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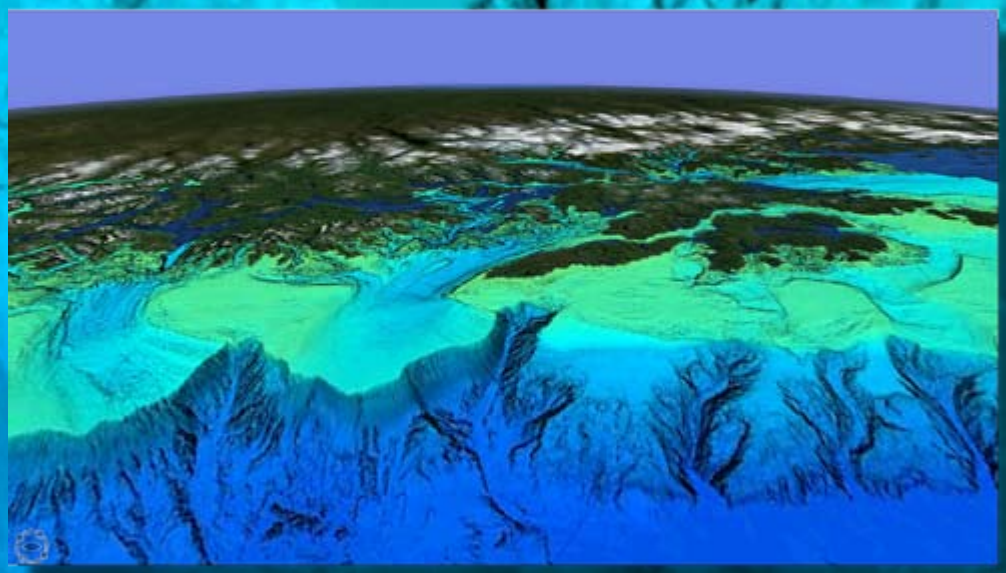


8th International Conference

GEOHAB 2009

MARINE GEOLOGICAL AND BIOLOGICAL HABITAT MAPPING

GEOLOGICAL SOCIETY OF NORWAY

Edited by Terje Thorsnes and Kim Picard

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OF NORWAY

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8th International Conference
GEOHAB – MARINE GEOLOGICAL AND BIOLOGICAL HABITAT MAPPING

Geological Survey of Norway, Trondheim,
Norway 5-7th May 2009

Edited by Terje Thorsnes and Kim Picard

Conference organizers:
Geological Survey of Norway

Preface

The Geological Survey of Norway with cooperating partners wish you all welcome to the 8th GeoHab conference in Trondheim, Norway May 2009. This conference brings together more than 100 scientists from 20 countries and 4 continents. A wide range of fields within geology, biology, acoustics, statistics and management will be addressed, providing a truly multidisciplinary and exciting forum for exchange of knowledge and ideas. As shown by the quality of the abstracts, it is obvious that the conference will give a global state-of-the-art perspective on habitat mapping. It is our intention that this GeoHab conference combines high quality science with a function as an informal meeting place for scientists providing an important part of the knowledge base for sustainable ocean management.

Themes for the 2009 conference include:

- Linking geology and biology – new developments in the use of proxies for ecosystem characterization
- Acoustic and statistical methods for substrate and biota classification and modelling
- Arctic habitats and climate change
- Broad-scale perspectives and case-study

GeoHab 2009 provides oral and poster presentations covering a wide range of topics related to habitat mapping, such as benthic–pelagic coupling, temporal variability, outreach, modelling and predictions, deep water and high seas habitats, cold water corals and sponges, vulnerable habitats and marine protected areas, the coastal zone, technologies for habitat mapping, processes, geo–bio interactions, regional mapping programmes, and ocean management policies.
The first official GeoHab conference was held in Moss Landing, California in 2002, after several preparatory meetings in Norway and Canada in 2001. Since then, GeoHab conferences have been held in Australia (Hobart), Ireland (Galway), Canada (Sidney), United Kingdom (Edinburgh), New Caledonia (Noumea) and the United States (Sitka). The conference series has grown in quality and attendance, and we are confident that this conference will represent a fruitful continuation of this trend.

Welcome to Trondheim and Norway

Terje Thorsnes,
On behalf of the programme committee

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Contents:

ABSTRACTS:

Spatial predictive distribution modelling of marine biota – kelp and eelgrass as case

Bekkby, T.[1]*, Rinde, E.[1], Erikstad, L.[2], Bakkestuen, V.[2,3], Longva, O.[4]

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Both the kelp species Laminaria hyperborea and the eelgrass Zostera marina host a high diversity of species. Managing these important habitats should be based on distribution maps and detailed knowledge on the main factors influencing the distribution. However, in countries with a long and complex coastline, as Norway, detailed mapping is practically and economically difficult. Consequently, alternative methods are required. Based on modelled and measured geophysical variables and presence/absence data, we have developed a spatial predictive probability model for kelp and eelgrass distribution. We used geophysical data (on depth, slope, terrain curvature, light exposure, wave exposure and current speed) that were quantitative and objectively defined (through GIS modelling). We analysed, using a Generalised Additive Model (GAM) and the model-selection approach Akaike Information Criterion (AIC), the influence of a the environmental factors on the distribution of the species. The result was spatial predictive models with high abilities to discriminate between sites where the species was present from those where it was absent.

Currents on the Lofoten continental margin, North Norway

Bellec, V.*, Bøe, R.*, Rise, L.*, Thorsnes, T.*

** Geological Survey of Norway (NGU), Trondheim, Norway*

The MAREANO programme was initiated in 2005 to survey and perform basic studies of the seabed's physical, biological and chemical environment in the southern Barents Sea. The information is systematically archived in a marine area database that will cover Norway's coastal and marine regions and especially the Lofoten - Southern Barents Sea area (www.mareano.no). This paper focuses on the continental slope northwest of the Lofoten Islands (Figure 1). Surface currents are dominated by the northwards flowing Norwegian Atlantic Current, along the continental slope, and the Norwegian Coastal Current on the continental shelf.

High-resolution multibeam data acquired on the Norwegian continental margin northwest of the Lofoten and Vesterålen Islands reveal many canyons and slides. The mounded Lofoten contourite drift, in water depths larger than 1000 m, and gravel waves, in about 300 m water depth show that the Norwegian Atlantic Current along the uppermost continental slope is very strong. Sediment supply and deposition in canyons are also influenced by the currents (Figure 2).

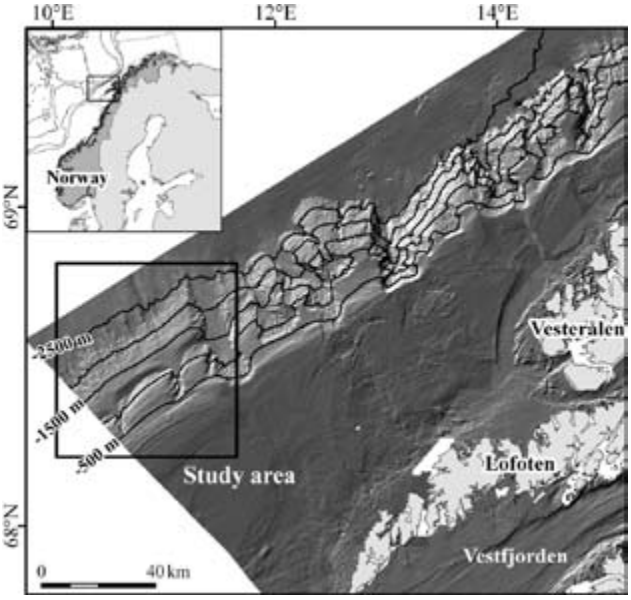

Figure 1. Location of study area.

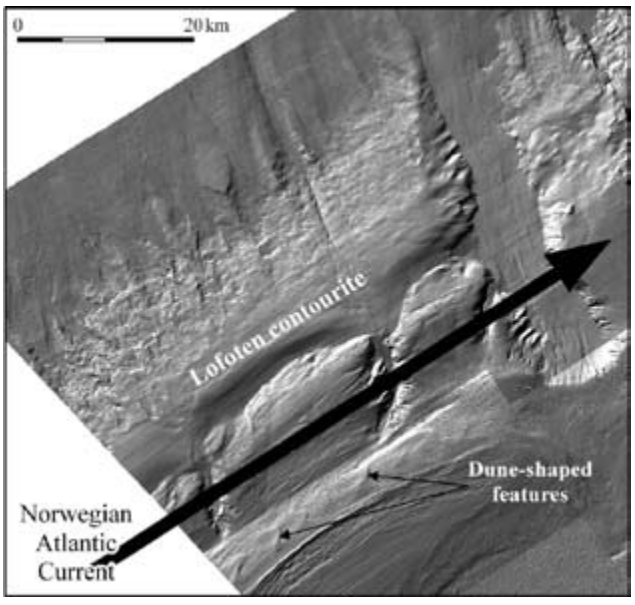

Figure 2. Shaded relief bathymetry in the study area.

Sedimentary processes on the Norwegian continental shelf and slope between the Lofoten Islands and the Andøya canyon (Norway)

Bellec, V.*, Dolan, M.*, Thorsnes, T.*, Bøe, R.*, Rise, L.*, Buhl-Mortensen, L.**, Buhl-Mortensen, P.**

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A large mapping programme (MAREANO) has been initiated in the Lofoten – Southern Barents Sea to investigate the physical, biological and environmental status of the seabed. Three institutions (IMR, NGU, Norwegian Hydrographic Service) cooperate closely with several other institutions to perform the mapping. Results are continuously published on www.mareano.no. Multibeam bathymetry and backscatter, samples and video data are acquired on the Norwegian continental shelf, slope and abyssal plain (Nordland VII, Troms II and Tromsøflaket areas) down to 3000 m water depth. The Norwegian shelf comprises shallow banks alternating with glacial troughs eroded by ice during the last glaciations. The continental slope is characterized by numerous slide scars and canyons alternating with plateau areas.

Nordland VII is characterized by sedimentary features indicative of both active and inactive processes. On the continental shelf, currents play an important role for sediment transport and deposition, but age relationships between features are not always easy to determine. The surface of the banks are extensively covered by lag deposit and crossed by lineations indicating strong currents. Some of the lineations are partly covered by sand/sand ribbons, indicating that they are relict. Sedimentation also occurs in depressions and on the deeper parts of the banks.

Glacial troughs are also influenced by bottom currents, with sandwaves, ripples and comet marks present. Relict sandwave fields occur, but ripples and other structures point towards active sand transport and sand accumulation. The sand is partly eroded from moraine and till deposits on the banks, but younger carbonate sand also occurs. Pockmarks are found in glacial troughs where fine sediments accumulate. Hard/coarse bottom in some of the pockmarks point to active leakage preventing deposition of fine-grained sediments.

The upper continental slope is characterized by till and contourites. Strong currents, especially between 500 and 700 m depth, have caused lag deposits to develop. Intensified erosion is probably caused by trawling activity, indicated by numerous trawl marks in the flatter areas. Canyons are numerous and mainly formed by sliding activity. Some of the canyons and slide scars have a cover of sediments deposited by the currents flowing along the slope. Canyon floors often show a few centimetres of coarser deposit (sandy mud) covering muddy sand or silt.

Combined use of benthic foraminifera and macrofauna to determine past and present ecological status in coastal environments

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The European Water Framework Directive (WFD) emphasises the needs to monitor and assess the ecological quality status (EcoQ) of coastal, estuarine and continental waters. The overall objective of the WFD is to achieve a "good ecological quality status" (EcoQ) for all water bodies in Europe by 2015. The implementation of the WFD has thus induced a fruitful debate amongst European marine scientists about how to define efficient, reliable bio-assessment tools. The problem is that, for most areas, traditional monitoring data do not exist from pre-impact times so there are no data with which to compare the present-day situation. As opposed to most macrofaunal groups, benthic foraminifera (protists) leave a fossil record and allow tracing of human-induced disturbance of the environment over decades or centuries. They can serve as ecosystem characterization tools in modern as well as in past marine and estuarine environments, The same ecological status information yielded by the macrofauna seems to be reflected in the benthic foraminifera. Consequently, they may provide an alternative to macrofauna for definining habitat-specific reference conditions in soft-bottom sediments of coastal and transitional waters. We assess a new method to determine in situ reference conditions for soft-bottom habitats based on paleoecological approaches using benthic foraminifera. Promising results from intertidal mudflats in the Pertuis Charentais (SW France) (VMPB PhD Thesis) and from a new project* conducted in silled fjordic systems along the Norwegian Skagerrak coast describe both macrofaunal and foraminiferal assemblages and associated environmental parameters. Canonical correspondence analyses summarize the relationships between a set of measured environmental parameters and the responses of both benthic foraminifera and macrofauna. Analogies and significant correlations between some foraminiferal and macrofaunal species and environmental data, allow environmental classification of the foraminiferal species using the ecological groups defined by the macrofauna. In order to develop foraminifera as a representative hindcasting measure for EcoQ status based on an integrated foram-macrofauna classification system, the boundary values between the EcoQ classes for the two groups of organisms are in the process of being calibrated.

*PES research project: Paleoecological reconstructions of marine soft-bottom Ecological Status and in situ reference conditions: calibrating benthic foraminifera with macrofauna and hydrographic data - 2008-2012 (more details: http://www.geo.uio.no/pes/)

Broad scale biodiversity mapping and environmental classification of the deep-sea around New Zealand

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New Zealand's exclusive economic zone (EEZ) is extensive and incorporates an extraordinary range of marine environments. With the prospect of increasing exploitation of both living and non-living seabed resources, reliable mapping of seabed habitats is needed to inform management policies. Like other maritime nations, we are faced with the problem of reconciling continuous broad-scale data from oceanographic and acoustic datasets with point-sampled biological and habitat data from the seabed. Our ultimate goal, again like others, is to develop robust methods by which broad-scale data can be interpreted to predict the distributions of habitats and biological assemblages at smaller scales. The route towards this goal, however, is complicated by the diverse datasets we have accumulated for a variety of purposes over several decades, and by the often disparate research agendas of geologists, biologists, and statisticians. Here we describe methods we are developing to: (1) make use of existing datasets to generate objective statistical classifications of seabed environments in the EEZ, (2) design and implement standardised broad-scale hierarchical seabed surveys to test the utility of these classifications for predicting the distributions of habitats and faunal assemblages, and (3) further refine the environmental classification by incorporating new data from these structured surveys. A first marine environment classification (MEC) of the entire NZ EEZ was developed in 2004 using multivariate statistical methods on primarily broad-scale physical environmental data. Subsequent refinements have been optimised for demersal fish distributions and some epibenthic invertebrates by selective weighting and transformation of variables and inclusion of additional biologically relevant variables. These classifications function as heuristic devices because they generate hypotheses about the nature of the seabed and biological assemblages in areas for which we have little or no sample data. Sampling voyages to test these classifications have been undertaken in which photographic and physical seabed samples are nested within broader scale acoustic transects, which in turn nest within strata defined by an initial multivariate classification of environmental data. If variability within nested strata is not too high, the hierarchical structure of these surveys will enable mapping of habitats and fauna at spatial scales from 1-100 m within individual seabed photographs and video transects, up to 1-100 km scales within acoustic transects and between sites. Data from these voyages will first provide a direct test of the existing MECs, but we will also explore whether their incorporation into subsequent iterations of the classification will increase predictive ability.

Application of two modelling techniques for mapping distribution of perennial red alga *Furcellaria lumbricalis*

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The exposed coast on the tide-less south-eastern Baltic Sea is generally unsuitable for large perennial, habitat forming macrophytes, such as eelgrass and bladder wrack. In this area the dominant perennial *Furcellaria lumbricalis*, serves as natural spawning ground for herrings. This alga is limited to the hard substrates and occurs between 1 to 16 m depths. However the distribution of *F. lumbricalis* is very patchy due to the effects of exposure linked to inclination of underwater bottom slope, abrasion and/or burring by mobile sediments.

Underwater surveys have been performed in the coastal waters along the mainland coast of Lithuania between 2003 and 2008. In total, database consisted of 833 diving and video transects, where the cover of *F. lumbricalis* and bottom sediment composition was estimated. Two modeling methods were applied for distribution of the red alga: Generalized Regression Analysis and Spatial Predictions (GRASP) and Natural Neighbor interpolation (NNI). Cover and occurrence of *F. lumbricalis* were used as response variables, where 5 raster layers were used as input for prediction in GRASP model: bathymetry, occurrence of substrate, distance to the Curonian lagoon mouth, and exposure measure based on distance to the depths 20 and 30 m. Interpolated species cover by NNI method was set to zero in areas covered by unsuitable substrates (sand and gravel) or below euphotic zone (< 15 m).

In the results we found that GRASP model could give reliable prediction of *F. lumbricalis* occurrence (r= 0.7, ROC= 0.9). The occurrence of substrate was one of the main explanatory variables in this model, followed by exposure and bathymetry. However, these factors could not explain the dispersion of species cover above 50%, most likely, due to sampling resolution of predictive factors. On the other hand predicted *F. lumbricalis* cover by NNI model was consistent to observed values (r= 0.9), although without evident scientific justification. Nevertheless, combination of both models may serve as reliable the species modeling tool and applied for different coastal management and conservation issues, especially, where low information on environmental data exist.

Multiple scale nature type classification – a case study from MAREANO, Norway

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Nature types are characterised by environmental conditions and taxonomic composition. The MAREANO (Marine AREAdatabase for NOrwegian coast and sea areas) mapping programme includes comprehensive, integrated biological and geological sampling programme in addition to acquisition of multibeam bathymetry and backscatter data. Experience from a "pilot" mapping area off northern Norway show that the distribution of biological communities is strongly related to water depth, bottom types and terrain. However, it is not possible to gather biological data with full areal coverage from large study areas. By using depth, backscatter, and several terrain indicies from multibeam echosounder (MBES) data as environmental variables in multivariate analyses (detrended correspondence analysis) we identified predictors with full-areal coverage that successfully were used to predict naturetypes in a neighbouring area. It is clear the importance of different environmental variables for the distribution of biological communities may vary between regions and landscapes. Therefore, we employed a quick method to identify groups of locations with similar fauna based on observations made during video recording in the field. The dataset of field records from 194 video transect locations recorded during two cruises in 2008 revealed two highly different groups of locations (shelf and deep slope) that should be analysed separately to identify nature types at a more detailed level during post cruise analyses. The two major groups of locations could be further dived into groups based on sediment types. By performing a "stratified" analysis with different levels of details we are able to identify clear patterns of nature type distribution efficiently. Important attributes of nature types (such as species diversity, sensitive and rare species and details about the sedimen structure) are described based on results from bottom samples with grab, boxcorer, beamtrawl and hyperbenthic sledge.

Subtidal seafloor classification in the Hörnum Tidal Basin (Sylt, Germany)

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In September 2008 a central part of the Hörnum Tidal Basin (North Frisian Wadden Sea) was mapped with the Simrad EM 3002 300kHz multibeam echosounder mounted on R/V Ludwig Prandtl. Objectives of the survey were to derive a sedimentological map of the area, and to define and distinguish between seafloor habitats present in the subtidal wadden sea. Ground truthing is available from several video surveys and box core samples. Additionally data from an Innomar SES-2000 parametric echosounder allow to study shallow sub-seafloor structures. The surveyed area consists of deeper parts with water depths between 20m and 30m, showing only few sediment structures, seafloor at intermediate depths of 10m to 20m with large sand waves and ridges, and smooth shallow areas of less than 10m water depth along the tidal flats. The backscatter strength of the multibeam system, used as a proxy for the sediment properties, does not correlate with the water depth. To find out the relationship between seafloor substrate and backscatter amplitude, a grain size analysis of the sediment samples is done, and the seafloor along the video tracks is categorized into several seafloor types. For each type of seafloor substrate the statistical properties and spatial texture of the amplitude response is investigated (e.g. mean, 80% quantile, standard deviation, contrast and pace [Pace and Gao, 1988]). In addition the gray-level co-occurrence matrix of the backscatter pattern is used to discriminate between the different seafloor types. For classification of the seafloor imagery a boxcar filter is then applied. The statistics of the filter matrix is compared with the defined classes and assigned to the class with the minimum discprepancy. On a larger scale several morphological parameters are derived from the high-resolution bathymetry. These are wavelengths and orientation of structures, and roughness. The combination of the classification based on amplitude response and the morphological characterization of the seafloor allows a further subdivision of the seafloor. The results of this analysis are compared to habitat information from the surrounding eulitoral zone of the wadden sea, and to results from an earlier project, which studied the seabed shear stresses induced by waves and currents.

The geology of Beaufort's Dyke: uniquely common

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Beaufort's Dyke is a submarine valley located in the North Channel of the Irish Sea. Although previous studies have investigated the affects of munitions dumping within the Dyke, this is the first comprehensive interdisciplinary investigation of the area. In 2007, the Agri-Food and Biosciences institute of Northern Ireland (AFBINI) carried out the first multibeam echosounder (MBES) survey of Beaufort's Dyke, ground-truthed with grab samples and drop down video data. In 2008, the British Geological Survey (BGS) carried out a sparker seismic survey of the Dyke to interrogate subsurface characteristics and seabed features highlighted by the MBES data. Hydrographic data has also been obtained from the British Oceanographic Data Centre (BODC) to investigate the contemporary tidal current regime. Combining these data sets will enable the first holistic study of the ecology of Beaufort's Dyke.

Similar geological features are reported from both terrestrial and submarine environments throughout formerly glaciated regions with multiple theories for the dominant processes that form glacially associated valleys. Whilst Beaufort's Dyke seems to have been formed as a result of peri- and subglacial processes during the Weichselian (Devensian), it differs from most European tunnel valleys in that it is isolated and open. The enhanced depth of the Dyke indicates that environmental conditions around this differ(ed) compared to those areas where tunnel valleys are buried, potentially attributed to the constraints enforced on the Dyke by the land masses of Scotland and Northern Ireland. This may also explain the lack of an anastomosing network of tunnel valleys that is usually characteristic in formerly glaciated areas. The nature of Beaufort's Dyke as a 'uniquely common' feature within the continental shelf provides an ideal opportunity to interrogate theories of tunnel valley evolution and determine the habitats provided by the novel conditions of the Dyke within the continental shelf.

Ecological effects of scour processes on the Pisces Reef system, Irish Sea

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The Irish Sea, like many marine areas, is threatened by anthropogenic activities. In particular the Pisces Reef system, a series of smothered rocky reefs are subject to fishing pressures as a result of their position within a Nephrops norvegicus fishery. The reefs cause modification of the environment by increasing exchange of material and energy with the surrounding area resulting in localised scouring. Little research has been carried out on scour operating on large-scale natural systems, such as Pisces Reef, and the resulting effects on the benthic community. To facilitate more effective management of the benthic habitats of the Reef system this study integrates acoustic, seismic, grab sampling and video ground-truthing methods for benthic habitat discrimination. Utilising a multibeam echosounder to provide bathymetric and backscatter data, spatial and acoustic facies maps were produced using ArcGIS. Seismic data provide information on the subsurface geology and enable estimates of the palaeo-scour environment. Biological data was obtained using grab samples and video ground-truthing to allow habitat delineation of these maps. Orientation of the scour hollows also suggest that seabed features could be used to model dominant tidal regimes such as the Irish Sea Gyre.

Integration of the ground-truthing data with the acoustic data sets allowed exploration of geology-benthos relationships and diversity gradients on the reefs. For example, linear regression revealed backscatter mean values correlate with species diversity (r2= 0.60) and multivariate analysis of grab sample fauna illustrated community similarity within sample regions and community dissimilarity between sample regions. Also, video analysis indicated that sediment type influences megafauna burrowing density. Seismic data revealed palaeoscour signatures indicating that the Pisces Reef system is gradually being buried and that the dominant tidal currents have been in operation over a large temporal scale. The orientation of Reef scour signatures varies, this was supported by vector patterns (derived from the trajectories of 55 satellite tracked Argos drifters) and modelling of the cold water gyre. Combining the above it was possible to assign a new biotope within the JNCC biotope classification. Also, regional current regimes may be inferred from patterns revealed by acoustic mapping systems before initiating hydrographic surveys. This holistic approach could provide more accurate habitat maps enabling subsequent testing of existing habitat classification indices and more effective environmental management.

Arctic benthic biodiversity, habitats and implications in a changing climate

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The biodiversity at the sea floor is a widely used tool for inferring environmental conditions, based on the environmental preferences of the individual organisms and predictable community responses to various environmental drivers. Because benthic faunal communities respond over a period of time, they act as integrators of conditions, as opposed to 'snapshot' measurements of variable parameters. Changing climate conditions may influence the current drivers of benthic biodiversity, and a series of changes in community structure in Arctic areas may be expected. Benthic fauna are a primary food source for bottom-feeding fish, marine mammals and seabirds, and climate-induced changes in the food web may alter the role of the benthos in an ecosystem perspective. With the current need to study ecosystem implications of climate change, long-term data has become increasingly important. Harmonisation of approaches is required, and means of detecting broad-scale patterns using disparate data sets need to be devised. The utility of benthic studies across a variety of spatial and temporal scales, and needs for closer integration with geological and other disciplines is discussed.

The Geo-Habitats of the central English Channel: a generation on from Holme and Cabioch, how do their interpretations match-up to modern mapping techniques?

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In the latter half of the 20th century, Norman Holme and Louis Cabioch reported separate programmes of work describing the benthic fauna and habitats of the 'English' Channel. Holme was based in southern England, while Cabioch was based in northern France. Naturally, each tended to focus their sampling effort in their own national waters, with only a few stations being sampled across the Anglo-French 'divide'. Both researchers developed their own interpretation of the channel ecosystem, describing similar latitudinal gradients in habitats and fauna that reflect the notable environmental gradients of the area, and both produced a 'map' of sorts to show the distribution of the different benthic communities they had identified. These interpretations were based predominantly on samples collected by small trawl or dredge and only in the later years made use of the (then) emerging technologies of underwater cameras and acoustic systems. A generation on, these technologies have reached a level of maturity and reliability that enable them to be used routinely on seabed surveys, and there has recently been another tranche of survey work in the channel, aimed at describing and mapping seabed habitats. This paper will compare and contrast the 20th and 21st century work. The modern surveys are consistent with the interpretations made by Holme and Cabioch, but provide significantly greater resolution to the habitat maps through greater understanding of the linkage between the geology and biology of the seabed.

LiDAR-assessed seamless littoral ecosystems in 2D and 3D.

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A lack of spatially, structurally and thematically accurate habitats data complicates conservation and management planning, as well as ecological research, within amphibious coastal environments, characterized by technology-veiled structural patterns. The Scanning Hydrographic Operational Airborne LiDAR Survey (SHOALS) has considerable potential to provide such data, by means of its ability to generate high resolution measurements of emerged and immersed elevations, synoptically, and to create thematic maps. Return signals, i.e., waveforms, contain signatures and structural information from salt-marsh and benthic covers. This paper focuses on the capability of the SHOALS to assess the structural complexity of emerged and immersed coastal habitats (Gulf of Saint Lawrence, Canada), and define the contribution of SHOALS data, both elevation and intensity, to accurately and seamlessly map these habitats from supratidal environments to nearshore's. The study area was selected based on the spectrum of littoral cover types, encompassing kelp fields, eelgrass meadow, beach, salt-marsh, arable and urban coastal environments. Firstly, the capability of the LiDAR-derived green waveform, through an ad hoc decision-tree, have satisfactorily assessed the structural complexity of littoral habitats, emerged and immersed ($r=0.75$, $p<0.01$). Secondly, synergistic combination between NDLVI (LiDAR-derived red and near-infrared data) and topographic / bathymetric surfaces (LiDAR-derived near-infrared and green, respectively) allowed to accurately map 19 emerged and immersed littoral habitats (overall accuracy and kappa coefficient were 90.09% and 0.8883, respectively) (Fig.1). Accordingly, a single survey multispectral and ubiquitous LiDAR holds significant potential for monitoring the structural complexity, the spatial patterns and the temporal evolution of the seamless coastal habitats with fine-grain resolution and reliability.

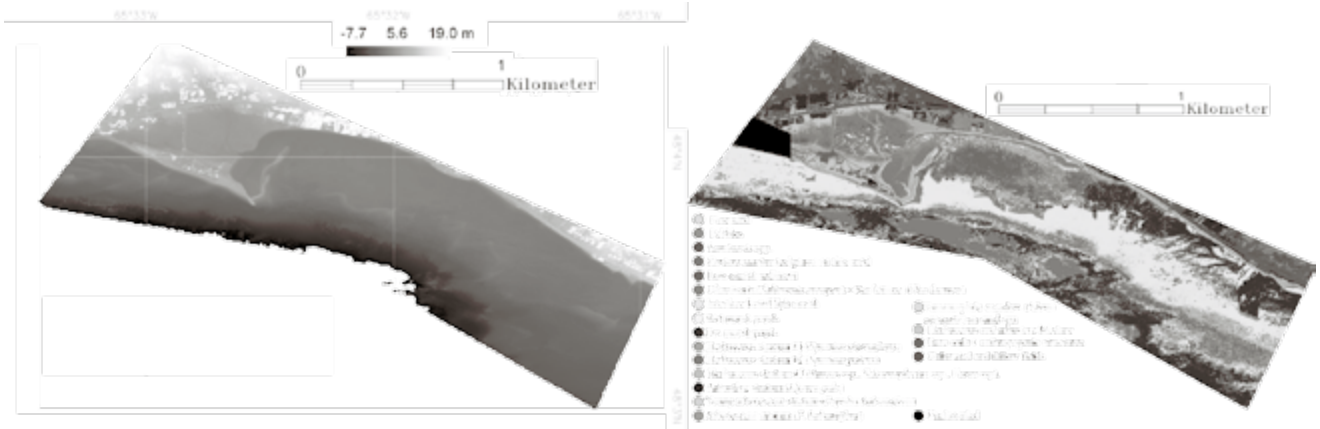

Figure 1: LiDAR-derived topographic/bathymetric and littoral habitat classification maps of the study area at Bonaventure, Gulf of St Lawrence, Qc, Canada (2 m resolution).

Developing a predictive tool linking geomorphological and biological associations: an example from the East Anglain coast, UK

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In 2008, the British Geological Survey (BGS) began work on a collaborative project with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Envision, Marine Ecological Surveys Ltd (MES) and Wessex Archaeology, to develop a broad understanding of the geomorphology, archaeology and biological communities present off the East Anglian coast of the UK. This area is of particular interest to the marine aggregate industry which facilitated the need to develop a base map of the region before further aggregate licensing rounds. The base maps will provide a starting point on which a comprehensive monitoring programme of the potential anthropogenic effects will be based.

An important part of the project was the development of a GIS based system that intrinsically links information on sea-bed geomorphology, texture and sediments; hydrographic conditions; species / faunal diversity / numbers; sediment mobility; along with other factors such as slope; into a predictive tool.

The pilot system presented here takes a hierarchical approach, with each layer within the scheme representing a GIS layer. This enables datasets of different resolutions and scales to be overlain for the most detailed interpretation possible whilst remaining flexible enough to incorporate new descriptive dictionaries.

A grid with a size representing the maximum resolution for mapping (jn this case 250m) is used to link information at a finer scale (e.g., grab samples) to the broader scale features in which they lay. The model then "analyses" the data looking for patterns of biological assemblages that appear to be associated with specific geomophological, sedimentalogical and hydrodynamic regimes. This technique can then be extended into areas where there is no biological ground-truthing available through inferential modelling.

It is envisaged that this tool will help inform ecosystem characterisation in areas where time and financial constraints on surveys mean that a corridor approach to surveying is taken, or where the geological and geomorphological component is known but biological ground-truthing has not been undertaken.

Improving acoustic seabed classification through the use of multiple frequencies

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Acoustic energy reflected by the seabed can be used to detect differences in surficial substrate. In general, larger particles reflect more acoustic energy. The acoustic energy is dependent on a number of factors, including frequency and grazing angle. Existing approaches to acoustic seabed classification (ASC) of surficial substrate typically use one acoustic frequency. Combining more than one acoustic frequency should improve the accuracy of substrate classifications when there is a wide range of sediment sizes within the surveyed area. Hence, this approach is expected to add information, as a lower acoustic frequency penetrates deeper within the seabed and a higher frequency detects smaller spatial feature on the surface of the seabed.

The goal of this research was to determine the improvement in ASC of surficial substrate using 120 kHz and 38 kHz frequencies from a single beam echo sounder. Backscatter data were compared to interpreted surficial geological structure on the Scotian Shelf, Canada. The study area comprised preferred and non-preferred fish habitat areas previously identified. The acoustic data were processed for the near nadir (coherent) backscatter component which emphasizes the contribution of particle size as opposed to surface roughness. As an initial comparison, backscatter intensities were classified and compared between frequencies for the original point source data collected along 5 km survey lines within each area. There were clear spatial patterns in acoustic energy that were similar for each frequency over large distances (5000 m), but differed over smaller distances within each study area. Over large spatial distances (>1000 – 3000m) there are two obvious classes in the non-preferred study area corresponding to sand and gravel from the interpreted surficial geology. The preferred study area revealed three classes at large spatial distances (~250-800m). It was evident, however, that there were no major differences between frequencies when examining backscatter over large distances. However, differences between frequencies are observable when examining backscatter over smaller spatial distances. Continuous surfaces of backscatter strength were interpolated and classified for each frequency and combined to evaluate frequency dependency. The classification results were compared to the interpreted surficial geological structure to evaluate the improvement in the detection of differences based on two frequencies.

Production of benthic communities – can terrain parameters explain differences?

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In order to withstand the steadily increasing demand for services and goods, a sustainable management of aquatic resources should be based upon an ecosystem approach. Benthic invertebrates form the major food source for many commercially exploited fish species. Thus the production (i.e. species energy that is turned into biomass) of benthic communities is of direct relevance for the management of commercial fish stocks and other ecosystem functions the benthos provide. However, before managing benthic ecosystems, a sound knowledge on the species composition, distribution and functioning of communities is required.

The MAREANO project (Marine AREA database for NOrwegian coasts and sea areas) was initiated to address this lack of knowledge about seabed and environment as the base for a sustainable management. The project is a collaboration between the Institute for Marine Research (IMR), Geological Survey of Norway (NGU) and the Norwegian Hydrographic Service. MAREANO aims at linking the hydrographical, chemical and geological environment to the benthic ecosystem in order to map the environment and fauna along the Norwegian coast.

The study area Tromsøflaket in the Barents Sea (approx. 16 km2, 150 – 200 m depth) serves as a case-study area to develop suitable habitat mapping methods. It was intensively studied by multi-beam echo sounder for terrain analysis and by several biological sampling gears (video, beam trawl, grabs and epibenthic sled) in order to analyse benthic habitat distribution. Based on the combined parameters, six different benthic habitats were characterised for the Tromsøflaket. First results on benthic production showed significant differences between habitats. Relations between benthic production and environmental parameters were analysed to explain these differences. The results deliver important information to ground truth the prediction of bottom fauna production in the wider MAREANO area. Consecutively, this will enable us to designate highly productive and/or sensitive areas which serve as essential feeding habitats or provide other important ecosystem functions for the Norwegian coast.

Investigating the use of geological and biological maps in designing a potential network of Marine Protected Areas for the UK's deep-sea

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Increased demand on offshore resources, in conjunction with the need for countries to meet their obligatory international and national commitments to conserve biological diversity through Marine Protected Areas (MPAs), has led to a marked interest in both Marine Spatial Planning and MPAs as a conservation tool.

A high resolution data set (acoustic and biological) was collected from three canyons on the European continental margin (SW Approaches) during a MESH (Mapping European Seabed Habitats) survey in June 2007. The acoustic data were interpreted to produce a complete substrate map and a number of derived layers, including slope and rugosity. Biological data were overlain on the spatially referenced geological and terrain attribute layers. The relationship between biological communities and the interpreted geological layers were used to make assumptions about the distribution of fauna throughout the canyon system (work presented at GeoHab 2008).

This research is a continuation of work presented last year. The mathematical simulated annealing algorithm MarXan has combined these maps and other data layers to investigate possible MPA scenarios for the SW Approaches, with the principal objective of achieving representation of biological diversity. We present the results of the 'best-fit' scenarios from MarXan.

This approach will be extended to the rest of the UK's deep-sea area and will provide a strong scientific basis to support the development of a network of MPAs in the UK's deep-sea area.

Unravelling the 4D architecture of cold-water carbonate mounds

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Cold-water corals are widespread along the Atlantic European continental margin. At some locations, these cold-water corals constructed carbonate mounds, for example in the Gulf of Cadiz. Previous studies in the Rockall Trough and the Porcupine Seabight off Ireland already revealed more information about these structures. Nevertheless, few details are known regarding the genesis and architectural framework of these mounds.

During the R/V Belgica 07/13 CADIPOR III cruise, thick cold-water coral rubble plates were discovered on top of the carbonate mounds in the El Arraiche mud volcano field in the Gulf of Cadiz. Based on these data, combined with data, previously obtained in the Porcupine Seabight, an important question was raised: can these coral plates be the building stone of a carbonate mound? To unravel this hypothesis the 3D characterization of these coral plates will be investigated.

ROV 'Genesis' of Ghent University was used to investigate the distribution, spatial characteristics and biodiversity of these rubble plates. Facies interpretation maps were made and compared with side-scan sonar data. Next, four on-mound gravity cores were obtained during the R/V Marion Dufresne 169 cruise for sedimentological and palaeoceanographic analyses in order to unveil the history of the uppermost meters of these cold-water coral build-ups. In parallel, four on-mound cores were acquired on approximately the same location for microbiological and biogeochemical analyses. By comparing and correlating both results, more information will be revealed about the sedimentological and (micro)biological processes acting in the dead coral rubble fields. In conjunction with dating and palaeoenvironmental analyses of the corals and the sediment matrix, this will yield valuable information about the build-up of the cold-water coral mounds in the Gulf of Cadiz and the palaeoenvironmental characteristics at the time the corals were living.

Finally, these results will be compared with other regions, for example with the Bay of Biscay where no carbonate mounds were reported. During the R/V Belgica 08/13 BiSCOSYSTEMS cruise, the cold-water corals reported earlier by Le Danois (1948) in the Penmarc'h and Guilvinec canyons were rediscovered. Based on multibeam data and ROV video images two different areas were distinguished. First, mini mounds, covered by dead cold-water coral rubble were found in a shallow area in a water depth of 290 m. Secondly, living and dead cold water corals were observed in water depths of 650-750 m. At some locations they form coral fields with a size of about 25-50 m with mostly dead corals and a few living ones. Why did these cold-water coral reefs not develop into carbonate mounds and what is the missing link between reef formation and mound development?

Developing a EUNIS seabed habitat map for the Dogger Bank

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The Dogger Bank is a shoal located in the southern North Sea. It was formed by glacial processes before being submerged through postglacial sea-level rise some 7500 yrs before present. The Dogger Bank has recently been recommended to UK Government as a draft Special Area of Conservation (dSAC) by the JNCC (http://www.jncc.gov.uk) for its Annex I sandbank habitat ('sandbanks which are slightly covered by sea water all the time') under the European Commission's Habitats Directive. Part of the process of recommending the Dogger Bank as a dSAC involved further investigations to identify a scientifically robust boundary for the dSAC, along with gaining a better understanding of the marine environment and habitats incorporated within it. Ultimately this resulted in the creation of a EUNIS seabed habitat map for the Dogger Bank.

The production of the Dogger Bank EUNIS habitat map involved a number of processes, analysing data from a recent survey commissioned by the JNCC as well as modelled and remotely sensed data. The Dogger Bank is exclusively composed of sublittoral sediment. The first step involved dividing this up into sublittoral coarse sediment and sublittoral sand, based on multibeam bathymetry, acoustic backscatter and particle-size data from surface sediments. Sandy substrates were subsequently split into fine sand and muddy sand with a cut-off at 5% mud-content. Photic and aphotic seabed was derived from analysis of MODIS satellite data. Together with data of the maximum wave base modelled for UKSeaMap (http://www.jncc.gov.uk/default.aspx?page=2117), this served as an input for the delineation of biological zones (or étages), namely infralittoral (photic and above wave base), circalittoral (aphotic and above wave base) and deep circalittoral (aphotic and below wave base). Finally, all relevant data layers were combined to yield a EUNIS (level 4) habitat map for the Dogger Bank. Comparison with the predictive EUNIS habitat map developed for the MESH (Mapping European Seabed Habitats, http://www.searchmesh.net/) study area revealed that coarse sediment habitats cover less area of seabed than previously thought. Such habitats are restricted to small-scale patches of 10s to 100s of metres in width and 100s to 1000s of metres in length and are also known as sorted bedforms. The dominant EUNIS habitats on Dogger Bank are infralittoral fine sand and circalittoral fine sand.

This work results from a survey undertaken by Cefas, BGS and Envision Mapping on behalf of the JNCC, as part of its Offshore Natura Seabed Survey Programme.

Drafting a habitat map based on available standard data

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Habitat maps have become a fundamental tool for marine spatial planning, the selection and delimitation of marine protected areas and in environmental impact assessments. Tools to carry out habitat mapping at high resolution and full coverage of the seabed are readily available, yet surveying large swathes of seabed is costly in terms of time and money. Available resources should therefore be used in the most effective way in order to maximise results under the given constraints. Here we present a case study from the western Baltic Sea, where a fixed link bridging the 20 km wide Fehmarnbelt, a narrow strait between Denmark and Germany, is planned. In order to provide baseline information for the respective environmental impact assessment, we have drafted a habitat map that is entirely based on available and accessible standard data like single-beam bathymetry, particle-size data of seabed surface sediments, Secchi depths and wind data. The result is a physical habitat map detailing the substrate type, seabed light penetration (photic or aphotic) and exposure towards prevailing winds and waves. The utility and limitations of such a product will be discussed. The draft habitat map will facilitate the selection of sampling stations for baseline investigations and monitoring as well as provide crucial information for the design of acoustic surveys to be carried out later in 2009.

Developing seabed nature-type maps offshore Norway: initial results from the MAREANO programme

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Maps showing the distribution of seabed nature types, or habitats, are an important component of regional seabed mapping, such as in Norway's MAREANO programme – www.mareano.no . Such maps are particularly important where economic interests in the offshore area require information as a basis for sustainable development of resources.

We present a case study from the eastern part of Tromsøflaket bank, and adjacent troughs in the southern Barents Sea, northern Norway. Tromsøflaket is an area of interest for both fisheries and hydrocarbon development. We show how physical data (multibeam data and derived terrain analysis) and biological data (species observations from video data) have been analysed and combined, with the help of multivariate statistics and GIS, to produce a preliminary nature-type map for this area. This map shows the distribution of 6 distinct nature types which vary in their physical characteristics and in their associated biological communities.

This case study represents an important first step in nature-type mapping in the Norwegian offshore area and contributes to the national effort to define both marine and terrestrial nature types and develop methods for their mapping and prediction. Seabed nature-type mapping remains a core component of the ongoing MAREANO programme and similar techniques will be applied to map benthic habitats across the rest of the MAREANO area as work continues.

Climate change impacts on coastal marine systems across the Canadian Artic

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Climate change has dramatic impacts on Arctic coastal environments, yet the nature and severity of those impacts differ radically among regions, and between specific locations. Interactions between climate change, surficial geology, isostatic sea level trends, and human activities can yield dramatically different outcomes for coastal marine systems across the Canadian Arctic. Increasing air and ground temperatures and decreasing sea-ice cover are common though variable factors across the Arctic. Here we present coastal terrestrial and marine survey results from five sites along an east-west transect across the Canadian Arctic. Terrestrial surveys using GPS-supported coastal profiles and hazard mapping focused on coastal erosion, permafrost degradation, and natural hazards. Marine surveys using benthic grab sampling, drop video transects, and bathymetric profiles delineated shallow marine habitats and identified habitat types sensitive to increased sedimentation or other impacts related to climate-mediated changes in coastal processes. Western Arctic sites with ice-rich surficial deposits, unlithified bedrock, and isostatic submergence suffer rapid coastal erosion, driven by wave action, thermal erosion, thaw consolidation, and surface runoff following summer rains. Associated nearshore mobile sand sheets have low biodiverstiy. Frequent ice scour of the seabed may play a role. An emergent Central Arctic site on coarse ice-contact Quaternary sediments exhibited no erosion. Muddy nearshore habitats there contained enough coarse gravel to support diverse epibenthic biotic communities, particularly of macroalgae, as well as diverse infauna. Flora and fauna at the western and central sites exhibited depth zonation; surprisingly, the influence of depth on species composition was greater than that of sediment type. Some slightly subsiding Eastern Arctic fjords exhibit local coastal erosion, and landslide risk associated with active-layer deepening and gelifluction on steep slopes, potentially causing impacts on nearshore benthic biodiversity. Labrador fjords, without extensive soft Quaternary deposits surrounding the fjords and with permafrost discontinuous or absent, display little evidence of sediment mediated climate change impacts on benthic communities, although some have other anthropogenic impacts from defense installations or fisheries. Floral and faunal zonation in Labrador fjords was most strongly determined by sediment type, which in turn was mostly a result of Quaternary glacial features. An extremely shallow photic zone in some Labrador fjords caused by high tannin levels may limit the influence of depth zonation. Predictive models of climate change impacts on coastal marine geological and biological systems require data on surficial geology, permafrost, and regional relative sea level history in addition to climatic data.

Mapping of submerged areas in the CARG Project

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Within the national geological mapping programme (geological maps at 1:50.000 scale including both emerged and submerged areas), rules for marine areas have been tuned to represent both the basic geological knowledge and the applied aspects of the seafloor and sub-bottom features. At present, approximately 20% of the total coastal maps at 1:50.000 scale, extending generally till the edge of the continental shelf, have been surveyed.

The cartography is focused both on the postglacial stratigraphy and on present-day distribution of sediments whereas depositional systems are obtained by means of both geophysical methods, remote operated video and seafloor samplings.

Main aspects of the mapping rules related to marine areas:

- Uniform criteria for geological surveying and cartographic restitution
- To identify seafloor conditions and the relationship between the sea bed and its underlying geology
- Usability for applied purposes and geothematical maps.

Cartography of outcropping units is focused on:

- stratigraphy: i.e. postglacial depositional sequence;
- interpretation of sedimentary processes within an evolutive and environmental frame;
- morphology and sedimentology of the seafloor: i.e. present-day distribution of sediments, main biocenoses (such as coralligenous buildups and the Posidonian meadows) and depositional systems.

The official mapping of the Italian continental shelf is also being carried out cooperating with several institutions such as University, CNR Institutes and public organizations (Hydrographic Navy Institute). A single method of representation is applied and all maps are georeferred.

A national geodatabase at 1:25.000 scale stores all the information obtained during surveying (morphology, seismic analysis, sidescan sonar interpretation, bio and thanato-coenosis.). The geodatabase structure is under continuous development and contents are updated regularly.

The Geological Survey also exchanges information and compares standards concerning submerged areas with local administrations, harmonizing data representation and database compilation and providing guidelines also for more detailed maps (1:10.000 scale) produced regionally. The detailed mapping, aimed at the management of coastal areas, is carried out by scuba diving as well.

The integration of this georeferred information and consequently a new nationwide classification for benthic habitats will be the main target of a new national project coordinated by ISPRA. The aim is to improve the understanding of how different marine biophysical elements can help in indentifying analysis methods and relating geological and biological data.

Automatic Construction of Acoustic Themes for benthic habitat mapping at Stanton Banks, UK

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In recent years, many attempts have been made to develop automatic methods for segmentation of hydroacoustic remote sensing data acquired by multibeam echosounders (MBES) in order to generate quantitative estimates of the spatial distribution of seafloor relief, bottom type and composition. The majority of the segmentation methods presented so far have been based on image processing techniques, which assume implicitly the existence of an image. This limits their ability to unambiguously discriminate seafloor properties, as the primary observation of an MBES is not backscatter imagery or mosaics, but rather backscatter angular response. Mosaics are only projections of the original observations, with resulting loss of information. The method we are developing is fully automatic and attempts to segment the acoustic remote sensing data simultaneously in the image-textural space and in the angular-response space. The output of this automatic procedure is a thematic map, where the individual themes have boundaries defined at the mosaic image resolution, but still have sufficient angular coverage to allow for seafloor characterization. Angular Range Analysis (ARA) inversion is then applied to the average angular response of individual themes, generating estimates of the acoustic impedance, acoustic roughness and mean grain size of the seafloor within the theme. The technique described above is applied to a Simrad EM1002 95kHz MBES dataset acquired from a study area covering an offshore reef at Stanton Banks, UK. The results are compared to still-images, grab samples and previous habitat maps existent in the area, to asses the ability of the acoustic theme segmentation to discriminate benthic habitats.

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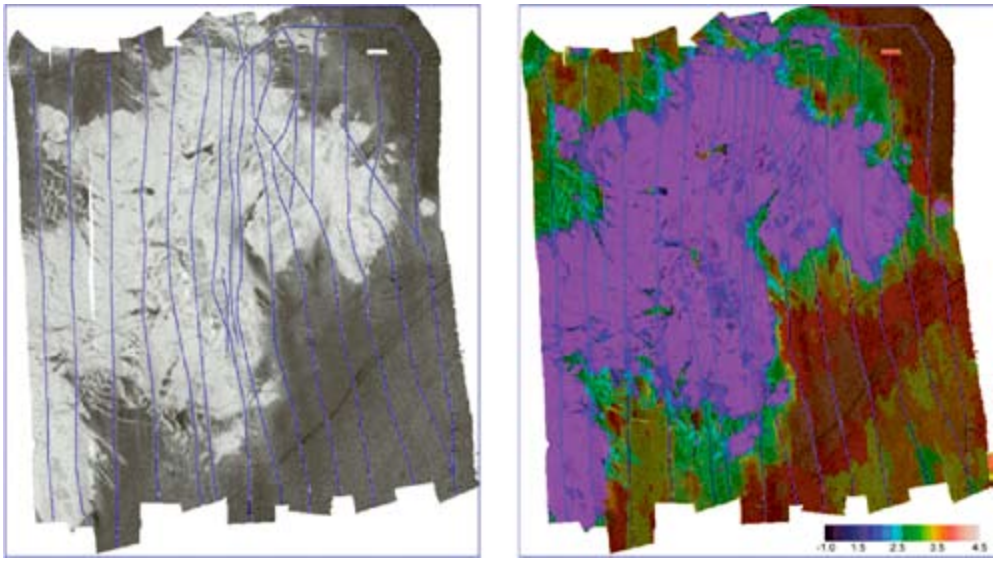

(a) (b)

Fig. 1. (a) Adjusted acoustic backscatter mosaic (0.5m resolution). (b) Automatic segmentation showing the distribution of grain size (φ units).

Optical and acoustic imagery in the Northeast Bentho-Pelagic Observatory (NEBO) to support fisheries and ecosystem management

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The Northeast Bentho-pelagic Observatory (NEBO) is designed to produce unique data products for fisheries and marine protected area managers and to foster development of ecosystem approaches to management (EAM). We are observing and quantifying key taxa, benthic community structure, species diversity, seafloor habitat characteristics, and coincident water column properties with repeated measurements in multiple, sentinel sites on time scales of months to years. At sentinel sites along the U.S. Northeastern Continental Shelf that have both high fisheries and conservation value, we are quantifying how communities respond to system change (climate events, fishing activity, invasive species, position of oceanographic features [fronts], etc). This requires fusion of disparate, synoptically acquired data sets, including high-resolution acoustic bathymetry and backscatter (on scales of meters to kilometers), stereo optical imagery (on scales of millimeters to meters), water column plankton distributions (microns to millimeters), and the development of image bioinformatic tools for classifying targets and substrates. Integrated data products are being developed using advanced visualization tools so key fishery target species and non-target community responses to regulatory practices can be observed and quantified at multiple, relevant space and time scales, in relation to variations in seafloor habitat and boundary layer conditions. Data products will be incorporated into predictive community dynamics models for use in fisheries and sanctuary management. Data products will be of direct utility to fishery and conservation scientists, fishery and sanctuary managers, and environmental policy makers and evaluated for their impact on management practices through socio-economic modeling (see http://nebo.whoi.edu and http://habcam.whoi.edu).

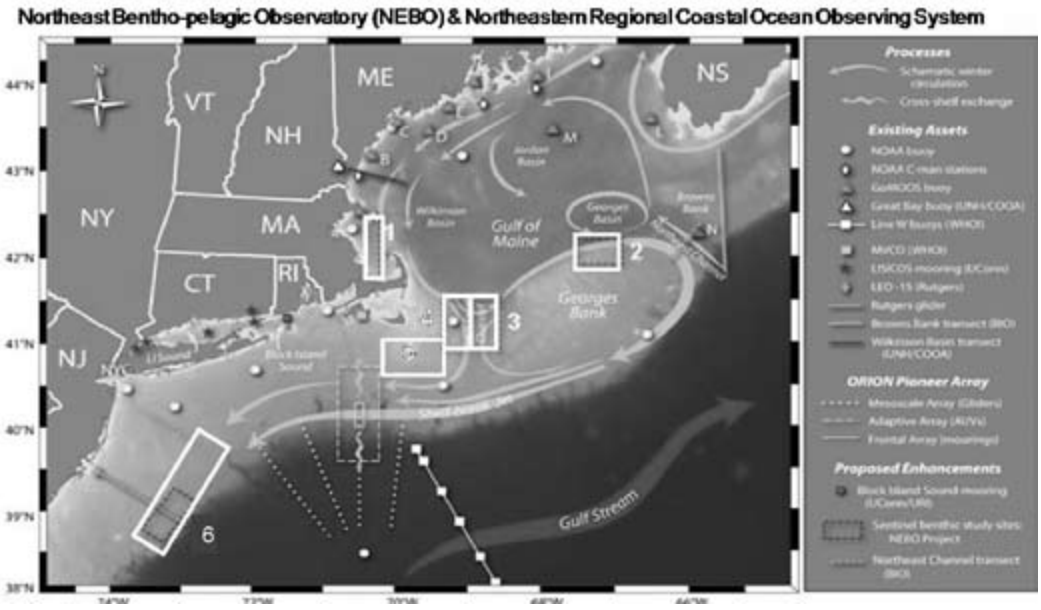

Figure 1. Six sentinel sites along U.S. Northeastern Continental Shelf. 1) Stellwagen Bank National Marine Sanctuary, 2) Northeast Peak of Georges bank, 3&4) eastern and western Great South Channel, 5) Nantucket Shoals, 6) Mid Atlantic Bight.

Predicting suitable habitat for the European lobster *(Homarus gammarus)*, on the Basque continental shelf (Bay of Biscay), using Ecological-Niche Factor Analysis

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Predicting species distribution and habitat suitability modelling, across broad spatial scales, is now a major challenge in marine ecology. The resulting knowledge is of considerable use in supporting the implementation of environmental legislation, integrated coastal zone management and ecosystem-based fisheries management. This contribution considers the identification of seafloor morphological characteristics, together with wave energy conditions, that determine the presence of European lobster *(Homarus gammarus)*; it predicts suitable habitats over the Basque continental shelf (Bay of Biscay), in summer. The results obtained, by applying Ecological-Niche Factor Analysis (ENFA), indicate that lobster habitat differs considerably from the mean environmental condition over the study area; likewise, that they are and that it is restrictive in terms of the range of conditions in which they dwell. The best of the environmental predictors found to be: distance to the rock substrate; Benthic Position Index; wave flux over the seafloor; and the underlying bathymetry. A Habitat Suitability map was produced, with a high model quality (Boyce Index: 0.98 ± 0.06). The most suitable habitat for European lobster are locations at the boundary between sedimentary- and: rocky-bottoms, coincident with seafloor depressions with a steep slope; with medium to high wave energy conditions; and located within a range of water depths of 35 – 40 m. This approach demonstrates the applicability of the method in case studies where only presence data are available, together with the inclusion of environmental variables obtained from different sources.

Single beam acoustic remote sensing for coral reef mapping

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Coral reef habitats that cannot be mapped with optical techniques are both extensive and ecologically important. For example, over 55% of the Florida Keys National Marine Sanctuary (about 1540 square nautical miles) has not been mapped due to water depth or clarity limitations. Acoustic mapping systems are the natural solution to mapping optically deep water, and inexpensive commercial single beam seabed mapping systems are available. Several studies have used commercial single beam systems to map coral reefs, but basic questions about what substrates can be reliably distinguished and how consistent classification schemes are in different areas have not been systematically explored. Acoustic datasets from the Florida Keys, USA, the Bahamas, and Navassa Island reveal that rock and sediment are almost always reliably distinguished and that sediment grain size and high seabed relief are other factors captured by classification results. Moderate resolution surveys in the Florida Keys are sufficient to delineate the extent of outlier reefs and to differentiate two distinct outlier reef morphologies: patches and linear ridges. Due to their low cost and portability, single beam systems can play a valuable role in coral reef mapping efforts, efficiently providing rapid reconnaissance and moderate resolution habitat maps of large areas.

Scale, depth and light: the geological-biological connection in marine benthic habitat mapping

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The science of geology and biology share common principals, yet the disciplines contrast in many different ways. A common interest between these disciplines that study the nature of, and processes on, the seafloor lies in the desire to map the benthic environment in a way that defines ecosystems and explains the synergies between geological and biological processes. However, historically geologists and biologists often think in differing spatial and temporal scales, regard depth at differing degrees of significance, and consider light either a hindrance or a driver to seafloor characterization.

Geologists that map the seafloor work at variable scales dependent upon the features to be mapped, while biologists generally work at scales that are of the resolution of a species or assemblage of organisms. Time is viewed differently as well, as geologists deal in millions of years yet biologists commonly deal in years to hundreds of years depending upon the life cycle of an organism and its evolutionary path. Nevertheless, a common thread between the two disciplines is the acceptance that "ontogeny recapitulates phylogeny". Depth is generally inconsequential to a geologist with the exception of when major physiographic features are described, while depth is critical to a biologist as it often defines what species live on the seafloor. Light plays little role in geological characterization, but is critical to the variability and abundance of flora and fauna that reside on the seafloor, either as an epibiontic or sessile and encrusting organism.

The common denominator for the geological-biological connection is the interstade, the conclusion of an interglacial period where the planet is warming and the seas are rising. This means that the shallow-water ecosystems we know today have essentially evolved since 12-10 ka in water depths less than 200 m and are advancing landward as the present transgression proceeds. Colonization of former ice covered shelves in high latitudes has essentially occurred in the past 12,000 years and seafloor geomorphology has shifted. These changes are common to both disciplines and have produced the multidisciplinary studies active today and that will be reported at this meeting. Proxies or surrogates using geology because of the state-of-the-art technology that allows for rapid high-resolution imaging of the seafloor at multiple scales is being used to define, predict and map marine benthic habitats critical to understanding ecosystems. Based on the advancement of marine acoustical and air optical geophysical technology and the geological-biological connection a new scientific field known as geohab is evolving, like the ecosystems we study.

Marine benthic habitat classification: analysis of existing and proposals for mapping coastal habitats in the Brittany region

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Marine benthic habitats mapping is necessary for the description, assessment and monitoring of seabed environmental conditions. The European directives (Habitats, Water Framework, Marine Strategy) Environment as well as international conventions such as OSPAR or Helcom call for a significant improvement of the knowledge of benthic habitats and lead to the development of harmonised approaches.

Marine habitat classifications frequently used for mapping are still heterogeneous according to the texts that define their national or local implementation. EUNIS, despite its high level of detail, is sometimes incomplete especially for some biogeographical areas and its implementation may prove difficult for mapping applications. At the French level, the implementation of the Habitats Directive has resulted in splitting its generic habitats (only in very limited numbers) into elementary habitats that are not always easy to reference in relation to EUNIS. This also remains insufficient to e.g. thoroughly describe a site or address the Ospar priority habitats.

The aim of this study is to propose a habitat classification system in line with the regulatory requirements and the main environmental issues while remaining suitable to operational mapping.

Based on the experiences of the multi-partner Rebent project in France, this study focuses primarily on coastal habitats in the region of Brittany chosen as a pilot area. It relies on outputs from the Interreg Mesh project approach as well as permanent discussions with JNCC in UK, in charge of new proposals for marine habitats within EUNIS.

This study helps clarify a number of concepts and leads to pragmatic proposals that meet the essential mapping needs. It also identifies actions that are still needed to characterize some habitats more precisely. This will lead to requesting the creation of missing habitats in EUNIS. It is intended to provide an update to mapping specifications operators have to comply with when tendering for habitat mapping.

Proposed template for case studies in the GeoHab global atlas: The aim is to publish examples of documented cases studies representing the full spectrum of geomorphic features that occur in the ocean. Each case study in the Atlas will comprise not more than 8 pages of text and figures describing a specific geomorphic feature or group of related features (eg. sandwaves and sandbanks), a derived habitat map, a description of associated benthic communities and any correlative analyses carried out between surrogates and benthic biodiversity. Rather than include lengthy methods and results sections, reference to published supporting information is encouraged. Below is an example of a case study, wherein red text is used to highlight the template that will apply to all case studies.

Title: Habitats and benthos of an oceanic plateau, Lord Howe Rise, Australia

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Introduction: (0.5 to 1.0 pages, geomorphic feature type, location, depth range, oceanography, general information on data reported in the case study, Figures should include a location map)

Lord Howe Rise is an oceanic plateau located in the Tasman Sea (Fig. 1), comprised mainly of continental fragments that detached from the eastern margin of continental Australia during the late Jurassic and Cretaceous (Wilcox and Jaques, 2003). It is clearly outlined by the 2000 m isobath, its crest lies generally at about 750 to 1200 m below sea level and it is surmounted by small volcanic islands (i.e. Lord Howe Island and Middleton Reef). Lord Howe Rise has a length of approximately 2500 km and a width of 450-650 km. It is associated with the lower-bathyal biome and is characterised by Harris and Whiteway (2009) as having intermediate surface primary production, low dissolved oxygen in bottom waters and mean bottom water temperatures of between 1.7 to 2.3o C. The region is influenced by eddies shed from the East Australia current (Mulhearn, 1988).

In October-December, 2007, the northern end of Lord Howe Rise was mapped and sampled using the New Zealand research vessel Tangaroa. Bathymetric data were collected using a 30 kHz Simrad multibeam sonar system over a survey area of 25,541 km^2 and underwater video and sediment information (including percentage mud, sand, gravel and percent carbonate) were collected at 23 representative sites across the survey area (see Heap et al. 2009).

Geomorphic features and habitats: (1.0 – 2.5 pages, description of geomorphic features and habitats mapped, information on scale and grid size used for mapping, sediment sample information, oceanographic measurements, modelled data etc., methods used to derive habitat maps, Figures should include a bathymetry map showing station locations and a derived habitat map, may include some limited illustrative diagrams such as 3D perspectives etc.).

Bathymetry across the survey area is characterised by a trend of increasing water depth toward the southwest (Fig. 1), with a regional gradient of approximately 0.3o. Within this area, large scale geomorphic features are broadly oriented north-south, tending to a northwest-southeast alignment across the western part of the survey area. Overall, the relief of the area is subdued and on the scale of tens of metres. However, local bathymetric anomalies exist where peaks, valleys and scarps introduce hundreds of metres of vertical relief to the sea floor.

The classification of seabed geomorphic features used here is based on feature names and definitions from the International Hydrographic Organisation (IHO, 2001), with additional terms for features taken from the literature (see Heap and Harris, 2008). Geomorphic features were identified using bathymetric profiles drawn in Fle-

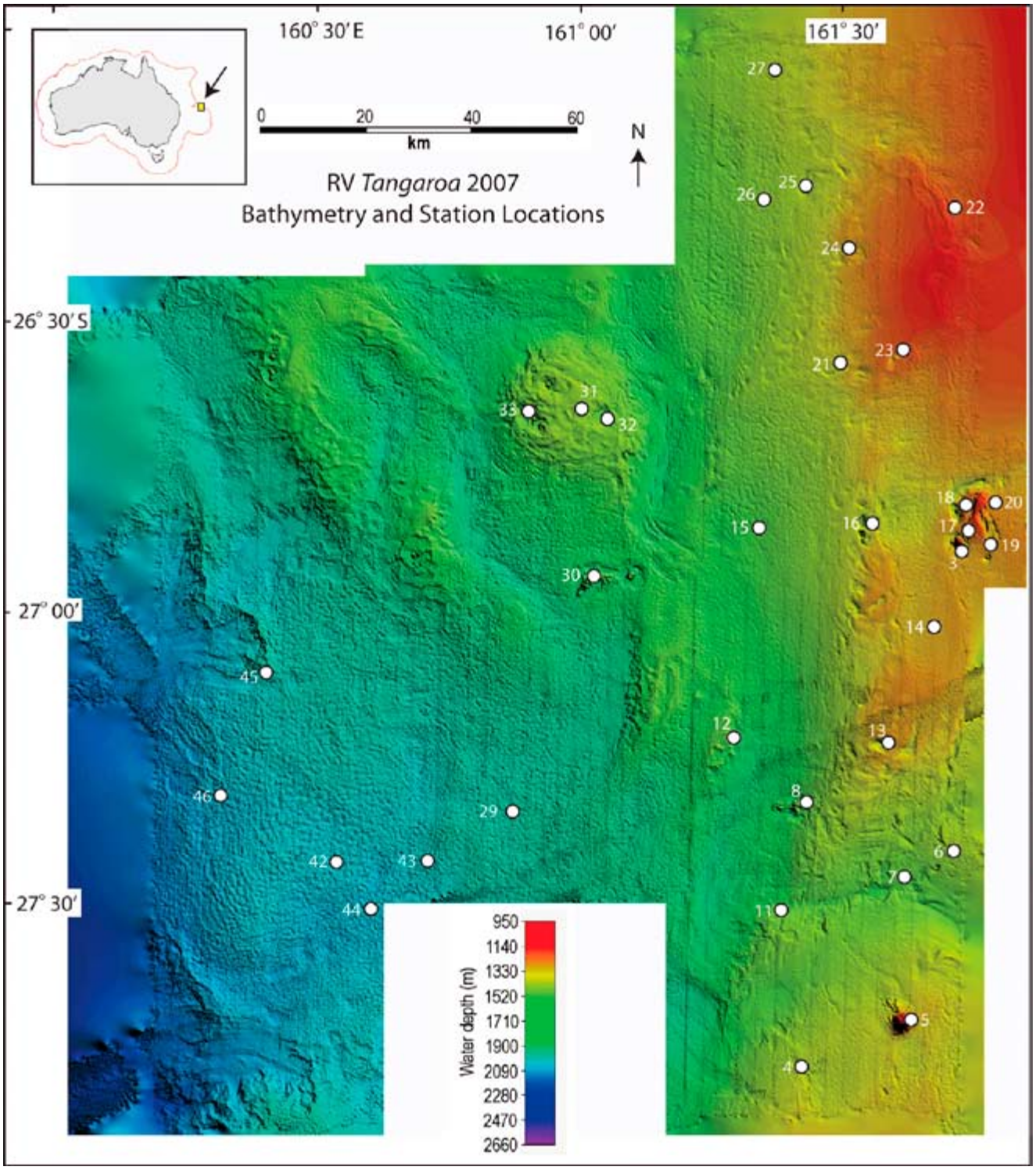

Figure 1: Multibeam sonar bathymetric map of northern Lord Howe Rise based on a 30 m grid, showing station locations (inset, location map showing Australian EEZ in red, and the survey area yellow shaded box).

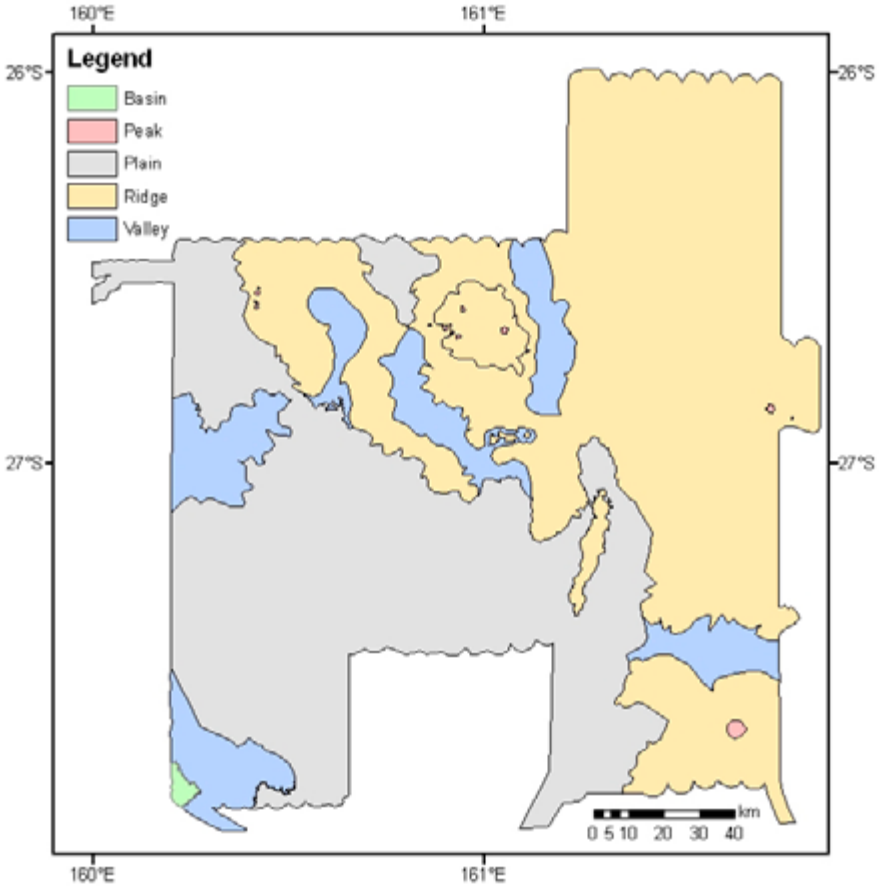

Figure 2: Large-scale geomorphic features and volcanic peaks of northern Lord Howe Rise, as listed in Table 1.

Basin - The southwest corner of the survey area captures a small section of steepening sea floor that extends from 2400 m to 2600 m water depth. This is the edge of the Middleton Basin which extends westward from this point (Heap and Harris, 2008).

Peaks – A total of 16 volcanic peaks are mapped within the survey area, covering 31 km^2 (Fig. 2, Table 1) and ranging in height from 65 m to 450 m, with the two largest peaks located in the shallowest water depth. These peaks are located in 1400 m water depth near the eastern margin of the survey area and rise to 950 m and 1020 m water depth, respectively. Overall, there is a general trend of smaller peaks with increased water depth to the west.

dermaus software. Boundary contours were then mapped as polygons in ArcGIS, from which two categories of geomorphic feature were identified, broad scale and fine scale (Fig. 2). Broad scale geomorphic features are those that have length and width dimensions of tens of kilometres and include plains, ridges, valleys and basins. Fine scale features are superimposed upon broad scale features, have dimensions of hundreds of metres to kilometres and include peaks, moats, holes, (polygonal) cracks, scarps and (potential) fluid escape features.

Plains - Low gradient plains cover 9837 km^2 of the survey area in water depths ranging from 1700 m to 2200 m (Fig. 2). The most extensive plain occupies 8363 km^2 in the southwest sector of the mapped area. Here the seabed slopes to the southwest at approximately 0.20 between 1900 m and 2100 m water depth, with maximum bathymetric relief of 20 m over 1 km. The central north sector is also occupied by low relief plains, but here they are smaller in area (<600 km^2) and part of a more complex geomorphology that includes valleys, ridges and peaks.

Geomorphic feature	**Definition**	**Surface area (km²)**
Basin	A depression in the sea floor, more or less equi-dimensional in plan and of variable extent.	51
Peak	A prominent elevation either pointed or of a very limited extent across the summit.	31
Plain	Low gradient, low-relief surface of extensive horizontal dimensions.	9,837
Ridge	An elongated narrow elevation of varying complexity having steep sides.	12,723
Valley	A relatively shallow, wide depression, the bottom of which usually has a continuous gradient.	2,899

Table 1: Definitions and areas (km2) for large-scale geomorphic features mapped within the Lord Howe Rise survey area (IHO, 2001).

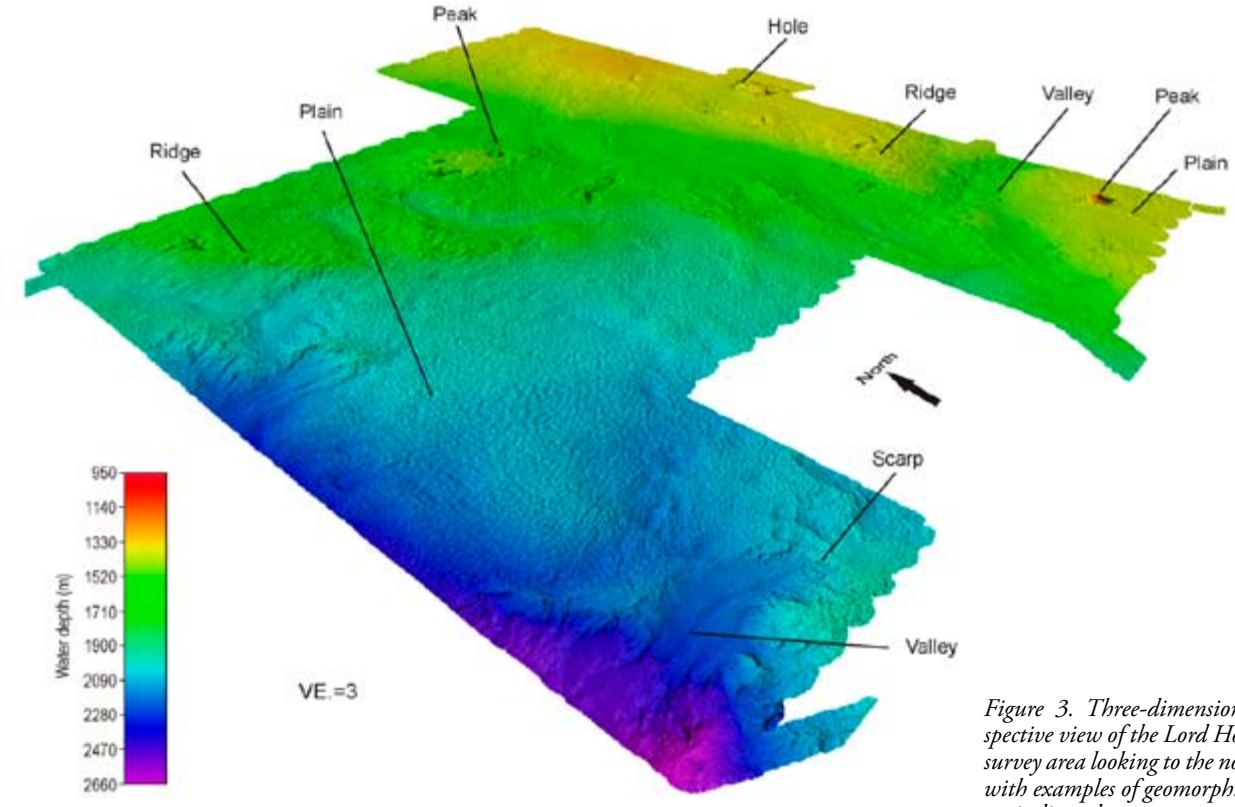

Figure 3. Three-dimensional perspective view of the Lord Howe Rise survey area looking to the northeast, with examples of geomorphic features indicated.

Ridges - Ridges are the most extensive geomorphic feature in the survey area, covering 12,723 km^2. Locally, holes and broad depressions introduce topographic variability of 50 – 100 m to the ridge crest across distances of 10 – 60 km (Fig. 3). North of latitude 27.1o S and within the central to western part of the survey area, the seafloor is characterised by a relatively complex terrain of a multiple valleys and ridges (Fig. 3). The ridges are associated with volcanic peaks that generally sit on the mid to lower ridge slopes.

Valleys - Valleys have formed across water depths ranging from 1600 m in the east to 2200 m in the west of the survey area and cover 2899 km^2. The deepest valley in the survey area is located in the far southwest, in 2000 to 2400 m water depth (Fig. 3). The valley extends approximately 30 km in an east-west direction, widening from 6 km at the headwall to 16 km at the mouth. The upper reaches of the valley floor display a rugose topography, with local relief of up to 60 m associated with small channels and interfluves that terminate at the 70 m high valley headwall. The slope of the seafloor in the valley decreases from 20 o at the headwall to ~1.5o along the upper reaches and ~0.5o along the lower reaches and thalweg.

Sediments – A total of 23 samples were collected, 17 samples of which are classified as sandy mud with the other six samples classed as muddy sand. Mean grain size ranges from 9 to 47 microns (moment mean), equating to medium to very coarse silt. All samples are very poorly sorted and have grain size distributions that are trimodal (19 samples), bimodal (3 samples) or polymodal (1 sample). Bulk calcium carbonate content ranges from 88 to 94 percent, with calcareous material including forams and other nannofossils that have formed stiff, dewatered deposits. Samples were collected from ridges, peaks, holes, a plain and a valley, with slightly coarser grained sediments (muddy sands) occurring on peaks, small ridges and holes. However, this is not a consistent pattern as other peaks, ridges and holes are characterised by sandy muds. Overall, there is no clear relationship between sediment type and geomorphic setting within the Faust-Capel Basin.

Biological communities: (1.0 – 2.5 pages, description of benthos associated with each mapped habitat or feature based on underwater video, photography or results of direct sampling via dredging etc., should include quantitative measures where possible, Figures should include photographs depicting important species and graphs or maps showing relationship between habitats and benthos).

Assessments of benthos in this study are based on underwater video and photography data, supported by epifauna collected from 13 rock dredges and 11 epibenthic sleds and infauna collected from 12 box-cores and 2 Van Veen grabs. Real-time video-characterizations were

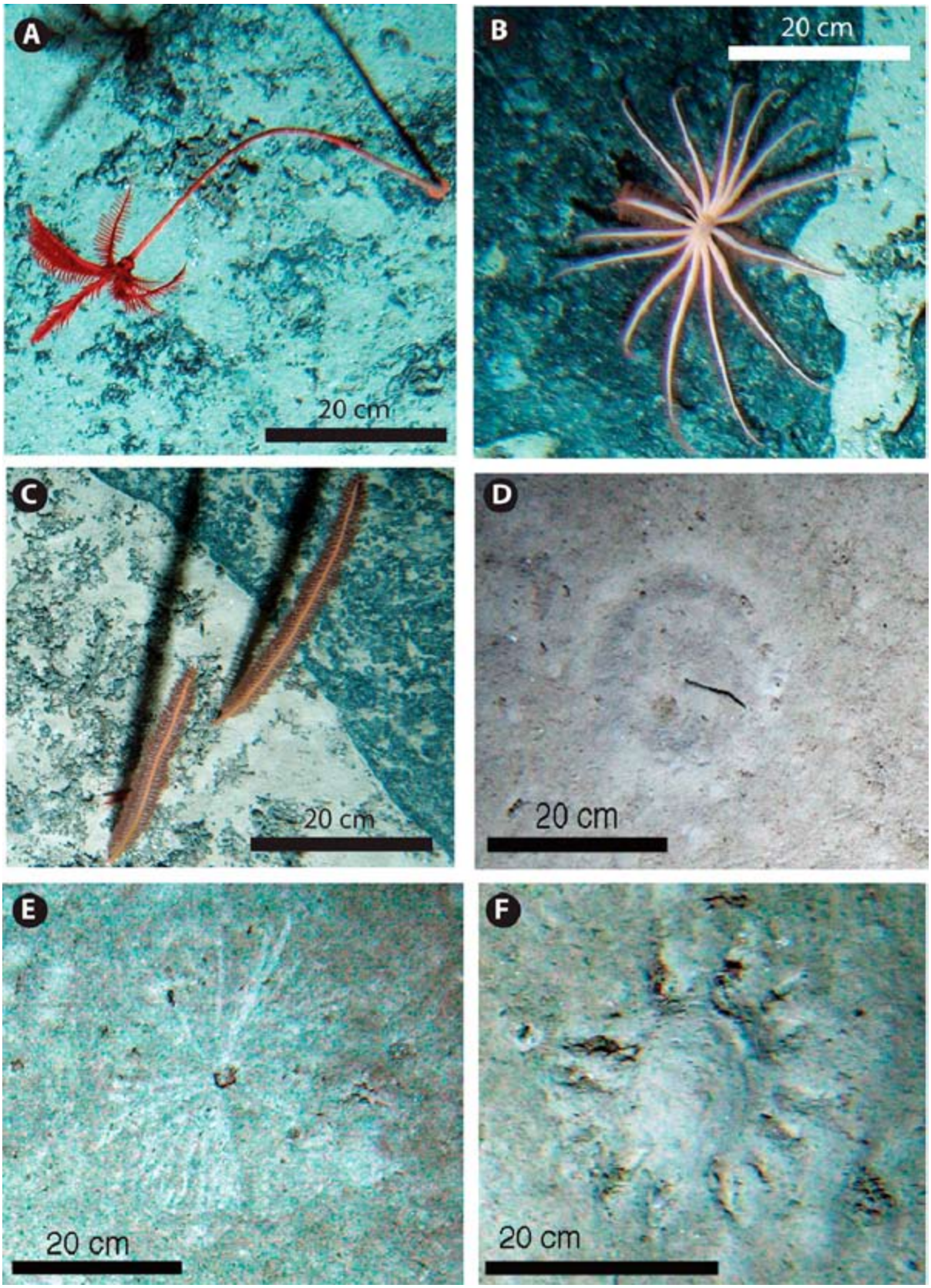

Figure 4. Photographs taken on hard and soft substrata of the Lord Howe Rise, deep sea plateau in around 1,500 m water depth. Filter-feeders on hard substrata: (A) stalked Crinoid; (B) Crinoid; (C) Cnidaria. Animal traces (bioturbation marks) in soft-substrata: (D) Quill worm (?);(E) Polychaete burrow with feeding foray or 'wagon wheel pattern' made by an unknown tubeworm, and F) ring of burrows known as 'fairy rings'.

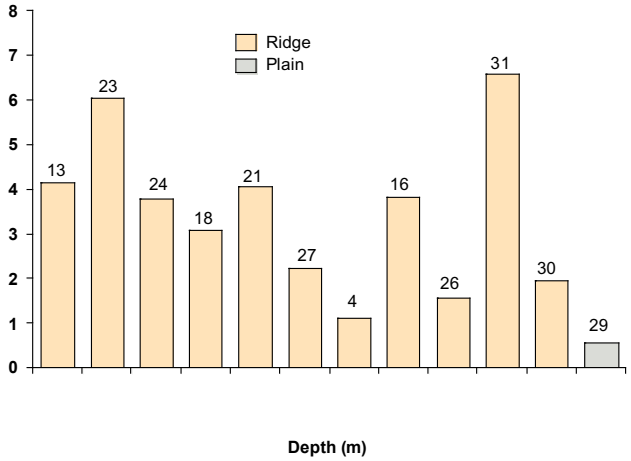

Figure 5. Species richness of infauna by station in relation to water depth and geomorphic features. from ridges (tan) and plain (grey) parts of the study area. Species richness is calculated as a standardised measure of species number per 10 ml of elutriate. Station numbers are indicated above each histogram bar.

recorded approximately every 30 seconds along each of the 36 camera-transects (see Anderson et al., 2008). Substrata composition (i.e. rock, boulders, cobbles, sand, and mud) was categorized by primary (>50% cover) and secondary (>20% cover) percent-cover. Relief was defined as either soft-sediment 'bedform' such as hummocky, sediment ripples, or sediment waves, or by the vertical 'relief' of hard substratum, in which relief classes ranged from flat (0 m), low (<1 m), moderate (1-3 m), to high relief (>3 m), or rock walls (high-relief with >80° incline). Benthic composition was described by recording the presence of benthic macro-organisms identified to groups (e.g. starfish and brittlestar), class (e.g. featherstars and anemones), or broad ecological categories (e.g. fish).

At total of 2,963 seabed video-characterizations were recorded. Over the entire survey region, substrata was dominated by homogeneous soft-sediments that comprised 84% of the seabed, with 12% volcanic outcropping, and the remaining 4% comprising a range of mixed habitats with gravels or boulders. Seabed relief was generally flat with rare occurrences of low (9%) and moderate (2%) relief habitats, and sand waves (1%). Overall, habitats were relatively depauperate of biota. Bioturbation marks (eg. burrows (53%), tracks (38%), mounds (32%)) were the most common signs of life (61% of all basin locations had bioturbation marks; Fig. 4), while sessile organisms, such as corals, crinoids and gorgonians occurred sparsely on rocky substrata. Motile species including shrimp and prawns (15%), fishes (8%), and jellyfish (5%) were also regularly recorded, but were sparsely distributed and were never abundant. Video-characterizations by geomorphic feature identified several patterns.

Peaks were characterized by hard substrata (71% of all locations within this geomorphic class), with 14% mixed substrata (mixture of rock and sediment occurring mostly at the base of the peaks), and 15% soft-sediments (sediment areas surrounding peaks). Although volcanic outcrops were bathymetrically distinct in the multibeam images, at fine-scales, these peaks were characterized by low (48%) or flat (44%) relief, with rare occurrences of moderate relief (5%) or sediment ripple (3%) habitats. The rocky substrata of peaks had surprisingly few attached or associated organisms, and almost no dense habitat-forming sessile invertebrates. Filter feeders, such as gorgonians (cnidarian - 55% of all locations) and sponges (18% of all locations) occurred most frequently (Fig 4a,b,c), but were always present in low densities (1-5 filter feeders per 15 seconds of video footage). Motile species such as shrimp and prawns (10%), fishes (4%), and jellyfish (1%) were only sporadically recorded, while crinoids (3%), brittlestars (1%), and starfish (1%) were rare.

Plains were characterized by bioturbated flat soft-sediments (>99% of all locations within this class) - bioturbated by burrows (86%), tracks (95%), and mounds (62%) (e.g. Fig. 4d,e,f). Acornworms (Pyllum Hemichordata, Class Enteropneusta) were an obvious component of this environment (7% of all locations), associated with distinctive spiral or meandering trails. Apart from bioturbation, plain habitats were fairly depauperate of biota, with sporadic occurrence of cnidarians (e.g. gorgonian whips, seapens, and hydroids – 6% of locations) and motile species, such as shrimp and prawns (20%), fishes (5%), and jellyfish (1%).

Ridges were dominated by homogeneous soft-sediments (92% of all locations within this class) with occasional outcroppings of hard (5%) and mixed (3%) substrata. Relief was mainly flat (94%) with rare occurrences of low (3%) and moderate (1%) relief outcrops or rippled sediments (1%). Bioturbation was the most common signs of life (79%), characterized by burrows (60%), tracks (42%), and mounds (41%). Motile species, such as shrimp and prawns (18%), fishes (10%), and jellyfish (7%), and sessile organisms, such as corals, crinoids and gorgonians (7% total occurrence in all locations) were occasionally recorded.

In some deep sea environments, rocky substrates support dense assemblages of suspension feeders, such as corals and sponges (e.g. Rodgers, 1994). In this study, however, organisms were only sparsely recorded throughout the survey, while large areas of rock remained uncolonised. Infaunal and epifaunal specimen collections were also low in diversity and abundance. The number of species/taxa varied between 3-25 per station, but this likely reflected different sample amounts. Standardised species richness values indicate that Station 31 at 1518 m depth in a ridge environment had the highest numbers of infaunal species, and Station 29 at 1935 m depth in a plain environment

had the lowest (Fig. 5). There is insufficient data to determine whether species richness is related to depth or other factors. While differences in sampling methodologies used between studies may explain some of the observed community differences, the fact that low occurrences of organisms were also recorded in the towed-video observations suggests that some factor(s) may be limiting diversity across this region. Factors which are known to influence faunal diversity and abundance include nutrients, oxygen, organic content, and trace element levels (Levin et al., 2001).

Surrogacy: (0.5 pages, description of any methods applied to measure statistical relationships between physical surrogates and benthos for this case study).

No statistical analyses have been carried out on this data set to examine relationships between physical surrogates and benthos.

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Testing the 'seascapes' construct: spatial data modelling and integrating biology

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Geoscience Australia has derived seascapes for its marine jurisdiction from a series of physical data layers in an effort to develop accurate proxies for benthic marine habitats. We present new developments in the derivation of seascapes for Australia's marine jurisdiction. Specifically, we address two principal criticisms formerly levelled at the seascapes approach, namely: 1) How might the quality of the underlying physical data affect the derivation of seascapes; and 2) How well do seascapes capture Australia's benthic marine biodiversity? We address the first question through a simulation experiment that applied 12 spatial interpolation methods to the underlying physical data, while also testing for the effects of sample density and stratification by geomorphology. Initial findings indicate that: 1) no minimum threshold was found for sample density; 2) the variability in the data affected the performance of all methods negatively; and 3) the data should be split into different sections because no one method is best for all margins. We address the second question by correlating benthic invertebrate data with the seascapes at a regional (>100,000 km2) scale and incorporating demersal fish data in the derivation of the seascapes at a geomorphic feature (>1,000 km2) scale. At the regional scale, assemblages are significantly differentiated by the seascapes but the strength and significance of the relationships varies according to taxonomic resolution, seascape type and spatial scale. Integration of biological data at the geomorphic feature scale results in the final seascapes being more closely matched to actual biotic distributions. Next steps are to test the effects of using more complex interpolation methods and to incorporate biological data for an area of high seascape complexity (e.g., Great Barrier Reef).

Investigating the relationship between Backscatter Strength and sediment grain size in a dynamic geological environment, Cook Strait, New Zealand

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As part of an effort to better identify the relationship between seafloor sediment and backscatter data, a number of relationships were tested between the mean grain sizes of 250 sediment grab samples and the amplitude of the backscatter data. The backscatter data were generated by a Kongsberg EM300 multibeam echo sounder, and subsequently calibrated and compensated using the SonarScope® software from IFREMER, France.

The geological and geophysical data were collected in Cook Strait, New Zealand. Cook Strait is a 20- 60 km wide oceanic passage located in central New Zealand, and is part of the convergent plate boundary zone between the Australian and Pacific plates. The northern Cook Strait locates over the continental shelf with average water depths of 150-180m, whereas southern Cook Strait covers the continental slope and deep Hikurangi Trough with water depths over 2500 m. Strong oceanographic currents, tides and atmospheric winds affect the strait between the Tasman Sea and the south-west Pacific Ocean. Hence, Cook Strait's environment is diversified and includes: high-energy shallow shelf to deep ocean basins, with gravel and sand waves; relict carbonate platforms; eroded post-glacial surfaces; active and inactive canyons; steep and unstable seascapes ; and mud.

Grain-size analysis followed by classification based on the percentage of mud, gravel, and sand was performed on all sediment samples. We also used the acoustic backscatter strength, which is associated with grain size, surficial heterogeneity and small-scale topography, to provide information on substrate composition and roughness. Different statistical analysis were applied to areas of homogenous backscatter and compared with each others. Overall the research indicate that the multibeam angle, slope and roughness of the seafloor directly influence the Backscatter Strength. The precision with which a multibeam echo sounder can separate the different grain sizes is in the order of a few millimetres, so for example it recognizes very fine sand from very coarse sand. The results also provides insights into the important question of how transferable the results of the relation between backscatter and grain size is for other regions globally.

Monitoring colonization processes in the inner Oslofjord: benthic foraminifera as a tool for ecosystem characterization

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The Oslofjord, Norway, has been contaminated by discharges from various sources since the early industrialization. In vast areas of the inner fjord nearly anoxic to anoxic conditions developed at the sea bottom during the 1900s. Due to general growing environmental consciousness, governmental regulations and advanced wastewater treatment, the environment recovers slowly. In connection with remediation of strongly polluted basins, capping the contaminated sediments with clean ones is becoming a common approach. In 2007 and 2008 parts of the strongly polluted sediments in the Bekkelagsbasseng, inner Oslofjord, were covered by clean Quaternary clay. This area offered a unique possibility to monitor both macro- and meiofaunal (here benthic foraminifera) colonization processes within the PES* project.

For benthic foraminiferal and geochemical analyses (bottom water O2 content, pigments, heavy metals) gravity core samples were collected at three stations in the Bekkelagsbasseng: one station located in the middle (RC5), one at the periphery (RC8), and one (RC9) just outside the capped area. First samples were collected in March, June, and September 2008. Regular re-sampling will continue until summer 2010.

Preliminary results from 2008 show that developments in the benthic foraminiferal community structure characterize the temporal changes in the ecosystem and reflect the two different recovery processes operating in the basin:

1. General appearance of living (Rose Bengal stained) benthic foraminifera in samples from the 'original', uncovered station (RC9) and a specific faunal composition indicate that the formerly anoxic environment started to recover. *Stainforthia* fusiformis is the most common species. This species is a successful colonizer of formerly anoxic environments and tolerates hypoxic sediments.

2. The area with the new substrate, Quaternary capping clay, represents a completely new habitat for the benthic community (e.g. size fraction, sediment density, oxygen conditions in the sediment column). General specific foraminiferal assemblage composition is comparable to that at station RC9. This indicates that the colonizers of the new substrate immigrated from the surroundings. However, the relative abundances of species show significant differences between the two different areas. *Bulimina marginata* is the most common species at the middle of the capped area (RC5). On the clean clay, this species flourishes in better oxygenated habitats and outcompetes the opportunistic *Stainforthia fusiformis*.

First scientific deep-water missions of Autosub6000 map giant deep-sea scours

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High-resolution mapping along the lower ocean margins and in deep basins is a significant technological challenge, due to the extreme depths and vast surface areas involved. Still, important sedimentary processes do affect those deep habitats, and can create seabed morphological features in the order of tens to hundreds of metres across. One example is scour due to powerful density flows (turbidity currents and debris flows). This process can result in a variety of scour mark morphologies (Wynn et al., 2002, AAPG Bull. 86, 1441-1462; Talling et al., 2007, Nature, 450,541-544) and forms a significant geohazard for seabed installations and cables. Shipborne mapping often lacks the resolution to image those features in detail, and towed systems are hampered by navigational uncertainty, unless supported by expensive transponder networks. One solution is the use of deep-water Autonomous Underwater Vehicles (AUVs).

This presentation will focus on the results of a recent scientific cruise on board of the RRS James Cook (August 2008), aimed at the study of deep-sea scours in unprecedented detail. On the one hand we will report on a major technological advance, namely the first scientific operations of the new UK deep-water AUV Autosub6000, carrying out detailed mapping surveys using new battery and navigational technologies that allow a longer endurance and higher positional accuracy, also at great depths and without transponder network. Within 2 hours of the Autosub6000 surfacing after each mission, the bathymetric data were available for further cruise planning – which could comprise station work such as precision piston coring, detailed video surveys or ROV dives. On the other hand the results obtained by this AUV give unprecedented insights in the morphology of, and processes behind, deep-water scour features. Several types of scours were mapped, in water depths of 4000 to 4800 m. The data illustrate how their morphology is influenced by the nature of the flow (size, speed, sediment load,..), bathymetric constraints, inherited seabed morphologies, and underlying geology (tectonic setting, sediment type, compaction, etc.).

The use and value of coastal geological rock outcrops in the analysis and mapping of marine habitat off the Lizard Peninsula, S.W. England (UK)

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The Lizard Peninsula has a unique geology compared to the rest of Cornwall and south-west England. It includes rocks which were originally formed within the Earth's mantle at many kilometres depth, plus rocks from the Earth's crust which lay above them. This ancient sequence of mantle and crust rocks is known as the Lizard ophiolite complex and includes a diverse mix of altered rocks which have undergone extreme variations in temperature and pressure to form metamorphic rocks such as schists, peridotite, serpentine and gneiss; many are highly mineralised. Above these are old igneous rocks including gabbro, basalt dykes and lavas.

How does this very complex geological mix translate to the offshore? Although much of the evidence for the geological interpretation of the Lizard lies in coastal cliffs and beach platforms translating this level of detail offshore has previously been difficult, there has not been adequate geological or geophysical marine survey data available around the Lizard to map the extent or detail of the ophiolite complex rocks. They are simply mapped as undivided basement rocks, or undivided Devonian and Carboniferous rocks on published British Geological Survey maps.

A recently completed project of Special Areas of Conservation (SAC) mapping for Natural England collected multibeam and sidescan survey data off the Lizard Peninsula and has enabled us to map the major sea bed morphological features and interpret these features in in terms of geology such as structural lineations, possible fault lines, river channels and bedforms. There is no sub-bottom seismic reflection seismic survey data therefore we could not make an interpretation of the exposed rock at the sea bed on the basis of their sub-sea bed character and thus be sure of the lithologies we were dealing with.

However, the offshore video and photographic data produced for the project does show distinctions and common features in rock type such as bedding, jointing and angularity and these can be translated to the multibeam and sidescan interpretation, but without physical evidence from rock cores or samples we could not explicitly identify the rock types. We therefore undertook a survey of coastal geological rock outcrops to use these as analogs for characterising the rock types seen on the offshore video. This enabled us to identify Devonian and Carboniferous well bedded sequences, igneous intrusions and extensive thinly bedded Permo-Triassic rocks and therefore provide a greater level of confidence in the results and conclusions of the SAC mapping.

Application of the Coastal and Marine Ecological Classification Standard a national benthic habitat mapping standard: Papahanaumokuakea Marine National Monument case study

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As large marine protected areas (MPA) are designated throughout the world it becomes increasingly important to develop methods for providing benthic habitat information to resource managers. Often these MPAs are remote areas that have had patchy surveys completed in the past and coarse data available for the remaining areas. Regardless of available data managers will still require information to base long-term planning and management decisions on. The Papahanaumokuakea Marine National Monument and partners have begun mapping the benthic habitat but will require many more years to complete the dataset. Until the data is complete the managers must rely on a dataset of mixed scales and mixed habitat classification systems. In order to address this issue and provide a framework for future data collection efforts the Monument has begun the process of implementing the Coastal and Marine Ecological Classification Standard (CMECS) developed by NOAA and NatureServe. Using the Monument as an example the system was evaluated for the potential of incorporating mixed scale datasets and previously classified datasets. In addition the usefulness of the classification system for addressing management questions was also evaluated.

CMECS is a hierarchical system composed of three component areas: Benthic Cover Component (BCC), Water Column Component (WCC) and Geoform Component (GFC). The focus of this project was developing a dataset using the Benthic Cover Component. Using the mix of data available for the Monument some of the hierarchy could be developed but certain refinements were not possible. Boundaries defined by depth could be successfully completed with the understanding that those boundaries will change as more accurate data becomes available over time. Using the existing shallow water benthic habitat maps it was possible to cross-walk much of the existing data into the CMECS system. As holes are filled in the benthic habitat maps and new data is collected the current data can be replaced.

The system does provide a framework for future data collections and some descriptive metrics that can be used by managers to describe the different habitats and begin to develop resource management plans. The hierarchical design provides flexibility for aggregating information from the local scale (island/atoll) to the regional scale (MPA) to the national and global scale. This scalability is important for managers as they look beyond individual MPA's to networks of MPAs. In addition the local scale data provides managers the information they need to make management decisions and examine habitat changes over time.

Distribution and Morphology of Horse Mussel Beds in the Bay of Fundy identified using Multibeam Sonar

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The presence of horse mussel (Modiolus modiolus) reefs in the Bay of Fundy has been known for the last decade since their discovery using sidescan sonar and high resolution seismic systems. The reefs are long, thin, and parallel structures covered with epifauna. Since 2006, the Geological Survey of Canada, in cooperation with the Canadian Hydrographic Service and the University of New Brunswick, acquired 12,465 square kilometres of multibeam sonar coverage in the bay. We have identified and outlined mussel beds by visually inspecting the multibeam bathymetry and backscatter strength maps. Horse mussel beds are expressed as elongated and elevated ridges with backscatter strength different from the surrounding seabed. Approximately 1500 mussel beds were mapped and measured. The beds are located in 40 - 100 m water depths with a median depth of 76 m. The beds ranged in length from 32 m to 2 km with median length of 185 m and were on average several meters high. The shape of the beds was more irregular and less linear in areas of multidirectional tidal current. The total area of the horse mussel beds in the bay is approximately 11,670,283 square meters. Seismic reflection data show that the reefs are associated with glacial till in shallow subsurface. Distribution maps and morphological data could be used to design and implement protection measures for this important ecosystem component of the Bay of Fundy.

Modelling marine ecosystem – case study in the Gulf of Finland, the Baltic Sea

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We show the results of the Finnish marine habitat mapping project (VALKO) conducted in 2008 in the Gulf of Finland, the northern Baltic Sea. The VALKO - project is part of the Finnish Inventory Programme for the Underwater Marine Environment (VELMU). The main aim of the ongoing VALKO project is to develop a collaboration model for the implementation of the geological and biological field inventories. In the 2008 our focus was on submarine diversity, marine landscapes and their ecological value. The marine landscape concept is a broad classification of the marine environment based on geophysical and hydrographical parameters that are ecologically valid. We identified marine landscapes in two 2 scales: broad scale landscapes for the whole Gulf of Finland study area and detailed landscapes for the sea area off Helsinki metropolitan area. Area was chosen as there is comparatively good data coverage. It is also an area of high human induced pressures (e.g. marine traffic).

In addition, we wanted to find out how extensive biotope maps we could model from the current data for the detailed study area and where possible future inventories should be directed. Data from bathymetry, substrate and exposure were used in the analysis. We had data also on benthic species from 2002-2006 and diving observations of marine vegetation from 2005-2007. Field observations were recorded using a BalMar classification tool (Backer et al. 2004). For extrapolating the fine-scale biological observations, we used habitat modelling with case-based reasoning (CBR). CBR is a method of computer reasoning based on findings in cognitive science. Using CBR solution to a new problem is retrieved by matching it against all cases stored in the case base and by generalizing all the similar cases. The solution can be further revised and if it 'works' then retained as a new case in the casebase. The resulting maps show the existence probabilities of the different habitat types.

We identified in total 12 different marine landscape types from the Gulf of Finland and 44 different kinds of landscape types from the detailed study area. On the basis of landscape distribution areas are generally alike. They are both characterized by soft-sediment bottomed basins and plains. In addition, the ridges of bedrock and till as well as valleys of postglacial sediments area characteristic to the detailed study area. We analysed the diversity and fragmentation of the physical environment on the basis of landscapes. The most diverse areas situate in the middle archipelago where both erosion and accumulation take place. Large homogeneous areas are met mostly towards offshore areas.

The modelling of nature types was successful. Our data covered 62 % of the detailed study area and 58 % of physical nature types. On shallow and fragmented areas the marine landscapes were found too coarse for the ecological validation. The validation in deeper areas was more successful. Nevertheless the biological dataset was generally considered inadequate for the validation. To ensure better coverage of the benthic data there is a need for samples from deep soft sediment bottoms. In addition, the poor coverage of the bathymetry and substrate data from the coastal area, where the pressures to use marine resources are greatest, is problematic.

It is evident that the development of landscapes and marine nature type mapping is still ongoing and that there is a general need for marine ecological data to create a confident description of marine ecosystem in Finland. However, it seems that we are on the right path on ensuring the sustainable use of marine resources. Although we were not able to validate marine landscapes they describe the physical submarine environment efficiently. They give the general picture of the seafloor and provide cost-effective tool for large scale marine management. Marine landscapes can be used e.g. on directing the use of marine resources like marine wind parks to most suitable areas and on planning extensive nature reserve systems in order to ensure sustainable development.

Tromsøflaket: do benthic assemblages reflect nature types established from video and terrain analyses?

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An important aspect of marine habitat mapping is the classification of areas of consistent environmental and ecological characteristics into nature or landscape types. Such marine nature types are a necessary and practical tool for the sustainable management of our seas. Classification should combine knowledge of the resident benthos and habitats with terrain information in order to render predictability. However, in deeper waters the necessary knowledge of benthic communities is often either scarce or even lacking due to the inherent difficulties of sampling in such waters, i.e., cost and labour-intensity in obtaining samples and identification of specimens.

Here we use a classification system based on 'quicker methods' such as video (using a towed video camera) and terrain analyses (using multibeam and sediment characteristics) to elucidate whether all aspects of the benthic communities, i.e., in- and epifauna, reflect such classification. How well are these nature types or landscapes met in benthic assemblage composition patterns? We address this question using data derived from two MAREANO voyages to the Southern Barents Sea in 2006.

MAREANO (Marine AREA database for NOrwegian coasts and sea areas) is an on-going Norwegian habitat mapping programme involving the Institute of Marine Research (IMR), the Norwegian Hydrographic Service (NHS) and the Geological Survey of Norway (NGU). Topographical, sediment compositional, chemical and biological data (benthos) are collected and integrated in order to create habitat maps which are necessary for managing Norwegian coastal and offshore regions with regard to sustainable resource use, potential exploitation and the introduction of marine protected areas.

A case study for developing suitable habitat mapping methods was established in the Tromsøflaket area (approx. 16 km2, 150-200 m depth). The different components of the benthos were sampled intensively by deploying a towed video camera, a beam trawl (mobile epifauna), an epibenthic sled (epifaunal crustaceans), and grabs (infauna). Combining data from video and terrain analyses stations were classified into six nature types ranging from areas characterised by muddy sediments in basins with pock marks to areas with mainly gravelly sediments containing also sand, cobbles and boulders. Multivariate analyses of the biological data were used to assess how well these nature types are met in the benthic assemblage compositions. Species typifying nature types and those characterizing the dissimilarities between nature types were identified. Multivariate methods were also employed to evaluate which environmental parameters are the main drivers of the assemblage composition patterns seen.

Combined processing of bathymetry and backscatter data for characterization of seafloor substrate - Application to Cook Strait, New Zealand

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We are developing a method to characterize seafloor substrate using object-oriented classification techniques applied to backscatter data from Cook Strait, New Zealand. Here, a wealth of multibeam data are augmented by an archive of geological samples (photos, sediment samples), which provides a unique opportunity to ground-truth and quantify the backscatter signal. Cook Strait's environments include: high-energy shallow shelf to deep ocean basins, with gravel and sand waves; relict carbonate platforms; eroded post-glacial surfaces; active and inactive canyons; steep and unstable seascapes ;, and mud. The region has been comprehensively mapped using a Kongsberg EM300 multibeam system. The backscatter data have been calibrated and compensated using IFREMER SonarScope® software so they can be used qualitatively and quantitatively. Backscatter signal processing removes modulation effects of the recording equipment, large-scale topography, and the water column variability, thus providing calibrated level of reflectivity. Grain-size analysis followed by classification based on the percentage of mud, gravel, and sand was performed on ground-truth sediment samples. Subsequently, we use the acoustic backscatter strength, which is associated with grain size, surficial heterogeneity and small-scale topography, to provide information on substrate composition and roughness. We generated Backscatter Strength (BS) angular profiles at key locations, with the aim of assessing the relationship between BS and incidence angle on the seafloor. The processed data emphasize topographic, geological, and possibly biological features otherwise not recognized with conventional surveying. The bathymetric data was used to derive a quantitative classification of seafloor complexity by adapting morphometry theory developed by terrestrial ecologists. The resulting fuzzy classification maps are geo-referenced, high resolution, scale-independent, reproducible, and have assigned levels of uncertainty. Combined with the backscatter interpretation the results have potential to improve our understanding of the degree and form of relationships between physical variables and benthic biota, and identify the best analysis methods to relate these variables to biological data. Many physical processes acting on the seabed are highly correlated with bathymetric features, such as ridges and channels which can be key predictors of habitat suitability, community composition, and species distribution and abundance. This method improves insight into classification and related uncertainties of morphometric classification.

Preliminary results on the acoustic imaging of possible carbonate mounds in the Chella Bank (Eastern Alboran Sea - SW Mediterranean) and first characterisation of some of the mega-benthic communities in the area

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Possible cold-water carbonate mounds have been acoustically detected and mapped in the Chella Bank, off the Almeria Margin, along the Eastern Alboran Sea (SW Mediterranean). The Chella Bank is a seamount and is one of the prominent highs present in the slope domain of the study area. The study has been carried out by means of an integrated geophysical dataset, comprising large-scale sidescan sonar (TOBI), high-resolution swath-bathymetry, TOPAS and high-resolution sparker seismics. The acoustic dataset has been ground-truthed with images from a ROV and a deep-towed video-camera. Carbonate mounds range from 10 to 60 m in height and from 150 to 300 m in width, displaying a sub-circular to elongated shapes. They are found within a depth range of 80-400 m and generally occur along the structural ridges of the Chella Seamount. Some of the mounds are distributed NW-SE and N-S, coinciding with the orientation of the active fault lineations observed North and West of the study area. High-resolution seismics allowed to recognize a stratified seismic facies on the top of some of the volcanic ridges, suggesting the presence of bioconstructions above them. The presence of a depressed feature likely to be a pockmark suggests the potential relationship between fluid seepage and mound evolution. Unfortunately, the video inspections did not allow a detailed imaging of the rocky outcrops observed in the mounds area. Video stills have been used for the characterization of the mega-benthic species identified along the mounds. A wide and dense patch of the gorgonian Callogorgia verticillata has been observed on the top of the seamount, on a sub-horizontal terrace, well imaged with the MB echo-sounder. The sponge Fakelia ventilabrum prevails along the rocky steep walls of the potential mounds. Except for few and small colonies probably belonging to the coral species Madrepora oculata, not more cold-coral species were not directly observed in the videos. The integration of different high-resolution geophysical methods allowed to image in detail the morphology of probable carbonate mounds in the Chella Bank. Nevertheless discerning volcanic residual morphologies from carbonate mounds can represent a challenging task, and further investigations will be required to highlight their formation and evolution.

Very high-resolution seismo-acoustic imaging of Posidonia oceanica seagrass meadows (Mediterranean Sea)

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Posidonia oceanica is a widespread coastal Mediterranean seagrass which accumulates in its subsurface large quantities of organic material, named matte, derived from its roots, rhizomes and leaf sheaths embedded in sandy sediments. The high content in organic carbon of these deposits plays a relevant role in the global ocean carbon cycle. The distribution of *P. oceanica* has been widely assessed using acoustic methodologies. However, informations on *P. oceanica* internal structure obtained with seismic methods are still very rare. Very high resolution seismo-acoustic methods were applied to image the subsurface features of a *P. oceanica* seagrass meadow in the NW Mediterranean Sea (Catalonia, NE Spain). In many records it was possible to detect a strong reflector, from 2 to 6 m depth, that was interpreted as the initial substratum where the seagrass established for first time. A 3D bathymetric model of this substratum allowed us to reconstruct the palaeo-environment of the area prior to the settling of *P. oceanica*, which corresponded to a shallow coastal setting protected from the open sea. A core drilled in the meadow revealed the presence of a 6 m thick dense matte composed of medium to coarse sandy sediments mixed with plant debris and bioclasts. Radiocarbon datings revealed a constant accretion rate of the meadow of about 1.1 m/kyr.

Very high-resolution marine geophysical techniques allowed us to accurately define the volume occupied by *P. oceanica* matte, which in the study area reaches up to almost 220,000 ± 17,400 m^3. Results yield insights into the settling of the *P. oceanica* meadows in coastal environments during the last 6000 yrs, and define with unprecedented detail the potential volume occupied by the matte. This result is an important step forward in our efforts to estimate the size of the carbon sink represented by *P. oceanica* meadows along the Mediterranean coasts significantly contributing to the biosphere carbon cycle.

Mapping seabed texture homogeneity using multibeam backscatter data: Can we use it as a surrogate for biodiversity assessment?

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The combined used of backscatter and bathymetric data generated by multibeam echo-sounders provides a powerful tool to investigate substrate characteristics and seabed biotopes. However, these data are strongly scale dependant, and new methods integrating both physical and biological factors at various spatial scales must be developed to accurately assess how and why differences in backscatter texture indicate differences in substrate characteristics and seabed biotopes. The method we are developing to characterise seafloor substrate is based on object-oriented classification techniques applied to calibrated backscatter data. The case study presented in this paper showcases Cook Strait, in central New Zealand, which has proved to be an excellent location to develop such method. Its geological and ecological environments are varied, ranging from high-energy shallow continental shelf, to deep ocean water depths. The region has been comprehensively mapped using a Kongsberg EM300 multibeam system, and the entire backscatter image has been fully processed using IFREMER SonarScope® software. An extensive geological database (photos, sediment samples) collected in the strait provide a unique opportunity to ground-truth and quantify the backscatter signal. Object based image analysis is used to identify homogeneous regions in terms of acoustical response, which in turn enables us to map the distribution of marine biotopes. Backscatter image segmentation from colour, shape, smoothness, compactness and texture are applied at various scales across different depth strata. The object-oriented technique generates measures and maps of the classification uncertainty and segmentation reliability. The results provide an improved understanding of the utility of different marine biophysical variables as surrogates for benthic biotopes and promote the use of spatial uncertainty techniques, at local and regional scales, to assess the application of the methods for biodiversity assessment. Understanding the relationship between seafloor topography and substrate texture in marine ecosystems will eventually underpin biodiversity assessment and influence the success of ocean management in describing the biodiversity of our oceans. The methodology has the potential to be applicable to other seafloor types worldwide, and will advance the research that aims to answer the fundamental questions relating to the role of high resolution acoustic data in explaining patterns in biodiversity.

Development in a trawl-damaged coral habitat (Tisler reef, NE Skagerrak) during four years of trawl protection

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The Tisler reef is a relatively large (c. 0.25 km-2 live reef, c. 0.5 km-2 total) inshore reef dominated by the hermatypic scleractinian cold-water coral Lophelia pertusa. The reef was first documented by ROV in 2002 and has later been mapped in detail. The mapping revealed that large parts of the reef had been damaged by trawling. The Tisler reef and a small buffer zone around it was protected from fishery with bottom-impacting fishing gear in late 2003.

Quite a number of Scandinavian cold-water coral reefs have been protected against bottom-impact fisheries during the last decade. To our knowledge, however, there have been no previous studies to demonstrate the effectiveness of such protection or the rate of recovery in damaged coral habitats after protection. To study these issues, a bottom transect (weighted line with markers) was established through a trawl-damaged part of the Tisler reef in 2005. The development in the coral habitat surrounding the transect was then documented regularly by ROV (video, still photography and video mosaics) over a period of 3 years. Great care was taken to prevent impact of the ROV used on the coral habitat studied.

The studies have revealed frequent re-location of smaller coral colonies and fragments. In part of the transect, smashing and re-location of larger colonies was also observed. In a few larger and stable colonies growth rates (increase in polyp length) of c. 5-7 mm-year were measured from time-lapse photographs with laser markers.

Our findings indicate that during the study period there was no net recovery in the coral population studied, but instead a net loss and further fragmentation of live coral tissue. It seems likely that part of the negative development was related to continued illegal fishery with bottom-impacting gear, which was further indicated by loss or displacement of bottom-mounted recording instruments deployed withinin the protected area. Also natural factors, such as occasional occurrence of very strong bottom currents (as measured in the area by recording instruments), might contribute to hinder re-establishment of smaller coral fragments created by physical disturbance, due to frequent re-location of the fragments.

Acoustic remote sensing of benthic habitats: underwater vegetation

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The present study describes the use of an acoustic ground discrimination system (QTC VIEW, Series V) to assess benthic habitats in a shallow water system, and in particular to detect and map the distribution pattern of the macroalgae *Caulerpa prolifera*. For this, two different echo sounder frequencies (50 and 200 kHz) were used, to test the performance of this acoustic system to distinguish between different sediment types and different vegetation coverage and which frequency is the most useful for classifying macrophytes and/or sediment.

The study was conducted in Mar Menor, SE of Spain, a shallow tidal lagoon covered mainly by *Caulerpa prolifera* (Forsskål) J.V. Lamouroux. Since the 1970's, C. prolifera has greatly expanded its distribution inside Mar Menor, where it today occupies the majority of the seabed, at the expense of *Cymodocea nodosa* (Ucria) Asch., that retreated to a few very shallow areas, close to the shore line. The expansion in the distribution of the *C. prolifera* has also contributed to a shift in the seabed type, as its installation is accompanied by a silting up of the superficial sediment, due to fine particles trapped by the root system. Thus, the bed sediment grain size composition is predominantly muddy and sandy, with some areas of natural rocky bottoms around islands and some calcareous and volcanic outcrops. Muddy bottoms, which cover both the whole central area of the lagoon and the shallow zones showing lower hydrodinamism, are covered mainly by a dense meadow of the macroalgae *C. prolifera*. Sandy bottoms (with sand content up to 89%) are located at the margins of the basin and in the small bays surrounding the islands, in which sparse patches of the phanerogame *C. nodosa* grow.

The acoustic survey was undertaken in muddy bottom areas, densely covered by *C. prolifera*, and in sandy bottom areas, where its biomass per unit area is much smaller. In both areas, the survey included vegetated and non vegetated seabed. However, because muddy bottom areas appear as a result of the installation of *C. prolifera*, non vegetated muddy areas had to be artificially created, by diving and hand picking the algae.

The multivariate acoustic data obtained were analysed with PERMANOVA, under the null hypothesis that no differences would exist in the acoustic signature of vegetated versus non vegetated areas with similar and differing superficial sediment grain-size, at 50 kHz and 200 kHz echo sounder frequencies.

Deep-water multibeam seabed characterization for large-scale habitat and environmental studies within the Irish EEZ

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High frequency multibeam (EM120-12 kHz) bathymetry and backscatter datasets acquired during the Irish National Seabed Survey (2000-2002; www.infomar.ie) have been used in this study to characterise over 700,000 km² of the Irish EEZ (circa 7 times the size of Ireland). Large-scale seabed automated image classification on backscatter data has been performed, to provide baseline physical seafloor maps, over water-depths ranging between 500 and 5,000m, primarily for use in habitat and large-scale environmental studies (e.g. IOSEA). In general, the multibeam backscatter response within the study area ranges from low to moderate (interpreted as a range of fine mixed sediments), with discrete high levels corresponding to hard seafloor patches. Supervised backscatter image classification results shows a number of consistent classes across the study area related to soft-hard and smooth-rough descriptors. The primary control over the image classes are intensity features (e.g. mean, quantiles), however, textural features (particularly variance) provide valuable insight into the morphological aspects of the near-seabed composition. Bathymetric features (e.g. slope, rugosity) have been integrated and correlated to the backscatter results. Furthermore, classification scales, image features, validation and interpolation techniques have been topics examined and discussed.

New Zealand's Ocean Survey 20/20 programme: understanding the relationships between seabed habitats and biodiversity using broad-scale mapping surveys

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Since vast areas of the sea-bed are at best only poorly mapped, it is important to implement and test standardised methods for quantifying broad-scale relationships between sea-bed habitats and biodiversity in order to characterise large areas of the ocean domain. Over the next 15 years, a series of systematic surveys will be conducted under the auspices of an ambitious New Zealand government-funded, multi-institutional programme known as Ocean Survey 20/20 (OS 20/20). The first surveys associated with this programme were completed in 2006-07 and focused on two large, deep-ocean domains: Chatham Rise to the east of the New Zealand landmass, and Challenger Plateau to the west. These two regions are physically and oceanographically dissimilar, with the Challenger Plateau bathed in warm, nutrient-poor subtropical water and the Chatham Rise located beneath the dynamic Subtropical Front where subtropical and cold, nutrient-rich subantarctic waters meet. However, broad-scale marine environmental classification schemes using physical proxy data suggest similarities at some classification levels.

The Chatham-Challenger OS 20/20 project involved initial, detailed bathymetric mapping of the sea-floor with a multi-beam echo-sounder (Simrad EM300) across predetermined environmental and/or disturbance gradients. These geo-referenced back-scatter and bathymetric data were analysed with benthic terrain modelling and multivariate statistical techniques using physical proxy data (e.g., sea-surface temperature, modelled tides, satellite-derived surface chlorophyll concentrations) to identify environmental zones, or strata. These strata were then sampled directly for biological and sedimentological data (physical, chemical, compositional) on subsequent voyages using towed camera systems (video and still photography), sleds, corers and trawls. The methods used to plan the sampling strategy for the Chatham-Challenger surveys, together with initial results outlining the range of data acquired and the analyses that are planned, will be described.

Using environmental data to predict the occurrence of species and biotopes as part of the South Coast Regional Environmental Characterisation (UK)

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In 2007 the British government commissioned Regional Environmental Characterisation (REC) surveys of the Thames and South Coast regions through the Marine Environment Protection Fund (MEPF). Subsequent REC surveys were commissioned in 2008 for the Humber and East Coast regions. The primary objective of these surveys is to provide a broad scale characterisation of seabed habitats, which can be used to put smaller scale environmental impact assessments into a broader spatial context and to facilitate the identification of areas of conservation significance. The REC survey data will also be used to inform Marine Spatial Planning (MSP). Therefore, it is a pre-requisite that the end product is scientifically robust, fit for purpose and readily accessible to a multitude of stakeholders. The REC surveys have acquired numerous environmental and biological datasets at a variety of resolutions over extensive areas. Here we present the findings of the South Coast REC and the approach used to integrate these data into a comprehensive study.

Data collected using Side-Scan Sonar, Multi-Beam Bathymetry, Boomers, Magnetometers, Clam shell grabs, biological grabs, scientific beam trawls and seabed imagery were initially analysed in isolation prior to the creation of geological and biological character maps using a "bottom-up" approach. The completion of this stage allowed a comprehensive understanding of the data to be developed, providing solid foundations upon which to progress the integration of data. The relationship between environmental conditions and the occurrence of key species and biotopes was investigated, with the results subsequently used to predict species distribution across the area. This platform provided the basis for the final environmental characterisation, which was tested using alternative datasets from the area. Proofing the document in this way allowed us to give each of the final character maps an associated level of confidence, so that the end users are fully aware of the scope and limitations of the broad scale classifications.

Regional Environmental Characterisation Programme: Provision of integrated broadscale seabed maps for strategic aggregate extraction areas within UK waters to inform sustainable resource management

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Four Regional Environmental Characterisation (REC) projects are currently underway covering strategic areas of current and proposed future marine aggregate extraction in English and UK offshore waters. These projects have been commissioned by the Marine Environment Protection Fund (MEPF, http://www.alsf-mepf.org.uk/) under the UK's Aggregate Levy Sustainability Fund with the aim of developing a broad understanding of the seabed habitats, their biological communities and potential historic environmental assets within each region and provide an insight into the processes that influence them. The projects integrate new and existing geophysical, geological and biological data and will produce comprehensive broadscale seabed maps. The interpretations and maps produced will make a valuable contribution to the way in which the UK manages its marine aggregate interests in the future and will also provide a useful resource for wider marine management. The four regions covered by the programme are the Thames Estuary (off the Essex and Suffolk coasts), the South Coast (off Hampshire and Sussex), the Humber (off Lincolnshire and Humberside), and the East Coast (off the Norfolk coast).

Each REC is being conducted by a consortium of partners involving environmental and heritage experts and subdivided into a data acquisition and data interpretation phase. During data acquisition, geophysical surveys are conducted along regular grids, acquiring high resolution sidescan sonar, swathe and single beam bathymetry, subbottom profiler and magnetometer data. This is followed by geological and biological surveys utilising vibrocores, hydraulic grabs, Hamon grabs, 2m scientific beam trawls and digital still and video systems. These provide additional information and validate the interpretations of the geophysical data. The data are used to produce regional seabed maps, illustrating the distribution of seabed morphology and sediments, and of marine habitats and species, including those of significance for conservation and fisheries, and features of archaeological significance. All data will be provided in standardised GIS formats capable of being utilised by a number of organisations, and UK and EU marine data initiatives.

To date, geophysical surveys have been completed for all regions except the Humber collecting approximately 4,300 line kilometres of acoustic data. Biological and geological surveys have been completed for the Thames and South Coast region, and the data are currently being interpreted by the contractors. Biological and geological surveys for the Humber and East Coast region are scheduled for summer 2009. This presentation will summarise the survey and interpretation methods used, area covered, and, if available, results of the Thames REC.

The Bjørnøya Slide Scar revealed through high resolution bathymetric data, SW Barents Sea shelf margin

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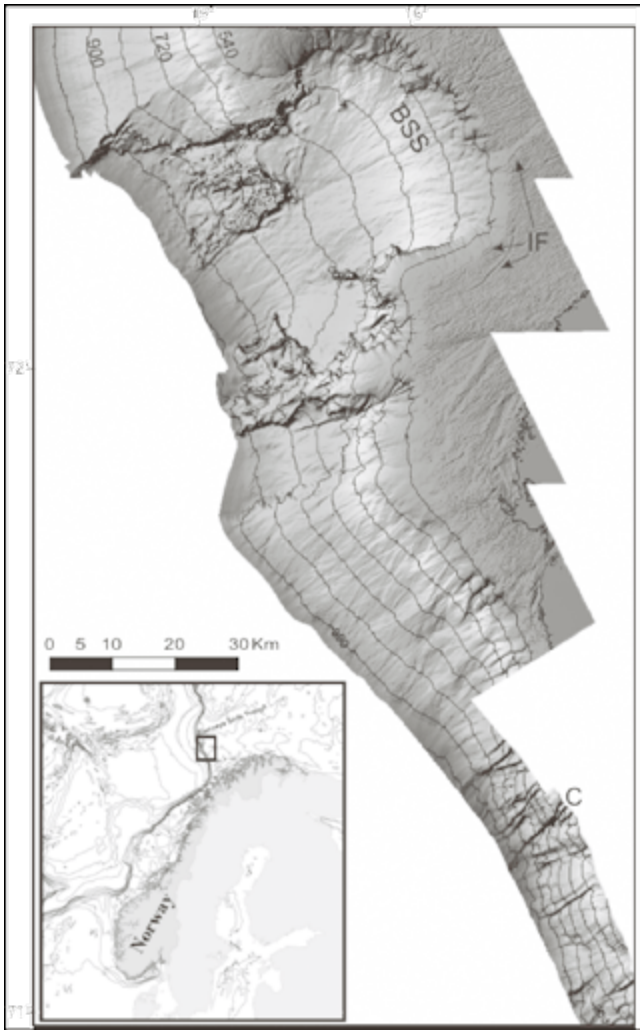
For the first time, the bathymetry of the Bjørnøya Slide Scar on the upper part of the Bjørnøya Trough Mouth Fan (BTMF), SW Barents Sea, has been mapped in great detail. As part of the MAREANO Program (www.mareano.no), initiated in 2005, the Bjørnøya submarine slide scar along with many other interesting features, such as small canyons, iceberg scours, large sediment waves and other bedforms on the upper continental slope were mapped in early 2009. The area covers around 18 000 km2 and is located between 71° and 72,5° N, and 14° and 16° E. This slope area is of special interest due to its location between the wide, open Barents Sea area to the east, and the deep ocean areas of the Norwegian Sea to the west. Some important topics are seabed stability, habitats, and depositional environments.

The MAREANO Program was initiated to map and study the seafloor of the SW Barents Sea and areas offshore Lofoten-Versterålen. Physical, biological and chemical information is collected to produce maps of hydrography, geology, biology, benthic habitats, nature types and environmental status to allow proper management of the Norwegian marine territory.

The objective of this poster is to present the bathymetry and preliminary data and hypotheses on some features identified in the southern part of Bjørnøya Island Trough Mouth Fan.



Location map and multibeam bathymetry of the study area. Contour interval=90 m. BSS=Bjørnøya Slide Scar, IF=Iceberg furrows, C=Canyons/Channels.

Analysis of relationships between seabed species/ assemblages and their physical environment using Random Forests statistical methods

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The distribution and abundance of marine species and assemblages is of fundamental interest to science and of considerable importance to management and conservation. For most marine species, such information is severely lacking, partly due to the great expense and time required for biodiversity surveys. There is increasing interest in the use of more easily obtained/existing data on the physical environment for use as surrogates for predicting biodiversity distribution. As a contribution to the synthesis phase of the International Census of Marine Life (CoML), this project is analysing mesoscale datasets from shelf biogeographic regions in tropical Australia and Gulf of Mexico and temperate Gulf of Maine Area using Random Forests (a bootstrapped randomized tree method). Contributing CoML programs are in the process of collating regional broad-scale biological survey datasets comprising site-by-species abundance data from trawls, benthic sleds, and grabs/cores, as well as site-by-physical datasets comprising as many available variables as thought to be important for influencing marine distributions at mesoscales. Newly-developed analytical scripts (undergoing simulation) will collate split points from regression trees and Δdeviance information for each species and physical variable. Results will be expressed as cumulative frequency distributions of splits, weighted by deviance, summed over multiple species within chosen levels of aggregation. These distributions are thus expected to represent patterns of biological (change) response along gradients for each physical variable. The outputs would also summarise the potential prediction performance of physical surrogates and the physical variables that contribute most. Through development of these Random Forest analyses we hope to: (1) summarize the extent to which physical surrogates may explain biological patterns; (2) rank the importance of physical variables for structuring biological patterns; (3) examine common biological responses to their gradients; and (4) identify critical values for each physical variable that correspond to 'threshold' changes in biological patterns; where "biological patterns" may be many individual species, multi-species assemblages, and some diversity attributes. Although still in the simulation and validation phase, we anticipate these new statistical methods to have significant potential to: (1) yield a robust method to compare across surveys using disparate sampling and tools; (2) contribute to understanding of ecological drivers in the marine environment; (3) provide information to facilitate design of future biodiversity sampling programs and (4) assist in first order seabed characterisation in data poor situations (eg. for spatial planning, effective ecosystem based management and conservation planning).

Towards image-based habitat classification

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Autonomous Underwater Vehicles (AUVs) and towed systems designed for benthic imaging routinely gather large amounts of geo-referenced optical imagery. It is now possible to generate large-scale 2D mosaics and 3D reconstructions from this data if the platforms are properly instrumented. These composite representations are useful for exploration and preliminary understanding but further analysis and abstraction is needed to address tasks such as habitat characterization, mapping and the development and appropriate zoning of marine reserves and marine protected areas. Human experts currently perform the analysis stage, which limits the speed at which data can be processed. While it is unlikely that machines will match the fine-scale classification ability of humans we argue that machines can now perform preliminary, coarser classification to provide timely and relevant feedback to assist human decisions and enable adaptive AUV behaviour.

Several object recognition systems inspired by the 'bag of words' technique for document recognition have been demonstrated on challenging visual tasks. These techniques represent an image (document) as a collection of visual features (words). A set of training documents is used to build a vocabulary of words so that query documents can be described by the frequency of occurrence of all the words in the vocabulary set. In the case of images, these approaches typically use local features that select distinctive regions and describe them in a manner that is robust or invariant to changes in scale and orientation. The approach essentially finds the images in the training set that are closest to the query image. Since we assign a class (habitat) label to each training image, it is possible to assign a class to the query image based on the class of the closest training image.

In this paper we investigate the use of visual 'words' to classify marine habitat based on imagery. We cover a basic 'bag of words' approach and a more sophisticated one that learns an intermediate level of abstraction analogous to 'topics' in text documents, allowing for an image to be represented as a mixture of topics (i.e., visible substrates and benthos), which provide a more accessible and relevant representation for science users. We discuss some implementation issues concerning visual features and the importance of colour information. The results section provides preliminary comparisons with traditional methods on data sets covering a broad range of habitats in Australian waters including Ningaloo Reef (Western Australia), Hydrographers Passage (Queensland) and the Tasman Peninsula (Tasmania).

The Astafjord project – collaboration between six coastal municipalities in Troms, northern Norway

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Fisheries and aquaculture generate huge values from marine resources along the Norwegian coast. At the same time, the knowledge of the environmental conditions is rather limited. The Astafjord project is a pilot project, which may serve as a model for a full coverage mapping effort for the entire coastal zone of Norway, facilitating economic growth and maintaining a sustainable environment.

Astafjordane is a fjord system located in Troms County, northern Norway. Here, a group of local municipalities have joined forces to make better plans for the management of their marine areas. The plan covers location of fishfarms, fishing- and spawning areas, environmental status, and the location of infrastructure to optimize the use of their marine areas.

As part of the project, swath bathymetry and backscatter data for the fjords have been collected and groundtruthed by video and grab sampling. The benthic faunal assemblages and content of pollutants in the sediments have also been mapped. Marine base maps are being developed including geological maps and derived thematic maps incorporated in the Astafjord area plan as a GIS. These include sediment grain size, geomorphological elements and their origin, slide hazard, anchoring conditions, relative bottom current velocity, potential oxygen deficiency areas and habitat maps. Simultaneously these base maps are made into electronic charts for use on chart plotters on work vessels, and they will be published on www.mareano.no.

Through the Astafjord project the municipalities get tools for knowledge-based management of their marine areas, including far better knowledge on potential habitats for vulnerable species and increased awareness and protection of important fishery areas. The environmental status for the area is presently good, and the data provide a base line for future monitoring.

Mapping the inshore zone and shallow waters: a strategy

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This paper describes how we designed a strategy for data acquisition and interpretation in the tidal and shallow water areas by using a combination of techniques and illustrates the main is-sues thereof. The scope of mapping is basically twofold: a) to provide comprehensive and reliable maps of habitats distribution for applications such as Natura 2000 site specific management or developments in the coastal zone, b) to provide a very detailed baseline map of some key habi-tats such as sea grass or maerl beds, with a view to design monitoring surveys schemes. The strategy breakdown is illustrated by a recent case study in Trégor, northern Brittany, France. The work is inspired by the Mesh recommendation featured in the project's guide for habitat map-ping, stating that remote sensing (of depth and facies) followed by directed ground-truth sam-pling is the optimal approach for habitat mapping surveys. The remote sensing allows the survey area to be segmented into ground types, each of which can then be targeted to ensure representa-tive ground-truth sampling.

After a gap analysis has revealed the value of historic data that can be made available to the pro-ject, survey scoping is performed, i.e. site coverage using a combination of optical and acoustic remote sensing techniques, design of ground truth operations, interpretation steps. In theory these steps are mostly sequential: a first step aims at providing a morpho-sedimentary map of the area, which in a second step is made into a habitat map by incorporation of biological data. This is mostly the case in the subtidal zone where a most comprehensive picture of the seabed is required to optimise the ground truth strategy and carry it out in one go. The tidal zone slightly differs in that a number of habitats can be identified right away from remote sensing data - hence reducing field work – and also field work can easily be adapted and repeated if it proves insuffi-cient.

The complete pattern of habitat coverage can be inferred from the associated data collected by remote sensing and ground-truth sampling, through a process of empirical analysis, direct inter-pretation or even modelling.

Developing habitat type maps according to the European standard (EUNIS) by linking geology, oceanography and biology

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The inner part of the Oslofjord (a bay in the south-east of Norway) is detailed mapped with respect to bathymetry and sediment characteristics. Additionally, information on the biological community at specified positions from numerous samples carried out by students and staff at University of Oslo and by researchers at Norwegian Institute of Water research is compiled for the area. In this study we have linked geological and physical data (depth, sediment type, wave and current exposure) to biological data in order to establish maps of a fine resolution of the most important habitat types (defined according to the European standard EUNIS) with respect to marine biological values within the area.

Linking substrate with biodiversity: how does the approach to substrate analysis influence our conclusions?

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Substrate has strong ties with biodiversity and video survey techniques have assisted in a better understanding of these relationships. However, the transcription of video data into quantitative and qualitative information is often too time consuming or costly to complete and consequently data is aggregated during this analytical phase. The approach to substrate analysis varies from recording substrate majority, to presence-absence, to percent cover, and this may affect our interpretation of the relationships between substrate and biodiversity. Currently, the choice of which substrate analysis technique to use is often an individual or situation specific decision. In this study we investigate how the scale of substrate analysis can affect our interpretation of the data and discuss the potential of this work as a decision making tool when approaching the analysis of video based data of the seafloor. We examine data obtained from video collected from a survey of deep seafloor habitats in the Gulf of Maine, Northwest Atlantic, in July 2006 using the Canadian underwater research vehicle ROPOS.

Use of underwater video for quantitative identification of benthic biotopes: experience from the Baltic, White and Black Sea

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The poster presents results of various underwater video surveys performed in 2004-2008 in the coastal zones of the Baltic, White and Black seas. A drop-down underwater video filming system was used, equipped with a depth sensor, two laser beams indicating a 10 cm scale and GPS positioning data embedded in the image. The system was used to record soft, hard and mixed bottoms. The recording was performed along the profiles of different lengths, from ten up to few hundred meters, depending on local conditions, mainly transparency of water, wind and currents. The laboratory treatment of video records included several subsequent steps: 1) preliminary reviewing of records obtained in a study area and delineation of biological and physical features to be used for quantitative analysis; 2) estimation of the exact length of the profile using GPS coordinates and record time; 3) partition of each video profile into segments of equal lengths, usually 20 m; 4) analysis of each segment as an independent sample using predefined quantitative and qualitative features; 5) use of multivariate statistical methods for designation of groups of segments with identical or similar features; 6) identification of benthic biotopes by description of common group attributes.

The physical features used for the identification of the biotopes included: type and uniformity of substrate (sand, gravel, stones or mixture of stones and sand, etc.), depth (as proxy for light availability for plants and comparative strength of wave action), presence of sandy ripples, etc. The biological attributes comprised: character of coverage of algal species, mussels, barnacles, number of sea stars, traces of crawling bottom animals, siphon and burrow openings and other conspicuous signals of bottom life. Both quantitative and qualitative features have been determined and used in the analysis. The poster demonstrates applicability of the technique for different marine environments.

This study in part was supported by the EU BONUS+ project PREHAB.

Morphological features of the sea bed and the relationship to marine benthic habitats on the western slope of Hatton Bank (NE Atlantic Ocean)

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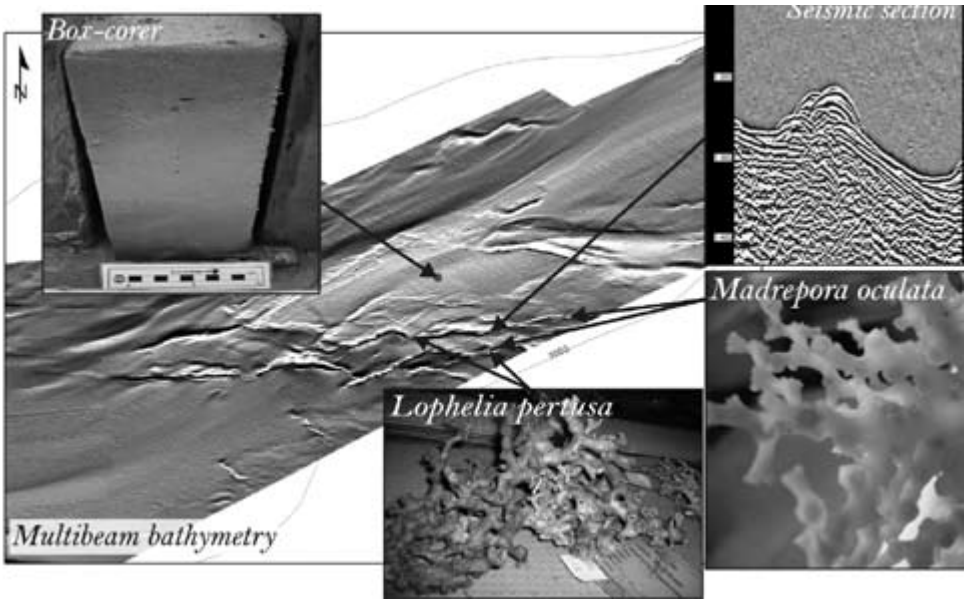
The study area of the interdisciplinary research project ECOVUL/ARPA is located on the habitual fishing grounds of the Spanish bottom trawlers on the western slope of Hatton Bank, between 700 and 1600 m water depth. The main objective of the project is to identify vulnerable habitats and suitable areas to protect. This study is being carried out using multibeam bathymetry and high-resolution sub-bottom seismic profile data correlated to dredge, bottom trawl and longline sample data and linked to information from observers on commercial trawlers. The various datasets were collected by the Instituto Español de Oceanografía and the British Geological Survey.

This work is focused on the relationship between the morphology of the sea bed and the habitats of invertebrate benthic species. It can be shown that benthic communities are sparse where the sea bed comprises mobile sediments, such as the Hatton Drift in the deeper water, and more common where the sea bed comprises a hard rocky substrate, as observed in shallower water on the top of Hatton Bank.

The majority of the species associated with a hard substrate belong to the Phylum Cnidaria, mainly colonial scleractinians such as Lophelia pertusa, Madrepora oculata and Solenosmilia variabilis. In addition, several species of the Phylum Porifera have been collected but in a lower percentage. Other specimens found in this area belong to the Phyla Annelida, Arthropoda, Mollusca, Bryozoa, Echinodermata and Chordata. Most cold-water corals are observed in the "ridges" area as well as in the central part of the study area. Hard substrate (often where basalt lavas crop out at the sea bed) acts as a suitable platform for cold-water corals to become established and develop into mounds (as for example on top of the ridges). These kinds of habitats are home to a high faunal biodiversity and are considered to be vulnerable ecosystems.



Tale of Two Seamounts: Mapping Cold-water Coral Habitats in the Drake Pas

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The Drake Passage is the 800-kilometer-wide, 5000-meter-deep, gap between the southern tip of South America and the Antarctic Peninsula, where the strong west to east flow of the Circum-Polar Current is intensified by constricting land masses on either side. The Drake Passage is of great importance because of the role it plays as a biogeographic barrier between South America and Antarctica and as a conduit for Pacific species to the South Atlantic and Indian Oceans. Sars and Interim Seamounts could provide stepping stones of hard substrate for sessile organisms such as cold-water corals. Because of the severe climatic and oceanographic conditions and remote location, however, the seafloor in the Drake Passage has not been well mapped and little is known about its benthic ecosystems.

We mapped two seamounts in the middle of the Drake Passage while aboard the R/V Nathaniel B. Palmer during April and May 2008. Sars Seamount lies about 180 kilometers northwest of the second, unnamed, seamount which we call Interim Seamount. We used the hull-mounted Simrad EM120 (12 kHz) multibeam bathymetric mapping system to collect nearly complete bathymetric data coverage of both seamounts. Over 2600 still photographs were collected along 5.7 km of towpath on Interim Seamount and 1700 along a 3.3 km towpath on Sars Seamount using WHOI's mini-TowCam camera system. In addition, dredges and trawls were used to collect rocks and animals from both seamounts. Six box dredges and three Scripps-style rock dredges were deployed at Interim Seamount in water depths between 759m and 1938 m. Seven box dredges and one otter trawl were deployed on Sars Seamount in water depths between 672m and 1977m.

Our multibeam bathymetry data show that both mapped seamounts are approximately 20 kilometers across, but have different morphologies, perhaps due to different origins and histories. Interim Seamount is elongate along a NE-SW oriented axis, approximately parallel to the axis of an extinct spreading center and perpendicular to the Shackleton Fracture Zone. This ridge-like morphology may reflect its origin at a spreading center, whereas the more equant, flat-topped morphology of Sars Seamount is more typical of a seamount formed in a mid-plate setting and subsequently eroded. Rock samples recovered from both seamounts are basalts, some are scoriaceous and some appear to be pillows.

A wide variety of live benthic animals were collected from both seamounts, including many octocoral orders and stylasterids. Live solitary scleractinian corals *(Caryophyllia sp.)* were found on Sars but not on Interim. Fossil solitary scleractinian corals *(Caryophyllia sp.* and *Desmophylum dianthus)*, however, were found on both seamounts, suggesting a possible change in environmental conditions.

Quantitative comparison of independent single-beam, sidescan and multibeam benthic habitat maps, Te Matuku Marine Reserve, New Zealand

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The mapping of benthic habitats by means of echosounder data classification and ground-truthing is becoming increasingly popular following the accelerating decline of global marine fisheries. With an ever-growing number of acoustic systems and processing methodologies available, a need for the comparison of the effectiveness of different systems and techniques is emerging. However, while comparative studies on a theoretical level are flourishing, experimental comparison studies are still relatively rare. This paper aims to (i) present measures for the comparison of maps, inspired mainly by the literature in land cover mapping, (ii) illustrate their use with a case study that includes a collection of single-beam echosounder (SBES), sidescan sonar (SSS) and multibeam echosounder (MBES) independent benthic habitat maps, and (iii) provide a first quantitative assessment of the complementariness of MBES with its more traditional counterparts for benthic habitat mapping. Three maps of the same subtidal habitats of the Te Matuku Marine Reserve (Hauraki Gulf, New Zealand) were formed and then compared. The SBES map was obtained from a 200 kHz SBES dataset (Simrad EA501P) classified with AGDS software QTC VIEW and ground-truthed with targeted video survey. The SSS map was obtained from a 100 kHz SSS mosaic (Klein 595) manually classified and ground-truthed with a randomly positioned sediment-sampling survey. The MBES map was obtained from a 300 kHz MBES backscatter dataset (Simrad EM3000) processed and semi-automatically classified and ground-truthed with a regularly positioned video survey. The quantitative comparison included measures of map accuracy ("overall accuracy", "Cohen's Kappa", "Tau"), maps agreement ("Average of Mutual Information"), and agreement between two statistical categorical variables ("Pearson's C", "Cramer's V"). All measures of similarity were found to be consistent with one another and the three benthic classifications were found to agree globally, but with different magnitude. The MBES and SSS classifications had strongest agreement while the SBES results were found to be in closer agreement with the MBES classification than with the SSS classification. Strong agreement between MBES and SSS classifications supports the idea that MBES backscatter can be used as an efficient alternative to SSS mosaic for full coverage imagery-based benthic habitat mapping. Relatively weak agreement between SBES and SSS classifications supports the idea of a need for systematic utilization of multiple systems for benthic habitat mapping.

Coastal-Marine Ecological Classification Standard (CMECS) of Govatr Bay,Iranian Coast of the Oman Sea

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The main aim of this research was classification of marine- coastal habitats in Govatr bay which located in Iran-Pakestan border and South East of Sistan-Blaluchetan Province, Oman Sea coastal zone, Due to fisheries and environmental importance in order to identical with international classification, Method is based on Coastal-Marine Ecological Standard Classification (CMECS) with three information and data layers including Water Column Component(WCC), Benthic Cover Classifier(BCC) and Geoform Component (GFC). Layers and habitats information analyzed by GIS for mapping and classified of coastal zones with coding system for diverse habitats in coastal zones, which indicators and sentinels species were determined for each of ecosystems. WCC classification for this zone was based on planktonic communities as column indicator species. The result was showed that spring habitat (including spring, summer and winter) and fall habitat were two specific habitats, based on monsoon season. According to different biotope Benthic Cover Component in Govatr Bay divided into unmixed Macrobenthoz community (polychaete) and mixed Macrobenthoz community including polychaete, Amphipoda, Gastropoda. And regarding Geoform this area is considered as embayment.

Key words: coastal-marine ecosystem, CMECS ,GIS, Govtr Bay,Oman Sea

INFOMAR –Towards 100% coverage physical habitat mapping of the Inshore Irish Seabed

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Between 1998 and 2005, the Geological Survey of Ireland and the Marine Institute worked together on the €32M Irish National Seabed Survey (INSS) project with the purpose of mapping the Irish marine territory using a suite of remote sensing equipment, from multibeam to seismic, achieving 87% coverage of the marine zone. Ireland was the first country in the world to carry out an extensive mapping project of their extended EEZ. The INSS was succeeded by the multiyear INFOMAR Programme (www.infomar.ie). INFOMAR is currently concentrating on mapping twenty six selected priority bays and three coastal sea areas. It will then proceed to complete 100% mapping of the remainder of the EEZ. Designed to incorporate all elements of an integrated mapping programme, the key data acquisition includes hydrographic, oceanographic, geological, biological and heritage data. These datasets discharge Ireland's obligations under international treaties to which she is signatory and the uses of these data are vast and multipurpose: from management plans for inshore fishing, aquaculture, coastal protection and engineering works, to environmental impact assessments and integrated coastal zone management. During the last three years of activity, INFOMAR carried out integrated surveys from the national research vessels, the R.V. Celtic Explorer and Celtic Voyager. Hydrographic, geophysical and groundtruthing data were acquired from Bantry, Dunmanus, Galway, Donegal, Sligo, Dublin, Tralee and Waterford bays. Airborne LiDAR (Light Detection And Ranging) and inshore- vessel survey have also been carried out, giving detailed bathymetric, topographic and habitat information for the shoaler waters and inshore areas. This paper will focus both on the general framework and scope of INFOMAR and the approach being taken and progress to date in achieving 100% coverage physical habitat mapping of the Irish Inshore Seabed.

European perspectives for marine knowledge and habitat mapping

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The value of a complete set of multidisciplinary interoperable marine data is much more than the sum of the parts. At present most marine data collection is focused on meeting the needs of a single purpose - as part of a regulatory requirement, for operational purposes or to further scientific understanding. The challenge is to develop a system that will allow a better identification of what is being collected, that will facilitate access to coherent data sets, that will permit the recognition of data gaps and that will shape a data collection and monitoring infrastructure directly suited to multiple applications.

Aware of these difficulties the Commission proposed a new European Marine Observation and Data Network (EMODNET) in its Green Paper on maritime policy [1]. Following an overwhelmingly positive response from stakeholders to its proposal, the European Commission, in its EU's Maritime Policy Blue Book [2], adopted in October 2007 and welcomed by the European Council in December 2007, undertook to take steps towards EMODNET in order to improve availability of high quality data.

Basic design principles of EMODNET have been formulated by the Commission together with a specially-constituted Expert Group [3]. These are (1) collect data once and use it many times (2) develop standards across disciplines as well as within them (3) process and validate data at different levels. Structures are already developing at national level but infrastructure at sea-basin and European level is needed (4) provide sustainable financing at an EU level so as to extract maximum value from the efforts of individual Member States (5) build on existing efforts where data communities have already organised themselves (6) develop a decision-making process for priorities that is user-driven (7) accompany data with statements on ownership, accuracy and precision and (8) recognise that marine data is a public good and discourage cost-recovery pricing from public bodies.

The "proof of concept" of EMODNET is being tested through preparatory actions. Portals for a number of maritime basins are being set up for hydrographic, geological, biological and chemical data as well as functional habitat maps. These portals will provide access to marine data of a standard format and known quality and identify gaps in coverage. The projects will identify the main challenges in moving from an ur-EMODNET to an operational EMODNET.

A roadmap has been published in April 2009. An impact assessment to be completed in 2009 will assess options for moving towards a definitive EMODNET, both in the intermediate period 2011-2013 and in the long term after 2014.

[1] COM(2006) 275 final
[2] COM(2007) 575 final
[3] http://ec.europa.eu/maritimeaffairs/eu-marine-observation-data-network_en.html

Preliminary results of sandbanks delineation in the Baltic Sea: matching of physical, sediment and biological characteristics

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Vast sandy bottoms are typical for the south-eastern part of the Baltic Sea. They are being explored as a possible source of sand and gravel. On another side, special formations of the sandy bottoms, sandbanks, are considered as potentially valuable nature conservation types according to EU Natura 2000 Directive. The aim of this study was to delineate characteristics specific for the sandbanks in the naturally stressed (low salinity) and species-poor Baltic environment. The study was carried in the Lithuanian coastal zone in 2006-2007. Two sandbanks, preliminary identified on nautical charts by seabed elevation were investigated: the sandbank A covering an area of 4.2 sq. km and stretching in N-S direction parallel to the shore; and sandbank B covering 1.9 sq km, stretching in E-W direction. Both sites were located within 4-6 nautical miles from the coastline. In total, 41 grab samples were collected for macrofauna analysis, and 30 for the granulometric analysis. The macrofauna comprised 15 species. The benthic community on the sandbanks were dominated by the polychete *Marenzelleria neglecta*. That community occupied the entire sandbank B and the central part of a sandbank A, while the edges were dominated by the bivalve *Macoma balthica* and polychete *Hediste diversicolor*. More sophisticated numerical delineation of the sandbanks using geological (sediment grain size and sorting) and biological (diversity, abundance, biomass) data did not reveal, however, confident differences between the sandbanks and surrounding bottoms. The study is planned to be continued applying benthic imaging methods and denser sampling of the sites. This research was in part supported by the EU BONUS+ project PREHAB.

Linking the geology and the biology on Hatton Bank, NE Atlantic

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Data acquired for the Strategic Environmental Assessment (SEA)[1] of Hatton Bank in the NE Atlantic in 2005 and 2006 have been used to interpret the substrate type and geomorphology of the Bank. The geological interpretations have been utilised as a framework on which to place smaller-scale biological interpretation. The relationship between the biological communities and the underlying geology has been used to extend the biological interpretation over the entire survey area which is crucial for the development of a network of Marine Protected Areas.

Hatton Bank is an elongate, relatively shallow bathymetric high (~500m) located on the western edge of the Rockall Plateau. The western margin descends into the Iceland Basin and the eastern edge into the Hatton Basin, sometimes referred to as the Hatton–Rockall Basin. The summit of the Bank is host to a number of geomorphological features such as iceberg ploughmarks, terraces, circular depressions and isolated topographic highs such as pinnacles and carbonate mounds. Much of the surface of Hatton Bank comprises predominantly sandy sediment, with gravel rich sediment characterising the base of escarpments, terraces and forming a ring around pinnacles and carbonate mounds. Volcanic rocks also form individual geomorphological features, for example Lyonesse volcanic centre, where the Paleogene volcanics protrude through the younger Cenozoic sediments to form a series of pinnacles at sea bed.

The geomorphology and sea-bed sediment layers have been overlain with the interpreted biological communities, mapped from video and digital camera data, within a GIS[2]. A clear relationship between the two is evident, for example: areas of cold-water coral reef tend to correspond with areas of rock outcrop forming a positive topographic feature; areas of lithic gravels associated with iceberg ploughmarks form havens for rock fish communities; and general areas of featureless sea-bed host xenophyophores where bottom currents are accelerated over subtle undulations of the sea bed.

These results will feed into ongoing work to designate Special Areas of Conservation as defined under the EC Habitats Directive and the use of Marine Protected Areas as a conservation tool.

[1]*The SEA surveys were paid for by the UK Department of Trade and Industry (now the Department of Energy and Climate Change www.offshore-sea.org.uk) and Defra (Department of Environment, Food and Rural Affairs www.defra.gov.uk/).*
[2]*Geographic Information System*

Constraining the geomorphological setting of deep-sea biotopes using high resolution bathymetry at the Condor de Terra seamount

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Condor de Terra is a seamount located 12 nm to the SW of Faial Island (Azores, NE Atlantic) that has been a traditional fishing ground exploited by bottom longline and hand-line. Given its typical seamount geomorphology, confirmed cold-water coral assemblages and accessibility from IMAR/DOP-UAz, the area is currently the focus of three complementary seamount characterization and monitoring research projects (CORALFISH, CORAZON and CONDOR).

Surveys of the seafloor types and associated biological assemblages present in the area started in 2006 with drop-down camera transects executed during the "Defending our Oceans" Greenpeace expedition. The planated summit exhibited collections of well-rounded boulders and was dominated by dense gorgonian stands typified by *Viminella flagellum* and *Dentomuricea sp*. The images obtained over the slopes prevailingly showed sediments that were generally devoid of tall habitat-building organisms.

In 2008, new multibeam data were acquired for the area by the Portuguese Task Force for the Extension of the Continental Shelf and one dive was conducted at the eastern end of the seamount with the new 6000m-rated ROV Luso.

This poster presents a preliminary habitat and biotope inventory for Condor de Terra seamount that brings together the multibeam data with the geo-referenced geological and biological features identified on the video surveys. The occurrence of well-preserved examples of *coral gardens* and *deep-sea sponge aggregations* (two biotopes of conservation importance under the OSPAR Convention) is recorded and suitably illustrated.

The new information (i) resolves the topography of the seamount in unprecedented detail, (ii) clarifies which physiographical features had actually been surveyed by the 2006 video transects and (iii) increases the understanding of the geomorphological associations of biotopes. This knowledge is instrumental to design the comprehensive surveys that are planned for the area in the scope of the ongoing projects.

Seafloor diversity and spatially-explicit predictive modelling of dominant macroalgae distributions on the volcanic island shelf of Faial (Azores, NE Atlantic)

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A multidisciplinary approach to marine habitat mapping is presented that brings together geologic, oceanographic and biologic data. The study focus on the Faial and western Pico shelves (Azores, NE Atlantic) - an area of great relevance for nature conservation that includes five Special Areas of Conservation (SACs - Natura 2000 network), one OSPAR marine protected area, one long-term biodiversity research reference site (project BIOMARE) and zones designated under the Azores network of Protected Areas.

A geomorphologic inventory based on extensive swath bathymetry surveys of the study area is firstly introduced that yields the first state-of-the-art of an island shelf area in the Azores archipelago. A complex pattern of tectonic, volcanic and erosion features is illustrated in previously unreported detail. Features described include (i) tectonic faults expressed on the seafloor surface, (ii) the submerged evidence of fissural volcanic activity associated with some of these faults, (iii) a variety of lava flow morphologies penetrating the present waterline, (iv) submerged palaeoshorelines, (v) boulder slopes generated by coastal erosion and (vi) a basin in the southern half of the Faial-Pico passage. Extensive sedimentary expanses are also mapped and their dynamics discussed in view of the large bedforms they contain and new data on the local hydrodynamic conditions.

The presentation is concluded with a demonstration of how high resolution seafloor parameters derived from the multibeam surveys (namely, substrate nature, depth and slope), together with oceanographic variables (average sea surface temperature, average chlorophyll-a concentration, maximum tidal currents and exposure to swell), can be effectively used to produce ordered logit regression models of the distribution of six dominant infralittoral macroalgae (articulated Corallinaceae, *Codium elisabethae, Dictyota* spp., *Halopteris filicina, Padina pavonica* and *Zonaria tournefortii*). The statistical model equations and the raster fields of the explanatory variables found to be statistically significant are ultimately used to present the first predictive maps of the abundance of these macroalgae and of the distribution of the main algal assemblages on the Faial island shelf.

The Coramm (Coral risk assessment, monitoring and modelling) Project

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The CORAMM project is aimed at improving the understanding of the impacts of high suspended sediment loads and drill cuttings on cold water coral communities. The project is multidisciplinary in approach, with sedimentologists, biologists, modellers and representatives from Statoil all involved in furthering the current understanding of these ecosystems. The project has four workpackages. WP1 concentrates on the development of new video and image analyses to better and faster evaluate coral community structure and varying health status. WP2 assembles and further develops sensor systems for environmental monitoring with special emphasis on particle dynamics. These systems can be used as autonomous stand-alone units or can be linked to the internet. WP3 carries out specific experiments with live coral colonies to better understand and predict the effect of different particle size and microbial composition. WP4 will build advanced ecosystem models for cold water corals and use a physiological- based model to predict the effect of different sediment loads on the performance of cold water corals. This poster presents the first insights of the project after 15 months of research.

MAREANO – an integrated program for marine mapping in Norway

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MAREANO maps depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian coastal and offshore regions. The Program aims to provide answers to questions such as:

- How is the seascape of the Norwegian continental shelf?
- What does the seabed consist of?
- How is the biodiversity distributed on the seabed?
- How are habitats and biotopes distributed on the seabed?
- What is the relationship between the physical environment, biodiversity and biological resources?
- What does the sediments tell us about pollution?

MAREANO is coordinated by the Institute of Marine Research, in collaboration with the Geological Survey of Norway and the Norwegian Hydrographic Service. MAREANO fills knowledge gaps related to seabed conditions and biodiversity defined in The Integrated Management Plan for the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands presented by the Government in 2006. The Plan will be revised in 2010, and MAREANO will contribute to a better knowledge base for managing human activities such as fishing and oil and gas exploitation. Priority mapping areas for this phase are located along the shelf break and on the continental shelf in the western part of the mapping area. In the Management Plan, these areas are regarded as being especially ecologically important and vulnerable. In 2010 MAREANO will deliver information about seabed characteristics and biotopes, information about the distribution of benthic fauna, communities, biological diversity and production, information about contaminants in the sediments, detailed bathymetric maps and a online database and map services collecting information on Norwegian coastal and ocean regions.

Landscapes and landforms on a high latitude glaciated continental margin

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Eight landscape types have been defined and spatially documented from a 40 000 km2 large area off Lofoten, Vesterålen and Senja in northern Norway. The area represents some of the most geologically diverse coast and offshore margin area in Norway. The basis for the classification is an integrated, hierarchical system for terrestrial, coastal and marine nature types, presently being developed in Norway. The system includes habitats as one of the levels in the hierarchy. This is the first broad-scale attempt to apply the new system in the marine domain. Detailed multibeam bathymetry data are the basis for 3D models of the seafloor, which have been analysed using modelling and GIS tools.

The study area is situated at that part of the continental margin off the Lofoten, Vesterålen and Senja islands, of northern Norway. The area has been mapped and studied as part of the MAREANO programme between 2005 and 2008. The area of interest was selected because it is topographically diverse and provides a good area for testing and development of a submarine landscape classification system.

The area we investigated is elongated in SW-NE direction, 350 km long and 80-180 km wide. It extends offshore from the coastal domain dominated by strandflats and fjords, and includes the continental shelf, continental slope, and deep sea plains to where water depths approach nearly 3000 m. The coastal region, with strandflats and fjords, are underlain by metamorphic crystalline complexes of the Fennoscandian shield, extending several kilometres offshore (Bugge et al. 1995). West of the metamorphic bedrock, seaward-dipping sedimentary rocks of Late Palaeozoic and younger age occur. The shelf is covered with Quaternary sediments, with a few exceptions, where sedimentary or crystalline rocks crop out at the seabed. The thickness of these Quaternary sediments is less than 100 m. The shelf is characterized by large banks, separated by cross-shelf troughs. The sediments on the shelf range from mud to cobbles. The deepest troughs are continuations of the fjords, and were formed by palaeo-ice streams. The continental slope has an overall dip of between 2 and 10°, and is heavily incised by submarine canyons which are up to 1100 m deep. Submarine canyons in this area form part of a high-latitude glacially influenced sedimentary system with10 canyons along the Lofoten-Vesterålen margin. Fans associated with the submarine canyons run out onto the abyssal plain.

The landscape types and landforms have a range of habitats associated with them, commonly with characteristic faunas. One of the challenges is to define landscapes in a way which has ecological significance, but still is compatible with traditional geological and geomorpho¬logical nomenclature. We will show how we have attempted to solve this challenge here.

Mapping the sea floor beneath the world's highest tides: preliminary surficial geology of the Bay of Fundy, Canada

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The Bay of Fundy is an estuarine embayment in the northeast Gulf of Maine between the Canadian provinces of Nova Scotia and New Brunswick. The largest tides in the world occur here; the tidal range is 4 m at the mouth of the bay where it joins the Gulf of Maine and attains a maximum of 17 m at the head. In 2006, the Geological Survey of Canada, in cooperation with the Canadian Hydrographic Service and the University of New Brunswick, instituted a broad-scale regional mapping program to map the entire sea floor of the Bay of Fundy. To date, 12,466 square kilometres of multibeam sonar coverage have been acquired. The resulting sea floor map demonstrates the impact of glaciation on the Bay of Fundy and the influence of the modern high tidal range, and associated currents, on sediment transport and deposition. In the Pleistocene Epoch, glacial ice flowed from the head of the bay in the northeast to the Gulf of Maine in the southwest. In the southwest, a topographically controlled ice stream existed in the bedrock trough between Brier and Grand Manan islands. Streamlined subglacial landforms (drumlins and megaflutes) are prominent on the flanks of the trough. Prominent lobate ridges, convex to the southwest, are widespread in the central portion of the bay. It is not clear if these ridges are subglacial or ice-front in origin; in any case they appear to mark a complex pattern of ice retreat to the northeast. During retreat, icebergs calved from the floating ice front; iceberg keels incised a dense pattern of scours and pits into the sea floor sediment and this pattern is used to infer paleocurrent patterns. Superimposed on the glacial landforms are Holocene Epoch sedimentary bedforms that reflect the modern current regime in the Bay of Fundy. Banner banks flank prominent headlands where currents are accelerated. The majority of the banner banks are composed of sand but gravel banks also occur. Fields of star dunes in the central bay suggest dominant and subordinate current directions. In Minas Passage, where currents reach 7–8 knots (13–15 km/hr), approximately 4 km3 of post-glacial sediment has been eroded, exposing 44 km2 of bedrock at the seafloor. Private sector interests are undertaking an engineering study for in-stream tidal power in Minas Passage. A thorough understanding of Bay of Fundy substrates and benthic habitat is required before full-scale tidal power development proceeds.

Linking backscatter, particle-size distributions and infaunal data – results from the Dogger Bank, North Sea

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Linking acoustic backscatter with seabed sediment properties as well as faunal communities via ground-truthing is crucial in habitat mapping, yet such links are only partly understood and often rely on expert judgement. Correlating backscatter with grain-size previously employed average statistics, but these are often inappropriate and do not allow for investigations into links with fauna. We therefore explored correlations in multibeam backscatter, sediment particle size and infaunal species abundance data from the Dogger Bank using multivariate techniques. The acoustic data consisted of backscatter intensity extracted from a circle of multibeam data (40 m diameter) around sampling sites. These values were used to construct histograms according to backscatter intensity, detailing the percentage occurrence of each 1 dB class. Backscatter histograms were examined using the SIMPROF routine, PRIMER v6, which identified seven genuine clusters. The clusters broadly fell into a group of high backscatter characterised by peaks in the histogram between –13 dB and –19 dB and a low backscatter group peaking between –24 dB and –31 dB. Similar analyses were performed on particle size and infaunal species abundance. Sediment particle size comprised five genuine clusters. One cluster was largely characterised by coarse sediment fractions whilst the others were fine to medium sands with varying proportions of mud and gravel. Infaunal species abundance data comprised two genuine clusters, of which Group 1 was characterised by *Bathyporeia elegans, Magelona filiformis* and *Echinocyamus pusillus.* Species that mainly contributed to the similarity within Group 2 included *Notomastus* sp., *Glycera lapidum* and *Protodorvillea kefersteini* and Nemertea. Group 1 coincided with sediments characterised as fine to medium sands and low backscatter whilst Group 2 was associated with coarse sediments and high backscatter.

Similarities in multivariate patterns between the three data sets were further explored using the PRIMER routine RELATE which measures how closely related two sets of multivariate data are by calculating a rank correlation coefficient between each component of their respective similarity matrices. Results indicated a significant correlation occurred between the multibeam backscatter and the sediment particle size ($\rho = 0.673$, significance = 0.1%) and also between the sediment particle size and the infaunal species abundance ($\rho = 0.64$, significance = 0.1%). However, whilst correlations between the multibeam backscatter and infaunal species abundance were significant ($\rho = 0.466$, significance = 0.2%) they were less pronounced than in the other comparisons.

This work results from a survey undertaken by Cefas, BGS and Envision Mapping on behalf of the JNCC, as part of its Offshore Natura Seabed Survey Programme.

A quantitative approach to seabed morphological description linked to macro-benthic variability

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Acoustic techniques, which allow us to visualise the seabed in great detail and in three dimensions, present a challenge to the marine scientist. How do we adequately describe the seabed in a way that is consistent, and useful, when relating it to biological communities? Whilst there are already well established classification systems for describing the physical nature of the marine environment at various scales, ranging from sediment grain-size descriptions through bedforms to broad-scale physiographic zones, there is a need for a quantitative approach to high-resolution seabed morphological description..

Current habitat mapping techniques employ a variety of approaches in classifying the seabed. These tend to fall into two main categories; relying either on expert opinion or statistical methods. Broadly speaking the geological community prefer to use expert opinion in producing habitat maps whilst scientist with a biological background utilise statistical methods to describe and correlate changes in biological communities with environmental parameters. Both approaches have strengths and weaknesses associated with them. The statistical methods can often be "black box" in their approach, resulting in mapped regions that are not linked to the physical processes that formed them. On the other hand, maps based on geological/process boundaries are much less likely to have the same quantitative consistency or repeatability as the statistically based methods.

By combining the two techniques it is hoped that quantitative, yet process based, descriptions can be used to create a more thorough and integrated understanding of the marine environment. At present the link between areas mapped using remote sensing and habitats is not always well understood. Accurately classifying the physical variables and understanding the process which led to their present state will assist us in making a process-based link between the physical and biological environment. This will not only lead to more robust maps but also allow better management decisions to be made. It will provide a more compete understanding of how the ecosystem functions and therefore the likely effects of future change.

The results of a pilot study at a disposal site for dredged material are presented. Within the disposal site there are areas with varying amounts of accumulated sediment ranging from high to low rates of accumulation. The physiographic changes in the seabed that result from the disposal of dredged material are quantitatively described and compared to shifts in the benthic infaunal community.

Observation of seafloor changes in Santa Barbara Channel after 25 years

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The California State Coastal Conservancy is conducting a comprehensive mapping program for all state waters. Recent results were obtained in the Santa Barbara Channel in an area that had been surveyed in 1983 for seafloor geological mapping in support of hydrocarbon exploration. The 2008 multibeam echosounder (MBES) data set records some changes on the seafloor over this period.

There was a high level of geological survey activity in the Santa Barbara Channel in response to offshore lease sales extending into the 1980's. Much of this seafloor information has become scattered over time; however, one proprietary data set was uncovered recently. It focuses on offshore reefs and outcrops in varying depths and includes mosaicked side-scan sonar (SSS) images of the seafloor in 1983. This old data set reflects the state of the technology in the early 1980's.

Some of these outcrop areas are within state waters and have been re-surveyed using multibeam echosounding technology for the California State Waters Mapping Program. The multibeam data also include acoustic backscatter, therefore allowing a direct comparison with the previous side-scan sonar data set.

The mapping program for California state waters is providing comprehensive coverage out to the three-nautical-mile boundary using the latest technologies. The accuracy and coverage of the new data set meets NOAA's hydrographic charting standards. Further, the acoustic backscatter data have the benefit of recent advances in digital data processing.

The poster presents 1) the apparent seafloor changes over this quarter-century period, 2) possible processes that account for the observations, and 3) the changes in survey technology over this period. The changes are observable as measurements of erosion and deposition of sediments around and within the rocky reefs. Wave-driven transport dominates the shallower (10m – 30m) sites, while current direction changes may have resulted in the observed differences in the deeper sites (50m – 70m). GPS navigation was assumed to represent the "true" location of these seabed features; the superior positioning of underwater features by hull-mounted MBES versus sonar towfish technology was the basis for adjusting registration of the 1983 and 2008 data images. Co-registration of bathymetry with acoustic imagery represents another significant benefit of MBES over the analog SSS mosaics.

Monitoring the invasive tunicate Didemnum vexillum and other applications of the HabCam optical benthic habitat mapping system

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The HabCam (Habitat Mapping Camera System, http://habcam.whoi.edu) was originally developed as a tool to access scallop stocks along the Northeastern U.S. Continental Shelf using high resolution, high frequency, optical imagery collected with a vehicle towed by a commercial scalloping vessel. This non-invasive system has yielded over 13 million images to date and provides the opportunity to not only survey scallops but also all visible macrofauna, and substrate composition. The system can also be used to calculate biodiversity indices, find marine debris, and ground-truth acoustic data. It also allows us to do things that would be impossible with a standard benthic dredge survey such as study species patch dynamics and witness predator/prey interactions, commensalism, mutualism, and how species associate with different types of structure.

Our work with the invasive tunicate species *Didemnum vexillum* is a good example of one application of the HabCam system. During our normal survey operations we have surveyed several areas along Georges Bank with the invasive tunicate *D. vexillum* (Fig.1). We have chronicled *D.vexillum* abundance and distribution, as well as abundance of other macrofauna in several areas on Georges Bank, an area important to commercial fisheries. *D.vexillum* mats were found to overgrow benthic organisms in addition to gravel, cobble, boulder, and shell substrate. Increasing density of *D.vexillum* was correlated with a decrease in density of sea scallops (*Placopecten magellanicus*) and 12 other benthic organisms. Percent cover of *D.vexillum* over the sea floor was higher in Closed Area II, an area closed to scallop and ground fishing, than in the heavily disturbed regions outside of the closed area. Repeated visits to the Northern Edge of Georges Bank, starting in August of 2007, have shown us that *D. vexillum* populations are extremely dynamic in their coverage of the bottom. Winter minimum temperatures or summer maximum temperatures may be responsible, in part, for *D. vexillum* die-back in addition to benthic shear stress, food availability, and other habitat characteristics. Continuation of this time-series along with other monitoring efforts will help delineate the chemical and biological limitations of this invasive species, and characterize long-term impacts on benthic community structure.

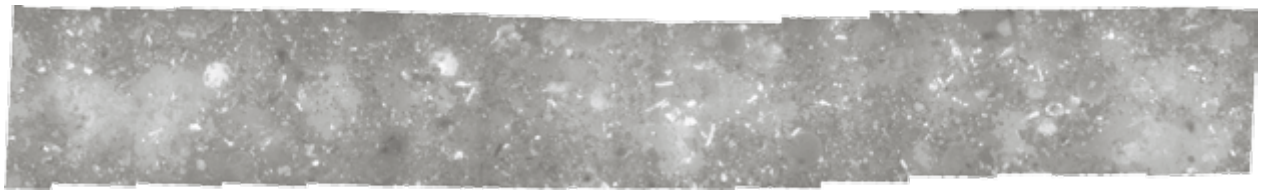

Figure 1: An image mosaic of Didemnum vexillum and Placopecten magellanicus (sea scallops) in the Nantucket Lightship area.

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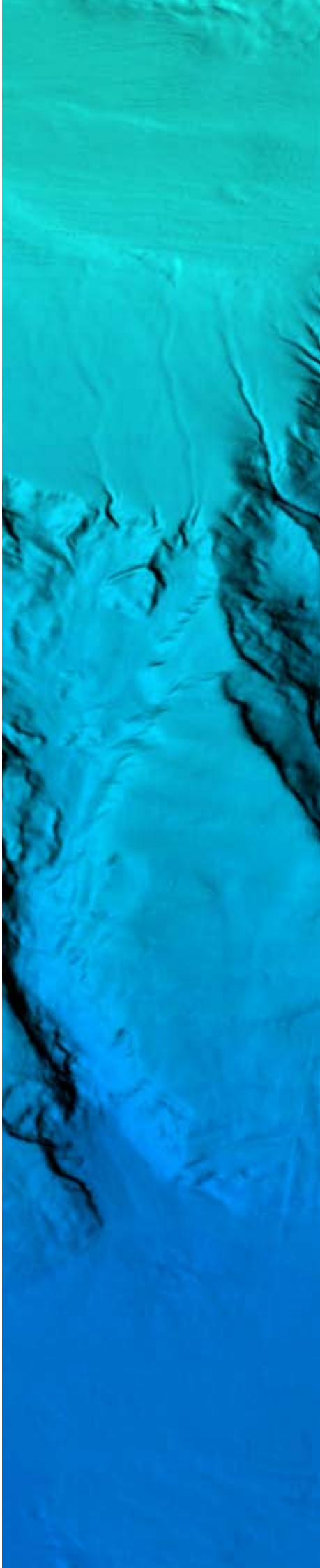

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