of the benthic ecosystems at a detailed scale covering large areas, should be considered as a relevant for model for future programs within EU. The dedicated web portal www.mareano.no has been proposed to serve as a Norwegian node in a future European information network sustaining holistic ecosystem based management of the oceans in a European dimension.

Using ‘seascapes’ to help predict Australia’s benthic marine habitat diversity

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One of the biggest challenges facing marine scientists is to develop a robust and defensible way to represent potential seabed habitats based on easily mapped and spatially-abundant biophysical properties. Geoscience Australia is currently developing a statistical approach to integrate multiple spatial biophysical data layers into a single map of seabed habitats or “seascapes” for Australia’s marine region. This approach utilises an unsupervised “crisp” classification, whereby all the biophysical data are combined with no prior assumptions about how each of the variables influences the benthic biota. Geoscience Australia’s “crisp” classification has been verified using an unsupervised “fuzzy” classification. The results of this analysis indicate that the unsupervised classification provides consistent and verifiable seascapes. Geoscience Australia is also developing an objective methodology to use the seascapes to assist in designing a representative system of marine protected areas. Areas of maximum seabed habitat heterogeneity are identified using a focal variety analysis in ARCGIS. Separate focal variety analyses are performed on the seascapes and other ecologically-relevant categorical data (e.g., geomorphology), and the results added together to provide a single map showing seabed habitat diversity, and denoting areas where placing marine protected areas could maximise biodiversity coverage. Future research includes working with Australia’s marine biologists to correlate the seascapes with high-resolution biology. Research into designing seascapes will be facilitated by the establishment of a A$6.6 M research Hub for predicting and managing Australia’s marine biodiversity

A decision support system supporting regulatory and management processes in the sustainable exploitation of marine aggregates

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Abstract
This paper describes a Decision Support System DSS (ref) that has been developed as part of the Irish Sea Marine Aggregates Initiative (IMAGIN) (ref). This DSS has been designed to facilitate key regulatory processes by supporting decision making associated with the sustainable exploitation of marine aggregates including strategic environmental assessments, (SEA, EIA), Risk Assessment (RA) and also in the wider context of marine spatial planning (MSP) (refs)

1. Introduction

The case for commercial exploitation of marine aggregates from the Irish Sector of the Southern Irish Sea is strengthening as a consequence of rapid economic expansion, and in the light of sustainability criteria assessments which favour this option over current terrestrial supply practices (refs). However, if extraction of these important construction raw materials is to proceed, the nature of extractive processes means that both Strategic and site specific environmental impact assessments will be required (refs). The decision making that follows will require detailed consideration of large volumes of complex marine environmental data. The competent authorities tasked with decision making often now rely on the use of Decision Support Systems (DSS) to provide them with crucial maps, information, and meta-information that is presented in a manner that is appropriate and specific to their requirements. (refs) Such a system has been developed as part of the Irish Sea Marine Aggregates Initiative (IMAGIN)[2]. The overall aim of this project is to facilitate the evolution of a strategic framework within which development and exploitation of marine aggregate resources from the Irish Sea may be sustainably managed with minimum risk of impact on marine and coastal environments, ecosystems and other marine users.

To achieve this, the project brought together a trans-national scientific consortium

[2]IMAGIN commenced officially on February 3rd 2005, and is a two-year project funded under the Ireland/ Wales INTERREG IIIA Community Initiative Programme 2000-2006. The total budget is circa €1.1m.

comprising organisations with expertise in coastal processes, geology and marine resource management for the purpose of developing a strategic framework to underpin future policy development for Irish Sea aggregates. It is intended that this framework, once developed, will provide the operational guidelines and regulatory processes necessary for the environmentally sustainable management of Irish Sea aggregates. Thus, two key aspects of the IMAGIN are:

Collection of Survey Data - Scientific studies to evaluate available aggregate resources and ascertain where they may best be exploited with the minimum of disturbance to the environment and human activities.

Planning Database - The development of a marine database and decision support system to (i) manage and present pertinent spatial information, including profiles of other marine users; (ii) inform stakeholders and scientists, (iii) act as an operational tool to facilitate the management of future regulatory processes.

SESSION 3A

Location of seamounts in the Western and Central Pacific Ocean (WCPO): screening and cross-checking of existing datasets.

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Seamounts are habitats of considerable interest in terms of conservation and biodiversity of their specific fauna and also in terms of fisheries for bentho-pelagic (e.g. orange roughy) and pelagic (e.g. tuna) species. About 20 datasets on seamounts and bathymetry at different scales (from individual cruise level to worldwide satellite data) have been gathered with the aim of compiling a detailed list of seamount features in the WCPO. None of the datasets is complete and errors exist in most of them. The Kitchingman and Lai (2004) dataset of seamounts predicted from satellite altimetry data formed the basis of this study because it covers the entire region of interest and includes depth information. All the potential seamounts identified by them were cross-checked with other datasets to remove any atolls and islands that were incorrectly classified as seamounts, to add seamounts not detected by this method and to update the database (geolocation, depth) and further classify the potential seamounts (type).

A typology of 13 categories was used to properly define the features as seamount, knoll, hill, guyot, ridge, plateau, pinnacle, bank, drowned bank, atoll, drowned atoll, island or unknown. Preliminary results indicate that the existence of many of the predicted seamounts could not be confirmed because of the lack of data. Of the 6144 potential seamounts identified by Kitchingman and Lai (2004) in the WCPO, 1537 (25%) could be cross-checked with other datasets, and 713 (12%) of these were misidentified for atolls and islands. The set of 1537 was further reduced because 694 were multiple identifications of the same feature (e.g. multiple peak seamounts). Thus, only 843 actual features were confirmed. 132 seamounts documented in the other datasets but not registered by Kitchingman and Lai were added to the dataset. The screening of all the potential seamounts produces a list of seamounts with accurate position and information for the WCPO that should have many applications such as investigation of seamount effects on fisheries and on the surface ocean parameters using remote sensing data.

However this list of seamounts is certainly not definitive and more work needs to be done. Specific improvements of the Kitchingman and Lai dataset would require a refinement of the algorithms to better identify seamounts and the use of well registered bathymetric data with improved depth interpretation of the altimetry data. At the regional level, many areas of the WCPO have not been explored thoroughly, and unconfirmed potential seamounts from Kitchingman and Lai may still exist. At the global level to obtain a more accurate and complete list of seamounts will require better resolution and accurate global bathymetric maps and it would greatly benefit from a clearly defined typology of underwater features at the global scale.

Ref.

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Mapping the Graveyard "seamounts": multiple techniques for multiple objectives

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The Graveyard "seamounts" are a cluster of small volcanic peaks on the northern slopes of the Chatham Rise, east of New Zealand. Orange roughy (Hoplostethus atlanticus) spawn in the area, and the seamounts have been the target of a commercial trawl fishery since the mid 1990s. A number of research programmes have been carried out on the seamounts to determine their physical characteristics, biodiversity, fishery status, and to describe the impacts of trawling. These programmes have used a number of techniques, including multibeam swath mapping for bathymetry, acoustics for estimating fish abundance and for habitat mapping, video and still cameras for bottom photography, and benthic sleds and fish trawls to sample the demersal fish and benthic invertebrate fauna. This multiple technique approach has given a range of data that collectively provide a good understanding of the physical structure and faunal composition of the seamounts. The research has been important for helping guide the exploitation and management of the fishery resources, as well as conservation of benthic habitat, of seamounts in the area.

High-resolution spatial variability in the megafauna of a deep-water active Samoan volcanic seamount related to habitat

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Submersible exploration of the Samoan hotspot revealed a new 300m tall, resurgent volcanic cone, named Nafanua, in the summit crater of Vailulu'u seamount. Nafanua grew from the 1000m deep crater floor in less than four years and could reach the sea surface within decades. This is a complex environment with low and high temperature hydrothermal venting and a range of habitat types from soft sediment to lavas. Data from georeferenced submersible video observations, swath bathymetry and physical samples were combined in a Geographical Information System allowing validated habitat mapping of this seamount at a sub metre scale. The spatial distribution of megafaunal taxa was assessed and found to vary significantly with habitat type. Four major habitat types were found: 1) Non-hydrothermal rocky substrata outside the crater support an epifauna dominated by octocorals and hexactinellid sponges; 2) The Nafanua summit vent area is inhabited by a thriving population of eels (*Dysommina rugosa*) living in and around low temperature vents; 3) The moat and crater floor around the new volcano are littered with dead metazoans that apparently died from exposure to hydrothermal emissions, acid-tolerant polychaetes (Polynoidae) are able to survive; 4) in areas where clean seawater enter the summit through breaches fish, crustaceans and stalked demosponges are abundant. Megafaunal density and diversity were found to vary significantly with presence of hydrothermal fluid, slope, depth and habitat type.

SESSION 3B

Remote sensing investigations into sediment bioturbation on the Oman continental margin.

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Three acoustic imaging systems were used to test whether variations in seafloor acoustic response could be attributed to sediment bioturbation. The imaging systems, a SIMRAD EM12, a surface-towed 3.5 kHz profiler and the NOC deep-towed MPV chirp profiler were used on two transects down the Oman margin, one near Muscat, and one off the headland of Ra's al Hadd. The locations were chosen to both encompass the well-known oxygen minimum zone which we expected to have a profound effect on the distribution of benthic fauna, and to look at any possible influence of deep Arabian Gulf outflow water. Benthic macrofaunal abundances were determined by deep-towed camera and sediment types and small-scale lateral homogeneity determined by both camera and sampling. There was strong evidence that within the oxygen minimum zone (c.100-1000 m) fauna create minimal bioturbation (burrow densities < 1 m-2, burrow diameters < 2 cm), while at greater depths there was an order of magnitude increase in burrow density (> 10 m-2) and almost doubling of burrow diameter. Although there were some instrument-related issues, systematic variations in seabed reflectivity were observed by all three instruments along the upper parts of the northern transect. In particular, local scale (100–200 m) lateral variations in seabed reflectivity were seen, although there was no evidence for a major transition in seabed response across the non-bioturbated to bioturbated boundary at about 1000 m water depth.

The biogeochemical role of shallow and intertidal soft bottom environments.

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Euphotic soft bottom substrates are a common feature of Pacific Island lagoon and inter-tidal environments and often are the dominate bio-facies in terms of substrate area. However, within our region their importance to ecosystem productivity and function is largely unknown and such environments are often subject to unchecked disturbance through dredging and reclamation. Whilst little work has been undertaken to better understand the role of soft bottom environments casual observation and experience from other locations would suggest this is a significant oversight.

Within shallow systems, particularly those which are enclosed (e.g. lagoons), extended water residence times combined with comparatively small volumes result in significant water column contact and interaction with the substratum. Studies in both temperate and sub-tropical systems indicate that under such conditions inter-tidal and shallow soft bottom environments not only provide habitat but can significantly contribute to primary productivity and influence marine water physiochemical parameters. Additionally, soft muddy to sandy environments in both shallow and intertidal zones have been observed throughout the region to be intensively bioturbated. Such large densities of infauna, in turn indicates a high likelihood that these environments contribute to the maintenance of higher food chains.

In other locations bioturbation has also been shown to greatly increase sediment surface area due to the matrix of tunnels infauna construct. As a result of the activities of these organisms within their tunnels the surfaces of such burrows are usually considerably more chemically reactive on a cm by cm basis than outside surface sediments. This in turn increases the potential influence that a given area of sediment may have over system productivity, oxygen dynamics and importantly the supply and removal of nutrients. In terms of nutrient removal bioturbated sediments are also associated with the enhancement of the biogeochemical process of denitrification, a natural process which removes dissolved nitrogen from the system. This is of importance since nitrogen is in turn associated with nearshore pollution and marine ecosystem imbalance.

In essence, little is known regarding the comparative importance of shallow euphotic and inter-tidal soft bottom environments in tropical Pacific Islands and certainly at a community level such features are often seen solely as a source of aggregate fill and/or an easy target for reclamation. In view of the importance of these habitats in other locations, a better understanding of their potential function and contribution to system productivity should be the subject of systematic study, particularly since the maintenance of near shore water quality is also becoming a regional priority.

Effects of eutrophication, ice scouring and invasive species on macroalgal communities in the northern Baltic Sea.

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In this study we analysed the effects of nutrient loading, ice scouring and invasive species on habitat forming macroalgae in the northern Baltic Sea. Macrophyte communities were affected by both nitrogen and phosphorus loads. There was a significant negative correlation between the load of total nitrogen and biomass of the prevailing charophyte species *Chara aspera*. Increased total phosphorus loads reduced the lower depth limit of the perennial macroalga *Fucus vesiculosus*. The increase in total nitrogen and phosphorus loads increased the biomass of the filamentous alga *Pilayella littoralis* and decreased the biomass of F. *vesiculosus*. The diversity of macrophytes was higher at the moderate nutrient loads as compared to both extremes. The effects of ice scouring were similar to nutrient loading. Following harsh winters the biomass of perennial algae and macroalgal diversity were reduced. The invasive mesoherbivore *Gammarus tigrinus* had no significant effect on macroalgal communities although clear shift in native invertebrate communities was observed due to intensive competition between native and invasive species.

Benthic Habitat and Biodiversity

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While accepting that benthic habitat depends on geophysical structure, we rarely ask the question why are we interested in benthic habitat. International conventions (and Australian policy) focus on conserving biodiversity not benthic habitat. Are benthic habitat and biodiversity the same thing – or put another way, what attributes of habitat do we need to describe to represent benthic biodiversity? Biodiversity is the sum of species and processes. When we look at benthic habitat we often concentrate on physical attributes (eg. depth, topography, bottom type) that can be measured once and preferably remotely. While these measurements are well suited to a static description of habitats and species' or communities' description, it is less clear that in the raw form they capture the dynamism required to describe the processes that structure, and are part of, biodiversity. Australian benthic bioregionalisation is based on a hierarchical system that relies on distinct processes operating at each level. The highest (provincial) level is based on patterns in species ranges – it represents the many processes affecting glaciation speciation that occurred through geologic time. The second (biome) level is based on patterns in species' and communities' adaptation to depth and/or correlated factors. We present results from surveys off SE Australia that show consistent patterns in functional community distributions over depth for different Provinces indicating its independence of the actual species present. The third (biogeophysical) level is based on biological and geophysical processes that structure communities within a Province and depth range (although biogeophysical units can extend over more than one depth biome or more than one Province). It is at this level that describing biodiversity requires both a map of species' or communities' distribution and a map that highlights spatially-distinct ecological processes. There is considerable progress being made in mapping community distributions from biogeophysical measurements, but comparatively little on how to map spatially-distinct ecological processes. We suggest that this would be a productive area of research for the next 10 years.

SESSION 4

Optimizing non-extractive bottomfish sampling strategies using GIS and multibeam data

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BOTCAM is an autonomous deep-water (50-450m) baited video camera system used as a cost-effective non-extractive method to assess and monitor exploited bottomfish populations in the insular Pacific. These baited video camera systems have been and will be deployed on a short-term basis (less than 48 hours) at various sites in American Samoa, Guam and the CNMI, the Hawaiian archipelago, and the Pacific remote islands under U.S. jurisdiction to collect data about bottomfish species (snappers, groupers, jacks) diversity and abundance. BOTCAM video has the resolution and fidelity to enable identification and accurate sizing of target species at depths of 100 to 350 meters (limited primarily by ambient light.

BOTCAM is only one of multiple operations that are undertaken during coral reef ecosystem surveys conducted by CRED. In order to optimize deployments with the limited number of instruments (3 at present) and the limited time at any given location, we must have robust sampling strategies that will allow interpolation of results from relatively sparse samplings. Using multibeam bathymetry and backscatter data, we have employed geographic information systems to identify benthic characteristics that may be suitable or unsuitable for bottomfish species of interest. These characterizations are then used to design stratified random sampling plans.

The distribution of marine biotopes and signs of fisheries impact in the south-western Barents Sea - Results from the first MAREANO cruises

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What is the relationship between the physical environment, species diversity and biological resources? This is one of the questions addressed by the MAREANO program (Marine Areal Database for Norwegian Coasts and Sea Areas). By complementing seabed mapping with sampling and video recordings of sediments and fauna we aim to increase our ability to predict occurrences of habitats and biotopes based on seabed information. The project partners (Institute of marine Research [IMR], Geological Survey of Norway [NGU] and Norwegian Hydrographic Service [NHS]) co-operate closely to perform the habitat- and fauna-mapping.

MAREANO aims to map marine benthic habitats and biodiversity on the Norwegian shelf. In 2006 the first full-scale ground truthing cruise of the project was conducted with visual observation and sampling of sediments and biota within an area mapped by multibeam echosounder earlier in the project. MAREANO is a multi-disciplinary programme, bringing together biologists from IMR, geologists from NGU, and scientists from NHS. A number of other partners will also participate in the field work and contribute to the MAREANO database. In addition to responsibilities for different fieldwork activities, the partners will collate existing information and present it integrated on www.mareano.no). The project was launched as an interministerial financial collaboration between the ministries of the Environment, Fisheries and Coastal Affairs, Trade and Industry and the Research Council of Norway. By 2010 major parts of the Barents Sea will be mapped.

On the first MAREANO cruise in 2006, sediment and fauna were sampled over an area of 3200 km 2 in the “Tromsøflaket” and “Lopphavet” regions, which previously had been covered by multibeam bathymetry. Fauna and bottom substratum were documented with a suite of sampling gears (video, multicorer, grab, boxcorer, beam-trawl, and epibenthic-sled). In total, 77 video-transects (~1000 m each) were recorded, and 56 sediment-samples and 133 fauna-samples were collected.

We will present habitat and biotope maps based on the correlation between the distribution of benthic fauna with environmental parameters (including bathymetry, sediment composition, bottom complexity, fisheries impact). Methods used to develop these maps will be described. In addition to the habitat maps our analysis of the faunal samples will provide a unique inventory of the shelf fauna of the Barents Sea and provide valuable information on biodiversity.

Sea scallop habitat in the Gulf of Maine

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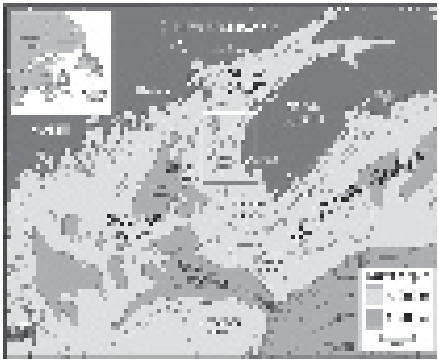
The sea scallop (Placopecten magellanicus) population in the Gulf of Maine off southwest Nova Scotia, Canada, supports a multimillion dollar commercial fishery. This resource is managed by the Government of Canada in cooperation with fishing groups. An interdisciplinary study is ongoing to improve the understanding of sea scallop habitat–specifically the relationship between sea scallop distribution, oceanographic conditions, and sea floor geomorphology and surficial geology. Study results will be used to improve sea scallop management in the Gulf of Maine and to reduce the impact of scallop fishing on other important commercial species like American lobster (Homarus americanus).

In the study area of Lurcher Shoal (see map below), the population of sea scallops has been traditionally assessed as one stock. However, the 1996-2006 spatial distribution of commercial sea scallop catch rates, and distribution of survey catches of commercial size animals and recruits, suggests the presence of an inshore population (within 30 km of shore) and an offshore population. The two populations may be associated with the oceanographic regime across the shoal or different characteristics of the sea floor. Recently-acquired single-beam sonar bathymetric data in the Gulf of Maine indicate that the sea floor geomorphology associated with the inshore sea scallop population is relatively smooth. For the offshore population, the sea floor geomorphology is irregular (on the scale of hundreds of metres to a kilometre). Future sea floor investigations of the sea scallop habitat study will encompass geophysical and geological grountruthing integrated with towed-video observations of scallop habitat. These large-scale observations will be extrapolated to underpin a regional habitat map of the Gulf of Maine.



Friday 4th May

SESSION 1

The status of the Millennium Coral Reef Mapping for Pacific Ocean Islands

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The Coral Reef Mapping Project is currently systematically mapping coral reefs throughout the planet using more than 1800 Landsat 7 images. Within the last three years, most of the Pacific islands, atolls and reefs have been mapped using a unique, consistent, and rich geomorphological classification scheme. Several atlases of coral reefs have also been produced (French Polynesia, New Caledonia, Southeast Papua New Guinea). The created maps provide a significant improvement to any regional scale coral reef map products, both in spatial accuracy and thematic richness, with as much as 180 classes of reefs per country. In many cases they provide the first robust and precise estimates of coral reefs extent and diversity. The talk will present an update on the classification scheme, general statistics and observations per country, availability of products, current applications, the gaps at the time of the conference, and the plan for the completion of a Atlas of Pacific Coral Reefs that will include American Samoa, Clipperton, Cook Islands, Coral Sea reefs, Fiji, French Polynesia, Hawaii and US islands, Kiribati, Marshall Islands, Nauru, New-Caledonia, Niue, Northern Marianna Islands, Palau, Pitcairn, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Wallis and Futuna.

High resolution optical remote sensing for a Reefscape Ecology perspective of the Amirantes Ridge, Seychelles

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Remote sensing data provide a synoptic picture of reefscapes in a format conducive to statistical manipulation in a GIS environment. Despite the wide adoption of remote sensing by coral reef managers for habitat mapping, the value of these data formats for applying landscape ecology theories to the marine realm has not been recognised. This study takes advantage of the benefits that remote sensing technology, in the form of imagery acquired using a Compact Airborne Spectrographic Imager, can offer reefscape ecology studies. Vector data formats are a useful tool for aligning image classification units with the concept of patches conventionally adopted by landscape ecologists. Typical landscape ecology metrics are analyzed for community patches with regard to predictable ambient environmental gradients across the reef shelf. Habitat maps are used to generate spatial variability models to test hypotheses commonly cited in reef science literature, based primarily on the geography of the data; a key property of remotely sensed imagery.

A Matter of Scale and Other Things:
The Ultimate Convergence of Multidisciplinary Mapping of Habitats

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One of the most common, and poorly addressed, parameters in marine benthic habitat mapping is scale. Scale applies to all phases of mapping from data collection to the published map. Confusion often occurs in regard to what scale and resolution the data were collected at verses the scale used in interpretation. Using GIS, presentation scale of habitat types can be made at any size but may not properly reflect the scales used for data collection and interpretation. Often the user of a habitat map is only aware of the final product scale and not cognizant of the scale manipulation made to derive the final product. We discuss a protocol that could make such scale manipulations more transparent and thus assist a user in evaluating the quality and accuracy of habitat interpretation. Such protocol can be embedded in metadata or could be a descriptive explanation attached to the final map product.

In addition, the use of spatial tools within GIS allows for the definition of such parameters as slope, or relief, and complexity and rugosity. Often these parameters will be derived at the same scale, while in fact they should be derived at different scales. Rugosity, for example, can occur on slopes of different scales with rugosity being a large-scale feature and slope being a smaller scale feature.

Time, the forth dimension, is another scale that may not commonly be addressed properly. For example, the use of accurately positioned and measured geo-referenced repeatable surveys of dynamic bedforms need to be done at time periods that correctly reflect the movement of sediment and the changes in morphology, perhaps at the scale of tidal motion or seasonally, if fluvial contribution is critical. Multibeam bathymetric datasets in a GIS can be manipulated in a fashion that provides excellent time-series analyses of a dynamic seafloor, especially when the period of sampling matches the period of sediment shifts.

Finally, perceived scale is another parameter that is often discussed by scientists involved in habitat mapping. For example, the statement that “we should map at the scale that a fish perceives” is used to justify only large-scale mapping for fish habitats. However, there may be other attributes such as morphology and depth, which is related to physiography, that influences the habitat that the fish perceives and these smaller-scale features should also be considered in mapping habitats as well.

SESSION 2

Mapping Benthic Habitats on Fijian Coral Reefs: Integrating Field and Remote Sensing Approaches

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Monitoring and management of tropical benthic habitats requires accurate and timely information on the composition and condition of the habitat over time. Environments containing these habitats are challenging to map due to their remoteness, extent and variable water clarities. Past studies have assessed the accuracy and cost-effectiveness of remote sensing techniques and field survey (by local communities or volunteers) for mapping tropical benthic habitats in developing nations. In this paper we assess the accuracy, cost and relevance of several benthic cover mapping techniques, which integrate field and image based mapping approaches for coral and seagrass, and can be used in areas with varying water clarity. Field survey and high-spatial resolution multispectral satellite image data were acquired for Suva, Navakavu and Solo Reefs in south-western Fiji from April to September in 2006. Three sources of field data measuring benthic cover quantities at specific sites were used for calibration and validation of satellite image based benthic cover maps: detailed georeferenced photo transects; existing monitoring programs; local expert knowledge. Several image data sets were used for the mapping: multi-spectral high-spatial resolution (Quickbird) acquired in 2006; simulated multi-spectral moderate-spatial resolution (e.g. Landsat 5 Thematic Mapper); and Google Earth high resolution image data. The 2006 acquired Quickbird image data were corrected for atmospheric attenuation using two approaches, basic (dark pixel correction) and complex (radiative transfer modeling). The benthic cover field data were then used with corrected Quickbird images in a supervised classification procedure to map benthic cover types. A second mapping approach manually digitised boundaries with the simulated multi-spectral moderate-spatial resolution image as a backdrop. The maps resulting from the different approaches were assessed based on criteria for, cost, accuracy and relevance from scientific and the local community's points of view. Preliminary results show that the maps produced by drawing boundaries on a Landsat TM scale image data using local knowledge were the lowest cost, and quickest to produce?. The findings from this work demonstrate how benthic cover information can be collected from a number of field and image data sources, and used separately or together, to provide useful information for reef monitoring and management.

Modelling and Mapping Coral Reef Habitats Transitions: an Integrated Remote Sensing and Artificial Intelligence Approach.

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High spatial resolution multispectral satellite images (Quickbird and IKONOS) and field survey data on benthic community structure were integrated with artificial intelligence techniques to model coral reef habitat trajectories in a change detection mapping process. Trajectories were modelled with a timed-automata formalism. The work was completed on Aboré Reef , New-Caledonia, which was significantly impacted by tropical cyclone Erika in March 2003, providing obvious patterns of changes in field and before-after impact image data. The main stages of the work involved: (1) building and testing a timed automata model of generic coral reef habitat trajectories; and (2) applying the model and assessing the accuracies of image-based habitat classification pre- and post cyclone. The generic trajectory modelling represented the reef habitat types and their possible changes in response to stress factors, such as cyclones, bleaching events, Acanthaster plancii outbreaks, phase shifts, strategy shifts, and recovery events. The model was applied to check the habitat modifications identified from the differences between pre- and post cyclone image classifications. The image classification results were revised if no trajectories could be identified by the generic model to explain the observed change given the time interval between the pre- and post-cyclone images.. The Aboré case study provided preliminary indication that understanding complex habitat changes over time is possible using a combined remote sensing and timed automata modelling approach. However, completely generic models were shown difficult to parameterize and use. A site-specific approach seems more adequate. Further studies are thus required to develop, on a selection of new sites, a spatially explicit implementation of the model with limited habitat trajectory complexity in time in order to determine how the model and image based mapping of habitat transitions can be used to contribute to established coral reef mapping and monitoring activities. This will involve the combination of object-oriented and fuzzy classifications techniques with timed automata and cellular automata formalisms to map and model coral habitat changes, through cycles of degradation and recovery.

Mapping depth and benthic habitats of a remote coral reef using a semi-analytical inversion/optimization approach and Quickbird data

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The MPA (marine protected areas) management team of the Australian Department of Environment and Heritage manages seven MPAs in remote tropical waters (outside of the Great Barrier Reef) where access for regular survey for monitoring values and threats is difficult and infrequent. Currently, the managers for the MPA, who are located 1000km's from the reef, rely on maps of benthic cover features and derived habitat maps for MPAs that are largely based on opportunistic aerial photography or occasional field surveys. In both cases these approaches only cover small portions of the terrestrial and sub-tidal components of the MPAs.

To develop a spatially extensive, remote and repeatable means for assessing the condition of these MPA's, we applied an advanced image processing algorithm for mapping benthic cover features to high spatial resolution multispectral (Quickbird) satellite image data of Northeast Coringa reef in the Coral Sea. Both image and field data were acquired in November-December 2006 and were used to evaluate the accuracy and cost of this approach for mapping benthic cover features and habitat zones. The field data collected included geo-referenced photo transects and optical properties of the benthos and waters of the study area. The latter data were used to parameterize our image processing method which used an optimization-based inversion approach. Output from the processing method included benthic habitat, bathymetry and error maps. These were evaluated against benthic cover measurements derived from the photo transects.

Based on our preliminary results, this methodology will be adapted and applied to other remote MPA's to provide baseline data for future change detection studies and reef monitoring.

Integrating Satellite Image Data and Photo-Transects: Mapping Benthic Cover Types to Coral Reef Habitat Zones

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Mapping and monitoring changes to coral reefs has been conducted using either detailed field survey or moderate to high spatial resolution satellite image data. The aim of this work was to integrate these approaches, and use detailed field survey data to establish a hierarchical grouping of benthic cover types to map reef habitat and community zones from high spatial resolution satellite image data. With few exceptions, the focus of most satellite image based mapping of reefs has been substrate or geomorphic zone mapping. From a reef management and science perspective, it is also essential to map commonly occurring assemblages of benthic cover, substrate and geomorphic zones/ types which occur on coral reefs, and which are able to be related to the habitat requirements of the flora and fauna of coral reefs. We established a hierarchical mapping approach that integrates field survey and high-spatial resolution image data to map reef composition at a higher level, where groups of these features make up habitat zones. Field survey from photo transects and a fully corrected high spatial resolution satellite image from Heron Reef, southern Great Barrier Reef, Australia in 2004 were used for the project. The methods comprised three stages. The first stage identified frequently recurring assemblages of benthic cover types by applying cluster analysis to percentage cover estimates of 20 benthic cover classes from 854 geo-located 1m x 1m photos of Heron Reef . The resultant clusters were examined on a graph using the first two principal components as the axes. The photo points for each cluster were then displayed on the coincident Quickbird image and a habitat zone label was assigned to each cluster. In the next stage the reflectance values for the Quickbird image pixels corresponding to the photo points in each cluster were extracted and tested to determine if there were any statistically significant differences between the clusters representing the habitat zones. Three zones had statistically significant differences in reflectance: rock and rubble; live corals, and turf algae, dead coral and bleached coral. The final stage of the project used the habitat zones identified as a basis for a segmentation of the Heron Reef Quickbird image. This resulted in a map of reef habitat zones that matched closely with the clustered photo points. This work provides a preliminary verification that field and image data can be integrated and multiple scale image based maps of reef habitat zones can be produced.

SESSION 3

Coral health monitoring – linking remote sensing and coral colour methodologies

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Abstract. One of the most common tools used to assess reef status is the percent of living coral cover. This study tested whether it was possible to supply additional information to live coral maps based on spectral signature characteristics. 1264 spectral reflectance measurements were taken in-situ from corals representing six levels of coral health, as defined by Coral Health Charts, at Heron Island in March 2005. Spectral analyses of reflectance magnitude, first and second-order derivatives plots were undertaken to test if it were possible to assign a coral health value to spectral reflectance signatures. Quickbird multispectral image data with 2.4m pixels were acquired to test for a correlation between in-situ Coral Health Chart values and corresponding pixel (R0-) values. Our study showed that living coral can be further classified into additional health categories including bleached, moderately healthy, and very healthy coral, with 72.41% overall accuracy, based on in-situ magnitude of reflectance measurements. First and second-order derivative analyses did not improve classification accuracy of coral spectra into health classes. That additional health categories could be distinguished using in-situ reflectance measurements is encouraging for potential remote sensing applications. An encouraging coincidence between image reflectance values and in-situ measurements indicated that it was possible to map coral reef health using satellite/airborne sensors and potentially use Coral Health Charts for image validation purposes.

Seagrass-Watch: mapping and monitoring seagrass habitats in the Pacific Islands

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Seagrass-Watch is the largest scientific, non-destructive, seagrass assessment and monitoring program in the world. In 2002, Seagrass-Watch expanded to the Pacific Islands to provide a reliable early warning system on the condition of near-shore seagrasses.

Seagrass-Watch brings together diverse groups from all sectors to work together towards a common goal of seagrass conservation. The program has a simple philosophy of involving those who are concerned and involves collaboration/ partnerships between community, qualified scientists and the data users. People involved in the program develop a deep sense of custodianship and understanding of their local marine environments that reaches throughout the wider community. Coastal communities are concerned about the condition and loss of seagrasses in their regions and are keen to play a primary information-gathering role and work in partnership with government/non-government agencies.

Seagrass-Watch currently has participants in Fiji, Solomon Islands, Papua New Guinea, Federated States of Micronesia and Palau, with interest from Tonga, Vanuatu and Samoa. The program has provided information about the distribution and status of seagrass ecosystems at local, regional and national scales. The program has shown clear seasonal patterns in abundance across the Pacific, identified areas important for seagrass species diversity and conservation, and has provided an early alert to detrimental effects from poorly managed coastal activities. The findings from the program have contributed information to MPA and LMMA planning, and used to track the possible consequences of global climate change.

Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. To protect the valuable seagrass meadows along our coasts, everyone must work together.

Linking spatio-temporal variability of benthic communities to abiotic environment: where and when to sample?

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Processes affect ecosystems simultaneously at various spatial and temporal scales resulting dynamic patterns of abiotic and biotic environment. The relative importance of small and large scale processes on the formation of benthic communities is little known. Often the patterns have been specified at one or a few scales only ignoring a infinite variety of other possibilities. However, the selected scales may or may not contain a substantial fraction of overall variance and thus, may or may not have ecological significance. Knowledge on how benthic communities vary through spatial and temporal scales is prerequisite for a number of management issues e.g. accurate habitat mapping, application of the concept of blue corridors, sustainable exploitation of resources, etc.

In this study the relationships between physical environment and community structure of benthic invertebrate feeding guilds were investigated at a number of spatial and temporal scales in a shallow water ecosystem of the Baltic Sea. We analyzed (1) whether similarity of invertebrate communities changed with geographical and temporal distance between communities, (2) whether the shape of such functional relationships varied among different invertebrate feeding guilds and (3) whether environmental variables predicted invertebrate communities the best at scales where highest dissimilarities between communities were observed.

The spatial variance spectra of benthic invertebrates resembled to ‘red noise’ i.e. the variability of communities increased with spatial scales. The spectrum of sessile deposit feeders, however, approximated to white noise i.e. there was constant variance per unit frequency from 10 to 100,000 m scale. The peak scale was either missing or observed at 100 or 1,000 m scale. Multivariate analysis was used to relate the patterns of abiotic environmental variables (depth, coastal slope, identity and uniformity of sediment) to biotic variables (abundances and biomasses of invertebrate species). Environmental variability at 1,000 m or higher spatial scales explained best the variability of benthic invertebrate communities. Surprisingly, environmental variability at 10 and 100 m scales practically did not account for the variability of invertebrate communities. The temporal variance spectra of benthic invertebrates were bell-shaped with high seasonal and decadal and low annual variances. The temporal variance was best explained by water temperature and nutrient loading.

To conclude, high variability of invertebrate communities at high spatial scales suggests weak biological interactions and strong physical control. The strong physical control is due to both clear seasonality in whether patterns and climate or human induced trends in eutrophication. The observed patterns of spatio-temporal variability indicate that the most cost-effective sampling of invertebrate communities should involve spatial scale about 1000 m and the sampling should be performed at a specified season.

Mapping, Monitoring and Assessing Seagrass Habitats in Tropical Australia

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Over the past decade the Queensland Department of Primary Industries & Fisheries has developed a range of mapping and monitoring programs for tropical seagrass communities that have been applied within Australia and other tropical waters in the Asia Pacific region. The diverse physical nature and often-remote location of many of these areas has required the development of some unique and varied mapping and sampling approaches. Many traditional methodologies including remote sensing have proved ineffective in many locations due to high water turbidity, lack of available imagery, the presence of dangerous marine animals such as salt water crocodiles and the often small physical size of the seagrass species of interest. In order to asses the status of seagrass meadows in the region the program has evolved an integrated strategy of assessment from intensive fine-scale mapping and monitoring in areas of high risk to seagrass through to development of broad-scale mapping techniques that have effectively overcome the environmental challenges of working in the region. A key to the programs success has been the ability to coordinate and integrate information collected from community based programs, partnerships with industries such as ports and assessments conducted by scientists in the field. Results of the program have greatly increased our understanding of tropical seagrass biology and the range of natural and anthropogenic changes to seagrass communities in the region.

Seagrass monitoring by underwater videography: disturbance regimes, sampling design, and statistical power

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Marine flowering plants (“seagrasses”) provide many economic and ecological benefits, yet populations appear to be declining in many locations throughout the world. An urgent management priority is the development of methods by which changes in the areal extent of such populations can be assayed quickly, repeatedly, and with high precision over managed spatial scales, so that recovery efforts can be successful. Surface-based underwater videography with submeter-accuracy differential GPS is a method with several advantages, including high spatial and visual resolution, effectiveness at all depths at which seagrasses occur, non-destructive sampling, and rapid data collection in the field. Here I investigate the statistical power of this method applied to a natural meadow and to virtual meadows created by a spatially explicit model of seagrass disturbance, regrowth, and colonization. The approach is found to detect a 5-10% loss in short timespans at 95% probability, with a sampling design emphasizing long transects (400 m or greater) and analysis in which transects are paired before and after disturbance. A field effort function shows that this precision is possible within a single working field day for sampling regions 1 km². Surface-based videography is a powerful monitoring tool that can provide managers with precise and timely knowledge of small changes in seagrass cover.

POSTERS

Habitat Classification and Mapping Product Development as a Tool to Support the Coastal Management Community

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NOAA's Coastal Services Center is devoted to serving the nation's state and local coastal resource management programs by linking people, information and technology. The Center program areas include Coastal Learning Services; Coastal Remote Sensing; GIS Integration & Development; Landscape Characterization & Restoration; and Human Dimensions. The Landscape Characterization and Restoration (LCR) program explores the interrelationships of a region's ecology, land use, socioeconomics, and management, and publishes this information for use by the coastal management community. The LCR program was developed in response to several observations, including:

- Recognition that resource management requires interdisciplinary approaches that integrate physical, ecological, and socioeconomic knowledge, often at the spatial scale of a watershed or larger unit.
- The importance of spatial analysis as a means for organizing the large amount of information needed to manage coastal resources.

Focus areas within the Landscape Characterization & Restoration include Environmental Characterizations; Benthic Habitat Mapping; Habitat Restoration; and Coastal Climatology. Environmental characterizations integrate ecological and socioeconomic information for a particular region or management issue; benthic habitat mapping projects focus on characterizing the physical and biological features of estuarine benthic habitats; habitat restoration resources assist coastal managers with habitat restoration planning and prioritization; and coastal climatology efforts focus on the incorporation of climate data and information into decision making processes.

Within the area of benthic habitat mapping, the Center works with resource managers and mapping professionals to promote use of these products to address coastal management issues. The Benthic Habitat Mapping focus area currently has four active projects:

- Habitat Classification Standard – This is an effort to develop a consistent framework for classifying benthic and water-column habitats that is capable of providing a systematic approach to relate existing classification systems. The Coastal/Marine Ecological Classification Standard is currently being tested by NOAA partners, and information technology needed to support the standard, such

as relational databases and geographic information systems, is being planned.

- Apalachicola Bay Oyster, Sediment, and Bathymetric Mapping -- The U.S. Geological Survey (USGS) Coastal and Marine Geology Program, the Apalachicola National Estuarine Research Reserve, and the Center are working together to map oysters, geology, and bathymetry within Apalachicola Bay. This mapping effort will integrate side-scan sonar, interferometric swath bathymetry, and seismic reflection acoustic techniques with video imagery and traditional sampling.
- South Carolina Oyster Mapping -- Approximately 1,500 square miles of digital multispectral aerial imagery is being collected for the purpose of mapping South Carolina's intertidal oyster beds. This acquisition is a follow-on to pilot work conducted by the Center to address a need by the South Carolina Department of Natural Resources' Marine Resources Research Institute for an updated oyster reef database. This imagery is currently being collected at 0.25-meter resolution under extremely tight flight windows constrained by lunar low tides and sun angles greater than 45 degrees above the horizon.
- Texas Coastal Bend Benthic Mapping Project – The Center is working with the Texas Parks and Wildlife Department and the Texas A&M University Center for Coastal Studies to support a statewide seagrass monitoring program. Existing digital camera (ADS 40) imagery, originally collected for the National Agriculture Imagery Program, is being used to create benthic habitat maps. The mapping process will use semi-automated methods and will be completed by private industry. The seagrass monitoring program in Texas will use these benthic maps to help locate, monitor, and protect seagrass beds.

This presentation will demonstrate the application of various classification and mapping products.

Development of a classification scheme for shallow water marine benthic communities for planning and management of marine protected areas in Western Australia

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Marine habitat maps, in conjunction with an understanding of marine wildlife distributions and marine biodiversity, provide baseline diversity and ecological function information essential for planning and management of marine protected areas (MPAs). Marine habitat data is usually presented in the form of a map, typically at community level (broadscale, 1:50,000 to 1:100,000), with focal areas such as "no take areas" (sanctuary zones) at functional group level (local scale, ~1:25,000) (Ward et al. 1999). Research has shown marine habitat diversity to be a highly representative surrogate of marine biological diversity (Ward et al., 1998), especially when supplemented with detailed fine-scale species level biodiversity data (Ward et al. 1999).

The shallow-water marine habitat classification scheme (SMHC) has been developed as part of Western Australia's (WA's) implementation of a representative system of MPAs, and in response to the confusion generated by the large number of mapping tools and methodologies commonly used both in Australia and internationally. The SMHC is a standardised, spatially nested scheme of marine habitat classes to be used for mapping the marine biological resources of coastal marine ecosystems. It classifies habitats according to a variety of environmental and physical factors, and has been designed to be compatible with national bioregionalisation frameworks.

The SMHC attempts to address scale and nomenclature issues and provides a framework for classifying marine habitats at different spatial scales (community and functional group levels). The intent is that SMHC will be adopted and utilised by Government agencies and environmental practitioners, thereby allowing a standardised approach to be followed in shallow-water marine benthic community mapping.

Cold seep habitats: use of a new towed camera array to explore and map chemosynthetic benthic communities on the east coast margin of New Zealand

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We describe the use of the towed camera array DTIS (Deep Towed Imaging System), during a research cruise in November 2006 (RENEWZ 1 – NEW ZEEPS, funded by NOAA and NIWA) to explore and map chemosynthetic benthic communities at cold seep sites off the east coast of New Zealand. DTIS has been developed at NIWA specifically to provide high-resolution digital video and still images of deep-sea habitats, yet be deployable from any vessel of suitable size equipped with a conventional CTD winch and cable. Cameras and lights are operated remotely from the surface and are capable of simultaneously recording continuous high-definition video and 8 mp digital still images at 15 s intervals. These high-resolution outputs are recorded in the vehicle and only a relatively low-resolution 'viewfinder' video image is encoded and streamed back to the ship in real time. Observers at the surface monitor this video image and use the tracking and annotation software system OFOP (Ocean Floor Observation Protocol v. 3.0.2, J. Greinert, Days Bay, NZ) to plot the camera's position and make time-stamped annotations of observations such as seabed substrate type, benthic fauna, and evidence of fishing impacts. DTIS position at the seabed is mapped in real time and all annotations, including the start and end of video recording and the positions of still images, can be selectively plotted as geo-referenced symbols on the track. Moreover, multiple transects can be displayed simultaneously, providing a powerful planning tool for the immediate and precise deployment of physical sampling gear. In the present study, DTIS was deployed as an integral element in a sequence of survey and sampling techniques nested at progressively finer spatial scales and designed to determine the location, extent, and biological characteristics of seep sites. Subsequent quantitative analyses of seep habitat and fauna distributions, using the high-definition video and high resolution still images, will enable correlations between faunal distributions and physical habitat characteristics to be explored in detail.

Seabed diversity of Keppel Bay, a macrotidal shallow-water embayment in the southern Great Barrier Reef

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Identifying sediment transport pathways and seabed sediment facies on the inner shelf provides valuable information for the management of coastal ecosystems, especially for coral reefs and seagrass meadows that are potentially vulnerable to enhanced river sediment loads. Keppel Bay is a macrotidal, highly turbid, episodic estuarine depositional setting and forms the interface between the Fitzroy River catchment of central Queensland and the coral-reef dominated outer shelf of the southern Great Barrier Reef. We examined the morphology, seabed sediments and sediment dynamics of the bay. The analysis of sediment data, modelled seabed shear-stress and three-dimensional acoustic imaging reveals that Keppel Bay is a mixed wave- and tide-dominated estuarine system with five distinctive seabed sedimentary environments. Areas of sediment starvation and shoreward transport characterise the carbonate-rich offshore zone, whereas a complex of both active and relict tidal sand ridges, and associated subaqueous dunes, dominate the relatively protected muddy southern Keppel Bay. Here sediment transport is highly dynamic and variable, with ebb-dominated transport through tidal channels into the outer bay where there is a switch to wave-dominated shoreward transport and greater proportion of carbonate. Ultimately, bedload sediments appear to be reworked back inshore and to the north, and are gradually infilling this bedrock-defined embayment.

Volcanic Features as Important Fisheries Habitats in Alaska – The Attraction of Negative Relief

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Volcanic edifices in SE Alaska offshore waters have been found to be excellent seafloor habitats for an assemblage of rockfishes (Sebastes spp.) and lingcod (Ophiodon elongates). These edifices are in the form of eroded volcanic cones that form high relief structures with rugged crests and flanks and rubble aprons that provide refugia for fish and interrupt nutrient-rich currents bringing food to the associated biological communities. Recent multibeam bathymetric surveys and occupied submersible dives offshore of Cape Addington in SE Alaska were undertaken to investigate a newly discovered pit crater, a 290 m deep, nearly circular, ~1 km diameter crater whose rim lies at a depth of ~74 m on the continental shelf. The steep-walled rim of this crater and the walls of other shallower and smaller circular depressions found on the seafloor in the surrounding lava fields were observed to contain large abundances of rockfish. The depressions appear to be collapsed lava tube roofs and lava lobes that provide negative relief with steep walls that appear to attract bottomfish.

Faunal Associations with Carbonate Mounds and Cold Seeps in Hecate Strait, British Columbia, Canada

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Carbonate mounds associated with hydrocarbon seeps were discovered on the continental shelf of British Columbia during a scientific survey in 2005 (Figure 1). Found at approximately 130 m, they are among the shallowest known 'cold seeps' in the world. Numerous carbonate mounds, 1 to 2 m in height, were observed within pockmarks that form a linear chain of seafloor craters. Hydrocarbon seeps are common in petroleum-producing basins and require hydrocarbon-bearing formations with broken seals and open conduits to the seafloor, a situation that occurs on many continental margins. Typically, faults are the rupturing agent, and a fault plane provides the pathway to the seafloor. Video of the mounds was collected using a Phantom HD2 ROV in order to determine the origin of the mounds, record hydrocarbon venting and, in particular, analyze the faunal assemblage associated with the mounds. The faunal assemblage is compared to the surrounding shelf fauna as well as assemblages associated with other known cold seeps.

The cold seeps have a high abundance of large epifaunal organisms, including the Oregon Triton (Fusitriton oregonensis) (Figure 2); however, none of the observed epifauna is known to be chemosynthetic. A 'halo' of shell debris immediately adjacent to the mounds indicates abundant infaunal clams, dominated by the Family Lucinidae. The fauna on the soft substrate habitat surrounding the mounds is typical of a shallow continental shelf community, with few large epifaunal organisms and evidence of scattered infauna.

The communities found at other deeper cold seep sites are dominated by abundant chemosynthetic organisms such as the seep mussel (Bathymodiolus), vestimentiferan tube worms and vesicomyid clams. Lucinid clams have been observed at a few sites in the Gulf of Mexico and are thought to house symbiotic sulphide-reducing bacteria. Large gastropods have been noted but are generally not abundant.

In conclusion, the faunal assemblage at the cold seeps in Hecate Strait is distinct from the surrounding soft substrate community and other known cold seep sites. The mounds are located in a key area of trawl fisheries and video surveillance undertaken during the scientific survey showed that many of the mounds are entangled with fishing gear. Consequently, this unique community holds considerable interest for the oil and gas industry, trawl fisherman and marine resource managers.

Mapping of cold-water coral habitats in the Minch, NW Scotland

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In summer 2006, during RV Pelagia cruise 250 in the Minch (NW Scotland), a total of 170 km of high-resolution deep-towed sidescan sonar data (100 and 325 kHz) were collected over cold-water coral mounds in the Minch, including the Mingulay reef complex previously surveyed with multibeam bathymetry in 2003, and other seabed environments. The sidescan imagery was ground-truthed using extensive underwater video observations and still photography. The ground-truthing is prerequisite to the creation of a habitat map because it complements the identification of the different facies/potential habitats from the sidescan sonar imagery. In case of the Minch data, healthy living coral, dead coral framework and rubble, as well as smooth background sediment and bedrock could be accurately identified and mapped.

Together with new multibeam data collected concurrently during this survey, the sidescan sonar imagery revealed the location of new mound structures. Some of those were home to live coral assemblages, while one had a particularly healthy reef structure on its top.

With the results of this work a fairly substantial picture of the cold-water coral coverage on the coral reefs of the Mingulay complex can be drawn. The mapping of the spatial distribution of the different habitat components together with the associated sedimentary environment gives further insight in the habitat structure of cold water corals in the Minch, and furthers the understanding of coral occurrence in the area.

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Habitat Mapping and Continental Margin Ecosystems (COMARGE)

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Continental Margin Ecosystems (COMARGE) is one of fourteen projects of the Census of Marine Life (CoML), a ten-year initiative to assess and explain the diversity, distribution, and abundance of marine life in the oceans. COMARGE is an international network of scientists which aims at addressing key ecological issues concerning continental margin ecosystems (c. 200 to 4000 m water depth), which are now known to be both very complex and active regions, strongly influenced by current flow, seabed character, photosynthetic and chemosynthetic productivity, water column and interstitial oxygen gradients. The project utilises existing data sets and has global coverage, from passive Atlantic to active Pacific margins. It also covers a variety of scales, from bathymetric and latitudinal gradients to small-scale patterns observed in fragmented habitats such as deep-sea corals and cold seeps.

Among the issues addressed by COMARGE are the quantification of habitat heterogeneity and the consequences of this on biodiversity, the prediction of species distributions, and the potential sensitivity of ecosystems to anthropogenic pressures. To address these questions, a common framework for the description and classification of continental margin habitats is required. Such a classification system has not previously been required for the deep sea. While the important ecological role of these ecosystems is increasingly recognised, however, the anthropogenic pressures on them are increasing. Adopting standard habitat classification schemes is essential to understand and manage these potentially sensitive ecosystems. To this end, COMARGE will bring together scientists from a range of institutions and discipline in order to i) develop, for the purpose of the project, a comprehensive deep seafloor classification scheme from existing, mainly regional, systems and ii) provide first comparable habitat maps for these important marginal regions. The workshop will be held at NOC, Southampton (U.K.) 4-6 June 2007. http://www.ifremer.fr/comarge/en/index.html

Image texture analysis of shallow-water sidescan sonar and multibeam backscatter data: comparability and compatibility

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High-resolution sidescan sonar (325 kHz) and multibeam backscatter (200 kHz) data were collected simultaneously in the Western Solent, Southern UK. This area is known for its dynamic sediment transport, resulting in an intricate pattern of bedforms and sediment features of varying size, consisting of gravel beds, mobile sands, sediment waves and occasional fine-grained patches.

The two acoustic data sets were processed to the same resolution with the in-house NOCS software PRISM; and spatially coinciding subsets were analysed with the University of Bath software TexAn. The latter uses Grey Level Co-occurrence Matrices to calculate entropy and homogeneity indices in moving windows across the imagery. Those quantify the amount of chaos/organisation and the amount of local similarities in a chosen neighbourhood around each pixel. The aim of the investigation was to distinguish between different seabed facies (potential habitats, including ripple fields, man-made objects etc.), and to assess the performance of this computer-assisted image analysis technique on both types of acoustic data.

The results show that there is a clear difference in the appearance and quality of both data sets. The sidescan sonar imagery has a better quality due to a higher intrinsic resolution during data collection, and because of its much wider swatch widths it also proves to be the most economic surveying technique. The multibeam backscatter data is less affected by shadows, but the signal-to-noise level is lower, which influences the local chaos/organisation in the imagery. Both classification results, in combination with the original images, help the human eye to map major morphological and facies units and guide the interpreter to observe subtle differences in bedform morphologies and reflectivities. However, so far the two instruments still have too many different intrinsic characteristics for the texture analysis results to be easily compatible.

A multidisciplinary investigation of the Wyville-Thomson Ridge and the European Continental Shelf intersection.

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A recent multidisciplinary study looking at the intersection of the Wyville-Thomson Ridge with the European continental shelf found that whilst the geomorphology and general physiological and acoustic backscatter characteristics of the seabed were very similar to either side of the intersection, ground-truthing found that the biological communities inhabiting hard substratum habitats below 600m depth on the northern (Faroe-Shetland Channel) flank of the Wyville Thomson Ridge are significantly different from those inhabiting the southern (Rockall Trough) flank. Lophelia pertusa was observed only on the southern, relatively species-rich, warmer water of the Rockall Trough side of the ridge, while diverse crinoid dominated communities were only observed on the northern species-poor colder Norwegian Sea Water side of the Ridge.

Morphometric characterisation of rocky reefs using swath acoustic bathymetry

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The increasing application of multi-beam and interferometric side-scan sonar to generate high resolution bathymetry has provided new insights into the topographic complexity of the seabed, particularly within areas of consolidated sediments (rocky reefs). Such data are now allowing a more detailed examination of the effect that variations in complexity has on benthic species diversity, assemblage composition and fisheries productivity. Greater complexity can result in more 'microhabitats' leading to greater species diversity, particularly for sessile assemblages (e.g. sponges, ascidians, bryzoans). It may also influence the abundance of commercial species such as abalone and rock lobster which prefer particular parts of reefs such as ridges and channels.

However, many studies have relied on remotely sensed data at coarse resolutions (10-100 m's), which is much greater than the spatial scale of habitat preference for particular species. Rocky reef structure is often defined using simple classifications such as rough or smooth. Surface complexity analysis examines how convoluted the reef areas are, not at just how steep or rough, though these both play a role. Complexity is similar but not the same as rugosity. Rugosity can be strongly influenced by a single large change in depth, however, complexity is less influenced, since all depth changes (slopes) are treated equally.

Applying similar geomorphic classifications used in terrestrial analysis a number of morphometric classes such as pit, peak, pass, channel, ridge and plane can be defined from acoustic swath bathymetric data. Such quantitative morphometric methods takes the process of classification one step further from simply using Digital Terrain Models (DTM) to classified features by visual assessment (i.e. using topographic hill-shading). The morphometric feature classification within the algorithm software passes a local window over the DTM and examines the relationships between a central cell and its neighbours. The features of slope, pit, channel, pass, ridge, peak and plane can be classified by measuring both the slope and curvature of each cell in the DTM. A maximum membership and a confusion index can be generated for the stacked morphometric layers, with the confusion between overlapping classes being explained by the confusion index.

The three major advantages of the method is that it is scale independent, it generates uncertainty layers and the process is completely quantitative with no user input required in the classification procedure. Comparison with the classification of seafloor topographic features using hill shading techniques to visually validate the classifications proves to be a reliable methodology to classify ridges and plains but is less successful in discriminating peaks, pits, channels or passes. The classification method is able to provide a systematic and objective description of the seabed that can be used to compare between study sites. The quantification of rocky reef complexity allows improved design of diversity surveys using video and still photography that aim to examine the relationship between complexity and diversity which may improve the capacity to predict reef diversity based on of these physical features. As detailed biodiversity surveys can only be conducted over small geographic areas, such analysis is particularly important for further defining habitat 'surrogates' often used in the Marine Park planning process to increase the likelihood of representing species diversity within the highly protected Sanctuary Zones.

Benthic Habitat Inventory and Mapping in NE Baltic Sea

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Large-scale benthic habitat mapping activities are carried out according to agreed methodology in coastal waters of Estonia, Latvia and Lithuania during the time period of 2005-2008. Inventory includes activities on actual field sampling of geological and biological features, habitat modelling, development of habitat classification system and inventory of existing literature data. Three indepemdent research teams including experts from six organisations are involved in the project. Main aim of this largescale international effort is to collect data for the establishment of basis for spatial planning of marine areas including network of MPAs. Altogether 10 target areas are mapped along the approx. 600 km of shoreline. Field studies include combination of actual sampling of the seafloor, SCUBA diving observations and use of UW video systems. During preparatory phase of the project special methods were developed and tested for processing of the video material. As no commonly agreed banthic habitat classification system currently exists for the Baltic Sea area the own classiofication system was developed using the principles of EUNIS classification. In this presentation the first results of the mapping activies will be presented together with description of ageed methods and habitat classification system.

Predicting the distribution of seagrass in a complex archipelago area using habitat modelling techniques; how to find eelgrass (Zostera marina L.) among 30 000 islands?

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Knowledge of where species occur and which factors limits or threats their distribution is fundamental for both science and management. In the marine environment, significant efforts are needed to reduce the negative impacts of human activities especially in coastal areas. However, if marine protection efforts are to be successful, there is an increasing need to locate and delineate key habitats, and to quantitatively forecast potential broad scale environmental impacts. The aims of this study were to based on available GIS data (1) describe the distribution of a key species, the seagrass Zostera marina (eelgrass) in the Archipelago Sea, SW Finland, (2) identify which environmental variables influence the distribution of eelgrass in this area using geographical information systems (GIS), generalised additive models (GAM), and environmental niche factor analysis (ENFA), and (3) to visualize these results by creating quantitative habitat suitability maps of areas where the appropriate combination of environmental variables occurs. The results showed that physical factors such as depth, exposure (fetch) and coastal slope to a large extent predicted the occurrence of eelgrass habitats in the geographically complex (>30 000 islands) archipelago of SW Finland. Simple GIS models performed surprisingly well, and yielded similar results as the GAM and ENFA analysis. ENFA (presence-only data) produced the most optimistic habitat suitability models, while GAM models (presence-absence data) produced similar, but less optimistic habitat suitability maps. Field validation efforts in terms of SCUBA diving and underwater drop video techniques combined with statistical cross-validations provided complementary support of good model performance. It is concluded that predictive modelling approaches perform well in marine settings, and may provide useful tools for identifying sensitive areas where potentially large occurrences or diverse habitats coincide with local environmental threats. In areas were remote sensing techniques are of limited use, a modelling approach may be the only alternative method to create distribution maps which may serve as a baseline for predicting shifts or declines in species range in response to environmental change scenarios.

Mapping Techniques for Evaluating a Potential Aggregate Site in Tarawa Lagoon, Kiribati

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Sand and gravel mining from the beaches for construction purposes is a key contributor towards coastal erosion on Tarawa Atoll, Kiribati. A 3 x 5 km area within Tarawa lagoon was investigated as a potential alternate and sustainable aggregate extraction site. A combination of multibeam bathymetry and backscatter, photographs, hydrodynamics, water quality, sub-bottom profiles, and sediment samples, were used for assessment of the aggregate resource.

The mapped area has water depths ranging from 1-25 m. SCUBA diver photographs show extensive sandy shoals and patch reefs in the area, which were delineated using the backscatter mosaic. Dry sieve analysis of the sediment samples showed facies dominated by sandy gravel, comprising coral debris, molluscs, Halimeda, coralline algae and minor foraminifera. Seismic boomer profiles were used to assess the volume of the potential aggregate resource. Hydrodynamic modelling was used to predict the dispersion of the sediment plume during dredging activities.

The data analysis indicates a good aggregate resource is present in the lagoon. However, the extraction of these sediments awaits an environmental impact assessment and the availability of a suitable dredge.

Mapping and typologies of mangroves of New CaledoniaLagoon, Kiribati

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A study relating to the biodiversity and the biogeography of mangroves of New Caledonia was recently launched within the framework of the ZoNéCo programme in collaboration between Sabrina Virly Consultant, the DTSI, the IRD (French Research & Development Institute), the UNC (University of New Caledonia) and the Queensland University of Australia.

The two main goals of the study are:
1.- to analyse the geographical distribution of mangrove forest in relation to local features (tidal zonation; longitudinal upriver gradient) and global parameters (latitudinal distribution; influence of catchment basin);
2.- to map and categorize all the mangrove forests, to provide details pertaining to the different vegetation strata in terms of structure and surface area and then to underline typologies of mangrove of New Caledonia.

Aerial photos used for the study were digitized and georeferenced, and the mangrove forests have been mapped by visual interpretation and using exogen GIS datas.

A fine scale habitat mapping of the mangroves of New Caledonia at 1:10 000 will be completed by the end of 2007.

The MAREANO project: integrated geological, biological and habitat mapping in the Barents Sea, Norway

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The MAREANO project (2005-2010) is a multidisciplinary seabed mapping programme conducting physical, biological and environmental mapping in the Lofoten - Southern Barents Sea area, northern Norway. The major project partners - Geological Survey of Norway (NGU), Institute of Marine Research (IMR), and Norwegian Hydrographic Service (SKSK) - cooperate closely to conduct the mapping. Maps, data and analysis arising from this project will contribute to a systematic database for Norway's coastal and offshore regions and will be made available via the internet (www.mareano.no). This information will provide the basis for ecosystem based management of the region.

Multibeam bathymetry and backscatter data were acquired by SKSK during 2005/2006 in eastern Tromsøflaket, Southern Barents Sea. This area (135-450m depth) includes numerous glacial features including iceberg ploughmarks, glacial lineations, moraines and extensive pockmark fields and hosts a variety of benthic fauna. The multibeam data have been processed to produce co-registered bathymetry and backscatter grids and these form the basis for further analysis and integration with other datasets including seismic data, seabed samples, and video surveys. Video surveys were conducted by IMR during 2006 using the CAMPOD towed video system. Seabed samples were acquired using a range of sampling gears (multicorer, grab, boxcorer, beam-trawl, and epibenthic-sled) and analysed for geological and biological information by NGU and IMR respectively.

Using multibeam data, seismic data, seabed samples, and video surveys, NGU have compiled a suite of seabed maps for eastern Tromsøflaket. These interpreted map products provide information on the seabed geology (sediment grain size distribution, sedimentary environment, genesis). Methods used to develop each of these thematic maps will be presented; including data processing, statistical analysis and terrain modelling. IMR and NGU also work in collaboration to integrate biological and geological information in order to develop benthic habitat maps, which are an important component of the MAREANO programme.

The mapping and sampling program is ongoing, and initial results will be used to optimise the efficiency of future sampling and ground-truthing surveys. We discuss how the 2006 results may assist in the development of a sampling strategy for surveys in neighbouring areas. To illustrate this we will present preliminary results from the April 2007 mapping programme in the Southern Barents Sea.

Nearshore habitat mapping: wellington South coast marine reserve

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In late 2005 NIWA completed an EM3000D multibeam survey of the Wellington South Coast in collaboration with the Department of Conservation, and School of Biological Sciences, Victoria University of Wellington. The survey mapping some 46 km2 of seafloor habitat between the Wellington harbour entrance and Cape Palliser including the area and immediate environs of the recently designated Taputeranga Marine Reserve. This study is the first multibeam mapping of a New Zealand marine reserve, and provides a suitable and easily accessible “test-bed” for further habitat mapping techniques around the New Zealand coastline. Such work will underpin the current policy aim to designate 10% of the New Zealand Excusive Economic Zone as some form of marine protected area. Previously, nearshore studies have only been based around sonar side-scan mapping bottom reflectivity.

The bathymetry grid, built from over 400 million individual beam soundings, has a 1 m2 cell-size resolution, and a vertical resolution of 15 cm. The multibeam data provide the first complete base-line map of the Taputeranga Marine Reserve. Ground-truthing of the multibeam mapping is currently underway via towed seafloor video analysis, biological sampling, and in situ diver observations. GIS analysis of the multibeam data has been used to produce various map layers to characterize seafloor morphology and associated habitats of the Wellington South coast. These layers include map products derived directly from the bathymetry grid (e.g., slope and aspect), but also more derived map layers like seafloor roughness (or rugosity), first derivative of the slope (seafloor complexity), and indices that integrate both seafloor backscatter and rugosity. Other GIS algorithms (e.g., Benthic Terrain Modeler) that are objective, seafloor classification schema have been used also. An overview of the project and examples of various map layers are presented. These maps products will be linked to assess benthic diversity and used to monitor environmental change. Habitat mapping methodologies developed for Taputeranga Marine Reserve will serve as a template for other coastal marine reserves in New Zealand.

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