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Marine Geological and Biological Habitat Mapping

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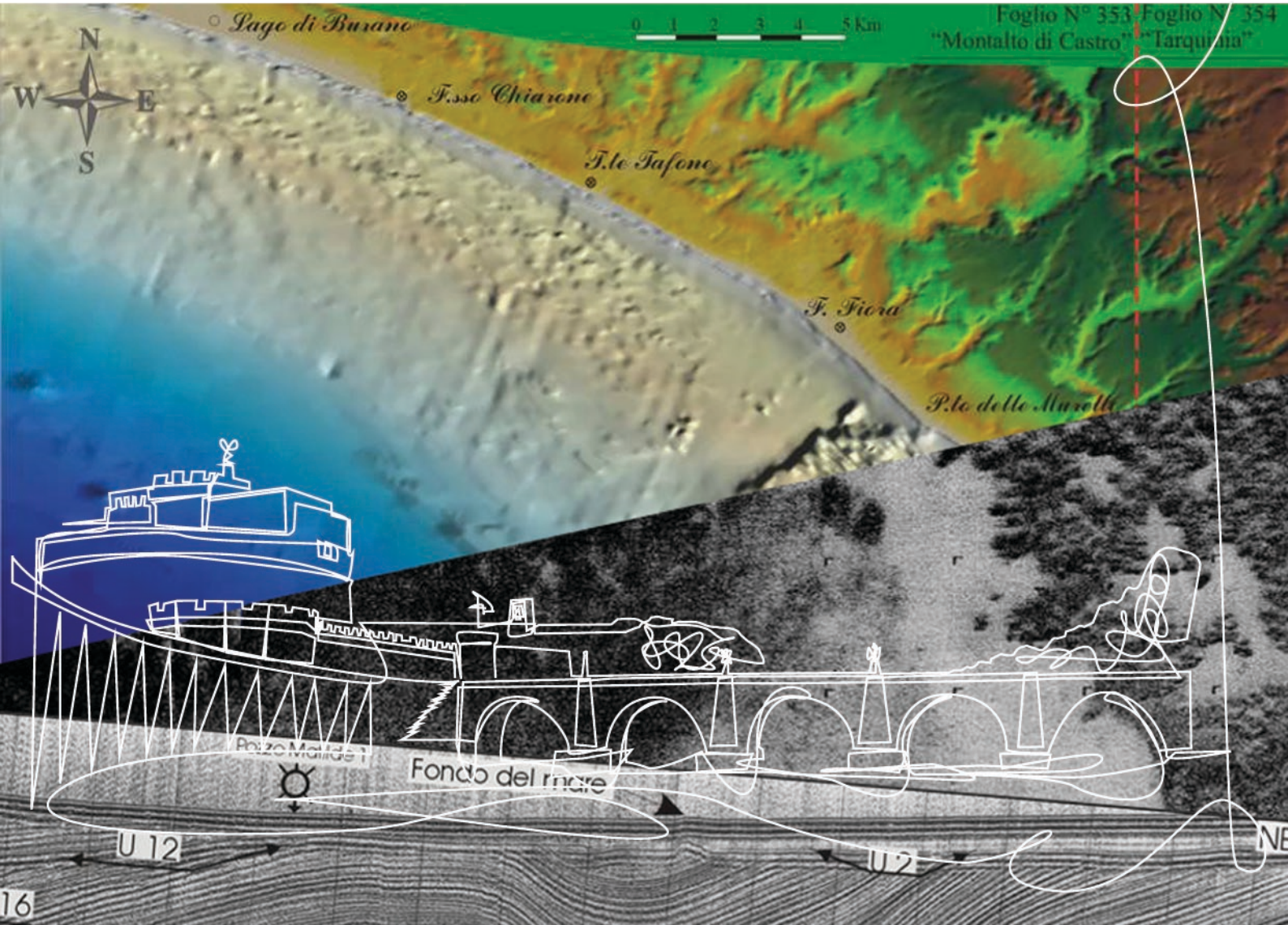
Abstract Volume



ORAL CONTRIBUTIONS

Sediment and habitat characterization of the Israeli Mediterranean shelf

Ahuva Almogi-Labin[1], Orit Hyams-Kaphzan[1], Rani Calvo[1], Simona Avnaim-Katav[2], R., Hadar Elyashiv[1] and Barak Herut[3]

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Over the past few decades the Israeli Mediterranean shelf has been exposed to perpetual anthropogenic perturbations. This includes the recent shut down of fine-grain sediment transport from the Nile River due to the building of the Aswan Dam. Following the ongoing rapid changes and the increasing demand for marine resources it is imperative to improve our awareness and understanding of sediment dynamics in this area.

In order to characterize the Israeli shelf sediments at present, we initiated a program consisting of surface sediment sampling in 15 transects from a depth of 10 m to 100 m. Grain size analysis of bulk and carbonate-free sediments was performed in conjunction with water, carbonate and organic carbon content analyses. In addition some short cores were taken at a S-N transect at ~40 m water depth in order to trace the rapid changes caused by the shut down of the Nile River discharge during the last decades.

Over the entire shelf two sedimentary belts were recognized i.e., a shallow water sand belt distributed parallel to the Israeli coast (up to 35 m) and a silt belt that extends to the west of the sand belt (up to 100 m). The sand belt has a well sorted uni-modal grain size (150-200 µm) and consists entirely of sand grains. Silt grains start to appear at a depth of 40 m and comprise the majority of the sediment (up to 85%) at water depths from 60 to 100 m. Silt appears in two distinct grain size populations, fine silt (5-6 µm) being the main component and medium to coarse silt being a secondary component. Clays comprise 10-15% of the sediment between 60 and 100 m with grain size of ~0.8 µm.

Towards the top of the core and parallel to the decline in Nile River discharge from the mid-60's, the sediment gradually became coarser at the ~40 m depth interval, mainly because of the sharp reduction in fine sediment flux. This is well reflected in the increase in $\%SiO_2$ and Si/Al ratio. The $CaCO_3$ content increased while the TOC content and its isotope composition decreased significantly in the post-Aswan period indicating a major reduction in primary productivity.

Time averaged, dead assemblages of foraminifera were used for biological habitat characterization. They were studied in east-west oriented transects extending from 3 to 100 m water depth. Five clearly defined benthic foraminiferal death assemblages occur in the shallow water off Israel. They are mainly substrate-defined. Two broad foraminiferal provinces are distinguished: The northern Levantine province, north of Haifa Bay, with calcareous sandy-silty sediments, with two abundant and diverse foraminiferal assemblages, and the southern Nilotic province, south of Haifa Bay, dominated by siliciclastic sediments, containing two foraminiferal assemblages of low diversity and low abundance. The diverse and prolific foraminiferal assemblages of the Levantine province reflect ecologically more stable environments. The low numerical abundance of the assemblages in the Nilotic province is attributed to dilution by the siliciclastic sediments. The low abundance and species richness values also reflect the instability of Nile-dominated environments due to the recent rapid hydrological changes related to the post-Aswan period.

Rocky mesophotic assemblages of the Eastern coast of Giglio Island (Tuscany Archipelago, Tyrrhenian Sea): a biodiversity hotspot

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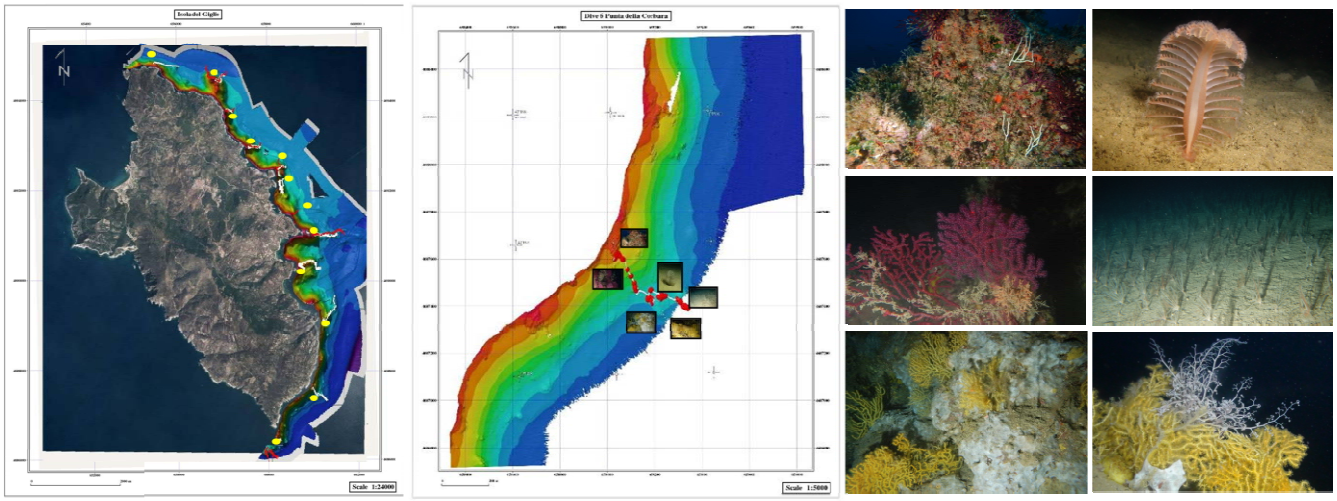
Rocky mesophotic environments (≈ 30-150 m) are receiving worldwide ever more attention due to their peculiar features, supporting high habitat complexity and diversity. The study of this environment has been recently advantaged by the development of new technologies, which have allowed a wider spatial and bathymetrical extent of explorations. Visual surveys have opened new perspectives in the study of deep benthic fauna from an ecological perspective, providing new and detailed records and allowing the qualitative and quantitative description of benthic assemblages. Moreover, geo referenced positions, spatial information and maps of habitats and species have represented essential instruments for ecosystem based management, necessary also to evaluate consequences of various anthropogenic activities. This work was carried out to collect specific information on the benthic assemblages along the Eastern coast of Giglio Island (Tuscany Archipelago, Italy), after the dramatic stranding of the cruise vessel “Costa Concordia” in January 2012. The study represent an example where detailed bathymetric maps have been combined with seabed video imaging and sampling to yield an integrated picture of the mesophotic communities that are associated with different types of benthic habitat. Two cruises were carried out in February and in May 2012. The Eastern shore of Giglio Island were mapped using Kongsberg EM 3002 and EM 2040 Multibeam and then, visually explored by a ROV ‘Pollux III’ equipped with Ultra Short Baseline underwater positioning system (Linkquest Tracklink 1500 MA). Twenty-four video-transects were conducted in 12 sites from shallow to 120 m depth. In this work data about the different assemblages of the mesophotic zone of Giglio Island rocky bottoms are presented and examples are given of deep-sea epibenthic facies identified on the basis of dominant conspicuous macrofauna and similar species compositions documented in different locations. Moreover, it is reported the impact by anthropogenic activities, especially those related to artisanal fishing, whose traces have been found in the explored sites. The rocky bottoms host diversified coral communities, mainly composed of arborescent colonies of gorgonians (*Eunicella singularis*, *Eunicella cavolinii*, *Paramuricea clavata*, *Paramuricea macrospina*, *Acanthogorgia hirsuta*, *Corallium rubrum*, *Leptogorgia sarmentosa*), antipatharian (*Antipathella subpinnata*) and zoanthids as *Savalia savaglia*. Corals, bryozoans and sponges were proven to be major structuring organisms in many assemblages but a variety of other organisms such as bivalves, ascidians, crinoids, sea-urchins, anemones and holothurians were also observed to be dominant in some habitats and/or represent important accompanying megafauna. Collected data show the presence of vulnerable benthic assemblages in the mesophotic environment of Giglio Island, characterised by several uncommon structuring species, creating complex three dimensional habitats enhancing biodiversity. This information should be the starting point for the definition of specific conservation measures of these biodiversity hotspots.



Lidar-based mapping of ecological values in shallow marine areas

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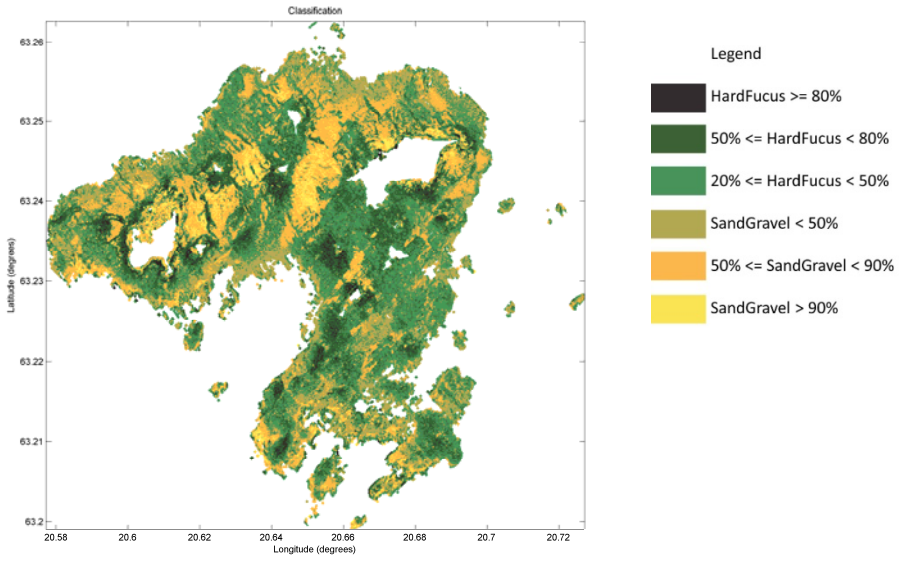
Sustainable use and protection of marine areas is to be ensured by efficient marine spatial planning. Functioning planning requires sufficient data and maps describing the area and its biological and physical properties. Despite effort being made all over the world today, present mapping methods do not supply decision makers with data needed in sufficient time for being able to base planning on actual knowledge. This is especially true for shallow marine areas with highly varying environment.

Aiming to find a new, efficient method for gathering needed data from shallow, marine areas, the project SUPERB started 2011. The project was located to Kvarken archipelago, a shallow and highly variable brackish water area difficult to map using traditional methods carried out from boat. The central method used in SUPERB was Lidar, an airborne laser based mapping technique used for gathering information about topography and bathymetry over vast areas in short time.

The objective was to classify the benthic substrate type using lidar data with a supervised classification method, where underwater video data were used for training of the classification models and for accuracy evaluation. The analysis was based on two lidar waveform variables (bottom pulse width and pulse area), in addition to a depth-derived variable (depth standard deviation). The classification was achieved using a maximum likelihood method. Classification of the seabed into two the classes hard substrate (bedrock, boulder, stones) and soft substrate (sand, gravel) was accomplished with a user accuracy of about 80%. This classification was performed in for each lidar data point. The classification point data were subsequently analysed on a 10 m by 10 m grid for calculation of cover of hard and soft substrate. By further analysis of depth data and substrate cover we generated a cover map which is closely related to, or directly applicable to the Natura 2000 class definitions Reef and Sandbank.

This method can, in a relatively short timeframe, produce comprehensive maps describing both the physical and biological features needed in marine spatial planning. The combining of bathymetry, bottom substrate data and key species distribution, makes it possible for decision makers to carry out planning based on actual knowledge.

The project SUPERB is financed by Interreg IVA Botnia-Atlantica.



Predictive substrate and benthic habitat mapping in the active volcanic environment of the Kermadec arc

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Ascertaining the distribution of benthic communities remains extremely difficult in large and deep oceanic regions given the challenges associated with mapping, sampling and characterising biological communities. Nevertheless this knowledge is essential for ensuring the preservation of unique biotas and the effective management of marine resources. Predictive habitat mapping, developed from acoustic multibeam echosounder (MBES) data, and validated using direct sampling techniques, allows us to generate models of the distribution of biological assemblages over large areas. This approach provides a powerful tool to assist scientific research and governmental policy in areas where no direct observation or sampling of biota has taken place.

The Kermadec arc to the north of New Zealand is of very high interest both geologically and biologically. Geologically, studying volcanism at the seafloor can provide insights into the deep subduction processes, a means to assess natural hazards such as eruptions and edifice collapses and the potential tsunami risk they pose, as well as information on potential economic value associated with hydrothermal deposits. Biologically, seamounts are of high interest as they are host to rich, but fragile, biological communities, due to a combination of the relatively shallow water depths and the presence of chemosynthetic microorganisms at venting sites.

We present backscatter and substrate maps for Rumble II West seamount in the Kermadec arc from (1) segmentation of MBES backscatter data collected by Kongsberg EM 300 and EM 302 echosounders over several research voyages, (2) ground-truthing information obtained from video and camera observations and (3) direct physical sampling of substrate and biota. Mapping will later be extended to Rumble II East, Brothers, and Clark seamounts. Substrate maps will then be integrated with data on the abundance and distribution of biological species that have been obtained through a combination of direct sampling and video observations, and other relevant physical parameters such as water depth and temperature will be introduced to determine the main controls on biological distribution. Through this approach predictive habitat maps can be generated.

A primary aim of the study is to provide tools and protocols that will help improve our understanding of the relationships between organisms and geological substrate, help characterise volcanic and tectonic processes, and help predict biological assemblage and biodiversity. Such tools and protocols are of use both to mining companies and for the identification and preservation of unique biological communities, and are essential to enable informed governmental policy-making with regard to the regulation of industry activity and/or protection of these areas.

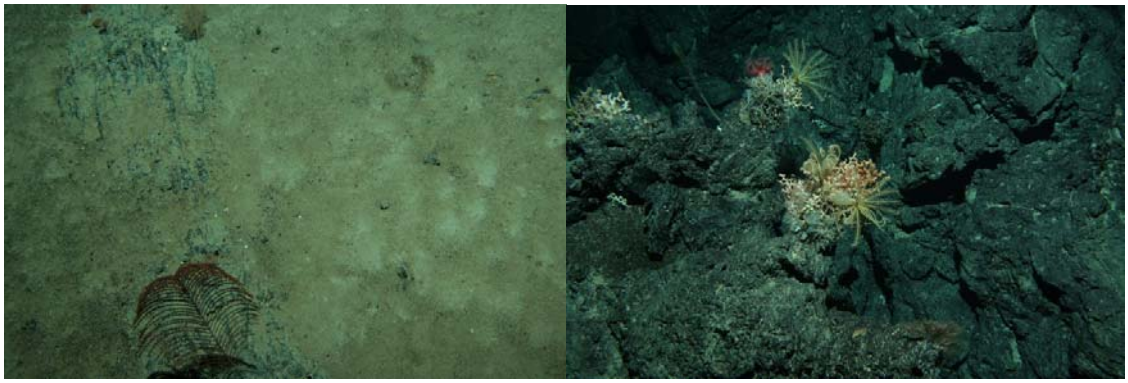

Figure 1: Images from video tows over Rumble II East (left) and Rumble II West (right) seamounts, showing contrasting substrates and associated biota.

Predictive habitat modeling as a tool in the Norwegian seabed mapping program

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In 2003, the Norwegian National programme for mapping of biodiversity – coast started developing methods and organisational structure for mapping selected marine habitats. As the Norwegian coast is long and complex, detailed mapping of the sea floor is costly. Consequently, it was decided to develop and apply spatial predictive modelling as a tool. We will here describe the methods developed and applied to the habitats "Large kelp forests" and "Carbonate sand".

Field sampling: In the period 2007-2010, programme has mapped selected nature types in about half of the coastal municipalities in Norway.

Stations were placed to cover the wide range of environmental gradients, i.e. depth, slope, terrain variability, wave exposure and current speed. Stations were selected randomly within stratified classes of the environmental factors. Kelp coverage was recorded by the NIVA and IMR, carbonate sand was recorded by NGU.

Predictor variables (GIS layers): The variables depth, slope, terrain curvature and wave exposure were available as GIS layers at a 25 m spatial resolution. The resolution of current speed varied between areas.

Analyses: We analysed the statistical influence of depth, slope, terrain curvature, wave exposure and current speed using Generalized Additive Models (Akaike Information Criterion for model selection) and Boosted Regression Trees (BRT).

Results: Spatial predictive models have been developed for several of the ecoregions in Norway, and the presentation will show the methodology and results. Figure 1 shows an example from Trøndelag. Here, dense kelp forest was best determined by the combined effect of depth, slope, curvature, wave exposure and current speed. Carbonate sand was best determined by the combined effect of depth, curvature (depressions), wave exposure and maximum current speed (90th percentile).

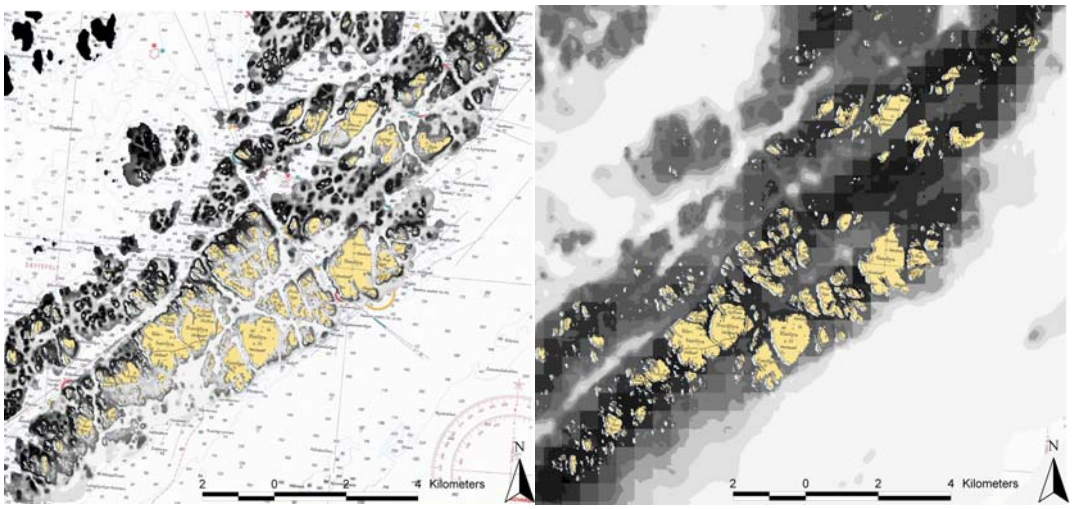

Figure 1. Predicted probability of finding dense kelp forests (*Laminaria hyperborea*, left) and carbonate sand (right), exemplified in a small area in Trøndelag (mid Norway), based on the response curves. The darker the colour, the higher the probability.

The Influence of Long-Term Sedimentary Regimes on Seabed Marine Habitat Distribution (Eastern Brazilian Shelf)

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Shelf morphology and sedimentary regime are influenced by distinct processes that act in different temporal and spatial scales, controlling the distribution of seabed marine habitats. Based on this assumption, the northern part of the Espirito Santo continental shelf (eastern Brazilian Shelf) is a good example of how long-term different sedimentary regimes define a complex and diverse distribution of marine habitats. Seabed acoustic imaging (side-scan sonar and sub-bottom profiler) and sediment sampling were used to investigate the influence of high and low sediment input regimes on marine habitat distribution. Results have indicated the occurrence of five distinct seabed domains or habitats: muddy beds, sandy beds, rhodolith beds, bioclastic gravel and rigid substrate. Based on an integrated analysis of seabed morphology and sediment distribution (composition and texture), it was possible to determine that two distinct sedimentary regimes occur along the area. The supply regime shelf is associated to high sediment input, characterized by the presence of a delta plain (Doce River) to the north of the area. Sediment is basically terrigenous mud. To the south, a low sediment input area, characterized by irregular morphology and coarse sediments, either terrigenous or bioclastic, represents the accommodation regime shelf. Thus, habitat distribution is associated to distinct sedimentary regimes. The supply regime shelf shows habitats associated to fine sediment beds (delta front and prodelta areas), where morphology is gentle and flat. This habitat, for the study area, is famous for shrimp trawling. The accommodation regime shelf is characterized by an irregular seabed morphology and coarse sediment beds. The irregular morphology is represented by unfilled paleochannels and erosive surfaces and sediments are either relict terrigenous sands or bioclastic (skeletal) gravel. This habitat presents high benthos diversity, mainly associated with a great variety of calcareous algae species, and famous for its fishing grounds. A third sedimentary regime could be described for the outer shelf, where rhodolith beds predominate. Rhodoliths predominate over the shelf for water depths deeper than 40m. With a rich and not very well investigated associated fauna, rhodolith beds are a very important habitat, as they can also be considered as a type of reef. So, the sedimentary evolution of an area and the concept of sedimentary regimes are controlling-factors on habitat distribution.

Multibeam Backscatter Workshop– State of the Technology, Tools & Techniques: Overview.

Erin Heffron[1], Moe Doucet[1], Craig J. Brown[2], Geoffroy Lamarche[3], Rhys Cooper[4].

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The establishment of multibeam echo sounders (MBES) as a mainstream tool in ocean mapping has revolutionized approaches towards nautical charting, seafloor geotechnical/geological surveys and benthic habitat mapping. The resolution of bathymetric and backscatter data collected by MBES has improved significantly in recent years through technological improvements of these acoustic systems. Furthermore, developments in data collection and processing of MBES backscatter have resulted in the increasing preferential use of multibeam technology over conventional sidescan sonar or single-beam sonar for these applications. However, techniques and approaches for processing MBES backscatter data are still evolving and improving at a rapid pace, with research and development focusing on data cleaning techniques, image enhancement, and automated classification procedures for objective identification and mapping of acoustic facies. The application of the findings from this research is highly relevant for benthic habitat studies, and is therefore highly relevant to the GeoHab community.

A one-day pre-conference GeoHab workshop on multibeam sonar backscatter was held on May 6th, 2013, focusing on the current state of the technology, ongoing and future research activities within this field, and to facilitate discussion regarding processing tools, techniques, uses, and user perspectives. The goal of the workshop was to provide attendees and contributors with an update on the state of backscatter processing, including hardware and software issues, new research ideas, the commercial and non-commercial tools for working with backscatter. Additionally, a common data set from Shallow Survey 2012 was made available to participants to compare and contrast processing methods and classification techniques.

Here we present an overview of the workshop, focusing on highlights, key discussion topics, a summary from the common data set analyses, and a synopsis of the state of progress within this field of research.

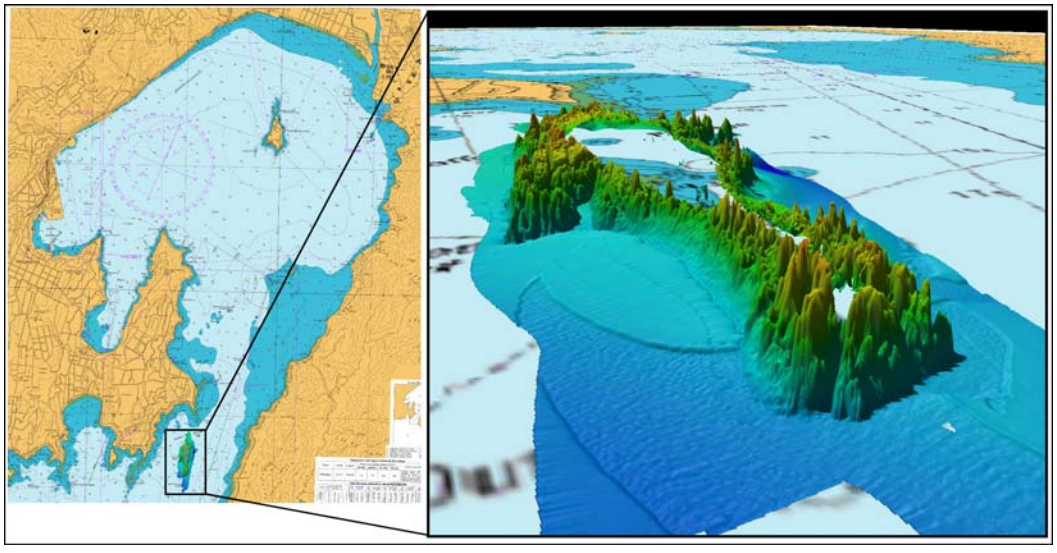

Image: Common data set used during workshop. Overview on left showing the location of the common data set (in box) near the entrance to Wellington Harbor, New Zealand. Close-up view on right showing combined bathymetry for the area. Chart and bathymetric data part of the Shallow Survey 2012 common dataset.

Developing new concepts for environmental monitoring: the WIMO Project (Germany)

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Since the last 20 years, with the first legal acts about wild life and nature protection (Habitat Directive 1992), the members of the European Union stressed the need of an increased effort for studying sensitive environments and adopting regulations for natural ecosystem conservation. In particular, marine areas have been the subject of more focused legislative actions (e.g. Water framework Directive 2000, Marine Strategy Framework Directive 2008, Birds Directive 2009) which forced the EU members to adopt specific strategies for mapping and monitoring the coastal zones, setting up a network of protected areas (Natura 2000), and planning the future economic development of such important sites in a sustainable way.

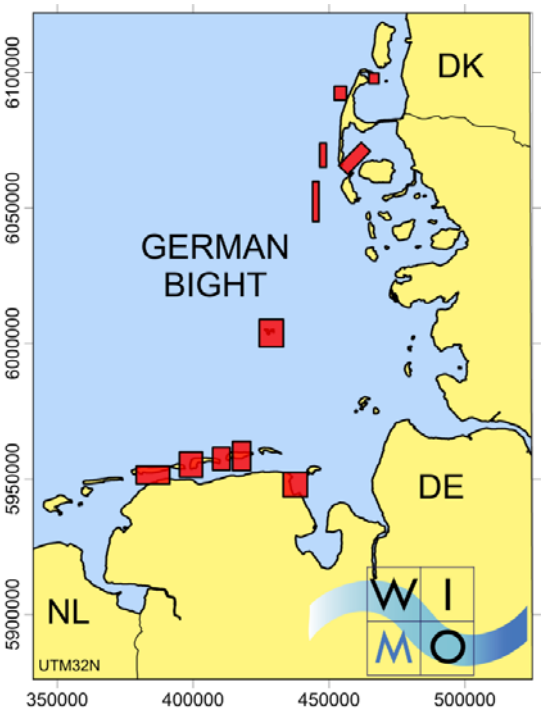
Several different approaches are nowadays available for qualitative and quantitative description of the environment: from airborne sensors to point sampling, from hydro-acoustic data to satellite scenes. The integration of these disciplines and systems is becoming a priority for a reliable and repeatable habitat mapping, which form the basis for decision and policy makers.

Within this framework the Lower Saxony Ministry for Environment and Climate Protection and the Lower Saxony Ministry for Science and Culture (Germany) launched in 2010 the WIMO Project (WIssenschaftliche MOnitoringkonzepte für die Deutsche Bucht, "*Scientific monitoring concepts for the German Bight*") to develop new solutions for:

1. Describing sensitive marine environments in the German Bight region;
2. Documenting ongoing geological and biological processes and changes;
3. Assessing the human impact on the ecosystem;
4. Modeling and planning future prospective.
5. Contributing to the concept of habitat assessment

Among all the possible future uses, the WIMO project in its second phase will investigate the application of these concepts in 3 fields:

- Eutrophication of the Wadden Sea;
- Oil sensitivity maps and risk assessment in the German Bight;
- Biodiversity monitoring and modeling, in terms of interaction and integration between physical data, biological parameters, and time.



Twelve German Institutions have been involved in the project, in order to bring together expertise from different disciplines (biology, ecology, geosciences, oceanography, geo-engineering, and geo-informatics).
Thirteen areas have been selected in the German Bight as research sites (Figure), including tidal systems in the German Wadden Sea (East and North Frisian Islands).

In the open North Sea study sites, several acoustic underwater remote sensing devices were used simultaneously to determine system specific resolutions and limitations. Different approaches of acoustic seabed classification were tested on the same ground truth data. In the intertidal zone of the Wadden Sea area airborne based remote sensing techniques were coupled with acoustic ones. High resolution habitat maps provided the base of modeling approaches on different time and space scale for working out tools to predict habitat dynamic. The multidisciplinary interplay were tested and demonstrated in several scenarios given in three overarching case studies.

Multidisciplinary and multiscalar approach for a sustainable management of Red Coral (*Corallium rubrum,L.1758*) from the island of Sardinia (West Mediterranean Sea).

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Red Coral, *Corallium rubrum* (L.1758), is an important socio-economic resource for the Mediterranean community and the island of Sardinia, due to its great commercial value. Since 1979, regional law regulates colonies harvesting for its correct management and conservation. Nevertheless, all available data that provided the scientific base for the actual law, came from landing data obtained from fishermen, leaving huge lacks of knowledge in terms of investigated areas (and relative geological features) and representativeness of the state of the stock. In this work we report an example of multidisciplinary and approach, both biological and geological, for an unprecedented multiscalar mapping of red coral colonies that can provide important improvement in its conservation. A Geological survey ("MaGIC" project, Marine Geohazard along Italian Coasts) using Multibeam, Side Scan Sonar and Sparker 500J was conducted in Summer 2009, providing a detailed data coverage of two key areas of South Sardinia continental shelf San Pietro Island and Cape Carbonara. Data collected during the survey were integrated with CARG project (Official National Italian Geological Cartography). This Geomorphological analysis provided a usefull guideline to define and map harvesting areas and planning the further ROV survey. The Biological R.O.V survey was carried out in Summer 2011; more than 2000 photos were Geo-referenced to the multibeam map of the bottom, and examined using CPCe (Coral Point Count with Excel extensions) Software in order to create a database on the abundance and morphometry of colonies. Colonies were divided in 3 categories: Ramified, non ramified and dead colonies. For the morphometric database, the basal diameter and maximum height of the colony was measured along with number and type of ramifications. The population structure was also calculated for better describe the status of the stock. This mapping approach has allowed scientist to discover new banks of coral that can could be harvested in a short/long- time period in less known areas as well as a better overview of sites already used for harvesting. Morphological adaptations of Red coral colonies to environmental features can be evaluated thanks to to the multibeam references. In conclusion these data can provide the new scientific base for a local-based specific regulation for *C.rubrum* harvesting.

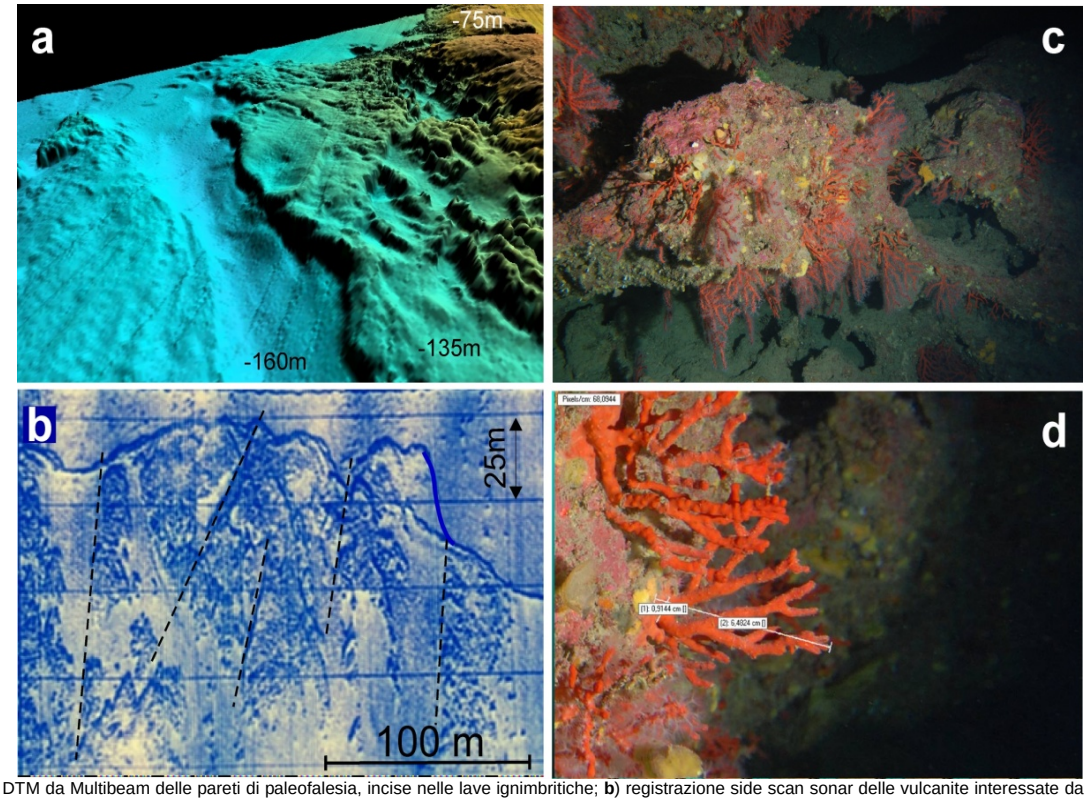

Figure 1: **a**) DTM da Multibeam delle pareti di paleofalesia, incise nelle lave ignimbritiche; **b**) registrazione side scan sonar delle vulcanite interessate da un sistema di fratture orientate N 5° e N45°; **c**) *C.rubrum* colonies **d**) CPCe Software

The Italian MaGIC Project: a National Seabed Mapping Program devoted to geohazard identification

F.L. Chiocci[1], D. Ridente[2], D. Casalbore[2], A. Bosman[2], F. Budillon[3], S. Ceramicola[4], F. Gamberi[5], E. Martorelli[2], P. Orrù[6], A. Sposato[2], M. Ingrassia[1], E. Morelli[1], M. Pierdomenico[1], and the MAGIC Party
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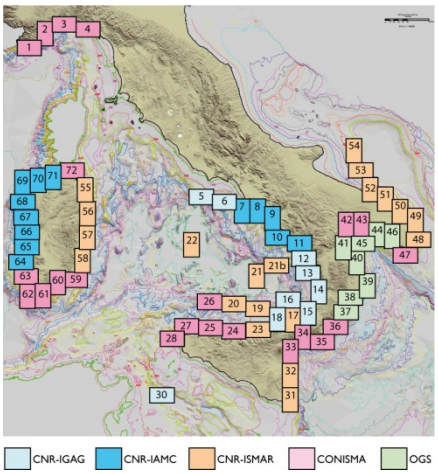
2 Istituto di Geologia Ambientale e Geoingegneria (IGAG)-CNR.
3 Istituto per l'ambiente marino costiero (IAMC)-CNR.
4 Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS).
5 Istituto di Scienze Marine (ISMAR).
6 Consorzio Nazionale Interuniversitario per le Scienze del Mare (CoNISMa)- Università di Cagliari.

Modern seafloor imaging and mapping techniques have greatly improved our capability of defining seafloor landscape and determining the relationship between geomorphic features and the complex interplay of physical processes responsible for their origin. This advance has considerably boosted the potentialities of seafloor mapping as prime to the characterization of submarine environments, with relevant outcomes in terms of providing background information for detecting, monitoring and managing natural resources of the submarine realm. Since many geological processes that shape the seafloor (both on long and short time scales) may reveal as catastrophic or highly impacting with respect to human activity and infrastructures, geomorphic mapping is a relevant tool also for detecting marine geohazard.

In this perspective, the recently concluded 5-years Italian Project MAGIC (MArine Geohazards along the Italian Coasts; 2007-2012) investigated most of the Italian continental margins, depicting and classifying geohazard features based on the acquisition of high-resolution multibeam bathymetry. More than 60,000 nautical miles of multibeam were analyzed and interpreted, of which ca. 40,000 specifically acquired during the project. The whole Italian marine geology community participated to the project that was funded by Department of Civil Protection. Besides the specific issue and results, the experience of MAGIC has been worth in evidencing how the flow of information from the morpho-bathymetric data to the conceptual definition of geological processes and related geohazard potential could be achieved efficiently only after that cartographic criteria had been codified according to the aim and scope of the project.

We present the main results of MAGIC, highlighting some of the conceptual and practical problems that arise when attempting to identify marine geohazard and to represent them in thematic maps based essentially on multibeam data. Notwithstanding the specificity of the issue relative to which standard criteria have been identified, some basic cartographic and interpretative criteria used in MAGIC could find general application in diverse setting where mapping of seafloor may also have aims other than mapping geohazards.



Location of the 72 sheets of the "Map of Geohazard features of the Italian Seas"; different colors refer to the Institution responsible for the acquisition and compilation of each sheet.

Predictive modeling of the distribution of the OSPAR threatened and/or declining listed marine habitat 'Sea-pens and burrowing megafaunal communities" in UK waters

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The ocean provides a wealth of goods and services which has led to multiple national and international legislative instruments such as the OSPAR convention for the northeast Atlantic, being set up to protect these environments. The OSPAR commission created a list of 16 threatened and/or declining habitats, which under the European Union Marine Strategy Framework Directive (MSFD), the UK and all coastal Member States are obligated to protect, monitor and assess. To make this process most effective, full coverage maps of OSPAR habitats at a UK scale are required. Information on the distribution of OSPAR habitats are also needed as a decision-making tool for conservationists, developers and marine spatial planners to fulfill international obligations for the Marine Protected Areas network by the European Commission.

There have been several studies on the distribution of benthic communities nationally and internationally however, no published studies could be found on the modeled extent of OSPAR habitat "Sea-pen and burrowing megafaunal communities" within UK waters. Current understanding of the distribution is limited to sample data points mostly collected from scientific research surveys investigating the health of the *Nephrops norvegicus* fishery. This case study is the first to model the distribution of the OSPAR threatened marine habitat 'Sea-pens and burrowing megafaunal communities" in UK waters and plots the potential presence/absence distribution.

The specific aims of this study were to identify the environmental variables that influence the distribution of the OSPAR priority habitat "Sea-pens and burrowing megafaunal communities", evaluate the spatial contribution made by each environmental variable to the final model prediction and compare the modeling performance of Generalized Linear Models (GLMs) and Generalized Additive Models (GAMs) in predicting and mapping the potential distribution of the habitat at a UK wide extent by comparing threshold dependant and threshold independent measures.

The study results identified the environmental conditions needed to support "Sea-pens and burrowing megafaunal communities" habitat and both models similarly performed statistically well. The models showed depth and substrate to be the major drivers of the habitat distribution and the comparison between GAM and GLM showed a 3 % increase in deviance explained in the GAM (83.5%) compared with the GLM (80.5%). Depth is regarded as an indirect variable; having no direct impact on species distribution but acting as a proxy for a variety of direct factors such as energy levels from waves, temperature, sunlight and pressure which can all be correlated with depth. The substrate is, biologically, an important factor, occurring on plains of fine mud due to the burrowing activates of species creating a complex habitat of bioturbated (oxygen penetration) substrate.

Mapped spatially both models predicted similar distributions in areas within the sample data range. Beyond 200nm from the coast where data was unavailable (i.e. beyond the test data sample range), the GLM was more conservative in its estimate whereas the GAM displayed an overestimate of predicted presence. This is likely due to the factors that affect distribution within the deep sea environment which could not be accounted for in the model. This study supports the ideas presented on broad ranging ecological niches, with most variables having a negative effect on distribution causing an over simplified model specification which can result in large areas of over predicted presence.

This study assists understanding on the implications of model specifications and selections on the predictive distribution of habitat suitability. The predictive outputs may go some way to guide survey effort in the future and provide baseline information on possible distribution of habitat.

Dogger Bank: Quantifying the temporal evolution in landscapes for a marine renewable energy development.

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In June 2008 The Crown Estate announced the opening of nine development zones within UK waters for offshore wind farm leasing. The Dogger Bank Zone is the largest of the Round 3 wind farm zones, extending over ~8660 km^2. It is located between 125 and 290 kms northeast of Yorkshire on the Dogger Bank, a topographic high in the middle of the North Sea. Water depths across the zone range from 18 to 63 m, with a historically mapped sediment cover comprising re-worked glacial sands and gravels.

The methodologies being utilised to map this extensive area were presented at GeoHab 2012. What the authors would like to present this year are some of the results from the landscape evolution analysis with respect to the diversity of benthic habitats that would have been present across the area throughout the late-glacial and Holocene.

The fluctuation between glacial and interglacial periods has a profound effect on this shallow basin environment, moving the range of habitable environments from peri-glacial tundra, through temperate forests to lacustrine, estuarine and finally fully marine conditions over a relatively short timespan. Archaeological investigations have revealed not only seabed shipwrecks and aircraft acting as modern day reef structures, but evidence of now extinct megafauna that occupied “Doggerland”, pollens suggesting a temperate forest and for human habitation around rivers, lakes and coastlines in the last 10,000 years. But how rapidly can benthic habitats accommodate such dramatic shifts in climate and environment, and what implications might this have for the future.

This detailed analysis of multiple datasets will inform a wide range of disciplines in the future, spanning topics from predicting coastline responses to changes in sea level to the diversity of potential benthic habitats that are associated with periods of significant climatic changes across a wide-spread but relatively flat basin environment. The study is also informing current investigations into geotechnical soil responses, and how historically varied and changing climates and landscapes are now impacting future renewable energy developments in areas that are generally considered as “offshore” zones but have previously been terrestrial.

An open source approach to Exploring seafloor habitats:
Geospatial data analysis using IPython Notebook with GRASS & R

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Development of cyber infrastructure to facilitate collaboration and knowledge sharing for marine Integrated Ecosystem Assessments (IEAs).

The main tool is based on a web application (IPython Notebook) that provides the ability to work on very diverse and heterogeneous data and information sources, providing an effective way to share the source code used to generate data products and associated metadata as well as save and track the workflow provenance to allow the reproducibility of a data product.

A key feature is that metadata, embedded in the final product, are acquired during the processing and plotting of the data, in order to record the provenance needed to reproduce the data products.

We are using the IPython Notebook as tool for collaborative data Processing, workflow Provenance and produts Publishing. IPython (Interactive Python) can be run interactively over the web providing to the user an effective way to work on his data.

In this work is described the cyberinfrastructure and the approach used to define the spatial distribution of communities and ecosytem components.

An end-to-end workflow is developped to combine a set of predictors (temperature, salinity, depth, species density, substrate complexity, morphological features) from different datasources in order to produce a map of Community distribution.

Mapping the rest of Norway's seabed in under 100 years – how can we do it?

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In Norway the MAREANO programme (www.mareano.no) has been underway since 2005. This national offshore mapping programme acquires multibeam data plus video and sampling data which facilitate the delivery of seabed maps required by management. The maps provide scientific information on benthic habitats, geology, biology, and environmental status. This information can be used as a basis for management decisions such as whether to open areas to hydrocarbon exploitation or what type of fishing activity to allow. To date MAREANO has operated in areas prioritised by central government, using full coverage multibeam mapping supported by a comprehensive geological and biological sampling programme including video transects and physical samples. Map products have been well received and are gaining impact through a widening means of delivery options (web, GIS services, vessel navigation systems etc.). The demand for information over wider areas is growing, however, it has been estimated that using the existing mapping and sampling strategy it will take MAREANO over 100 years to complete full mapping of all Norway's offshore seabed, not to mention the complex coastal zone. MAREANO is therefore conducting a strategic review in attempt to optimise future mapping efforts. This includes making best possible use of any existing data, targeting future multibeam mapping, considering new mapping technologies, and defining an optimal sampling strategy. All these aspects of the mapping programme need to be addressed in such a way that they allow delivery of timely information, at appropriate levels of detail, for offshore management.

We discuss the use of alternative bathymetry data sources for geological and habitat mapping and present some possible scenarios for mapping and sampling which are currently being considered by MAREANO as part of a strategic review.

Figure showing Olex, compiled single beam data coverage in Norwegian waters – one of the alternate bathymetry data sources for MAREANO.

Figure from Elvenes et al. 2012.Evaluation of alternative bathymetry data sources for MAREANO: A comparison of Olex bathymetry and multibeam data for substrate and biotope mapping. http://www.ngu.no/upload/Publikasjoner/Rapporter/2012/2012_030.pdf

The importance of abyssal hill features in the spatial variation of invertebrate megabenthic communities

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Abyssal hills are the most abundant landform on Earth and are potentially important in determining spatial variation in benthic megafaunal communities, but are little studied. Previous research at the Porcupine Abyssal Plain (PAP), one of the most-studied abyssal sites on the planet, has focused on temporal variability; only very limited data have been available for spatial analysis.

Spatial heterogeneity in the megabenthos of the PAP was assessed by analysing photographic transects, bathymetry and sediment core samples from eight locations collected in 2011. Photos were analysed for faunal abundance, composition and size, and also for phytodetrital coverage. Biomass was estimated from these data. Megafaunal communities on abyssal hills are different from those on the plains: 'hill' sites had a higher abundance and diversity per area of sea floor than 'flat' sites, correlated to sediment particle size. Ongoing work aims to address faunal activity on abyssal hills through the analysis of lebensspuren.

A subsequent field study in 2012 collected high-resolution bathymetry and additional photographic data along a set of gridded transects using the Autosub6000 Autonomous Underwater Vehicle (AUV). Future work using these data will assess variation in megafauna with detailed bathymetric features and to generate community and predictive habitat maps. An understanding of the spatial heterogeneity of these megabenthic communities improves our knowledge on the factors controlling the abundance, distribution and function of the studied fauna, and will provide context to the time series analyses at the PAP and other abyssal plains.

GEOHABITAT MAPPING IN THE AEGEAN AND IONIAN SEAS, MEDITERRANEAN SEA: A PILOT STUDY FOR THE SUSTAINABLE MANAGEMENT OF THE COASTAL RESOURCES

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Posidonia meadows, Coralligenous formations and corals are three of the most important habitats in the Mediterranean Sea. They are of prominent ecological value for the marine littoral ecosystem. They are under increasing threat for the last 20 years due to human activities in the coastal zone such as: harbours, marinas, fish trawling, aquaculture, anchorage and tourism. The aim of this presentation is to examine the present conditions of these habitats, asses their status and quantify the impact that human activities may have on these habitats.

The habitat mapping survey was carried out in two phases. In the first phase the seafloor was scanned using an Edge-Tech side scan sonar operating at 100KHz and a Geo-Pulse sub-bottom profiler operating at 3.5KHz. After processing the data using the Tar-Gan software, the second phase was carried out using ROV, divers and grab samples for visual inspection of the seafloor at selected sites.

Posidonia meadows in the Hellenic archipelagos develop in water depth between 5 and 40m. The meadows are mainly affected by fishing activities such as illegal trawling, under-water explosives used for fishing and boat anchoring. In the affected meadows, where the Posidonia plants were abraded, it was found that, they were fully replaced by the invasive toxic alga Gaulerpa racemosa. Furthermore, high densities of the polychaete Sabela pavonina were observed among the Gaulerpa racemosa fronds.

Coralligenous formations are developed between 45 and 115m but the majority of them are found between 70 and 90m. Two types of coralligenous formations were found, the first type consists of a surficial veneer less than 0.2m thick and the second type forms either individual reefs, or clusters of individual reefs with a height between 0.5 and 2.5m. The coralligenous formations were found growing on hard substrate but also on soft (sandy) substrate. The most of the aggregations occurs on gravelly muddy sands (gmS) or slightly gravelly sands ((g)mS) and few on gravelly sands (gS) or sandy Gravels (sG). The coralligenous formations are mainly affected by fishing activities such as illegal trawling, and boat anchoring.

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Surface area determination in underwater video transects: how 3-D modelling can help

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Sledges, ROVs and AUVs have become common tools to monitor the seafloor. When it comes to quantitative analysis, however, a major difficulty remains in the accurate determination of the area surveyed. 3-D modelling of the seafloor based on 2-D video data and a reference scale can be used to compute sub-transects dimensions. Here we compare sub-transects lengths obtained from 3-D models created with the software PhotoModeler Scanner with those determined from underwater acoustic positioning (Ultra-Short BaseLine - USBL) and bottom tracking (Doppler Velocity Log - DVL). 3-D models building and scaling was successfully conducted on all three tested setups. The distortion of the reference scales due to substrate roughness was identified as the main source of imprecision. Acoustic positioning was inaccurate and DVL unreliable on rough terrain. The dimensions assessed with the 3-D method were on average 20% longer than those derived from the USBL due to the higher spatial resolution and the inclusion of slope. The DVL and 3-D modelling yielded similar results. 3-D modelling is the most powerful method for the accurate determination of video sub-transects dimensions. Although extremely time-consuming it can help comparing data obtained by several vehicles or in environments with a rough topography.

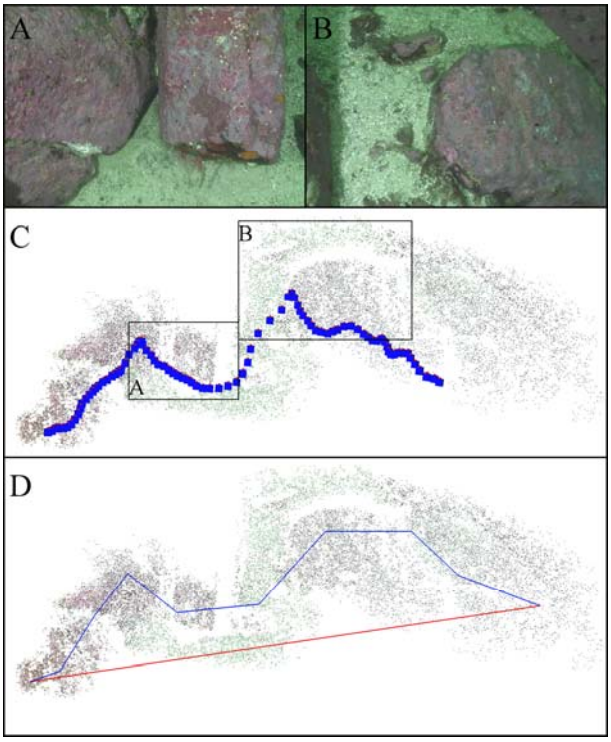

Figure 1: 3-D model of a sub-transect. (**A, B**) Two of the frames used to build the model (**C**) 3-D point cloud and reconstructed camera positions (blue squares) with the rough position of frames A and B. (**D**) 3-D points cloud, linear sub-transect length (red line) and projected sub-transect length (blue line).

Multi-step Approach to Validate a Seascape Classification at Three Levels of Spatial Resolution with the Beta-Diversity Distribution of Benthic Assemblages in the North Sea

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In terrestrial ecology and environmental planning, spatial classifications of land in terms of, e.g., habitats or landscapes have a long tradition relying on a scientific approach for which Troll (1939) coined the term *landscape ecology*. Landscape ecology aims at understanding the relation between spatial patterns and ecological processes across a range of spatial and temporal scales. The application of the landscape approach in marine environmental research provides ecological information at spatial scales that are operationally relevant to marine planning, protection and management. To this end, *seascape ecology* investigates for instance structural attributes of seascapes influencing biotic assemblages and maps spatial patterns of habitats which can be used to determine optimally connected marine protected areas (Costello 2009).

This paper presents a multi-step approach in which a seascape classification at three different levels of spatial resolution was compared with the beta-diversity distribution of benthic assemblages in a small area of about 330 km^2 the North Sea: Firstly, classification methods were applied to a set of twelve environmental factors extracted from measurements of sediment fractions and topographic analyses. We identified whether changes in cluster classification was driven by changes of resolution or by loss of information. Unsupervised algorithms (e.g. k-means algorithm, fuzzy c-means, Bayesian hierarchical clustering) were performed, validated and evaluated whether they yielded a sound description of the spatial distribution of benthic assemblages. Secondly, benthic assemblage patterns were described according to the performed classification in order to evaluate the adequacy of the chosen spatial resolutions. Beta-diversity provides a measure of distance between locations in term of taxon-specific differences and it is used here to detect how the potential habitat clustering was consistent with the assemblages' distribution. Thirdly, the distribution of benthic assemblages according to abiotic factors was investigated independently from the calculated clusters in order to detect the consistency with the cluster analyses. These analyses give insights on the spatial resolution, i.e. the relation between the number of sampling or monitoring sites and the extent of area covered, at which further habitat mapping of benthic assemblages in the North Sea should be conducted. Since the spatial resolution of sampling is a measure of sampling effort, its choice is crucial for eventually fitting the sampling procedures to their feasibility in an area where monitoring programs and / or measures of environmental protection have to be carried out.

Sensitivity Mapping at Small Scales: Input to Risk Based Decision Support for the Oil and Gas Industry

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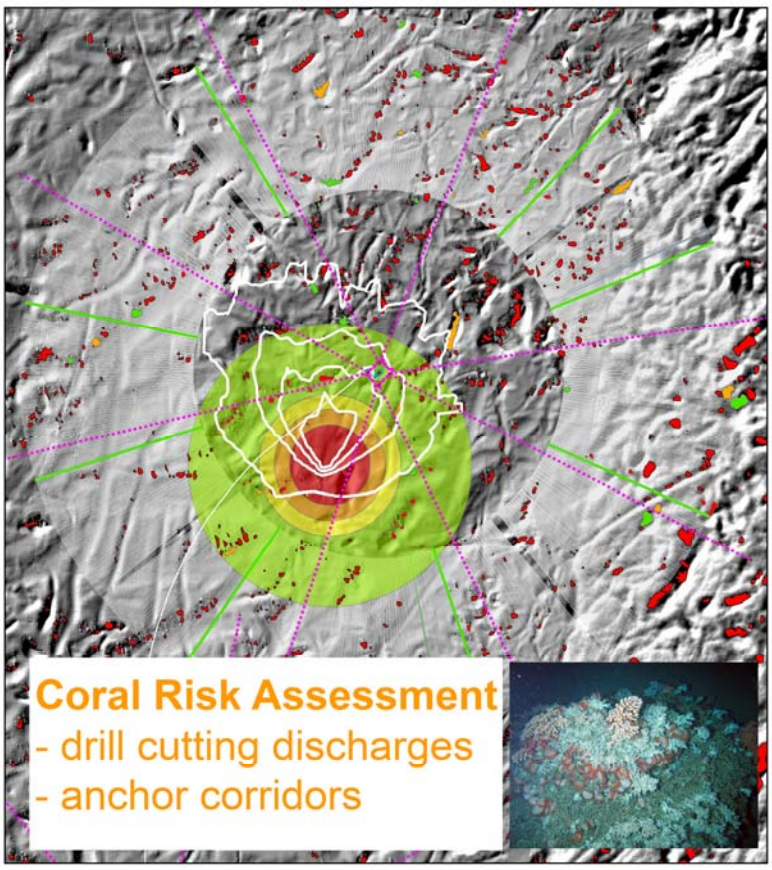
Before drilling in Norwegian waters operators need to prove that they are in control, particularly when it comes to risk of impact to sensitive or red listed fauna at specific sites. Communicating environmental risk is important not only within the organisation but also towards the general public and the government. Strict environmental requirements and a precautionary principle that is becoming more and more prevailing has led to increased need for high resolution survey data (SSS and MBES) and visual mapping of the seabed habitats.
Visual data from ROV's, drop cameras and in some instances AUV's are combined with sampled environmental data in order to produce habitat maps for whole oil and gas fields. Predictive habitat modelling is becoming more common. Presence of red listed fauna such as corals and sponges needs to be addressed when planning and executing the drilling campaigns, and impacts from drilling, anchor operations and pipe laying have to be minimised.

Risk based tools for decision support rely on habitat maps and incorporate dispersion models, historical data and spatial analyses in order to assess overall environmental risk. Based on the resulting risk picture, best fit analyses or other GIS based scripts and routines can be implemented for planning any mitigating measures. Ideal anchor corridors, locations for cuttings discharges and pipe laying routes can be planned. Finally, if needed – environmental monitoring can be carried out. Technological advances in mapping of seabed habitats and developments of new risk based tools have made it easier to understand environmental risk and taking actions, if needed.



Modelling habitats of special interest in support of spatial management: Vulnerable benthic habitats of Norway

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Governments often have a mandate to protect habitats. These are defined in terms of their species composition and substrate properties, but their spatial distribution or sensitivity to human impacts are frequently unknown. In this paper we describe methods to provide insight into the distribution and other properties of benthic habitats of special interest, and generate outputs well-suited to be used by management authorities so that managers can make informed decisions about which areas should be prioritized for management (e.g. protected). The point of departure is a list of habitat definitions and descriptions, which are in turn subject to special provisions (e.g. OSPAR habitats).

In Norway, the Directorate for Nature Conservation has asked for information on the location of valuable and vulnerable habitats so as to decide where to allow further oil exploration. In addition, "Vulnerable habitats" have been defined by the national mapping program MAREANO (Marine AREAl database for NOrwegian waters), including sponge, glass sponge, and seapen communities, hard and soft bottom coral gardens, and *Umbellula* stands. In this paper, we first modelled spatial distributions using machine learning methods. A conditional inference forest was created for each type of habitat, and all models were tested against field observations that had not been used to fit the models. We also explored patterns of variation of density of benthic megafauna across habitats. We then determined meaningful density thresholds and minimum patch sizes that can be used to flag priority areas from within model results. The outcomes of predictive modelling are also being used to improve definitions of vulnerable benthic habitats. We present the final maps (e.g. Figure 1), show new methods, and discuss some ways in which mapping can best support spatial management and inform policy.

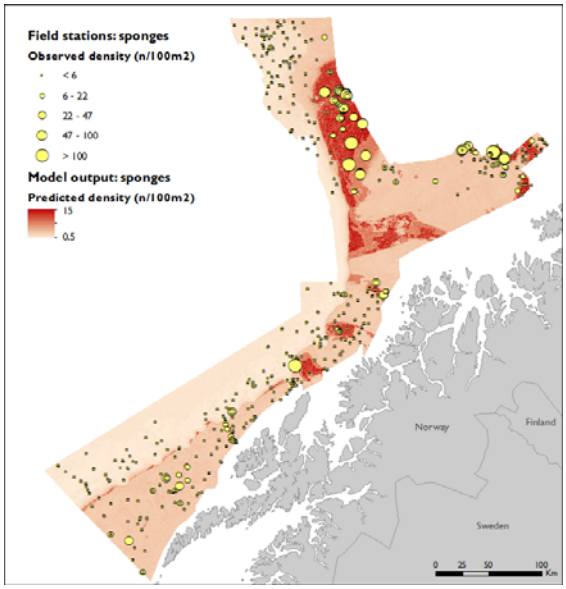

Figure 1. Preliminary results from modelling sponge communities using MAREANO field data

Hazards and Habitats – Construction and Destruction of Marine Benthic Habitats in the Pacific NW of USA and Canada

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Recent geohazards events such as the 2011 Fukushima Hamadori earthquake and tsunami in eastern Japan have focused attention on the adverse impacts to coastal infrastructures and the production of marine debris. Although the most sensational part of the ongoing reporting of the event is in regard to anthropogenic debris drift and landfall, the most significant scientific aspect is that this impact is the result of a natural hazard occurrence, many of which occur regularly and go unreported. These hazard events often produce habitats, as well as destroy habitats, on the seafloor. This is particularly true for the Pacific Northwest of the US and Canada. We report upon the many different natural geohazards that occur on and around the seafloor of the Salish Sea, in the waters around Vancouver Island, the Gulf Islands and the San Juan Archipelagos. Terrestrial and submarine landslides, fault movement, earthquakes, and volcanic activity all play a role in the generation of new marine benthic habitats that are beneficial to commercial fisheries and ecological diversity. Critical habitats are often destroyed or displaced from such events but the impacts might not be as destructive as perceived and over time may actually stimulate refreshment of the biota. We will discuss the geohazards of the Pacific Northwest region, their recurrence intervals, and the types of habitats produced or destroyed along with the benefits of the stimulation of new marine benthic habitats.

Global seafloor geomorphic features map:
applications for ocean conservation and management

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Seafloor geomorphology has proven to be a very useful physical attribute for ocean management because different geomorphic features (eg. submarine canyons, seamounts, spreading ridges, escarpments, plateaus, trenches etc.) are commonly associated with particular suites of habitats and biological communities. Although we now have better bathymetric datasets than ever before, there has been little effort to integrate these data to create an updated map of seabed geomorphic features (or habitats). Currently the best available global seafloor geomorphic features map is over 30 years old.

A new global map of seafloor geomorphology has been created based on the analysis and interpretation of the SRTM (Shuttle Radar Topography Mission) 30 arc-second (~1 km) global bathymetry grid. The new map includes global spatial data layers for 25 categories of geomorphic features, as defined by the International Hydrographic Organisation. The features mapped are classified as shown in Table 1.

Shelf	Slope	Abyssal	Hadal
- Low relief	Canyons	Abyssal plains	
- Medium relief	Blind	0-300 m relief	
- High relief	Shelf-incising	Abyssal hills	
Shelf valleys	Terraces	300-1000 m relief	
Glacial troughs		Abyssal mountains	
		>1000 m relief	
Sills	Sills	Sills	Sills
Basins	Basins	Basins	Basins
	Escarpments	Escarpments	Escarpments
	Seamounts	Seamounts	Seamounts
	Ridges	Ridges	Ridges
	Troughs	Troughs	Troughs
		Bridges	Bridges
		Trenches	Trenches
	Fans	Fans	
		Rise	
		Mid-ocean ridge	
		Rift Valley	

Table 1. Classification of geomorphic features. Features in shading overlap with more than one of the four main ocean biomes (shelf, slope, abyssal and hadal).

The new geomorphic features map will allow:

- Characterization of bioregions in terms of their geomorphic content (eg. GOODS bioregions, Large Marine Ecosystems (LMEs), ecologically or biologically significant areas (EBSA));
- Prediction of the potential spatial distribution of vulnerable marine ecosystems (VME) and marine genetic resources (MGR; eg. associated with hydrothermal vent communities, shelf-incising submarine canyons and seamounts rising to a specified depth) ;
- Characterization of national marine, or other institutional jurisdictions (eg. regional fisheries, or other management arrangements) in terms of their inventory of geomorphic features and the global representativeness of those features.

Predictive mapping of seafloor depressions on the Chatham Rise using supervised classification of backscatter data

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Multi-beam echo-sounder data collected on the Chatham Rise off the east coast of New Zealand revealed numerous pockmarks at water depths of 500-1,100 m. The seafloor depressions were originally thought to have formed as a result of explosive release of gas due to dissociation of gas hydrates during glacial-interglacial cycles. Recently collected data from the area has revealed that this hypothesis is improbable due to the lack of supporting evidence. There is some indication that gas or fluid migration has occurred in the vicinity of these structures; however this is no longer believed to be the main mechanism resulting in their formation.

This unique seafloor morphology does not occur anywhere else on the New Zealand continental shelf and the processes resulting in their formation are not yet fully understood. The extensive data set from the vicinity of the largest of these seafloor depressions on the Chatham Rise provides a unique opportunity to closely examine the complex relationships between volume backscatter, seafloor topography, substrate lithology, marine habitats and the subsurface processes relating to the formation of these structures.

Here, we use the supervised segmentation of the backscatter signal using the Ifremer SonarScope® software to generate a predictive seafloor lithology map in the vicinity of the seafloor depressions. The backscatter dataset includes new data collected in 2012 and 2013 onboard R/V Polaris II and R/V Sonne compiled with the New Zealand bathymetry database. Multibeam backscatter data collected in the vicinity of the largest seafloor depressions shows distinct variations relating to the seafloor lithology. This has been combined with ground truth data in the form of underwater video transects and sediment cores collected in the region to interpret seafloor lithology. Ground truthing is critical to validate the classification and produce predictive maps. The Chatham Rise and Canterbury Shelf are prime locations in which to test the supervised classification of seafloor lithologies due to the diverse range of substrate types and geomorphology. This presentation outlines the initial results of this project and discusses the merits and limitations of using supervised segmentation of backscatter data for mapping seafloor lithologies.

A continental-scale classification of submarine canyons for the Australian margin: a first-order approach using morphometrics, shape and location

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Submarine canyons are highly energetic and dynamic environments. Owing to their abrupt and complex topographies that are in contrast to the adjacent shelf and slope, they can generate intense mixing, both horizontally through internal tides and waves and vertically through upwelling and downwelling. Complex hydrodynamic processes and increased food supply in sediment and the water column can result in elevated primary and secondary production which can favour the development of highly productive and temporally dynamic food webs over canyons. Consequently, many submarine canyons, especially those that incise continental shelves, are considered as biodiversity hotspots.

On the Australian margin, submarine canyons have formed along all sides of the continent and are exposed to the potential influence of large-scale ocean currents, including the Leeuwin Current (western to southern margins) and the East Australian Current (eastern margin). Recognised in marine bioregional plans as potential biodiversity hotspots, many of these canyons sit within the new national network of Commonwealth Marine Reserves. To support the management of these reserves, the Marine Biodiversity Hub (funded through the National Environmental Research Program) is undertaking a national-scale analysis of submarine canyons on the Australian margin in order to better understand the ecosystem function of and ecological processes associated with canyons. The first step in the analysis has been the development of a first-order canyon classification based on their physical characteristics. A hierarchical classification scheme is proposed. At the top level, the submarine canyons are classified into shelf-incising canyons and confined-to-slope canyons. At the lower levels, the canyons are classified based on their morphometry, shape and location characteristics.

The accurate mapping of submarine canyons was the critical first step for the success of the proposed canyon classification system. To achieve this, national bathymetry data at a spatial resolution of 250 m was used, supplemented by a 50 m bathymetry grid representing all available multibeam sonar data for the Australian margin. The extent of individual canyons was manually digitised as a GIS polygon layer using hill-shaded bathymetry layers to aid mapping. Here we defined a canyon as a feature with the following bathymetric characteristics: (i) water depth at the canyon head less than 4000 m; (ii) depth range between the canyon head and foot greater than 600 m, and; (iii) incision of the canyon head greater than 100 m. On this basis, a total of 708 canyons were mapped for the Australian mainland margin.

The following metrics were then calculated as inputs to the canyon classification: (i) morphometry, including incision depth of the canyon head, standard deviation of the slope gradient, slope gradient between the canyon head and the canyon foot, and overall canyon rugosity; (ii) shape, including canyon area, number of branches, length/width ratio of the smallest bounding rectangle, border index, compactness and canyon volume, and; (iii) location, including depth of the canyon head, depth range between the canyon head and foot, canyon density, distance to coast, distance to the shelf break, incision depth (shelf-incising canyons only), and incision area (shelf-incising canyons only).

A hierarchical agglomerative clustering technique was used for the unsupervised classification. Among the 708 mapped canyons, 134 incise the continental shelf with the remainder confined to the continental slope. For the shelf-incising canyons, the morphometry, shape and location-based classifications all resulted in three classes. Combining the three lower level classifications yielded 15 classes. For the slope-confined canyons, the morphometry, shape and location based classifications resulted in three, four and four classes, respectively. Combining the three lower level classifications yielded 37 classes. Ongoing analysis of these canyon classes is focused on assessing their ecological significance by exploring potential interactions with ocean currents and testing against field observations of seabed biological communities and remotely sensed biogeochemical datasets for representative canyons.

Monitoring of deep-water conservation areas through AUV sidescan sonar mapping: checking the status of the Darwin cold-water coral mounds after 8 years of protection.

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The Darwin Mounds are small cold-water coral mounds, up to 5 m high and 75-100 m across, located at ca. 1000 m water depth in the Northern Rockall Trough, NE Atlantic. They were first discovered in 1998 as high-backscatter targets on 30 kHz TOBI sidescan sonar records of the area (Masson et al., 2003). Subsequent surveys, using a GeoAcoustics dual-frequency sidescan sonar (100 and 410 kHz) and the NOC WASP and SHRIMP video platforms, confirmed they were covered, and potentially built up, by cold-water corals. However, this high-resolution dataset also revealed that the mounds were heavily damaged by deep-water bottom trawling (Wheeler et al., 2005). These findings eventually resulted in an emergency closure of the area for all bottom fisheries under the EU Common Fisheries policy in August 2003; the measure was made permanent in spring 2004. Since then, the Darwin Mounds have also been designated as the UK's first deep-water Special Area of Conservation (SAC) under the EU Habitats Directive.

However, since the first observations in 1998-2000, no further surveys had been carried out in the area, and the status of the Darwin Mounds and their associated cold-water coral habitats was unknown until a revisit took place in 2011. Using the Autosub6000 Automated Underwater Vehicle (AUV), 2 areas of the Darwin Mounds were re-surveyed with an EdgeTech dual frequency sidescan system (120 and 410 kHz). Ground-truthing was carried out with a Sea-Eye Lynx ROV, equipped with a Kongsberg OE14-366 colour zoom camera and a Kongsberg OE14-208 digital stills camera. Both the new and the legacy sidescan sonar datasets were processed with the NOC in-house PRISM software. Image texture attributes were calculated in Erdas Imagine 2011, and formed the basis for unsupervised classification, mapping out the mounds, live/dead coral stands and coral rubble.

The 2011 results were compared with the 1998-2000 records to assess the potential recovery of the area. Although there was no longer any evidence for on-going bottom trawling activities (trawl marks), there were no clear signs of coral recolonisation/expansion in the area: very little has changed over the past 11 years. Cold-water corals are slow-growing, and recovery from physical impacts takes time, sometimes more than decades. Further repeated long-term monitoring will be necessary to follow up the recovery of the Darwin Mounds.

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Wheeler, A. J., et al. (2005). The impact of demersal trawling on NE Atlantic deep-water coral habitats: the case of the Darwin Mounds, UK. Benthic habitats and the effects of fishing. P. W. Barnes and J. P. Thomas. Bethesda, Maryland, America Fisheries Society**:** 807-817.

Modeling species distributions and biological conservation values for coastal zone management

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Marine species distribution modeling (SDM) is an increasingly used tool for producing layers for management purposes. In Sweden the first two projects using SDM for large scale map production for detailed coastal zone management are finalized, and the concept is now further developed in new areas. In the project MARMONI (Blekinge county) and MMSS (Södermanland county) we produce maps of several biota groups (benthic flora and fauna, fish recruitment areas, pelagic fish). Both natural parameters (depth, substrate, wave exposure etc) and anthropogenic pressures (nutrients, hazardous substances, boat traffic etc) were used as predictors. GAM statistics and/or random forest were the modeling techniques we used and predictions were validated using split sample. The spatial variation in prediction accuracy depends both on the model and the map layers used as predictors, and we will demonstrate how we map confidence levels based on that.

Marine spatial planning and other management tasks need often aggregated biological layers displaying biodiversity hot spots or conservation values instead of a large number of species distribution maps. In close cooperation with managers we develop a number of maps showing areas of biological significance based on criteria from the convention of biodiversity (CBD). The maps also take into account the spatial variation of accuracy in the biological maps they are based upon.

The project was performed by AquaBiota Water Research in cooperation with county administration boards in Blekinge and Södermanland, Swedish Maritime Administration, Swedish Geological Survey, Lund university. Both projects were funded by the Swedish Agency for Marine and Water Management, and MARMONI also by LIFE+.

Spatial modeling to predict and quantify areas of free gas in surficial sediments of the Belt Sea, Baltic Sea

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The occurrence of shallow gas in coastal and estuarine sediments as well as in deeper marine deposits is a common phenomenon and has been identified at numerous global locations. Shallow gas in sediments occurs due to methane oversaturation and has a dramatic effect on benthic ecology, biogeochemical flux, material transport, sediment stability, geo-acoustic properties and seabed. It changes the sediments physical properties like sediment stability, compressibility, and acoustic penetration. Therefore, embedded methane bubbles influence geo-hazards (gas hydrates, landslides, tsunamis ...) and are also important for offshore as oil and gas exploration as well as off-shore windmill construction. Furthermore, they effect the biological environment and the climate change acting as a greenhouse. The shallow gas relevance is clearly reflected in several international and national projects during the last decade, as e.g. the EU-project METROL which investigated the: controls and mechanisms of methane production and breakdown in ocean European margin sediments (2002-2005), the German BMBF-GEOTECHNOLOGY-PROGRAM contributing to the understanding of methane in the geo- and bio-system with 11 projects (2000-2008), and the EU-project BALTIC GAS that focused on the methane emission in the Baltic Sea (2009-2011).

Methane is the only gas component found in considerable quantities in the pore-waters of anoxic marine sediment, beside carbon dioxide, hydrogen sulphide, traces of ethane and propane. The methane oversaturation depends strongly on the geological settings and the environmental conditions and affects physical, biogeochemical, and biological processes within and above surface sediments. Pressure, temperature, and salinity conditions control the maximum methane concentration which can be dissolved in pore-water. The main purposes of this study is to discuss the capability of the multivariate machine learning model MaxEnt to quantify and to map quantitatively the distribution of shallow gas in the Belt Sea based on seismic-measured known and unknown gas area data. This includes the investigation of the controls on the relevant key variables; that means to investigate the spatial relationship between gas occurrence with data sets about bathymetry, sediment type, bottom morphology and chemical composition of the bottom water.

Sediment type, POC accumulation, TOC, depth, bedform and sulfate were found as key parameters for predicting shallow gas areas in the Belt Sea. The quality assessment the MaxEnt model was guaranteed by a) receiver operating characteristic (ROC) and area under the curve (AUC) calculation; b) Jackknife test and estimates of the relative contributions of the environmental variables to and c) cross-validation.

However, predictive scenarios covering non-investigated areas trying to identify hotspots of gas and potential future methane emission need to be verified.

Seabed mapping to support new marine estate governance arrangements in New South Wales, Australia

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Surveys of the seabed on the continental shelf of eastern Australia have been conducted in various forms for more than one hundred years. A program is underway in New South Wales, Australia that aims to address key gaps in our understanding of the spatial extent, distribution and structure of the major subtidal marine habitats and biodiversity on the continental shelf. Analysis of existing bathymetric, sediment, seabed habitat and biodiversity data is being incorporated with high resolution swath acoustic and towed video data. Surveys have been conducted primarily with a Geoswath 125 kHz interferometeric sidescan which provides georeferenced bathymetry and backscatter. Over 2500 sq/km of swath acoustic data has been collected in depths from ~5-150 m, targeting inner continental shelf waters.

The program objective is to provide statewide bathymetric and backscatter data layers, and derived seabed habitat maps at a range of hierarchical levels. Further information on benthic assemblages is being examined from broad scale towed video data and targeted high resolution Autonomous Underwater Vehicle (AUV) surveys. The project is working closely with a number of government agencies and universities to assess the extent and condition of seabed habitats and identify current and potential pressures and threats. Educational material is also delivered that aims to provide greater community awareness of marine habitats in NSW and their associated biodiversity.

The key driver for seabed mapping in NSW has been marine protected area (MPA) planning and research in order to assess the planning criteria of representativeness within no-take zones, and evaluate their effectiveness and related management arrangements. The establishment of marine park boundaries and their subsequent zoning in NSW coastal waters has progressed over the past 20 years resulting in six marine parks covering around 2,480 km^2 (~32% of coastal waters). With extensive marine park coverage along the NSW coast, seabed mapping and monitoring in the parks is a key component of the overall research program, particularly due to the need to monitor sites where key pressures and stressors have been removed, and compare these to sites with differing levels of protection.

Proposed changes in governance arrangements for NSW coastal waters indicates that there is a need to consider the MPA's in the broader context of a 'Marine Estate'. Such broader management focus will be dependent on ongoing seabed mapping to improve our understanding of the spatial distribution of habitats and associated biota throughout continental shelf waters, and allow monitoring programs to be effectively developed. In addition to presenting the key outcomes from the seabed mapping program, the need for improved marine management and planning through changes in governance arrangements will be discussed.

Geological inventories of FINMARINET project

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Inventories and planning for the marine Natura 2000 network in Finland (FINMARINET) is a Life+ -funded project that has carried out inventories of the marine habitat types of the EU Habitats Directive along the Finnish coastline including the Finnish territorial waters and the Finnish exclusive economic zone (EEZ). The projects aims to produce cartographic images to underpin decision making regarding the key marine habitat types related to the Habitats Directive. The project is coordinated by the Finnish Environment Institute (SYKE), with four associated beneficiaries: Geological Survey of Finland (GTK), Metsähallitus Natural Heritage Services, Åbo Akademi University and the University of Turku. The FINMARINET project is implemented in close relationship to the Finnish Inventory Programme for the Underwater Marine Environment (VELMU).

GTK has carried out marine geological inventories in five research areas with special emphasis on marine habitat mapping. Areas are located in and around marine Natura 2000 sites along the entire Finnish coastline and they represent different geological environments, giving an overview of geological habitats in the Finnish waters. Geological inventories of seabed topography and substrate were carried out alongside biological surveys of habitat types and their flora and fauna. Research methods included continuous sub bottom profiling, reflection seismic, side scan sonar and multibeam echo sounding as well as bottom sampling. In addition, the automated approach to classify seafloor surface material was tested. Here we will discuss the lessons learnt and present the outputs of the geological inventories: substrate and landscape maps for the study areas.

An object-based semi-automated method to assess fine-scale benthic complexity in deep-water continental shelf habitats

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Structurally-complex benthic habitats are commonly found on glaciated continental shelves basins and banks. Complexity arises at varying spatial scales, from the mesoscale patterns of topographical features (e.g. cliffs) to the fine-scale (≤ 1 m^2) variety of particle grain size observed on the seafloor (from mud to boulders). In these habitats, multi-scale seafloor complexity is an important factor influencing the distribution of biological communities, in particular for sessile epifauna. This relationship underscores the importance of developing methods to accurately describe, quantify and map 'complex' habitats at multiple scales.

Digital seafloor photographs are a non-invasive tool used to describe biological communities and substrate characteristics in deep waters. They form large datasets that allow high-resolution mapping (at scales of centimeters). Automated (and semi-automated) methods to process these datasets have the advantage of both eliminating subjectivity in interpretation and accelerating processing time. A photographic dataset (more than 4,000 samples) was acquired along transects in 5 physioregions in the Gulf of Maine (northwest Atlantic) at depths of 100 to 320 m. High-resolution images (illuminated field of view of ~0.375 m^2; 9 megapixels; ~2,400 pixels/cm^2) were taken at set intervals of ~5 m on the seafloor using a three-legged platform equipped with a downward-facing camera (35mm Nikon F4). This presentation introduces an object-based semi-automated method to process digital photographs of the seafloor. The goals of this method are to: 1) quantify complexity of the substrate (using measures of entropy), and 2) describe the distribution of particle grain size (using color-texture segmentation and statistical clustering methods). The resulting segmented images are compared (i.e. probabilistic Rand index) with manual ground-truthing annotations.

Validation of supervised segmentation and classification of backscatter data of Barrett's Reef, Wellington South Coast, using drop-camera videos.

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The south coast of Wellington is situated along the high energy environment of the Cook Strait and is composed of rugose bedrock reefs, large patches of boulders, cobble fields and areas of gravel and sand. This complex habitat supports a high diversity of ecologically and economically important species. Physical and biogenic habitats are key components when siting marine reserves and a section of the south coast was designated as the Taputeranga Marine Reserve in 2008. Barrett's reef lies just to the east of the reserve boundary and is composed of similar habitat and depth regimes and therefore is an ideal control site for marine reserve effectiveness monitoring. Barrett's reef is near the harbour entrance and is one of the last reefs that link the south coast and the harbour therefore having the potential to act as an ecological corridor.
In 2010-11, Barrett's Reef was mapped using multibeam echosounders for the Shallow Water Survey 2012 conference common dataset. Here, we use the data collected with a Kongsberg EM2040. The multibeam data coupled with compilation and interpretation of the video provides information on the substrate and biogenic habitat of the reef. We have processed the EM2040 backscatter data using the IFREMER SonarScope software, and generated a supervised segmentation of the backscatter image.

Barrett's Reefs' water depth ranges 0 to about 15 m, with a ridge line trending North-South. The top of the reef is breaking the sealevel. The topography is complex with rocky outcrops, incisions with rippled sediment flows, post-glacial gravel beds overlain by finer sediments, boulder fields. In preparation for the Geohab 2013 pre-conference workshop "Multibeam Backscatter – State of the Technology, Tools, & Techniques", we conducted video surveys for ground truthing and class validation purposes in March 2013. The survey consists of a number of drop camera stations on an initially random distribution adjusted to cover all backscatter facies identified on the fully processed EM2040 dataset. High definition videos will be collected at each location for duration of 120 seconds. Videos will be reviewed in March-April 2013 and the substrate classified into a small number of classes to include: mud, sand, gravel, cobble, boulder, continuous bedrock. Relative abundance of algal communities will be scored and classed into the following categories: crustose coralline, articulated coralline, understory, canopy.

The video data provides ground-truthing information which will enable us to validate the classes identified in the SonarScope generated segmentation map. This multi tool and scalar approach will produce an accurate habitat map and enables the understanding of the ecological importance of the area.

Ultra-high resolution acoustic survey in turbid waters. Initial results from Britain's Atlantis – Dunwich town.

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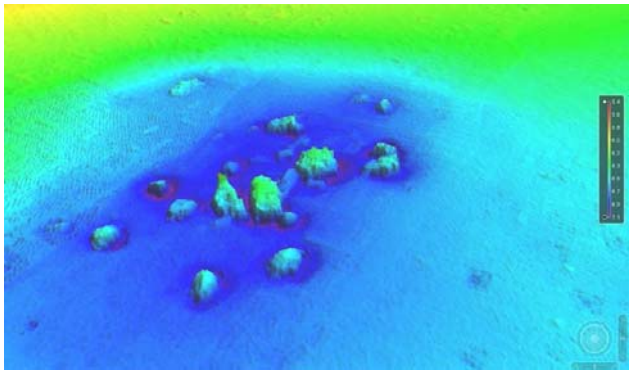
[3] *Wessex Archaeology*

Habitat mapping often depends on high resolution acoustic data from sidescan sonar or multibeam bathymetry systems to map large areas of seafloor terrain. To see ultra-high resolution features usually requires photography or video from a towed system, ROV or diver. In turbid water where visibility is minimal or none, optical methods are not practical. We present a new acoustic system called a Didson (™ McCartney) working at very high-frequencies of 1.1MHz and 1.8MHz for finer-scale mapping. The very high frequency does mean that the acoustic viewing range is restricted (< 20m), and thus needs to be finely controlled. The system is mounted on a tripod plate, to be placed on the seafloor and rotated on the spot by a diver; the results then to be compared with multibeam bathymetry survey and high frequency sidescan imagery.

Our test area was an archaeological site off the Suffolk coast showing the remains of Dunwich town. In the 12th century Dunwich was a thriving port (the 5th largest port in Britain). Coastal erosion however took its toll over the hundreds of years, possibly due to coastal works begun in the 13th century, so that today Dunwich is a fraction of its former size with only a few houses remaining onshore. Most houses from the period would have been wooden and thus would not survive to this day, but many of the 17 churches were of brick or stone construction and it is these remains which are visible on the seafloor. Mapping allows reconstruction of the history of the port and can provide rates of coastal erosion. Methodology and trials from the survey will be shown together with plans for future work and new systems – possibly up to 3MHz.

Gravestone very close to edge of the cliff in Dunwich's last remaining cemetery, which will soon be lost to the sea by coastal erosion.



3D multibeam bathymetry image of St Katherine's Chapel now submerged under the North Sea.

Exploring the role spatial scale plays in marine habitat mapping using multiscale geomorphometric analyses

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The study of terrestrial ecosystems at various spatial and temporal scales has proven beneficial for understanding a number of important ecological processes, but has not received the same level of attention in marine ecology, largely due to a more difficult access to data at multiple scales. Broad-scale data can miss patterns linked to local-scale processes. While Remotely Operated Vehicles (ROV) allow the collection of high resolution data in the deep sea, such detailed data sets are not necessarily the most appropriate for understanding distributions. In most studies, the scale of analysis is often arbitrarily based on the available data, which can be misleading if the scale of analysis does not match the scale of ecological process under investigation. Spatial scale is therefore probably one of the most misunderstood concepts in marine habitat mapping.

The research presented here aims to further explore the role that spatial scale plays in understanding and mapping deep-sea benthic habitats. Environmental and topographic variables are known to be important to understand the spatial distribution and spatial ecology of benthic organisms and habitat structures at several scales. We apply an approach which studies these variables and patterns across a continuum of spatial scales, using different resolution bathymetric datasets, in order to create a continuous range of scales.

We present preliminary results obtained from the application of this multiscale approach to cold-water coral habitats in Canada. High-resolution multibeam sonar, video and oceanographic data were collected in 2010 and 2011 in the Northwest Atlantic (Flemish Cap and Orphan Knoll, near Newfoundland) and on the Pacific continental shelf (Strait of Georgia, British Columbia), using the Canadian ROV ROPOS. Multibeam bathymetric data were collected using the ROV either close to the seafloor (1-2m height), and/or at an altitude of 20m off-bottom. Vessel-mounted multibeam bathymetric data are also available from both study areas. These data allowed bathymetric models (grids) of the seafloor to be generated at the following spatial resolutions: ROV-derived bathymetry, ranging from 0.1 to 1m resolution; vessel-mounted multibeam bathymetry ranging from 2 to 50m resolution; General Bathymetric Chart of the Oceans (GEBCO) derived grids at 30-seconds resolution (around 865m at this latitude). Observations of corals were obtained from the ROV video data at the local scale, and from scientific trawl surveys at the regional scale.

Using these data, the importance of seafloor morphology in structuring coral habitats was studied across the range of spatial scales in order to characterize their respective niche and to define their most appropriate scale for which to investigate their predicted distribution. Geomorphometric attributes (e.g. slope, aspect, curvatures) were measured for each bathymetric datasets, with a particular emphasis given to attributes expressing the complexity of the seafloor, such as Bathymetric Position Index (BPI) and Vector Ruggedness Measure (VRM). Linear correlations were calculated between geomorphometric attributes and area-normalized presence of six functional groups of corals: soft corals, small gorgonians, large gorgonians, sea pens, stony cup corals, and black corals.

Using the GEBCO bathymetry and the observations from scientific trawl surveys, depth showed a positive relationship with all the functional groups except soft corals. Slope was positively correlated with cup corals, soft corals, and small gorgonians. Standardized fine-scale and broad-scale BPI were negatively correlated with black corals and sea pens, but positively correlated with soft corals. Fine-scale BPI presented a negative correlation with stony cup corals and small gorgonians, but not broad-scale BPI. VRM was positively correlated with all coral groups except soft corals: the three scales of measured VRM had a relationship with small gorgonians, the broadest scale with stony cup corals, and the two finest with sea pens.

More analyses are required to explore more geomorphometric attributes and the multicolinearity effect between them, and to understand the complex interactions between the different morphological characteristics of the seafloor and cold-water coral habitats at different scales.

Submerged reef structures and benthic habitats surrounding the Balls Pyramid shelf, Southwest Pacific Ocean: Implications for reef development beyond the modern boundary for coral reef growth

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Coral reefs are particularly vulnerable to climate change impacts of warming sea surface temperatures, increased frequency and severity of storm events, rising sea level and ocean acidification. While concern has grown about loss of corals from tropical, shallow reefs, less attention has been paid to how coral reefs will respond at high latitude locations. It has been suggested that these regions may potentially see expanding coral communities and that deep reefs may act as refuges during times of stress.

The southernmost coral reef growth in the Pacific Ocean occurs at World Heritage listed Lord Howe Island, whose extreme latitudinal location results in a unique mix of tropical and temperate flora and fauna. On the mid-shelf surrounding the island is an extensive submerged reef structure, the upper few metres of which is Holocene material, demonstrating significant past reef accretion in a marginal environment. Balls Pyramid, a pinnacle that lies about 23 km to the southeast of Lord Howe Island, is recognised for supporting abundant marine life, though the submerged shelf surrounding Balls Pyramid had not been mapped.

The region is protected by state and Commonwealth multiple-use marine parks, with the Commonwealth recently announcing further protection of the Lord Howe Region through the Temperate East Marine Reserve Plan. A recent zoning review undertaken by the marine park outlined the need for a comprehensive habitat map for the marine environment with the detailed mapping of the Balls Pyramid shelf identified as a key research priority.

High resolution multibeam echosounder data and TOPAS sub-bottom profile data collected aboard the R.V. Southern Surveyor in early 2013 is used to reveal the complex morphology and sub-surface characteristics of the Balls Pyramid shelf. Underwater towed video footage is used to ground-truth acoustic data and develop a comprehensive benthic habitat map. Of particular focus is the depth and spatial gradients of coral and algae, which may identify existing growth regions and predict potential regions that may act as suitable growth areas. This data is integrated with existing coverage for the Lord Howe Island shelf to build a deepened understanding of past coral reef extents and modern distributions in a deep, high latitude location.

The habitat map generated by this research directly fulfills the need identified by the marine park to complete shelf coverage and better understand the habitats of the Balls Pyramid shelf. The results of this study have implications for our understanding of the potential of these lesser known marginal environments to support coral reef growth in the context of a changing environment. Detailed habitat map products will be provided to managers of this region of high conservation value as a baseline study which can be used in longer term managing of the park.

A deep sea dilemma: a practical method for assessing the conservation importance of deep sea sponge communities

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There is increasing evidence that deep sea sponge aggregations constitute key components of deep marine ecosystems. They increase the number of available microhabitats in an area by adding to the heterogeneity of the ocean floor, resulting in reservoirs of elevated species diversity. The ecological significance and sensitivity of these communities resulted in their inclusion within the 2008 'OSPAR List of Threatened and/ or declining species and habitats'. This list is utilised by OSPAR contracting parties, to aid in the identification and selection of marine protected areas. Despite the widely accepted conservation importance of deep sea sponge aggregations within the North East Atlantic, the ecology and distribution of these habitats is currently poorly understood. Moreover, there is as yet no universally accepted method to quantitatively assess the relative ecological importance of different examples of the biotope.

Sponges are long-lived, slow-growing, and comprise fragile structures that are easily damaged by physical disturbances. As such, the expansion of oil and gas activities into deeper water environments and the colder waters of higher latitudes is thought to pose some threat to deep sea sponge aggregations. Increased operational activity in these areas, however, offers an opportunity to expand upon the current knowledge and understanding of these habitats. Seabed photographic data collected during offshore surveys may provide useful information regarding sponge community density and taxonomic composition. The geophysical data routinely acquired during such surveys may also assist with the identification of suitable areas for sponge aggregations, potentially allowing predicative mapping models to be developed in the future.

The establishment of a consistent framework by which deep sea sponge aggregations can be assessed from photographic data is essential if they are to be effectively protected within the OSPAR area. A matrix combining sponge cover and a growth form-weighted size index, acting as a proxy for the biomass of sponge colonies, is suggested as the basis for development of an assessment method. The technique has been tested using photographic data collected during offshore surveys and its effectiveness is discussed. Thresholds have been defined within the assessment framework, suggesting a means by which deep sea sponge aggregations may be evaluated in terms of their ecological importance, so as to minimise impacts from offshore development activities.

How robust are your prediction derivatives? Error propagation modelling for seafloor terrain analysis of multibeam bathymetric data using dynamic simulation tools

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There are many potential applications of seabed habitat mapping for which estimates of uncertainty in seafloor terrain derivatives will provide additional crucial information. This information is useful to assess the robustness of multibeam bathymetric data for seabed monitoring, change detection and habitat prediction analysis.

As multibeam data collections build up over time a method to assess the compatibility to spatially merge these data are essential. These datasets then become the input data for spatial analysis procedures to characterise the seabed. The accuracy of seabed terrain first and second order derivatives and their associated levels of uncertainty are extremely hard to convey visually or to quantify with existing methodologies.

In this study Monte-Carlo simulation techniques were used to represent DEM (digital elevation model) uncertainty and its effect on three topographic parameters (slope, curvature and aspect). Different methods for representing error and quantifying uncertainty are investigated. In these results the analysis the multibeam bathymetric error are assumed to be spatially auto correlated across a neighbourhood zone, methods for the assessment of autocorrelation will be discussed. Each terrain derivative layer was perturbed using its error model with increasing levels of error, and the effect on the seabed map was assessed.

Quantifying uncertainty in the input data for habitat suitability modelling is imperative to establishing methods for prediction, and monitoring, as we need to be able to separate potential mapping error from change and variation in the system that we are monitoring. By combining bathymetric processing and uncertainty modelling techniques we can make an important step towards identifying tools for seabed monitoring and risk assessment for policy-making. These tools will improve our ability to assess and communicate the accuracy of the seabed maps through spatially mapping the degrees of uncertainty in our predictions and therefore make more informed choices of the data we use to inform ocean management policies and subsequent seafloor analysis.

Habitat mapping and morphological characterization of extremely shallow environments through spectral and textural analysis of high resolution bathymetric and backscatter data

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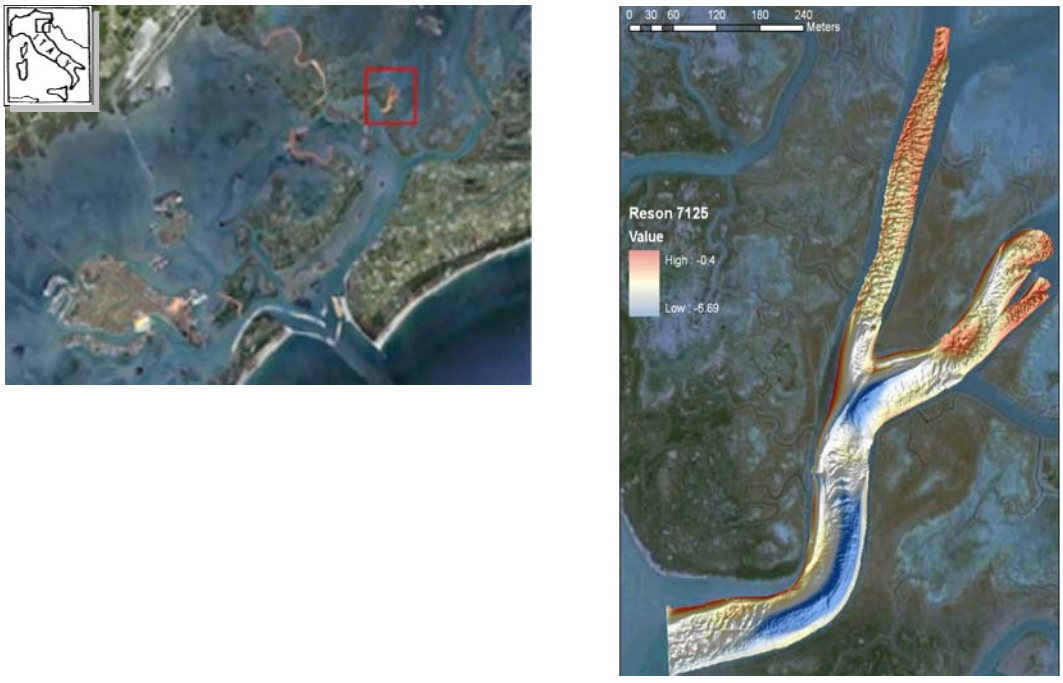
Among the coastal systems, transitional environments, like lagoons, deltas and estuaries, are often extremely shallow (of the order of 1 m deep or less) and morphologically complex. These environments often undergo strong natural and human-induced actions that need constant monitoring. The changes of these environments can be assessed using acoustic bathymetric surveys. Bathymetric surveys with multibeam echosounders (MBES) and interferometric systems allow to collect at the same time bathymetric and backscatter data that can be employed for geomorphologic studies and habitat mapping. These instruments have become a very important tool to study the evolution trends of the highly dynamical coastal areas.
However, transitional environments represent a challenge for acoustic bathymetric surveys. To assess the potentiality and the limits of acoustic surveys in extremely shallow environments, we carried out two surveys in the Lagoon of Venice, Italy, with an interferometric sonar and a MBES.
As a case study we focused on a natural channel in the northern part of the lagoon (Figure 1) combining the data from the different surveys. In particular we carried out a two-dimensional (2D) spectral and textural analysis of the high resolution bathymetric and backscatter data collected. As a result of the 2D spectral analysis on the elevation data, we were able to identify and parameterize the geometrical characteristics of the main morphological features of the channel, like dunes, scours, crests and troughs and sedimentation areas and to extract the channel bottom roughness. We then performed an unsupervised classification of the backscatter data. As a result, we were able to identify different backscatter areas where several grab samples were collected for ground truthing. With the help of this sampling we calibrated a textural analysis and obtained a classification of the different kinds of substrate. Within this multidisciplinary approach, we could map the main morphological and sedimentological features of the seabed trying to relate them to the habitats of an extremely shallow water dynamical environment.

Figure 1. Bathymetry of the Scanello Channel in the Northern part of the Venice Lagoon, Italy (vert. ex. = 5, DTM resolution = 0.5 m).



The differing requirements for habitat maps for UK marine conservation.

Fionnuala McBreen[1] & Nicola Church[1]

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Seabed habitat mapping is a useful tool in marine conservation. Offshore survey technologies have advanced significantly in the last decade but still remain extremely expensive to conduct with data collection often being opportunistic in nature. As such, detailed habitats maps produced using both acoustic and ground-truthing survey techniques exist for only around 15% of UK waters. Broad-scale predictive habitat models therefore provide an alternative solution to the production of full-coverage habitat maps for UK marine waters.

The requirements for habitat maps in terms of scale, resolution and production method vary depending on the associated policy and technical drivers. The habitat maps required to identify the location of Marine Protected Areas (MPAs) may differ in resolution from those needed to monitor and assess the condition of the MPAs. The recent recommendation of Marine Conservation Zones (MCZs) under the Marine and Coastal Access Act required a full-coverage habitat map for UK waters to identify the range and location of broad-scale habitats. This was conducted by selecting survey maps with a high MESH confidence score where available. Gaps were filled using the UKSeaMap2010 predictive model to ensure a full coverage EUNIS Level 3 habitat map for UK waters. The result was a continuous map that consisted of a “patch-work” of maps of different levels of detail.

Habitat maps at a finer scale (i.e. at a site level) are required to monitor and assess changes in extent and condition of the designated habitats within MPAs. In order to verify the presence and extent of habitats at this finer scale dedicated surveys are required to ensure the resolution of habitats maps in MPAs are appropriate for the selection of monitoring stations which will be able identify changes in indicators such as habitat extent and condition. These more detailed maps will also be required to monitor and assess the effects of management measures at a site level. The frequency required for recording an indicator such as habitat extent for the MSFD and the Habitats Directive will vary depending on the feature. The extent of an offshore rocky reef is unlikely to change whereas the extent of sandbanks or biogenic reefs which can change due to natural and\or anthropogenic reasons may need to be recorded more frequently.

Due to the differences in the size and nature of designated features within MPAs different survey techniques will be required for creating detailed habitat maps in UK waters. For example, the extent of reef in the Darwin Mounds Site of Community Importance (SCI) cannot currently be delineated using ship mounted multibeam systems. This is due to the depths at which the mounds are located and their relatively small size. Ship mounted multibeam systems would however be an appropriate technique for delineating the extent of rocky reef in Haig Fras SCI.

In the UK, habitat maps are also required at a national scale to facilitate the reporting to the European Commission as required every 6 years under Article 17 of the Habitats Directive. This involves the use of both predictive broad-scale habitat maps and maps produced from detailed habitat surveys to calculate the area and range of Annex 1 habitats in UK waters, as well as to estimate the proportion of these features included in the Natura 2000 network of MPAs.

The appropriate scale, resolution and method of production for habitat maps for UK marine conservation are influenced by the associated drivers for the maps which dictate the extent and range of the study area thus these factors will differ depending on the purpose of the map.

Seabed characterisation for predictive grain-size mapping using multibeam backscatter data and spatially weighted regression models

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Multibeam sonar is the most widely used seabed mapping technique with most systems simultaneously recording depth and acoustic backscatter information. This results in sizable and myriad repositories of such datasets, including those collated by the INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resources), Ireland's national seabed mapping programme.

While the efficacy of backscatter for discrimination of seabed type has been convincingly demonstrated, research to improve accuracy and establish limitations is still on-going. The most conventional approach uses image analysis techniques to partition and classify the data. Class assignments are then described by means of groundtruthing. However, the information produced in this way is not always ideal for the purposes to which it is applied. For example, the seabed types identified may be insufficient for estimation of particular habitat distributions. Furthermore, it is not possible to produce continuous maps of specific physical parameters from classified data.

The physical interplay between backscattered sound and seabed properties is governed by complex multivariate functions, but is known to correlate, particularly in soft substrates. The large numbers of parameters involved make inversion for the purposes of seabed prediction impracticable but in this study we suggest that simplification of the mathematical models employed is appropriate for certain seabed conditions. In these simplified scenarios, a number of sediment grain size parameters can be quantitatively estimated together with statistical measures of accuracy and confidence indices.

We present results from our pilot study area, Dunmanus Bay in the southwest of Ireland, where several multibeam surveys and a series of high-density groundtruthing campaigns have been conducted. The data was subject to a rigorous quality control procedure prior to analysis, including examination of global trends and elimination of samples with errors such as mislocation or mismeasurement. Of the initial 175, 111 samples were validated for inclusion in the analysis. Within the confines of the seabed scenario under investigation - that is soft, fine-grained sediments – and using non-spatial analysis, we observed strong linear correlations between backscatter and grain size parameters. This relationship is strongest for backscatter strength, averaged over patches of 20m x 20m, and the percentage sand content in the sediment sample (R = 0.67). These preliminary results suggest that this method can be used to predict sediment grain size properties within specific confidence bands. In addition, exploratory analysis of the data suggests that the application of spatial statistics will further refine the accuracy of predictions.

Information derived from backscatter in this manner has potential applications in a range of marine disciplines including geotechnical mapping, environmental monitoring and marine habitat mapping.

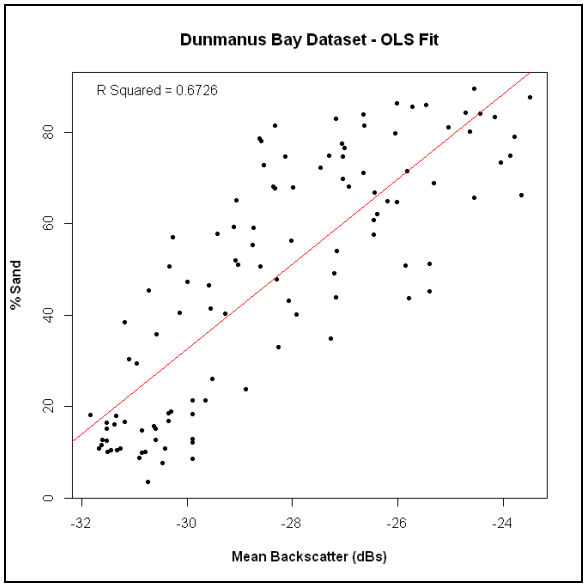

Figure showing the strong linear relationship between Mean Backscatter values averaged over a 20m by 20m grid and the % Sand content of groundtruthing samples collected from Dunmanus Bay, SW Ireland.

Species distribution modelling as a management tool to protect vulnerable species

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With contemporary extinction rates rising, understanding the vulnerability of marine species to disturbance is critical for proactive management. Vulnerable species are those at risk of undergoing local or global loss following disturbances such as fisheries exploitation, oil spills and climate warming and variability. Known indicators of vulnerability include geographic range, numerical rarity, ecological or dietary specialisation, age at maturity, body size and other life history traits. Having an understanding of the distribution of these species, and the spatial extent of habitat supporting them, is a vital step for prioritising management and reducing risk. As coral reefs are among the first ecosystems to show marked ecological responses to climate change, species dependent on these ecosystems can be particularly vulnerable. Of even greater concern is growing evidence that an entire community may be vulnerable when exposed to multiple stressors. We present research focussing on the submerged oceanic shoals of Australia's North West Shelf. This remote region supports some of the world's most pristine and biologically diverse ecosystems, while also supporting major oil and gas infrastructure. The oceanic shoals support mesophotic (30-60m deep) coral reef ecosystems with many of the same species found on the emergent coral reefs of the region (e.g. Ashmore, Cartier and Scott Reef). It has therefore been suggested that these submerged reefs may provide refuge from warming events and act as important stepping stones for enhanced biological connectivity among the emergent reef systems of Australia's northwest. With very limited knowledge of the marine species and communities represented by this region, the investigation explored the application of species distribution modelling to characterise vulnerable species distributions and identify potential conservation priorities.

Habitat mapping in upper bathyal seabed: target species in soft sediments (*Isidella elongata,Esper 1788*) **and hard surfaces** (*Leiopathes glaberrima,Pallas 1766)*
(SW Sardinian margin – West Mediterranean Sea).

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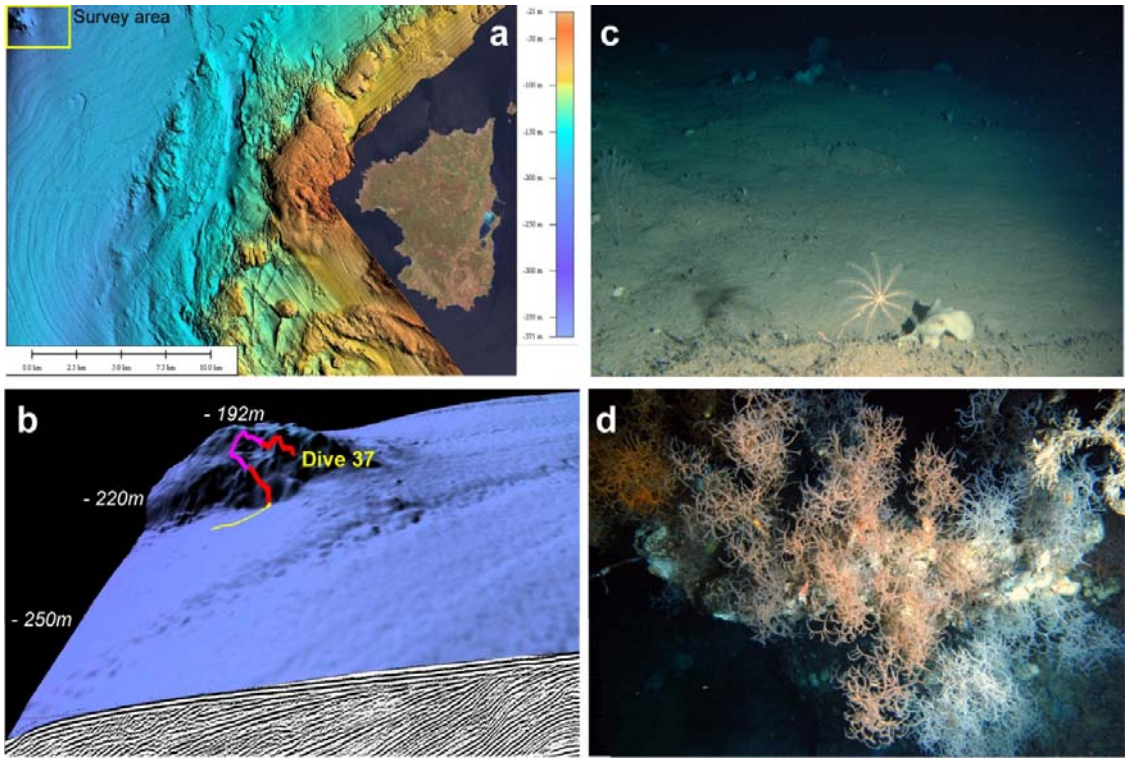
Although the ecological importance, along with economic relevance, upper bathyal seabed habitats are not widely investigated. In this work we propose a case of multidisciplinary study for habitat mapping. Geomorphological investigation using Multibeam, Subbottom CHIRP and 500J Sparker surveys was carried out on shelfbreak sea bottoms located 12 nm offshore San Pietro island (south-western Sardinia). Moreover, the geophysical dataset constituted the base for a Biodiversity ROV survey carried out in Summer 2011, Images collected were analyzed with CPCe software (Coral Point Count with Excel extensions) in order to investigate different species and coverage.. The Sardinian western continental margin is characterized by the setting of high-angle fault system (Oligo-Miocene), which borders the Sulcis shelfbreak on south-western side and gives rise to escarpment and intra-platform basin. On top of the Pliocene sequence, between upper slope and the distal platform, lies the prograding sedimentary prism. The prism is composed by different system tracts characterized by various types of clinoform pattern, laterally associated to four falling-low stand system-tracts related to as many glacio-eustatic oscillations which occurred between Middle Pleistocene and Holocene. The continuity of the prograding sedimentary prism is interrupted only by an undifferentiated tertiary basement outcrop, a tectonically isolated monoclinal "Cuesta" relief where hard bottom anthozoans corals (*L. glaberrima*) are located. At the base of the isolated relief the seabottom sediment stock is composed of plastic silty.sands and sandy silts with high water content slipping structures and creeps are detectable all over the soft bottom. On the soft bottom different facies of the biocoenosis "detritique du large" (DL) were examinated, recognizing ecologically important species (I*sidella elongata,Esper 1788, Leptometra phalangium, Clark 1908* **).**



Figures 1 - **a) Shadow relief from Multibeam** data of continental shelf offshore San Pietro Island, the Survey Area in the shelfbreak; (b) 3D display of DTM, showing the R. O. V course Dive 37, and the Sparker 500 J seismic section of the prograding late quaternary sequence; (c) Soft bottom (DL) with L.*phalangiu*m , *I.elongata* (d) Rocky bottom (RL) with *L.glaberrima*

High Resolution, Time-Series Acoustic Surveys Identify Ecological Benefits of Windfarm Developments

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Britain is the world leader in offshore wind energy production with as much capacity already installed in UK waters as has been installed throughout the rest of the world. There are currently 18 operational windfarms in our seas, with a further 7 under construction and 6 with planning consent. This level of offshore development is a reflection of the British government's commitment to reduce the environmental impacts of energy production. However, offshore windfarm developments present their own threats to the environment. Turbine installations and cable laying associated with offshore windfarm constructions involve a physical disturbance to the seabed and therefore, accurate mapping of sensitive habitats plays a critical role in the planning of these developments.

The largest offshore wind farm in operation in the UK (and worldwide) is the Thanet development off the coast of Kent which produces 300 MW of energy per year. High resolution acoustic surveys at the Thanet site revealed extensive *Sabellaria spinulosa* reefs which are protected under Annex I of the EU Habitats Directive. Detailed mapping of the extent and quality of this habitat using high resolution side-scan sonar data and seabed imagery, allowed the construction to go ahead with individual turbines being positioned in such a way that damage to the most important parts of the reef was avoided.

The reef extent and condition is being monitored on an ongoing basis through repeated high resolution acoustic surveys with associated ground truthing. Comparisons between the initial characterisation and pre-construction surveys revealed significant variability in the extent of this habitat which may in-part have been caused by damage from commercial fishing activities. It was hoped that the once constructed the windfarm would limit the exposure of the reef to commercial beam trawlers which target this sensitive habitat because of the known association with flatfish and this has now been proven by the first post-construction monitoring survey. Just one year after construction the reefs have been found to have grown in extent and improved in their condition, highlighting a direct ecological benefit to the constriction of offshore windfarms.

This is case study highlights the important application of seabed mapping in a marine planning and monitoring context and demonstrates the value of such methods in advancing our understanding of the interaction between offshore wind farm developments and the benthic habitat upon which they are placed.

Mapping the distribution of deep-sea Vulnerable Marine Ecosystems: an assessment of different modelling methods.

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Predictive modelling is now a key tool in the provision of maps upon which spatial planning and management of the marine environment can be based. However, with a multitude of methods available for use advice is needed on the best methods to select for the task at hand. Recent studies have used maximum entropy modelling (Maxent) to assess the distribution and extent of selected Vulnerable Marine Ecosystems (VMEs) in the NE Atlantic deep sea. However, this method requires that individual models are made and validated for each VME. This can be time consuming and produces maps that may provide conflicting information. Classification based methods such as Random Forest modelling provides a single output map where raster cells are classified into different VME types simultaneously. This has the benefit of producing one map upon which decisions can then be based; however this method may not provide the best maps. We predictively modelled the distribution of 3 VME habitats (*Lophelia pertusa* reefs, Stylasterids and lobose sponges' and Xenophyophore fields) on the eastern flank of Rockall Bank using three modelling methods: Maxent, Random Forests (single VME models), and Random Forests (classification based model) and input variables derived from multibeam acoustic datasets. All three models suggest *Lophelia pertusa* reefs have a highly restricted distribution found as pockets in a narrow band along the flank of the bank in areas where the terrain abruptly falls away. 'Stylasterids and lobose sponges' assemblage is also distributed in a narrow band all along the flank of the bank but its distribution is less restricted than that of *Lophelia pertusa* reefs. Xenophyophore fields have a very different distribution and are found deeper at the base of the bank feature. Although all three models broadly agree in the distribution of the three VMEs the RF-classification model predicts a much broader distribution for all three VMEs. Performance metrics (percent correctly classified, sensitivity and specificity) indicate no model performed the best.

Opportunistic Habitat Mapping from Archeological Surveys in the Egadi Islands, western Sicily (Mediterranean Sea)

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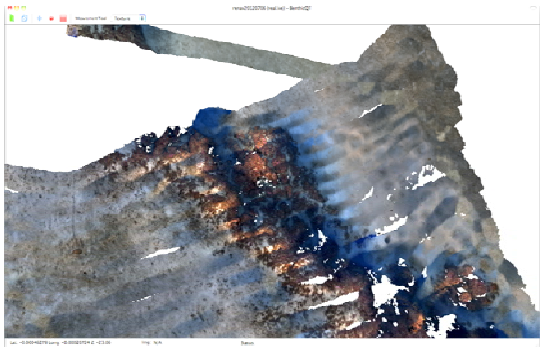
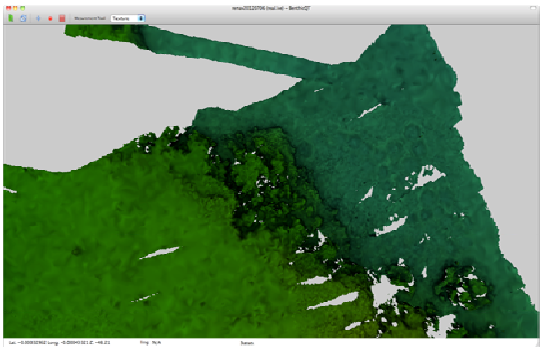
Since 2005 the RPM Nautical Foundation (http://rpmnautical.org/) has undertaken an intensive study of the site of the final naval battle of the First Punic War between Romans and Carthaginians in 241 BC, which took place around the Egadi Islands (western Sicily, Mediterranean Sea). Their combined fleets totaled approximately 1000 vessels, with at least 50 ships sunk and 70 captured by the victorious Romans.

RPM's Egadi Island Survey Project has returned to the battle site for a few weeks every year, and has mapped over 200 km^2 with a hull-mounted Konsberg EM3002D multibeam sonar and has identified potential targets, mapped wrecks and recovered important artifacts with a SAAB Panther XT ROV.

The Australian Centre for Field Robotics (ACFR) was invited to trial their benthic mapping AUV and 3D reconstruction techniques on a few areas of interest, including the Levanzo wreck and some of the rocky outcrop formations that are difficult to explore with the ROV and that are too complex to provide clear targets from the multibeam survey.

This presentation is motivated by the question: can the vast amount of data collected for archeological purposes be used to create a habitat map of the region? We present a brief overview of the RPM archeological program and the automated image clustering and habitat mapping tools, the ACFR participation during the 2012 season, and preliminary results using multibeam data, optical imagery from the AUV and ROV archeological surveys and largely unsupervised and supervised classification techniques to generate an opportunistic habitat map of the area. Extensive reefs and bioherms, coarse sediment areas and high-hydrodynamic sediment structures have been observed. Results are contrasted to prior knowledge of the area. We also include a discussion of the possible sampling biases and how future surveys could accommodate improved results with minimal additional effort.

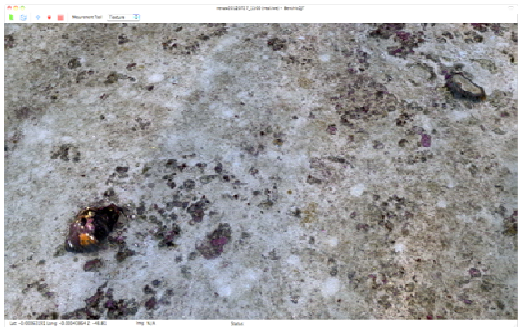




[Top Left]. Partial view of a rocky reef 3D mosaic from imagery collected by the ACFR AUV.

[Top Right]. Corresponding depth information (~90m).

[Right]. Oblique view of Archeological remains on a medium to coarse sand bottom (left foreground, and right background).



Understanding the seabed: full coverage sediment mapping and modeling of morpho- and sediment dynamics in the German EEZ

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There is a substantial need for a better understanding of the nature and dynamics of the seabed in the southeastern North Sea (German Bight) due to enhanced offshore activities and demands on the marine environment and its potential changes concerning a rising sea level.
Sustainable use of the seabed and management of Natura 2000 sites require a detailed picture of the distribution and stability of seabed sediments and habitats, especially within the Exclusive Economic Zone (EEZ) of the German North Sea and the Baltic, where data is scarce compared to the coastal zone.
Midyear 2012, the Federal Maritime and Hydrographic Agency (BSH) and the Federal Agency for Nature Protection (BfN) started a full coverage sediment and habitat mapping program for the whole German EEZ, an area of 33.000 km². In the first phase (2012-2014) the emphasis of the mapping activities is on the Natura 2000 sites, roughly 30% of the German EEZ.
The BSH is responsible for the full-coverage mapping of seabed sediments which is performed together with network of research institutes, namely the Alfred-Wegener Institute for Marine and Polar Research, the Institute for Baltic Sea Research, the University of Kiel and the Senckenberg Institute. The data of side scan sonar, grab samplers and under water video imaging will be used to create sediment distribution maps in a high resolution of 1 meter.
As the seabed of the German Bight is highly dynamic, the results of the full-coverage mapping will be combined with results of large-scale analyses of morphodynamical processes and sediment transport of the German Bight on a multidecadal scale. This has been performed within the R&D project “AufMod”, where a seabed model based on huge bathymetric and sedimentological datasets in space and time was developed. The comparison of data-based analyses and process-based simulations provide new insights and perspectives on morphological changes and sedimentological variations.
This extensive information of both approaches linked with spatial information on benthic communities will provide an excellent interdisciplinary view and deeper insights into the nature and dynamics of the mobile seabed in the German Bight.

Benthic habitat mapping to support marine reserve management in Australia: A case study from the tropical carbonate shelf of the Timor Sea.

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In November 2012, the Australian Government finalised a national network of Commonwealth Marine Reserves (CMR) covering 3.1 million km^2 and representing the full range of large scale benthic habitats known to exist around mainland Australia. This network was designed using the best available regional-scale information, including maps of seabed geomorphic features and associated Key Ecological Features. To support the management objectives of the marine reserves, new site-specific information is required to improve our understanding of biodiversity patterns and ecosystem processes across a range of spatial scales. In this context, the Marine Biodiversity Hub (funded through the National Environmental Research Program) recently completed a collaborative 'voyage of discovery' to the Oceanic Shoals CMR in the Timor Sea. This area was chosen because it hosts globally significant levels of biodiversity (including endemic sponge and coral taxa), faces rapidly increasing pressures from human activities (offshore energy industry, fishing and climate change) yet is recognised as one of the most poorly known regions of Northern Australia.

Undertaken in September 2012 on board *RV* Solander, the survey acquired biophysical data on the shallow seabed environments for targeted areas within the Oceanic Shoals CMR, with a focus on the carbonate banks that characterise this tropical shelf and are recognised as a Key Ecological Feature. Data collected included 500 km^2 of high resolution (300 kHz) multibeam sonar bathymetry and acoustic backscatter across four grids, plus seabed sediment samples, underwater tow-video transects (~1 km length), pelagic and demersal baited underwater video, epifaunal and infaunal samples and water column profiles at pre-determined stations. Station locations were designed to provide a random but spatially balanced distribution of sample sites, with weighting toward the banks. This design also facilitated observations of patterns of benthic biodiversity at local to feature-scale and transitions associated with depth-gradients and exposure to tidal currents.

Results reveal the banks rise to water depths of 50-70 m, are broadly circular to elliptical with steep sides and mantled by muddy sand and gravel with areas of hard ground. The banks support benthic assemblages of sponges and corals (including hard corals at shallower sites) which in turn support other marine invertebrates. In strong contrast, the surrounding seabed is characterised by barren, mud-dominated sediments in 70-100 m water depth, although infaunal samples reveal diverse biological communities within seabed sediments. While the bank assemblages are locally isolated, the potential exists for connectivity between shoals via tide-driven larval dispersal. Ongoing work is aimed at identifying species to determine overlap between bank communities, as well as modelling the sources, pathways and sinks for larvae as a proxy for understanding the physical processes controlling the patterns of biodiversity across the Oceanic Shoals CMR at multiple scales.

Reefs better heard than seen. "Mapping mesophotic reef habitats using generalised assemblage models and sparse hydroacoustic data".

Ben Radford, Andrew Heyward, Ross Jones, Jamie Colquhoun, Cordelia Moore, Mike Cappo, Mark Case, Marcus Stowar

Australian Institute Of Marine Science, Australia

Historically, the application of remotely sensed data as a tool for mapping coral reefs (such as satellite imagery or aerial photography) has been largely limited to waters shallower than 30 m because of light penetration. However, hard coral species can still thrive at depths to 70 m or greater but these mesophotic reef systems have received very little attention. This is primarily because of the technical challenges associated with quantifying their location, function and extent. In North Western Australia this changed in August 2009 with a major oil spill in the Timor Sea in lasting 74 days. Environmental studies post the Montara spill focused interest on mesophotic reefs and the potential impacts the spill event. Prior knowledge suggested that the Timor Sea contained over 160 discreet shoals that could support mesophotic coral making then very regionally significant but very little was known about the extent of coral cover on these shoals and the processes influencing coral distribution. Here we describe the first detailed survey of 9 shoals using hydroacoustic sensors combined with towed underwater video systems to collect high resolution bathymetry and targeted imagery. We employed generalised assemblage models to accurately predict coral and other sensitive habitats on a number of these shoals. However these models were not universally applicable and failed in some cases. Therefore, while generalised models make efficient use of sparse data and often produce useful predictions, most likely reflecting processes widespread across shoals (i.e. physiological niches) they may not account for local scale processes such as founder effects, connectivity and disturbance history, which can have a pronounced influence on reef habitats.

Quantification and predictive modelling of local-scale relationships between cold-water corals and hydrodynamic settings on the Irish continental slope

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Cold-water coral reefs thrive in areas of enhanced hydrodynamic activity, where currents reduce sediment deposition and provide a plentiful food supply for the suspension-feeding coral polyps. Near seabed hydrodynamics are influenced by terrain morphology and bathymetry-derived parameters such as slope and rugosity are often used as surrogate variables in habitat mapping and predictive modelling projects. While the corals' preferences for current flow have been investigated via in-situ current measurements, spatially explicit relationships between coral distribution and local hydrodynamic conditions are not yet well established.

This study investigates local-scale relationships between the known distribution of *Lophelia pertusa* reefs (presence/absence) and oceanographic key parameters derived from 3D hydrodynamic models in three carbonate mound provinces along the Irish continental margin: the Logachev mound province, the Arc mound province and the Belgica mound province. Generalized linear models are applied to quantify these relationships and to estimate the full-coverage distribution of coral reef habitat within each of the three study areas. To determine the applicability of hydrodynamic variables for prediction of suitable coral habitat, we have developed and compare three conceptual model types: i) a purely terrain based model, ii) a purely hydrodynamic model and iii) a model combining both terrain and hydrodynamic parameters. Model success is evaluated in terms of predictive power, model accuracy, and model transferability between study areas.

Keywords: cold-water coral, current regime, hydrodynamic modelling, *Lophelia pertusa,* predictive modelling, terrain morphology

Predicting the occurrence of Natura 2000 habitat Reefs in complex archipelago areas of the Northern Baltic Sea

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In the European Union, The Annex I of the Habitats Directive (Council Directive 92/43/EEC) lists habitats that are important in biodiversity protection and should be maintained (or restored) at a favourable conservation status. The habitats listed should be protected within an ecological network of protected areas, the Natura 2000 network. However, the lack of spatial distribution data on marine habitats often presents an obstacle to their efficient protection.

Marine habitats in Annex I are large physical habitats, primarily defined by topographical and geomorphological attributes, but also typical species and communities associated with the habitats have been identified. The primarily physical nature of the habitats enables the use of topographical and geological attributes to map potential habitats, but a challenge is met when biological attributes need to be incorporated. We present a methodology where the best data currently available are used to create distribution maps of Annex I habitat Reefs. The work is carried out using GIS methodology and species distribution modelling (SDM).

According to the habitat description, Reefs are formations of hard compact biogenic or geogenic substrata, which arise from the seafloor in the sublittoral and littoral zone. The study area is a complex archipelago area in the south-western Finland where reefs are rocky outcrops in a heterogeneous landscape. The associated algal communities and blue mussel beds are vital in maintaining biodiversity of the northern Baltic Sea.

The data used in the study were gathered and produced as a part of the EU Life+ funded project FINMARINET. Most of the biological data and some of the geological data were gathered during the project, but already existing data were used to produce the background information needed for the study (e.g. models on depth, exposure, salinity, Secchi depth, nutrient concentrations). In order to identify elevations at seafloor, a topographic model and Benthic Terrain Modeler (BTM) were used. The identified structures were classified into 13 classes and a comparison between the identified structures and seafloor substrate was carried out where geological data was available. The elevated structures that were identified as commonly rocky were considered as probable reefs. The information on associated species was incorporated using species distribution modelling (Maxent software). The probability maps were produced for species listed as typical to reefs in the national description of the Annex I habitats. The information on species occurrence was finally combined with the information on rocky elevations to produce reef maps with indications on species numbers.

The results of the modelling efforts were successful as ground-truthing of the identified reefs showed high accuracy. The maps produced provide valuable background information for more detailed mapping of Reefs, as well as for efficient management and monitoring of these important habitats.

Multibeam backscatter-driven investigations reveal previously unknown cold seeps in the southeastern Tyrrhenian Sea

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High resolution swath bathymetry data (EM 710), 3-7 kHz seismic CHIRP profiles, water column multibeam measurements, box core and gravity core samples were acquired during the 2011 R/V Urania MVP11 cruise in the Paola basin, southeastern Tyrrhenian Sea. The area was investigated with direct sampling techniques to preliminarily test a recent hypothesis, interpreting the study area as a mud mobile belt, located along an anticline at 700-1000 m water depth, due to intense hydrocarbon-seep activity. Different structures associated with fluid escape and/or seepage have been classified, based on their morphology, geophysical character and nature of the sediment deposits and byproducts, they include: (1) active venting sites (mud volcanoes), (2) low venting sites (mud flows), (3) inactive seepage sites (mud diapirs). Geological response at the seafloor to the hydrocarbon-rich fluids and gases is highly variable and dependent largely on rate and duration of delivery, as well as fluid and gas composition. In the study area three structures have been recognized as sites of rapid expulsion at the seafloor of fluids and fluidized sediment resulting in buildups of sediment in the form of mud volcanoes, with about 10-km-wide diameters and sheet-like mudflows, characterized by a high backscatter signature, extending from 10 to 14 km downslope. Associated to the mud volcanoes are: precipitation of iron-oxy-hydroxide crusts and pirityzed and sulphur burrows in the sub-surface and tubular authigenic siderites in the deeper section. The EM710 water column acoustic measurements at the top of one mud volcano revealed a nearly 700-m-high gas plume. The mud flows are characterized by the deposition of very thin drapes of water-rich mud downslope the mud volcanoes, which prevents active venting at the seafloor and favors oxic conditions of the near-surface sediment and precipitation of authigenic carbonates in the sub-seafloor. A large number of mud diapirs have been discovered in the area, but only three mud diapirs have been sampled, they are associated with large fields of pockmarks, they show variable sizes and planforms and have relief of hundreds of meters above the seafloor. Slow seepage promoting lithification of the seafloor through precipitation of organogenic carbonate crusts has been evidenced in one of the mud diapirs, where normal faulting exposed the sub-seafloor; associated to the carbonates and the faulted pathways, dead communities of chemosymbiontic organisms were found, suggesting a ceased gas seepage activity.

The UK Marine Environmental Mapping Programme (MAREMAP)

Alan Stevenson (British Geological Survey), Russell Wynn (National Oceanography Centre) and John Howe (Scottish Association for Marine Science).

The UK Marine Environmental Mapping Programme (MAREMAP) is a long-term NERC-led initiative that was launched in June 2010. MAREMAP is applying a 'partnership-based' approach that will ensure effective co-ordination of marine mapping and sampling activities within NERC and the wider UK community. The lead partners are the British Geological Survey (BGS), the National Oceanography Centre (NOC) and the Scottish Association for Marine Science (SAMS). Associate Partners include the University of Southampton, the Channel Coastal Observatory (CCO), the University of Plymouth, the Maritime and Coastguard Agency (MCA) and the Centre for Environment, Fisheries and Aquaculture Services (CEFAS).

The aim of MAREMAP is to maximise dissemination and interpretation of marine maps and models that contribute to science and policy. This multi-disciplinary programme involves geoscientists, biologists, oceanographers and technologists, and will deliver maps, scientific papers, policy advice and associated products that meet the needs of end-users operating in the marine environment. Key drivers include sustainable use of marine resources, spatial conservation planning/monitoring and submarine geohazard assessment/mitigation. End users of MAREMAP products include offshore industries (e.g. aggregates, fishing, aquaculture, renewable energy, oil and gas, tourism, cables), research scientists, UK government and non-governmental conservation bodies, and UK government departments concerned with marine spatial planning and marine hazard mitigation.

The Research Programme is focussed on the UK offshore area, although there will be an international component that contributes to wider NERC strategy. The Research Programme is divided into seven themes:

- Marine habitat mapping to underpin spatial conservation policy
- Developing geological maps and models of the UK offshore area
- Reconstructing the onshore-offshore Quaternary history of the UK
- 4D mapping and monitoring of seabed and sub-seabed environments
- Mapping and modelling of coastal and shelf sediment dynamics
- Assessment of human impacts and marine geohazards
- Developing innovative technologies and techniques for marine mapping

MAREMAP products will be delivered through a dedicated website (http://www.maremap.ac.uk). Online data will be free-to-access in line with UK government and NERC open data policy. Some mapping products, e.g. seafloor sediments, will be available for the entire UK offshore area at 1:250K scale, with the results of more detailed mapping at 1:50k added in areas where available.

Deep-sea biotope cataloguing and mapping in the Azores (NE Atlantic)

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Cataloguing, characterizing and mapping *vulnerable marine ecosystems* dominated by habitat-building megafauna has been the priority of recent research conducted in the Azores under European programmes such as CORALFISH, HERMIONE and MESH-Atlantic.

This presentation introduces the deep-sea biotope catalogue compiled through the examination of imagery collected by expeditions that visited the Azores region over the last 60 years. A total of 50 different megafauna-dominated benthic facies are inventoried in a study area totaling 1.6M km2. The diversity of coral gardens, scleractinian reefs, and deep-sea sponge aggregations present between 50 and 3,500m depth confirms the rugged seafloor of the Azores plateau as a NE Atlantic deep-sea hotspot.

The work to go beyond the known point occurrences and develop spatially-explicit coral habitat suitability models is subsequently presented. Predictive mapping of the mesoscale distribution of coral genera and species is based on the coral records in the COLETA database (currently containing over 1600 historical and modern occurrences belonging to 34 families). Covariates are a selection of oceanographic, biological, geomorphological, physical and chemical parameters upscaled to a 300-m resolution from publicly available databases and climatological atlases.

Fine-scale cases studies are also presented where habitat-building coral occurrence data from new ROV and drop-down camera surveys are used. The potential of using terrain-based proxies (e.g., depth, slope, aspect, bathymetric position index, curvature) are investigated on the Condor seamount and southern flank of the Faial-Pico Passage, where oceanographic data is insufficient to characterize the actual fine-scale near-seabed conditions experienced by benthic organisms.

This work is a contribution towards the mapping of some of the most important deep-sea biotopes of conservation importance and informs the development of the deep-sea section of the EUNIS habitat classification system.

Using hullborne multibeam systems, autonomous underwater vehicles (AUVs), Synthetic Aperture Sonar (SAS) and optical systems to map habitats associated with gas seepage

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Habitats associated with gas seepage are important, as they provide possibilities for chemotrophic organisms, three dimensional habitat structures and associated benthic communities. However, they are often difficult to find and map. A cooperation project between Lundin Norway, the Norwegian Defence Research Establishment and the Geological Survey of Norway has given data showing the potential for combining multibeam data from hullborne vessels, with ultra-high resolution acoustic devices (Synthetic Aperture Sonar mounted on an AUV).

The experience from the project is that multibeam echo sounders with the capability to record water column data is an important first step. For this project, we have used Kongsberg EM710, covering several hundred square kilometres. In 2011, the first user-friendly and commercially available software for analyzing these data was launched from Fledermaus, and gave the possibility for the first time to efficiently identify a number of gas flares in the Barents Sea. The next step was to use the HUGIN HUS AUV, equipped with the new HiSAS 1030 Synthetic Aperture Sonar from Kongsberg, to investigate the seabed in detail around the flares. Giving a resolution up to 2x2 cm per pixel over a swath width of 280 meter, the SAS gave imagery covering a few km^2 which was used to guide the next step in the survey – using the TFish optical photo system on HUGIN HUS to provide high resolution photos of the seabed and near-bottom seabed. Each photo covers an area of c. 20 m^2. With a flight height of c. 7 meter, we were able to identify gas bubbles in the water column, and carbonate crusts on the seabed.

The carbonate crusts are formed when the seeping gas meets the seawater, resulting in methane oxidation and carbonate precipitation over an area which is commonly 20 - 200 m^2. They commonly form a three dimensional structure, up to 50 cm high, often looking like randomly distributed concrete slabs. Bacteria mats cover parts of the crusts. Sea anemones and other benthic organisms preferring a hard and perhaps elevated substrate occur frequently. Rock fish (probably *Sebastes marinus)* occur in very high numbers, in contrast to the surrounding areas where they are sparse or absent. Spotted wolffish (*Anarchichas minor)* uses caves in the crust as hiding places.

This nested approach – with multibeam echosounder, Synthetic Aperture Sonar and the TFish photo system has proved to be efficient for identifying habitats associated with natural gas seepages over large areas. Starting with surveys covering several hundred kilometre, it is possible to identify habitats covering only a few square meter of the seabed. The presentation will also deal with other fine-scale features that can be detected using this approach.

Habitat mapping of Romanian marine SCI Natura 2000 sites

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The objective of the present paper is to present the methods and results of habitat mapping of the marine Natura 2000 SCI sites from the Romanian coastal area. This program represented the first habitat mapping in Romania using acoustic methods.

The Romanian littoral comprises two distinctive units, from a genetic point of view, the northern accumulative one and the southern with active cliffs (Ungureanu, 2005). Two of the sites, “Danube Delta- marine area” and “Submarine metanogenic structures Sfantu Gheorghe” are found within the northern unit whereas the other four, “Eforie Nord-Eforie Sud- submerged beach”, “Cape Tuzla- marine area”, “Mangalia submarine sulfourous springs” and “Vama Veche- 2 Mai”, are found within the southern unit.

The knowledge of the spatial distribution, quality and quantity of seabed resources is fundamental to our understanding of marine ecosystems and our ability to manage human activities to deliver effective sustainable development and maintain marine ecosystem function (Foster-Smith, 2007). The methodology we used for mapping comprised of a side-sonar scanning of the area using an IXSEA Elics 400-1250 system, and groundtruthing by grab sediment sampling using a Van Veen greifer and analyzing the grains size using a Horiba Laser Particle Analyser, combined with diving and submarine photographing done by a team of biologists.

The fish of the sonar system was towed by a 9 meters long boat at a depth of 2.5-3 meters with a speed of approximately 6 knots. The selected working frequency was 400 kHz. For georeferencing a GPS system was connected to the recording computer, that stored the data as .xtf files. The recorded lines were drawn perpendicular to the contour lines for providing an equal insonification of the both ports of the sonar. The limit towards the shore was the 5 meters bathymetrical contour line. For assuring a full coverage of the nadir blind zone another set of recorded lines was done with an offset corresponding to half of the range.

The data were processed using Delph Interpretation software package. Manual bottom-tracking was applied for providing a better image when the slant correction was applied. Sonograms were merged to form a mosaic, offering an image over the seafloor. Based on a visual examination of the mosaic ground truthing spots were selected for offering samples from the main acoustic facies. The samples were photographed for recording features of the seabed still visible and then analyzed in the laboratory for grain size. Using QTC Swathview and QTC Clams and based on the previously known information a map of the acoustic facies was created. It helped biologists to extrapolate the results of their field work and provide the final habitat maps for the Natura 2000 sites. The acoustic facies were then associated to marine habitats after biological observations and measurements.

The identified types of habitats, according to the European Commision Habitat Directive (92/43/CEE), are: 1110- Sandbanks which are slightly covered by sea water all the time, 1140- Mudflats and sandflats not covered by seawater at low tide, 1170- Reefs and 1180- Submarine structures made by leaking gases. The 1140 type is not visible on the sonograms, as it is found towards the shore, and 1170 can be seen whether as mussel beds or rocks.

Based on all data detailed maps of habitat distribution were created for each site.

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Coupling hydromorphologic and habitat models to project changes in seagrass distribution under two sea level rise scenarios

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Seagrasses play an important role maintaining biodiversity and water quality in estuarine and coastal ecosystems; their importance has been recognised under different international, European and national conservation frameworks (e.g. Habitats Directive (92/43/EEC); European Water Framework Directive (2000/60/EC)). Several studies have projected a sea level rise throughout the 21st century caused by the global warming which could induce changes in species distribution. In this context, the main objective of this research was to project changes in the potential distribution of *Zostera noltii* meadows in the Oka estuary (Basque Country) under mean sea level rise (MSLR) scenarios.

To address the objective, firstly, the MOHID Water Modelling System was applied in order to simulate hydromorphologic changes in the Oka estuary under two different MSLR scenarios: one optimistic and another pessimistic (0.49 m and 1.0 m above actual mean sea level, respectively). Maximum current velocity was simulated for present and future conditions, together with the height differences between present day and future scenarios. The simulation was based upon high-resolution topographic and bathymetric data extracted from airborne LiDAR sensor, current velocity, sediment grain size, and rugosity values. Secondly, three different Species Distribution Models (SDM) were applied: (1) Maximum Entropy model (MaxEnt), (2) Generalized Additive model (GAM) and (3) Ecological Niche Factor Analysis (ENFA). Models were evaluated in order to select the best performing algorithm in predicting the species distribution. Thirdly, selected SDM was coupled to the hydromorphologic model in order to estimate the changes in the potential distribution of the species under both scenarios.

Results from the simulated future scenarios showed an increase in maximum current velocity values, resulting in a redistribution of sediments within the estuary. GAM model based on intertidal height, slope, mean grain size and maximum current velocity as environmental predictors, outperformed MaxEnt and ENFA models. GAM model explained 95.1% of the species distribution and accounted with a very low omission error of the species presence (1%). Estimation of the changes in the species potential distribution showed an overall increase of the suitable habitats availability (Figure 1), which could be related to an increase of the intertidal areas induced by the intrusion of sea water produced by the MSLR. The future conditions will induce the shift of the seagrass meadows to the inner estuary by 337 m (under optimistic MSLR scenario) and by 982 m (under pessimistic MSLR scenario). As a consequence of the projected movement, the meadow from the outer estuary will disappear.

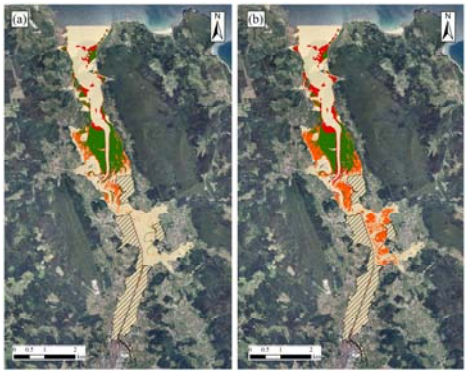

Figure 1. Estimated changes in the species potential distribution under (a) mean sea level rise of 0.49 m (b) mean sea level rise of 1 m. In red, currently suitable areas which will disappear in the future scenarios; in green, areas currently suitable which will continue being suitable under the future scenarios; in orange, areas currently not suitable which will become suitable under future conditions; in light yellow, areas which are not currently suitable and neither in the future. Dashed polygons, exclusion areas due to anthropogenic protection structures.

Identification of fine-scale ecoclines describing species-environment relationships in a marine sediment system

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The species-environment relationship is a fundamental structural property of natural ecosystems. Marine benthic macrofauna is known to be structured by a range of environmental variables, but there is still much work to be done with regard to how environmental variables work in concert to form complex-gradients, i.e., groups of intercorrelated environmental variables, and how these are related to gradients in species composition. In an attempt to sample as much environmental variation as possible, we divided our benthic study area into coarse-grained geomorphological features with help of a slightly modified algorithm by Lundblad et al (2006). Based on this division we deviced a Guided Stratified Sampling Strategy, in which each coarse-grained feature was sampled between 1 and 4 times depending on their spatial coverage. The resulting 28 sites were sampled for macrofauna using a van Veen grab, which gave us a species-abundance matrix containing 122 species of polychaetes, molluscs and echinoderms. This species-abundance matrix was subjected to indirect gradient analysis by applying DCA and GNMDS in parallel. The ordination results of the two ordination methods were highly congruent, which made us more certain that the ordination axes represented the 'true' underlying gradients in species composition. We used the DCA ordination for subsequent ecological interpretation of gradients in species composition. The interpretation was done by correlating values of environmental variables with gradients in species compositions (represented by position of sites along DCA1 and 2). Subsequently, we identified the *major* complex-gradients, i.e., groups of environmental variables that are highly correlated with the gradients in species compostion: a) the biophysical *sediment stability* gradient, b) the chemical *organic content* gradient, and c) the physiochemical *organic quality* gradient. We argue that indirect gradient analysis, by which identified gradients in species composition are related to environmental complex-gradients as a basis for inferring ecoclinal relationships, is the obvious choice of strategy for basic, general-purpose ecological studies when hypotheses are to be generated rather than tested.

Marine spatial planning tool for the conservation of the most sensitive under-water areas in the Eastern Baltic Sea

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The Baltic Sea is the second largest brackish water basin in the world in terms of water volume. The water is a mixture of ocean water streaming through the Danish straits and fresh water brought by numerous rivers. The salinity of surface water varies from the 20 per mil in the Baltic Sea Proper to 6 per mil in the Bothnian Bay in the north. At river estuaries, *e.g.* off St. Petersburg, the salinity is almost zero. In the Baltic Sea ice conditions vary greatly. On average, ice covers the northern and the eastern parts of the sea, and ice cover is at its thickest between January and March. The Gulf of Finland (hereafter denoted as GoF) is the easternmost part of the Baltic Sea and its coastal states are Finland, Russia and Estonia. The drainage area of the GoF is 420 990 km^2 maintaining a population of 12.5 million inhabitants. Since its physical properties the GoF is a vulnerable sea area. Environmental problems in the GoF are *e.g.* eutrophication, which is caused by internal and external load of nutrients, the lack of oxygen in the bottom layers of the sea, and the accumulation of the environmental toxicants e.g. dioxins to the food-web. Also the invasive non-indigenous species may disturb the ecosystem.
TOPCONS is a Finnish-Russian co-operation project where the knowledge on the geology, biology and human pressures is collected. The objective for data collection is to study the correlation between the sediment and substrate type and species diversity, and also create the methodology to forecast the most diverse and sensitive under-water landscapes.

The data collected will be utilized in the ecosystem-based management tool. The impacts of certain human pressures on marine environment, *e.g.* dredging on bottom type and the effect of water turbidity to species diversity, will be analyzed probabilistically. Based on that, a stochastic risk analytical model will be developed. The model will also include Bayesian structure learning, *i.e.* the network structure can be learned from the data and human reasoning can be improved by a computational inference. The created model is also programmed to communicate in interaction with the spatial data-layers in the GIS environment (Fig. 1). As an output, the spatial planning tool will be developed to act as an advisory tool for the end-users such as planners when the sustainable reconciliation of human activities and marine nature values is pursued.

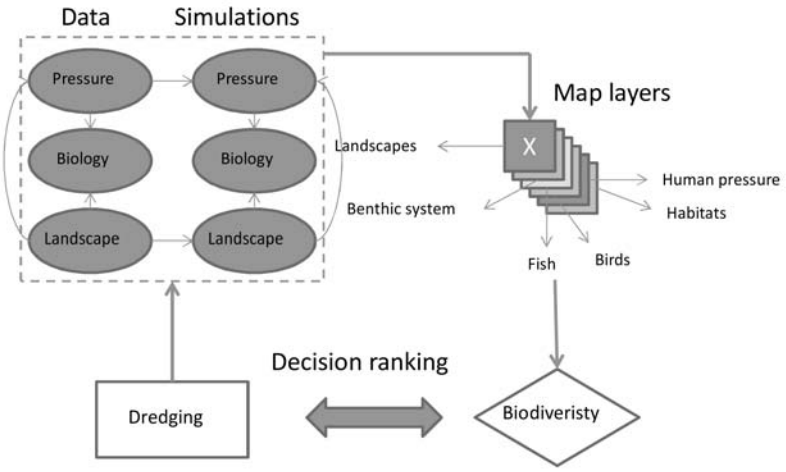

Figure 1. Risk analytical model combined to the geological and biological data and the map layers on geology, biology and anthropogenic pressure.

The submerged landscape and habitats off the Cilento coast (Eastern Tyrrhenian Sea) – Linking geo- and bio-diversity at different scale in a European Geopark

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The Cilento and Vallo di Diano National Park is the largest park in Italy. Recently it has been acknowledged by UNESCO in the European Geoparks Network, a special category of territories with particular geological and geomorphological features, that enhance the value of the geodiversity and geological heritage. Within the Cilento and Vallo di Diano Geopark are found marine species and habitats of priority importance for the European Union, that led to the institution of two Marine Protected Areas: "Santa Maria di Castellabate" and "Costa degli Infreschi e della Masseta".

The Geopark Administration appointed the Geological Survey of Italy (ISPRA), in collaboration with the Italian National Research Council (CNR) and the University "Parthenope" of Naples (DISAM), to map the seascapes off the Cilento down to a depth of 100 m, as part of the official Geological Map of the Park. The marine area is about 460 square kilometers and had been previously surveyed with multibeam and sidescan sonar by CNR in the frame of the CARG Project, the Italian cartography project at 1:50.000 scale coordinated and supervised by the Italian Geological Survey. The map is based on seabed substrata resulting from the CARG project, morphology from swath bathymetry, and benthic assemblages. The mapping work is still in progress and is aimed at emphasizing the link between geodiversity and biodiversity off the Cilento coast.

Morphology and substratum are considered, together with hydrodynamics, the leading parameters affecting biological life on the seabed. This linkage between biotic and abiotic features is well represented in the study area, which is characterized by minor embayments with soft seabed sediments, separated by rocky headlands. Such a physiographic configuration creates a diversity of benthic environments whose identification and classification were carried out both at a large scale (1:120.000) with a seascape approach, to match the resolution used for the on-land geological mapping, and at a fine scale (1:30.000) with a habitat approach in the Marine Protected Areas.

In the first case the seabed classification was simplified, from the eleven classes identified by the CARG project to six, and only the conspicuous fauna was considered. This led to the identification of seven seascape units: shallow sandy plain, shelf muddy plain, rock, rocky bank, bank with sandy cover, bank with coarse sediment cover, bank with organogenic sediment cover. Two more classes are represented by *Posidonia* and *Cymodocea* seagrass cover.

On the other hand the mapping of benthic habitats in the Marine Protected Areas at 1:30.000 scale will consider all the classes of substratum identified by the CARG Project. In this case it is expected that the availability of biological data will allow to characterize the seabed with respect to both geophysics and living communities at a fine scale.

LARGE – SCALE SEABED CHARACTER AND HABITATS OF NORTHERN RIO GRANDE DO NORTE INNER AND MIDDLE SHELF, NE BRAZIL

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The northern Rio Grande do Norte continental shelf (Figures 01) is a high hydrodynamic, narrow carbonate-siliciclastic ramp system, where sediment transport pattern and continental shelf evolution can be validated from satellite down to scuba diving studies, and across disciplines. The integrated data set used in this study includes remote-sensing, SRTM, oceanographic, hydroacustic and sedimentological data corroborated by diving surveys. The continental shelf edge runs parallel to sub-parallel to the coast with shelf break from 70 - 80 m water depth around the Touros High and 40-50 m depth water depth westwards. The climate is tropical dry to semi-arid, and the waters are nutrient depleted, with low suspended sediment concentrations. The study area presents an average width of 40 km along most of its length, and widening particularly around Touros, where it extends to ~ 75-90 km. Distinct geomorphic features can be observed in the inner and middle shelf in bathymetric map and in Landsat imagery (Figure 01), those include very large dune fields (longitudinal, oblique and transverse), submerged sandstone outcrop, coral patch reefs, isolated shallow-marine sand bodies, and incised-valleys. The inner-middle-, and outer-shelf are broadly distinguished according to the water depth, geomorphology and sediment characteristics as follows: inner shelf down to 15 m water depth, presents very large longitudinal dunes adjacent to Touros and Açu River, characterized by coarse bioclastic sands (crests) and gravelly bioclastics sands (troughs), composed mainly of coralline red algal and *Halimeda* fragments and rhodoliths . Very large oblique dunes are found adjacent to Guamaré, composed mainly of quartz sands (slightly coarser on the troughs than on the crest). The middle shelf, between 15 and 25 m depth, is characterized by very large transversal dune field, composed of fine- to medium-grained siliciclastic sand on the crests, whilst the troughs are composed of coarse bioclastic gravel, stabilized by living coralline algal maërl and *Halimeda* meadows. No living macrobenthos was found on the tops and slopes of the transversal or oblique dunes. The transition from longitudinal to transverse dunes is marked by an irregular but well-cemented algal pavement. Whereas the transition from mid- to outer-shelf, around 25 m isobath, is defined by alignments of submerged outcrops, composed of carbonate cemented sandstones and grainstones, often covered by seaweeds, rhodoliths and sponges. Isolated shallow marine sand bodies are composed mainly of fine siliciclastic sand on the crest, with no living benthos. Holocene and modern coral patch reefs occur in the inner shelf near Touros, and are mainly built by *Siderastrea* and *Millepora* in association with crusts of coralline algae.

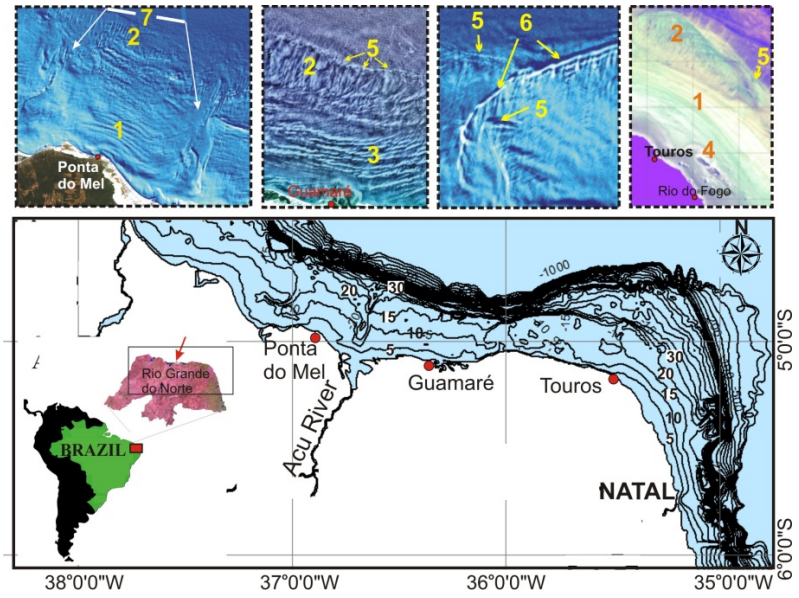

Figure 01. Location map and bathymetry of the northern Rio Grande do Norte State. Main seabed features are highlighted in Landsat 7 ETM+ image (bands 321) and indicated as different numbers: 1. Very large longitudinal dunes, 2. Very large transverse dunes, 3. Very large oblique dunes, 4. Coral reefs, 5. submerged sandstone outcrops, 6. Isolated shallow marine sand bodies, 7. Incised valley.

(CAPES - Ciências do Mar 207-10; PRH22-ANP/MCT; PLAT N-NE_Rede05/FINEP/CTPETRO, CNPq; INCT AmbTropic/WG 2.1).

Predictive Mapping of Groundfish Species to Advance Stock Assessments

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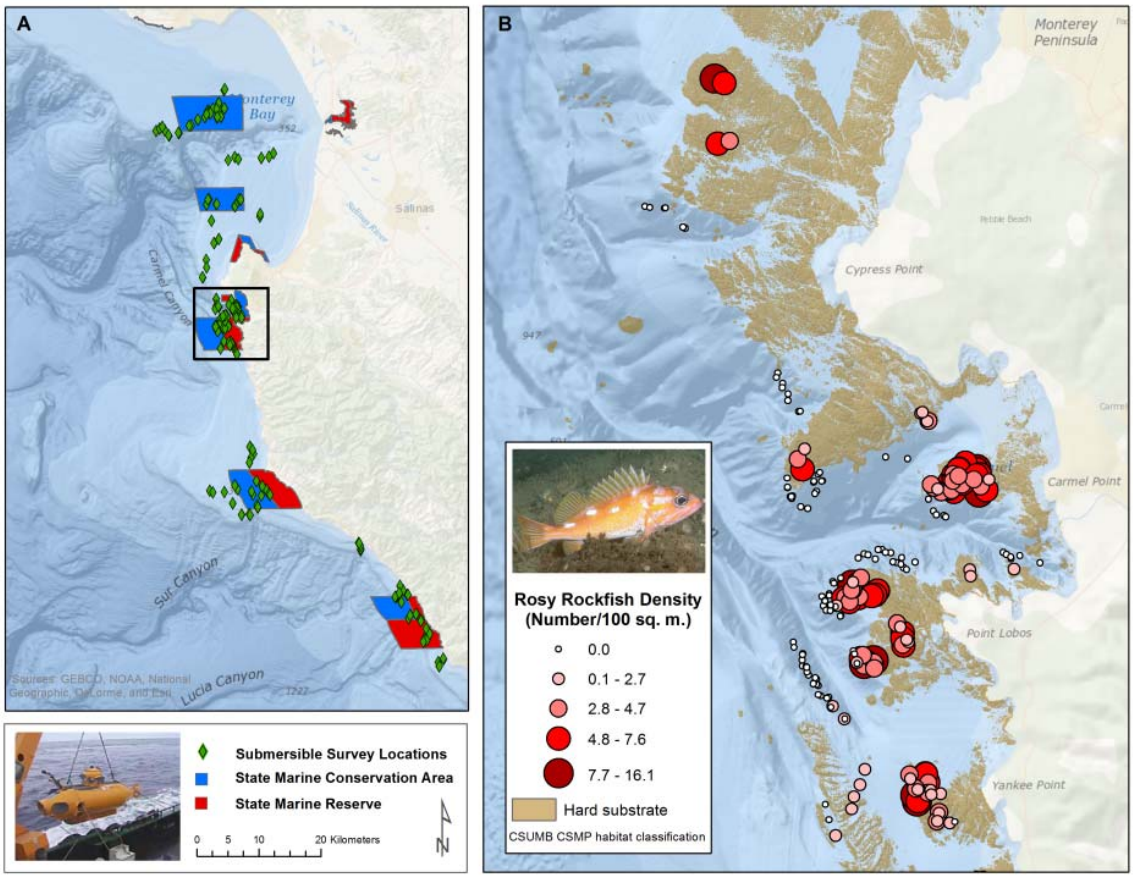
Rocky areas on the continental shelf and upper slope off central and southern California are dominated by more than 40 species of rockfishes, some of which have been declared overfished or are in a rebuilding status. Sedentary rockfishes living in high-relief rocky habitats are particularly difficult to appraise accurately with conventional fisheries-dependent methods. Further, in the absence of fisheries-dependent data from inside the large fishery closures, it is imperative to focus efforts on improving assessments using fisheries-independent observations as characterized by this work. Predictive maps of density and biomass can delineate areas of critical habitat and represent a robust approach to support the assessment and management of fish stocks.

In this study, we spatially integrated remotely sensed habitat data to create predictive models and maps of demersal fish density and biomass. Using a manned submersible, scientists surveyed fishes from 341,000 m^2 of seafloor habitat (19–365 m water depth) inside and outside marine protected areas in central California during 2007-2008 (Figure 1A). Fish density and biomass were estimated from 648 quantitative visual transects and used, along with environmental covariates, to develop linear mixed effect models. Models were compared using AIC (Akaike Information Criteria), and thematic accuracy of the predictive maps was evaluated using Kappa and Tau coefficients. Complex habitat structure, depth, and slope were important predictors of demersal fish density and biomass (Figure 1B). Our results will assist NOAA NMFS in fulfilling their mandates to identify and protect essential fish habitat and areas of particular concern, and to improve stock assessments in untrawlable rocky areas.

Figure 1. (A) Spatial extent of visual surveys along central California coast (B) Rosy rockfish (*Sebastes rosaceus*) density at transect locations overlaid on hard seafloor habitat as classified from high-resolution bathymetry.



The perfect habitat map

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Habitat mapping is difficult. It is a process severely constrained by limitations in data collection, financial resources and fundamental research. It is proposed here, with the goal of encouraging new perspectives on the challenges of habitat mapping, that we attempt to envisage a scenario with no such constraints. What then would qualify, as the perfect habitat map?

Under these, hypothetical, conditions we are left facing a new problem, not of incompleteness but of overcompleteness; where every environmental parameter has been measured. Such an exhaustive description of habitats would be no more understandable than the reality it was meant to portray. The statement by Paul Valéry captures our dilemma “Everything simple is false. Everything which is complex is unusable.". Our thought experiment leads us to the conclusion that, even if we had the capability of making a perfectly accurate habitat map, we would still need to take decisions on how to make such a map operationally useful.

When approached from this viewpoint it becomes evident that all maps will have limitations (even perfect ones), and that we need means of objectively assessing the various contributing parts. This process allows the compromises that have been made in the production of the map to be recognised. We can then take account of what effect these compromises will have for the relevance of any map when used for a specific purpose. With the limitations of any particular map explicitly recognised in this way it should then be simpler to avoid maps being used at inappropriate scales, with incorrect assumptions as to their temporal relevance or misguided expectations about their utility in detecting change. In the present study these limitations are addressed primarily for the physiographic elements, using an information-theoretic approach, but the method should be just as applicable when considering the biological and end-user components of a successful map.

The reasoning behind attaching such descriptive metrics to habitat maps would be to allow:

- the management of expectations about what can be achieved with existing maps/data and,
- the provision of a framework for specifying the nature of future mapping and monitoring work.

The need for such a system to benchmark mapping products is all the more pressing as they become more widely and intensively used to define Marine Protected Areas and in the implementation of legislation such as the European Marine Strategy Framework Directive.

Detection of factors that control the marine habitat distribution in a periglacial environment (Potter Cove, King George Island, Antarctica)

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Rapid regional warming has been observed in the Antarctic Peninsula region for more than 50 years, changing the marine and terrestrial environment ever since. It is important to observe those environments in flux and record significant variations in order to trace not only local but also regional change. The objective of this study was to provide insights into the habitat distribution in Potter Cove and to link it to environmental processes using geomorphological and sedimentological information as well as bed shear stress estimations. Hydroacoustic data was obtained from a seabed classification system and combined with underwater video images and sediment samples by statistical means in order to characterize the different seafloor habitats in Potter Cove. Numerical modelling of the circulation has been performed using an unstructured grid coastal ocean model FVCOM as the basis for the calculation of current-induced bed shear stresses and a structured-grid wave model SWAN for wave-induced bed shear stresses. The evaluation of the hydroacoustic data set revealed the occurrence of two different habitat classes, including soft-sedimentary and stony habitats. Results from the numerical modelling approach showed that the bed shear stress distribution is controlled by wave action, rather than by current activity. Furthermore, the bed shear stress calculations were used to delineate zones that are prone to sediment erosion. It has been demonstrated that habitat distribution in Potter Cove results mainly from wave action as a major control for bed erosion and resuspension of fine-grained materials, besides sediment supply and coastal morphology.

Using species distribution models to evaluate the placement of California marine protected areas

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With the continued increase in human impacts on the ocean and the realization that the single species approach to management is not adequate, the use of marine protected areas (MPAs) is widely being adopted to supplement traditional fisheries management methods. With the implementation of these spatially explicit policies, there is a need to acquire reliable spatial information on species distributions. California has rapidly established an unprecedented state-wide network of marine protected areas and the development of species distribution models can be utilized to help evaluate the placement and efficacy of these MPAs. In addition to the designation of MPAs, California has also designed and implemented a state-wide mapping project called the California Seafloor Mapping Program, which has provided a high resolution (1-10m) basemap for the entire state waters of California. In this study, we focus on the Central Coast region of California and combined these habitat maps with spatially-explicit ecological observation data (Figure 1) to create species distribution models and advance the understanding of ecosystems further than what is achievable through the use of *in situ* data alone. Using generalized linear models (GLMs) and generalized linear mixed models (GLMMs), we developed species-habitat models for the densities of 7 species (e.g., kelp greenling, gopher rockfish, etc.) of ecologically and economically important demersal fish using SCUBA-based biological observation data collected by one of the MPA monitoring organizations (i.e., PISCO) responsible for monitoring the nearshore ecological communities within kelp forests across the networks of MPAs in California. I related these observations to a variety of seafloor variables derived from the multibeam bathymetry including seafloor complexity, slope, and depth and kelp biomass values derived from LANDSAT imagery. We found that all variables were important in predicting the species distributions; however, seafloor complexity and kelp biomass were consistently the most important predictors. Once the best models were chosen using AIC, these species-habitat associations were extrapolated over the study area to evaluate the distributions of species inside and outside the MPAs. We found the density of several key resource species to be higher inside the MPAs compared to outside. The results of this study help to further our understanding of how the variation in habitat affects the distribution of species and evaluate the effectiveness of the MPAs that were put in place to protect these species.

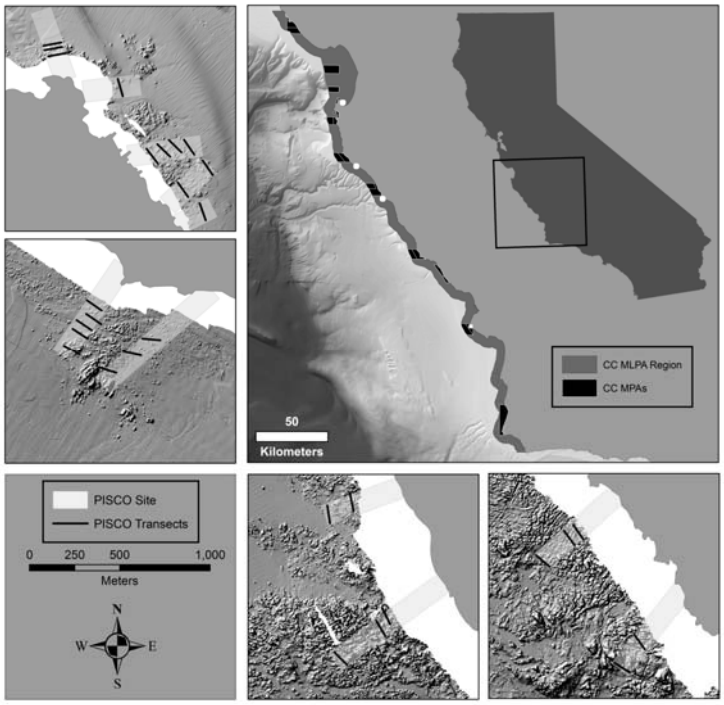

Figure 1: California's Central Coast network of marine protected areas (MPAs). The zoomed in portions of the map are signified by white dots in the image and show four of the sites where biological sampling occurred (the black lines are the SCUBA transects) and are overlaid on the high resolution seafloor data.

POSTER

Implementing downscaling concept in mapping shallow waters marine habitats

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The rapid development in aerial photographs and satellite images resolution, classification, depth of penetration and accessibility make these products a potential tool for mapping shallow water marine habitats. This tool can be used to reduce the cost of the geophysical survey as well as provide seamless coverage of the seabed features.

GEUS together with Orbicon A/S, funded by the Danish Nature Agency (NST), has conducted a geophysical survey followed by a ground truthing campaign in 2012, in order to map the shallow water Natura2000 areas in the Kattegat region. Due to the limited budget available, orthophotos and satellite images were used extensively in the final product.

In the downscaling concept the remote sensing images are used to assess the general settings of the investigated area and aid the planning and optimizing of the geophysical survey lines. The final downscaling stage is the ground truthing which was also optimized by the geophysical survey results and the aerial images.

Conventional geophysical surveys are normally spatially delimited by the survey ship draft and the water depth. Shallow areas are therefore not generally surveyed thus creating mostly a gap in the final seabed sediment map. The orthophotos can provide an additional attribute to fill this gap with a considerable accuracy and manageable budget.

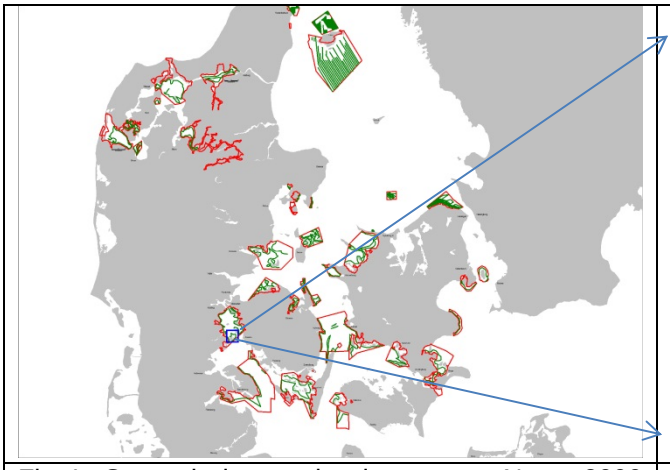

Fig 1. General view, red polygons are Natura2000 areas mapped in 2012. Blue-polygon area shown in Fig. 2.

Fig 2. Orthophoto and satellite images of the blue bounded area in Fig 1.

Application of side scan sonar images as a tool for the management of the coastal protected area Costa dos Corais – northeast Brazil

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Dept. of Oceanography, Federal University of Pernambuco, Brazil

The objective of this study was to recognize the actual phisiographic and sedimentologic features of the adjacent continental shelf of Tamandaré-PE, northeast Brazil, located in the APA Costa dos Corais, using a side scan sonar and an echosounder. The submarine phisiography of the area was characterized by positive (submerged reefs) and negative (paleocanal) reliefs, intercalated by plain surfaces. Hard bottoms indicates that, during sea-level fluctuations, the shoreline was approximately at 16, 20 and 24 m below of the actual sea-level. Seafloors (benthic habitats) had been classified as: rocky, muddy and sandy. This last habitat was predominant in all the area, being composed mainly by coarse to very coarse carbonatic sands. Muddy habitats had a more restricted distribution, being located between the lines of beachrocks observed at depth of 16 and 20 m, mainly, near to a smooth depression to the east of the Tamandaré Bay. Rocky habitats represented by “tacis” and “cabeços”, had occurred in the bands of depth of 16, 20 and 24 m. The location of these habitats is a contribution to the management in the APA Costa dos Corais. Based on this, new points of reef monitoring and visual census of associated ictiofauna could have been suggested. Moreover, in the case of muddy seafloors explored by shrimp fishery, the mapping becomes relevant for ends of stock assessment.

Marine Habitat Mapping on the Continental Shelf off Salvador, Bahia, Brazil

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This study aims to evaluate the geodiversity of the continental shelf off the Salvador city, Eastern Brazil and how this controls the biodiversity of its benthic communities. The Continental Shelf off Salvador(CSS) has an average width of 9 km. The shelf break occurs at 50 meters and it is directly influenced by the South Brazil Current which is characterized by a salinity greater than 36.5, temperatures between 24 º C and 26 º C and low nutrients. The city of Salvador is the third largest metropolis in Brazil and its continental shelf is intensively used (recreation-shipwreck diving, effluent and dredging disposal, telecommunication cables, fishing, and conservation - marine turtles and whale breeding and feeding grounds). These multiple uses generate a great demand for detailed knowledge of the continental shelf marine habitats, which are controlled by shelf geodiversity. Porifera (sponges), Cnidaria (corals, anemones), Polychaeta, crustaceans (shrimps, lobsters), molluscs, Echinodermata (star biscuits, brittle star, sea cucumber), bryozoans and foraminifera are examples of benthic organisms found in the CSS. The term habitat is used here to describe tracts of the seafloor where organisms are subjected to the same environmental conditions. The habitat mapping has been done integrating bathymetry data, sidescan sonar and sub-bottom surveys , grab samples of surface sediments, sampling of benthic communities and video surveys. Bottom heterogeneity or geodiversity provides a variable number of micro habitats and consequently the probability of a greater biodiversity. The highest percentages of the sand fraction are found on the inner shelf, and associated with a major ebb-tidal delta located at the entrance of the Todos os Santos bay. Muds dominate in low lying areas of the shelf whereas bioclastic gravels are common on the outer shelf and topographic highs.

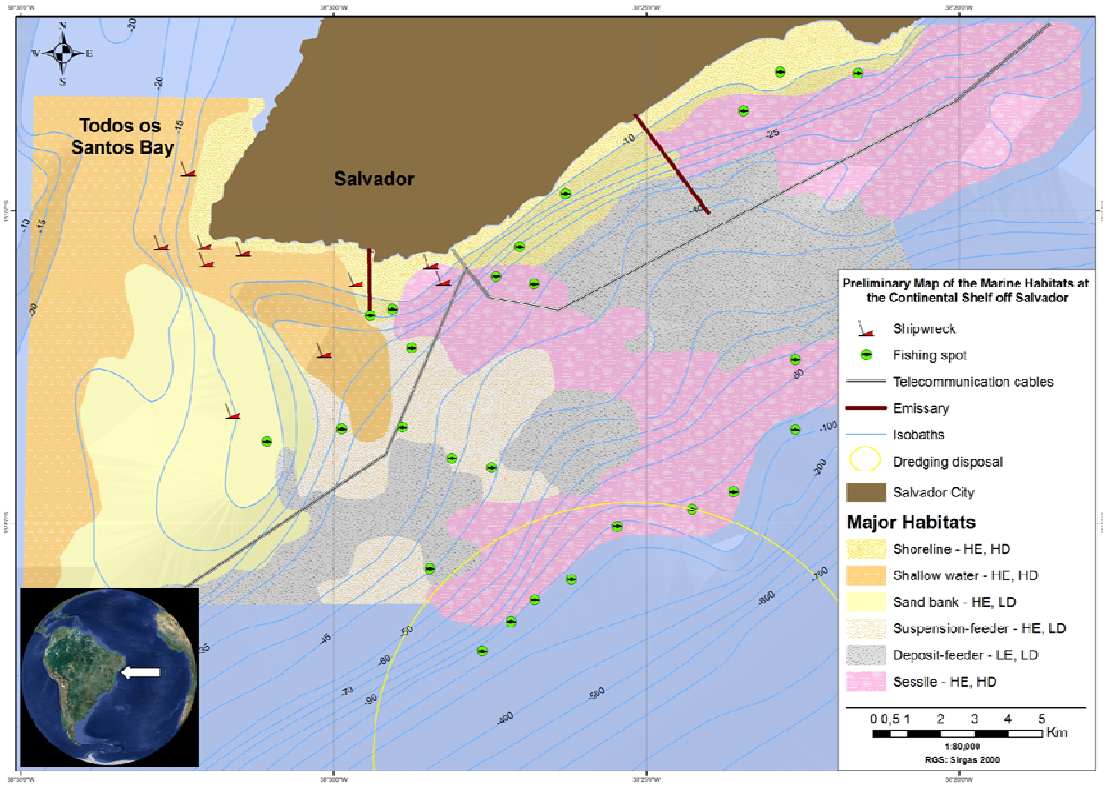

Figure 1 – Major habitats so far identified for the CSS and the multiple uses practiced in this region.

THE COASTAL PLAIN AND SEAFLOOR MAPPING OF AN OCEANIC ISLAND SHELTERED COAST – THE CASE OF SUESTE BAY, FERNANDO DE NORONHA, SOUTH ATLANTIC, BRAZIL.

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[1]Marine Geology Laboratory, Oceanography Department, Pernambuco Federal University (UFPE), Recife, Brazil; [2]Pernambuco State University (UPE), Recife, Brazil; [3]Pernambuco Federal Rural University (UFRPE), Recife, Brazil.

The Fernando de Noronha archipelago is comprised of 21 volcanic islands (26km^2) located in the south equatorial Atlantic (4°S/32°W), 540km from Recife, Pernambuco State, Brazil. The tropical islands emerge from an insular shelf presenting 10km in diameter and around 100 m in depth, formed by Quaternary glacio-eustatic sea level variations. The Sueste Beach is a 450m length pocket beach and its width vary from 80-100m in the western side to 30-50m in the eastern side. The adjacent bay presents shallow depths (< 2m) and many obstacles such as islands and headlands that print a particular hydrodynamic circulation, reducing the wave action on Sueste Beach and also protecting it from the strong ESE currents originated by the trade winds. The mangrove (8,900 m^2), associated to the Maceió river drainage, is isolated from the beach by a vegetated dune system (2.5 to 8.0 m in height), except in a portion adjacent to the Maceió river inlet, located in the west beach side. The vegetation of Sueste mangrove is composed only of *Laguncularia sp*., and it represents one of the only places of occurrence of these species in the South Atlantic Ocean. This study describes the distribution and morphological characteristics of the coastal plain and seafloor surface from a sheltered sedimentary system, located in an oceanic island composed by different coastal environments and habitats: bay (bioclastic sandy sediments, coral reefs and aeolianites), beach, mangrove, lagoon and dune systems. The used methodology integrated the sedimentological data with remote sensing processing stored on a georeferenced bank. Twenty-two surface sediment sampling stations were collected in 7 seasonal fieldworks held in the 2010-2011 period, compounding an amount of 152 samples. The research methods also included grain-size and calcium carbonate analysis. The collected samples are fine sandy (> 99% of sand in 87.5% of samples), well to moderately sorted and bioclastic, presenting high carbonate contents (> 90% in 83.9% of the samples) composed by remains of marine organisms (algae, sponges, bryozoans, shellfishes, coral fragments, foraminifers, sea urchins, etc). The surface mapping results indicates 6 different morphological classes (see figure 1): 1) Modern sedimentary biogenic deposits, composed by bioclastic fine sands (2Ø), which covers the majority of the area and occurs on the Sueste Beach as well as in central portion of Sueste Bay; 2) Active and vegetated dune field, that presents well sorted and finer sands than the beach and bay sediments; 3) Mangrove-lagoon system, mainly composed by poorly sorted sediments (silts and clays) from volcanic origin; 4) Coral reef banks, the feature that prevails in Sueste Bay area; 5) Aeolinites, from pleistocenic paleodunes, are present in the SW bay portion, associated to non living coral forms and benthic organisms such as sea urchins; 6) Basaltic rocks (boulders, pebbles and cobbles) occur associated to the rock cliffs on both bay sides, as well as surrounding the Chapéu do Sueste Island. The generated map is unpublished and could support future management programs for the Fernando de Noronha National Park, especially in the Sueste Bay Environmental Protection Area (Brazilian National Research Council -CNPq- project n°: 577369/2008-3).

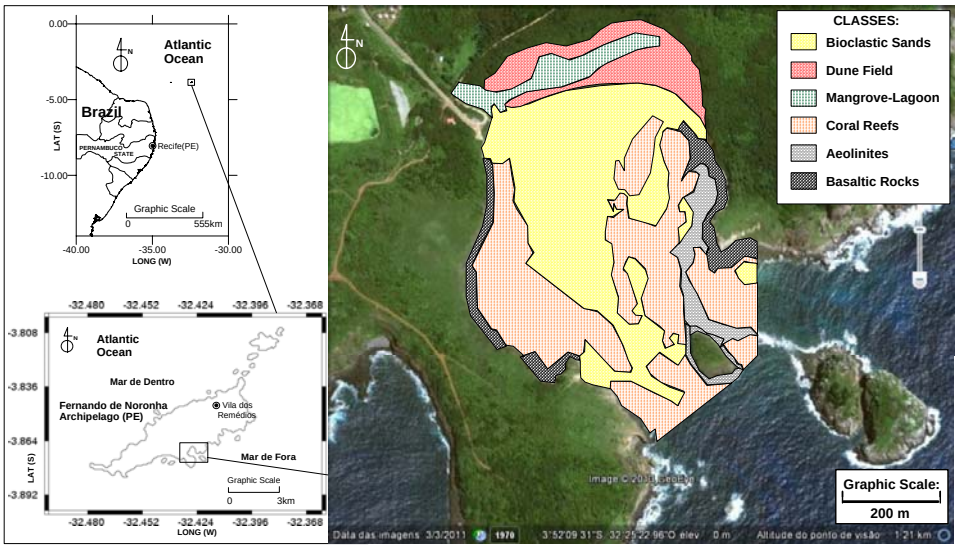

Figure 1 – Fernando de Noronha island location and morphological features in Sueste Bay sedimentary System

THE MORPHOLOGY OF SOUTH PERNAMBUCO CONTINENTAL SHELF, NORTHEASTERN BRAZIL

Barcellos, R.L.[1]; Camargo, S.R.R.M.[1]; Ferreira-Júnior, A.V.[1]; Araújo, T.C.M.[1] & Vital, H. [2]
[1] *Pernambuco Federal University (UFPE), Recife, Brazil;* [2]*Rio Grande do Norte State University (UFRN), Natal, Brazil.*

Studies carried on the Brazilian continental shelf are still incipient, especially in northeastern Brazil, and particularly in Pernambuco State. In general this shelf is characterized by the narrow width (33km), shallow depths (shelf break: -55/-65m), warm waters (26-28°C), high salinity (>36PSU) and is covered in majority by sandy biogenic sediments. Siliciclastic palimpsests sediments are predominant in the inner shelf, except the presence of modern muds trapped in corridors between submerged beach-rocks chains, adjacent to river mouths and filling channels on the shelf. Several seafloor features are found in its dominion: organic and inorganic reefs, submerged dunes, paleo incised-valleys, wave-cut terraces and canyons. The study area is located off the southern coast of Pernambuco State in an Environmental Protection Area (APA) called Coral Coast. This work intends to organize the existent information about the bathymetry, morphological features and sediment cover in the South Pernambuco continental shelf. The used methodology integrates the bathymetric and sedimentological data from 159 surface sediment samples stored on a georeferenced bank. A Digital Terrain Model (DTM) was devised by means of twenty bathymetric profiles (about 300 km) obtained with an echosounder and also using bathymetric data acquired by the Brazilian Navy. These data collection allows a delimitation of this continental shelf into three different compartments. The first is the narrow (5km) and relatively steep inner shelf (0/-20m isobath), composed mainly by medium and fine silicibioclastic sands (> 2Ø and < 50% $CaCO_3$). Another characteristic of this compartment is the bottom irregularity directly related to the occurrence of submerged beachrock found at -16, -20 and -22 m depht. This last beachrock chain (-22m) marks the limit between inner and mid-shelf. The mid-shelf (-20 to -40m depth) is characterized by a lower steepness and a large area (20km wide), occupying more than 50% of the whole shelf. It is composed by coarse bioclastic sediments (< 1Ø and > 70% $CaCO_3$) and at -40 m isobaths, a relatively steep slope marks the limit with the outer shelf (-40 to -60m). This last compartment presents, in general, the same sedimentary cover found on the mid-shelf, but particular seafloor features, such as canyons and incised-valleys, are present, probably related to sea-level still-stands. Two paleochannels were indentified and named (Formoso River and Una River palleovalleys), with both presenting a WNW-ESE orientation (see figure1). Although paleovalleys network indicate a good correlation with positions of modern coastal rivers and the same sub-parallel drainage system trend, the dimension of the “Channel/Valley” Systems are quite large (4 km wide in the Formoso paleovalley) in relation to the size of the fluvial basin and the modern drainage network in the area. These morphological features are related with the coastal evolution of the southern Pernambuco continental shelf during Holocene sea-level variations and their description and location will be useful in future works concerning ancient conditions of sea-level stability. Mapping of submerged beach rocks contributes, as well, to the biodiversity conservation initiatives and the national and global coral reef monitoring programs. Finally, the sediment cover is one of the most important parameters to understand the shelf system as a whole, because they reflect geological and hydrodynamic processes, present and past, and define, together with other environmental variables, the kind of biological community installed (Brazilian National Research Council - CNPq: Science and Technology National Institute - INCT AmbTropic).

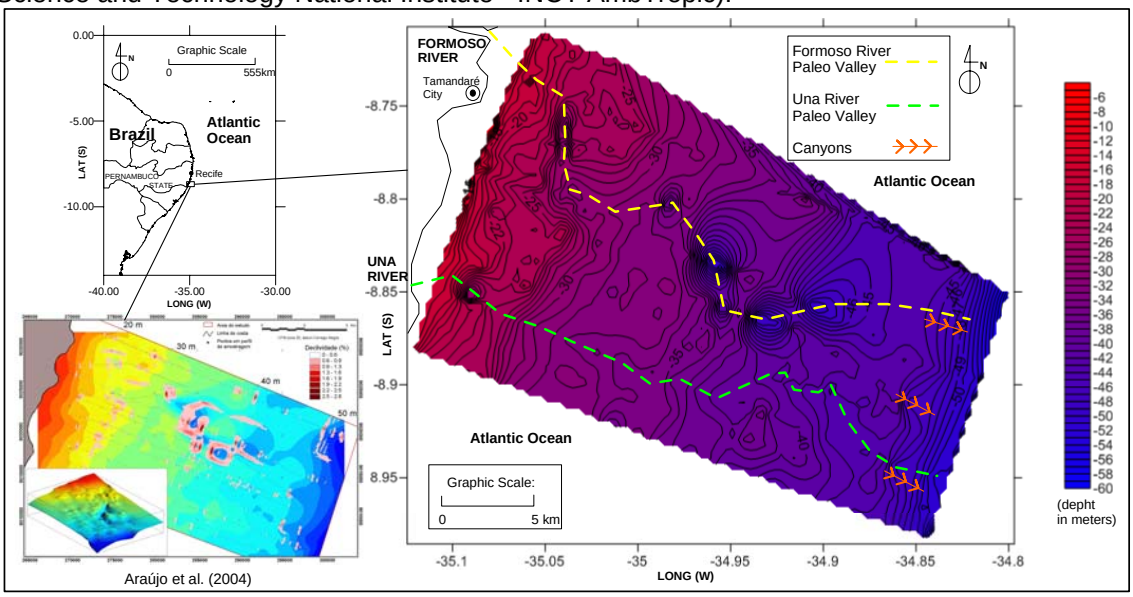

Figure 1 – South Pernambuco continental shelf location, bathymetry and 3D DTM of Formoso River Paleo Valley

Sinkhole-like features (Buracas) as an Important Marine Habitat in the Abrolhos Bank

Alex C. Bastos, Rodrigo L. Moura, Gilberto M. Amado-Filho, Daniele P. Dagostini, Ronaldo B. Francini-Filho, Arthur Z. Güth, Paulo Y. G. Sumida, Michel Mahiques, and Fabiano L. Thompson

UFES, Brazil

Sinkhole-like features are described for the Abrolhos Bank continental shelf, eastern Brazil, based on geophysical and geological assessments. These unusual structures are locally known as *buracas* (holes) and they form an important marine habitat as they enhance productivity and aggregate biomass in a region under growing fishing pressure. A total of 36 *buracas* were found between 41-161 km off the coast and between 24-65 m depth. These structures were initially mapped by side scan sonar and single-beam bathymetry. They are large cup-shaped depressions similar to sink/blueholes (10-75 m in diameter, 8-39 m in height), occurring in a consolidated carbonate substrate in the mid and outer shelf. The buracas' walls are mainly composed of encrusting coralline algae. Radiocarbon dating has provided ages of 5,400 ± 90 yr Cal BP, 8,630± 90 yr Cal BP and 39,200 ± 400 yr BP. Besides providing a comprehensive description of these novel structures within the mesophotic zone, the potential mechanisms by which these sinkhole-like structures originated are discussed here, as well as the possible active mechanisms impeding their filling with sediments and biogenic material. We hypothesise that their origin could be related to either typical sinkhole formation during subaerial exposure or to a Holocene growth pattern influenced by antecedent morphology and gas/fluid escaping due to organic matter decomposition.

Revealing habitats, surficial geology and seabed processes of Norway's continental slope and deep sea plain

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The Norwegian seabed mapping programme MAREANO (www.mareano.no) has recently obtained the first detailed results from areas of the deep sea off Lofoten-Vesterålen. MAREANO has acquired multibeam bathymetry and backscatter, seabed samples, video data and shallow seismic data which provide the basis for mapping geology, sedimentary processes and habitats on the seafloor. During several research cruises in the period 2009 to 2012, more than 100 video lines have been recorded in areas deeper than 1000 m, documenting a variety of structures and bottom types hosting a variety of fauna. These videos have shown that the seabed, even in these deep waters, is far from being a uniform environment.

From the continental shelf break to the deep sea plain, multibeam data have revealed huge structures including canyons, slide scars and slide deposits, channels and contourites. Glacigenic debris flows, seabed cracks, small slide scars and small canyons are also observed. Video footage from the slope and on the deep sea plain highlight the significance of the slide deposits, especially in the deeper areas where coarse sediments and compacted sediment blocks contrast strongly with the surrounding hemipelagic mud, offering distinct habitat conditions. Small canyons possibly created by leakage of gas and/or fluids, and holes and chimneys have also been observed.

Interpretation of high resolution shallow seismic data shows debris flows eroding contourite deposits or covering slide deposits. In the deep sea area, slide deposits occur between canyons whereas outside canyon mouths mounded deposits form possibly submarine fans. The seabed is inhomogeneous, with alternating hemipelagic mud, gravel, stones and compacted sediment blocks creating habitat oases for various animals.

Creating seabed sediment maps based on backscatter data is a challenge as different frequency multibeam systems are used dependant on water depths, creating different acoustic responses for the same bottom types. The technical challenges of interpreting data from these areas will be discussed and presented together with examples of the geology and benthic habitats occurring in this varied deep sea environment.

Seabed types at 2000 m water depth. Picture on the left shows foot of video-rig sinking into soft mud. Picture on the right shows compacted sediment block with gravel. Ten centimeters between red laser points.

Predicting coral gardens habitats in the Southwest coast of Portugal

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Coral gardens are vulnerable and sensitive habitats protected by the OSPAR Commission. Knowledge on their distribution is essential to provide protection and integration in marine protected areas and also for marine spatial planning actions.

Predictive habitat mapping is a technique that could supply continuous habitat distribution maps from sample data particularly when surveys are located in deep waters.

In the south-west coast of Portugal deep coral gardens (50-80m) are characterized by several gorgonians species, *Eunicella labiata, Eunicella verrucosa*, *Leptogorgia lusitanica*, *Leptogorgia sarmentosa, Paramuricea clavata* and occasionally the Sea-finger *Alcyonium acaule*.

A rocky area with depths ranging from 53 to 86 meters was studied using multibeam bathymetry and ROV transects as part of a collaborative survey between University of Algarve, National Oceanographic Institute of Spain in the scope of the European project MESHATLANTIC and also Oceana.

Based on the ROV observations, a Maxent predictive modelling was used to assess the probability of coral gardens distributions. The model was elaborated with multibeam bathymetry and derivate layers, such as, aspect, slope, bathymetric position index and curvature and also bottom type and fraction of light. The AUC value obtained indicates good performance of the model with depth and bottom type as the variables with higher contribution to the model. The predicted distribution and the observed value suggest that this approach could be a valid contribution to predict coral gardens habitats in wide surrounding areas.

“Marine Spatial Planning - from the seafloor to the decision maker’s desk”

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There is an increasing need for detailed information on underwater habitats in shallow coastal areas. Not only do these areas contribute with some of the oceans widest array of species and habitats but they are also among the areas which are most strongly affected and used by humans. While realising the importance of the welfare of our marine areas has lead to directives and strategies such as, Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP), enough reliable data and information to implement these methods is still missing in large parts of the world.

Hence a method for gathering high quality data for large scale areas effectively is a pressing need. But this however is only the first part of the problem. To be able to implement strategies and directives, reliable maps and data is of the outmost importance. This information also needs to be in a format easily interpreted by individuals that don’t have an extensive university degree in biology. To complicate things further mapping of underwater habitats can be extremely difficult; there is a seemingly never-ending struggle between cost, quality and precision. E.g. diving gives accurate information on very small-scale areas but the methods is too time consuming to implement on larger areas.

The shallow Kvarken area between Finland and Sweden has been one of the pilot areas in the international SUPERB project trying to improve underwater mapping techniques for shallow areas and generate information and maps that can be used by decision makers at every level. The project has used three data collection methods; drop-down video, diving, and LiDAR (light detection and ranging). Combining these methods with different modelling and statistical treatments has yielded magnificent results. The first results were achieved by combining data from LiDAR and drop-down video, this produced a god general map. When data collected during diving was incorporated the accuracy of the maps were radically improved the results where jaw dropping.

The final product can be in the form of maps or data layers and with a bit of clever classification and a focus on habitats and habitat forming species the use of the maps can be infinite. Easily interpreted and relevant maps should be a priority. Developing maps with a principle of ‘stop, wait, go’ is exceptionally desirable because these maps can be an excellent option for getting your message through (Fig. 1).

We have come to the conclusion that *in situ* data collection and remote sensing techniques need to be used in a complementary way and only then is there a possibility of developing a method by which the biological attributes along a coastline can be mapped with precision and within a reasonable time span. One also needs to strongly consider for whom and what purpose the information is needed, this is vital for there to be any type of benefit from the work done.

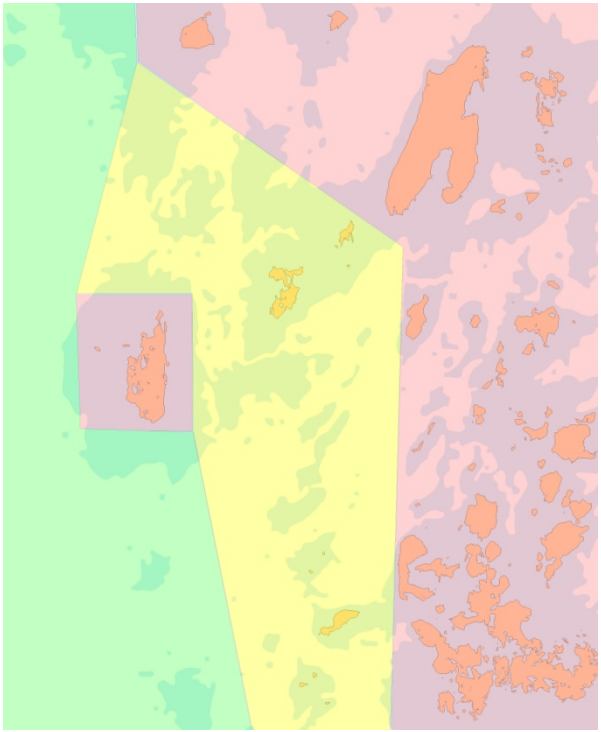

Figure 1. An example of how a ‘stop, wait, go’ map regarding use of sea area resources could look. Green ‘exploitation OK’, yellow ‘more information needed before decisions can be made’ and red ‘high natural values exploitation not OK’.

Shallow water carbonate buildings in the Mediterranean Sea: geomorphological expression of coralligenous habitat

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Coralline red-algae are considered one of the most important carbonate sediment contributor in the benthic communities of Mediterranean area, representing one of the most productive ecosystems in temperate regions. Several types of assemblages and seafloor features have been described so far, due to the high heterogeneity of coralline growth-forms, distributed from the intertidal down to 160 m water depth (wd), from *corniche* to *maërl* to coralligenous build-ups.
It represents the most monumental expression of coralline-algae ability to produce carbonate.
Coralligenous build-ups are autochthonous carbonate build-ups, producing frameworks with three-dimensional structure that serve as shelter and provide storm protection by buffering wave action along coastlines. It represents the most monumental expression of coralline-algae ability to produce carbonate, patchily distributed along the Mediterranean coasts.
It plays a primary role in the geomorphological development of continental shelf.
The areal definition and the investigation of these environments are fundamental scientific topics with strong implications for resource management and preservation policies.
The coralligenous is recognized as protected habitats in the EC Regulation No. 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Different actions have been favoured to collect new data on its range of extent and distribution and in the Mediterranean and European seas.
In the framework of BIOMAP project (P.O FESR 2007/2013) promoted by Puglia Region, Italy, several oceanographic cruises were carried out along the Apulian continental shelf (central Mediterranean sea) to collect acoustic data (through MultiBeam Echosounder Systems (MBES) and high-frequency Side Scan Sonar (SSS)) and video inspections, to identify and locate coralligenous habitats, between 10 and 100 m of water depth.
Selected-area data set was processed and analysed through proper GIS-based tools, to investigate the variety of morphologies that coralligenous habitat developed at the explored locations.
Detailed Digital Terrain Model (DTM) have been obtained trough MBES data-processing and have been merged with the SSS backscattering mosaics.
Morpho-acoustic facies were identified in the framework of literature models and the main features of the acoustic response and associated to the collected ground-truthing information (i.e. video inspections).
Different geomorphological expressions of coralligenous habitat have been thus identified. A precise relationship between the identified coralline facies and its acoustic response is here proposed, in order to improve the detection and spatial delimitation of these biogenic carbonate deposits and high biodiversity spots.

A comparison of EM3002 multibeam backscatter and LiDAR reflectivity for separating seabed classes

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EM3002 multibeam backscatter data were collected in a joint project with Geoscience Australia in September 2010 over a test area mid-way between Perth and Rottnest.

LiDAR waveform data were collected by Fugro LADS in a survey conducted for WA Transport in April 2009 off the coast of Western Australia from Two Rocks to Cape Naturaliste.

The multibeam backscatter data are centred by subtracting an overall backscatter - incidence angle curve, and scaled by dividing by the pooled standard deviation at each incidence angle; this flattens out the average backscatter response, while still retaining the relative integrity of the values.

The LiDAR relative reflectivity data are corrected for differences in attenuation due to turbidity, by estimating the linear trend (on the log scale) for the volume return region between the surface return and the bottom return.

Canonical variate analysis (CVA) of contiguous segments is used to compare the separation, based on plots of the CV scores against easting.

There is good agreement between the CV score plots for the multibeam backscatter and the LiDAR reflectivity for discriminating between hard-bottomed and soft-covered seabed types.

There are differences in the effectiveness of the discrimination when the seabed classes are closer, for example when there are changes in seagrass density; the multibeam backscatter tends to provide more subtle discrimination.

A comparison of depths derived from WorldView 2 spectral data with those from a LiDAR survey and a single-beam echosounder

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LiDAR depth data were collected by Fugro LADS (Kidman Park, SA) in a survey conducted for WA Transport off the coast of Western Australia from Two Rocks (north of Perth) to Cape Naturaliste in April 2009. CSIRO has developed procedures to calculate consistent relative reflectivity values from the LiDAR waveform data. Single-beam echosounder depth data provided by NOAA are freely-available off the coast of St. Thomas (US Virgin Islands (USVI)).

Multispectral WorldView 2 (WV2) data have been acquired over the Marmion Marine Park (north of Perth) from an overpass in June 2012, and over the coast of St. Thomas from an overpass in September 2011, to allow comparisons with the LiDAR depths and the single-beam echo sounder depths respectively. The quality of the WV2 data and the environmental conditions represent two cases: (i) poor data quality of WV2 due to sensor errors such as striping and noise (the fifth band of WV2 had to be replaced), as well as high in-water turbidity for parts of the Marmion Marine Park test site; and (ii) good data quality and clear water for the test site off the coast of the USVI. EOMAP has derived proprietary physics-based algorithms to decouple effects such as path length, bottom reflectivity and in-water turbidity to derive depths from the WV2 spectral bands.

Plots of the EOMAP-derived depths vs the single-beam echo sounder depths for the USVI test site show a tight linear relationship for sandy as well as vegetation and reef areas. Plots of the EOMAP-derived depths vs the LiDAR depths for the Marmion Marine Park show a reasonably tight linear relationship for the sandy areas (higher values of LiDAR reflectivity). However, there is a virtually flat pattern for the reef areas (lower values of LiDAR reflectivity). Plots of the spectral bands against depth show an obvious attenuation effect for the sandy areas, and a much flatter pattern for the reef areas. The variation in predicted depths is lower for the USVI sites when compared with the sandy areas over the Marmion Marine Park.

The physics-based model used by EOMAP to calculate depths depends on optical depth, in-water turbidity, seafloor reflectivity and spectral composition, as well as residuals from other impacts, on a per-pixel basis. A more basic model simply assumes that the level of response of the log spectral bands attenuates linearly with depth. The detailed physical calculations by EOMAP for the Marmion Marine park are verified by a regression of the LiDAR depths on the blue, green and yellow log offset-corrected spectral bands which accounts for only 45% of the overall variation; the coastal blue band adds virtually nothing to the regression. The blue and green bands account for nearly 41% of the variation. A regression for the sandy areas alone explains 54% of the variation in the observed depths. However, a regression for the reef areas explains only 11% of the variation in the depth values. There is a marked difference in the intercepts for the sandy regions and the reef-covered areas.

One of the practical implications of the results is that for an area with good data quality and clear water, the deviation of predicted and observed depths is between 5% and 20% for depths up to 25 m. In areas with less favourable environmental conditions, the possible errors can increase significantly. For the Marmion Marine Park at 10 m depth, the satellite-derived depths showed a deviation of as much as 50% of the observed depths.

In practical applications, satellite-based methods are useful in many locations worldwide as a cost- and time-effective operational service for extended and difficult-to-access areas, where highly-accurate depths are not essential.

From 630 km to the ground: a new multiscale approach to scientific habitat monitoring of intertidal and subtidal areas

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Scientific mapping is a challenge. Various system limits, techniques, resolutions, and parameters need to be considered, while a worldwide standard for data collection and outputs is lacking. At the same time, mapping has become a crucial key tool for organizing the information on the present status and planning the future of sensitive coastal ecosystems.

In this study, we present preliminary results from a new interdisciplinary and multiscale approach for mapping and monitoring intertidal and subtidal areas. The aim is to test and compare the ability of different systems to infer and integrate information from different data sources.

Remote sensing techniques (e.g., multispectral and radar satellite scenes, optical records/orthophotos, LiDAR data) have been largely applied for land mapping at large and medium scale. Their relevance in seafloor mapping is limited by the light penetration in the water and by residual water on the surfaces of tidal flats. Issues are also represented by timing of measurements (weather and day light for optical sensors, and tidal conditions).
Acoustic devices are scarcely deployed for mapping extreme shallow water environments (i.e. intertidal areas), due to the reduction of effective survey time , reduced coverage, and increase of acoustic noise causing artifacts.
Point sampling and *in-situ* observations are used as a direct source of information for describing, documenting and monitoring habitats. They represent a discrete source of relatively high resolution data. Depending on the heterogeneity of the environment and on the sampling grid, information about areas not directly covered by sampling can generally be inferred by means of interpolation or coupling point records with continuous spatial datasets (remote sensing and acoustic data).

Within the framework of the WIMO Project (WIssenschaftliche MOnitoringkonzepte für die Deutsche Bucht, *Scientific monitoring concepts for the German Bight*), the Norderney tidal flat was chosen as a testing site to combine different methods for habitat mapping. Norderney is one of the German East Frisian Islands and lies within the borders of the Wadden Sea UNESCO World Heritage Site. The back-barrier sand- and mud-flat area (65km²,max. tidal range 2,4 m) is drained into the open sea by the Riffgat Channel (to the west) and by the Ostbalje and NeßmersielerBalje Channels (to the east).

A survey was undertaken in Sept. 2012. Sediment and macrofauna samples were collected coupled with *in-situ* observations, RTK-based topographic measurements, and side-scan sonar (SSS) data (by Starfish™ 452F). Previous acoustic records were available for the Riffgat Channel (by Benthos™ 1624), sampled in the same time frame (Sept. 2011). Remote sensing data (TerraSAR-X images 2009-2012, RapidEye images 2011, and LiDAR records 2010) covered the whole tidal flat area, forming the basis for the survey plan and, later, for the multidisciplinary approach to the habitat spatial analysis.

Macrozoobenthos records were statistically analyzed and compared with an existing database (DeMarine-Umwelt). The outcomes proved to be consistent with the previous benthic community description. The SSS seabottom classification of the Riffgat Channel area was mainly controlled by the characteristics of both seabed morphology and sediments. The RTK height measurements only partly fitted the LiDAR data, which is likely due to the time-lapse between the two records. RapidEye classification led to a general distinction of sediment/flora composition. Further improvements focus of atmosphere correction/noise reduction. Relatively large scale surface structures like mussel beds, water-covered depressions, fields of shell detritus or freshly settled mud were distinctly recognizable in the TerraSAR-X images and could be charted over time.
The main morphological and sedimentary structures could be mapped in all the remote-sensing and acoustic systems, with different resolution and ability to recognize specific features (e.g. mussel beds, depending on their stage of development).

From multibeam seafloor mapping to standard cartography of geomorphic features. Problems from a Mediterranean perspective

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Over the last decades, advances in seafloor mapping systems provided an unprecedented high-resolution views of the seafloor up to at metric or sub-metric resolution. Moreover, the extensive use of seafloor mapping led to the convergence of scientific expertise and fuelled multi-task and multidisciplinary approaches in the management of the submarine realm. The definition of the submarine environment via a better understanding of the relationships between seafloor morphology and geological/oceanographic/biological processes is needed. Nevertheless, the gathering of a huge amount of morpho-bathymetric data, in a relatively short time, has prevented from the organization of standard cartographic criteria in order to homogenize results and products, and fully exploit their potentialities for all disciplines.

Defining standard criteria for classification and cartographic representation of geomorphic features is rather setting-dependent. In the Mediterranean sea, the young and active geology created very heterogeneous landscapes with volcanic, tectonic, erosional and depositional features overlapping in space and time. Therefore the nature of seafloor processes has to be achieved by the interpretation of geomorphic features, the shape of which is not straightforwardly indicative of their genesis. At present, there is also a feedback between the aim of the morphological mapping (habitat, hazard, marine management, archeology, etc) and the mapping criteria. To overpass this fact, a joint effort among different disciplines and application to different physiographic\climatic setting is needed. Some examples from the Italian Seas will be discussed to highlight problems and possible solutions in standardizing interpretative and cartographic criteria, allowing to define some basic guidelines that may share a common application in different research fields relying on seafloor mapping.

Using scientific evidence to underpin advice on UK Marine Protected Areas – an MCZ example

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A network of Marine Protected Areas (MPAs) will ensure we meet our commitments under international agreements such as the Convention on Biological Diversity and the OSPAR Convention, as well as national legislation such as the UK Marine and Coastal Access Act 2009 and Marine (Scotland) Act 2010. The Joint Nature Conservation Committee (JNCC) is responsible for the identification of Marine Protected Areas (MPAs) in the UK offshore marine area (beyond 12 nautical miles). In English inshore waters and English, Welsh and Northern Irish offshore waters, one of the types of MPAs that will contribute to our network will be Marine Conservation Zones (MCZs).

In 2009, four regional MCZ projects were created to identify and recommend MCZs in their geographical regions. JNCC and Natural England provided advice to the regional MCZ projects on how MCZs were to be selected. The two key pieces of guidance were the Project Delivery Guidance and the Ecological Network Guidance. Through meetings and discussions with sea users, the projects involved over 600,000 stakeholders in the process. The use of best available evidence is a vital element of building an ecologically coherent MPA network and where there is scientific uncertainty a precautionary approach is taken. The recommended MCZs were identified for broad-scale habitats, and habitats and species of conservation importance. The evidence that underpin these recommended sites included habitat maps, stakeholder knowledge, modelled information or groundtruth sample stations.

The regional projects' final recommendations of 127 rMCZ's were then reviewed by JNCC, Natural England and a independent Science Advisory Panel. In September 2012 JNCC and Natural England submitted their advice to Government, and included the assessment of confidence in the evidence for presence and extent of features as recommended by the Regional MCZ Projects. This assessment was based on best available data and helped guide decision making. In December 2012, Defra initiated a public consultation on all 127 recommended MCZs. Of those 31 are under consideration for designation in 2013. Survey work has been undertaken in partnership with Cefas, Natural England, the Environment Agency and Defra to provide data to help better determine and confirm the presence and distribution of a feature within sites.

This presentation will outline the levels of evidence and data used in at each stage of the processes, highlighting the assessment of scientific confidence in the presence and distribution of features inside the recommended MCZs, from a policy requirements perspective.

To obtain more information on all of the MCZs recommended by the Regional MCZ Projects visit the MCZ interactive mapper: http://www.mczmapping.org/

Use of the Coastal and Marine Ecological Classification Standard (CMECS) in Glacier Bay National Park, Alaska

Guy Cochrane, USGS, Santa Cruz, CA
Timothy Hodson, NIU, Dekalb, IL

The U S Geological Survey (USGS) is one of four primary organizations (along with the National Oceanographic and Atmospheric Administration, the Evironmental Protection Agency, and NatureServe) responsible for the development of the Coastal and Marine Ecological Classification Standard (CMECS) over the past decade. In June 2012 the Federal Geographic Data Committee approved CMECS as the first-ever comprehensive federal standard for classifying and describing coastal and marine ecosystems. The USGS has pioneered the application of CMECS in Glacier Bay, Alaska as part of its Seafloor Mapping and Benthic Habitat Studies Project. This presentation briefly describes the standard and its application as part of geological survey studies in the Western Arm of Glacier Bay.

CMECS offers a simple, standard framework and common terminology for describing natural and human influenced ecosystems from the upper tidal reaches of estuaries to the deepest portions of the ocean. The framework is organized into two settings, biogeographic and aquatic, and four components, water column, geoform, substrate, and biotic. Each describes a separate aspect of the environment and biota. Settings and components can be used in combination or independently to describe ecosystem features. The hierarchical arrangement of units of the settings and components allows users to apply CMECS to the scale and specificity that best suits their needs. Modifiers allow users to customize the classification to meet specific needs. Biotopes can be described when there is a need for more detailed information on the biota and their environment. USGS efforts focused primarily on the substrate and geoform components.

Previous research has demonstrated three classes of bottom type that can be derived from multibeam data that in part determine the distribution of benthic organisms: soft, flat bottom, mixed bottom including coarse sediment and low-relief rock with low to moderate rugosity, and rugose, hard bottom. The West Arm of Glacier Bay has all of these habitats, with the greatest abundance being soft, flat bottom. In Glacier Bay, species associated with soft, flat bottom habitats include gastropods, algae, flatfish, Tanner crabs, shrimp, sea pen, and other crustaceans; soft corals and sponge dominate areas of boulder and rock substrate. Video observations in the West Arm suggest that geological-biological associations found in central Glacier Bay to be at least partially analogous to associations in the West Arm. Given that soft, mud substrate is the most prevalent habitat in the West Arm, it is expected that the species associated with a soft bottom in the bay proper are the most abundant types of species within the West Arm. While mud is the dominant substrate throughout the fjord, the upper and lower West Arm are potentially very different environments due to the spatially and temporally heterogeneous influence of glaciation and associated effects on fjord hydrologic and oceanographic conditions. Therefore, we expect variations in the distribution of species and the development of biotopes for Glacier Bay will require data applicable to the full spectrum of CMECS components.

Seabed discrimination based on WorldView 2 size-adjusted log spectral bands

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A LiDAR survey from Two Rocks to Cape Naturaliste was carried out for WA Transport by Fugro LADS in April 2009. CSIRO has developed procedures to calculate consistent relative reflectivity values from the LiDAR waveform data.

Multispectral WorldView 2 (WV2) data have been acquired over the Marmion Marine Park (just north of Perth), to allow comparisons with the LiDAR depth and reflectivity values.

Plots of the log spectral bands against depth show an obvious attenuation effect, especially over the sandy-bottomed regions. Plots of the scores from a canonical variate analysis (CVA) based on the log spectral bands also show an obvious relationship with depth.

An empirical correction of the overall attenuation effect is carried out by removing the overall "size" effect for each pixel; size-corrected bands are calculated as log band i / (log band 1 + … + log band 4).

Plots of the CV scores and of the size-corrected bands against depth show only a small residual depth trend, suggesting that for practical discrimination purposes, much of the attenuation effect can be removed by this simple size adjustment.

An image of the first CV scores from the size-corrected CVA shows strong agreement with an image of the LiDAR reflectivity values.

Seamless reflectivity mosaics from LiDAR waveform data

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LiDAR has been employed quite extensively for depth sounding in shallow marine environments. A measurement of reflectivity is also produced, based on the energy of the returned LiDAR signal from the ocean floor. Ideally, the reflectivity measure should be consistent, so that the same cover type measured in different depths and water conditions has the same reflectivity measure. This is not always the case, however. The LiDAR reflectivity data sometimes show marked differences from flight line to flight line, due to differing levels of turbidity in the water column, differing sensor and scene geometry, and instrument effects that are inherent in the equipment.

A marine LiDAR survey from Two Rocks to Cape Naturaliste along the Western Australian coastline was carried out for the Western Australian Department of Transport by Fugro LADS Corporation during April and May 2009. While the depth data are of primary interest, the survey also provided relative reflectivity products which can be used to map habitat and cover types.

This paper outlines an approach for correcting and calibrating the reflectivity data from the LiDAR bathymetry dataset to produce seamless mosaics that are consistent from one area to the next.

The main steps are: (i) calculate the maximums of the bottom return (or the area under the bottom return); (ii) correct the maximums across each swath for a small pulse-width effect; (iii) determine the water attenuation, by fitting linear trends to the log waveform values, and then smoothing the linear coefficients spatially; (iv) correct the maximums for the water attenuation, to give relative reflectivity values; and (v) implement a CSIRO-developed algorithm which essentially matches the edges of the reflectivity images for overlapping flight lines, to produce a seamless mosaic of relative reflectivity values. A test area over the Marmion Marine Park near Perth is used to illustrate the process.

A complete mosaic of the relative reflectivity values for the overall survey from Two Rocks to Cape Naturaliste has been produced at 6 m resolution. Images of the survey will be presented.

A map of the morphological characteristics of the Italian seas

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The description and mapping of geomorphological features of a sea basin constitute a base knowledge used to understand the many peculiarities of the marine environment: the basin genesis and evolution, the sediment dynamics and the presence of habitats and biological communities. All of this information was indispensable to meet the demands of the European Commission in the implementation of the **Marine Strategy Framework Directive (MSFD)**, which foresees the definition of the environmental status of the marine basins of each member state.

The present study, using different available data sources, has led to the creation of a map that identifies the main morphotypes (canyon, morphological high and bench, hill and isolated seamount, ridge, slope change) of the Italian marine basins. The map has been realized through the **interpretation of the bathymetry** available which allowed to evidence the physiography of the sea basins and the identification of the morphological features characterizing each of them. To support the interpretation of the bathymetry, cartography and data from previous studies have been used, particularly geological data collected during the surveys for the Italian geological mapping project (CARG Project).

The database underlying the map has been realized in a GIS environment, in order to obtain a nationwide harmonized basic knowledge of marine basins, which can be updated whenever new data become available.

Holocene pollution signals and associated changes in the benthic habitat of a freshwater lake: A case study from Windermere, UK.

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High resolution airborne LiDAR (Light detection and ranging) and multibeam bathymetry data have been supplemented by geomorphological and geological field mapping and coring to begin to investigate the post-glacial history of Windermere, the largest lake in the English Lake District. One significant aspect of this has been the analysis of grab samples, ROV footage and short cores to assess the impact of mining and quarry development and anthropogenic activity in the surrounding catchment area on the lakebed habitat, and the impact of any changes on Spring and Autumn spawning grounds for the Arctic charr (*Salvelinus alpines)*. This location is the southernmost known spawning ground for the Arctic charr globally, and as such is an important indicator when considering the impact of environmental and climatic changes on habitats.

Taking an approximate sedimentation rate of 2mm yr^{-1}, (rates vary from 0.8mm yr^{-1} to 5mm yr^{-1} depending on the analysis technique and the age, with rates appearing to increase in the Holocene record), ITRAX results suggest that whilst most element concentrations have been stable over the top 73cm of core (representing ~360 years), there was an increase in lead concentration ~175 years ago, with a significant further jump ~20 years ago. Caesium concentrations are elevated in the top 10cm of the short cores, with distinct peaks at 4.5cm and 10.5cm being related to the 1986 Chernobyl disaster and the beginning of atmospheric nuclear weapons testing in the late 1940's – early 1960's respectively.

ROV imagery over most of the spawning sites indicated in a paper by Frost (1965) has shown a significant decrease in the "walnut" sized pebble environment that the fish prefer, with an increase in finer sediment cover and also vegetation growth covering the larger grain sizes. In addition, there was a noted cover of filamentous growths forming mats across the lakebed, particularly in the southern basin. Scanning Electron Microscope and epifluorescence work on some of these growths captured in short cores is ongoing. However, current work suggests that the larger linear filamentous structures, ranging from 1 – 2 cm in length, could be fungal hyphae such as *Sphaerotilus natans* (Mason, 1996), with the larger globular aggregates comprising sediment and diatom skeletons bound together by bacterial extracellular matrix or environmental DNA. It is suggested that these "growths" correspond to an increase in phosphorus being pumped into the lake by nearby sewage treatment plants, with the south basin being more impacted than the north by this type of discharge, and catchment specific anthropogenic mining activity in the north basin.

Whilst further results are still in the process of being obtained from various analyses conducted on the core material, this study has already shown that adopting an integrated dataset approach can reveal important insights into the changing behaviour of freshwater habitats.

A cold-water coral biota classification scheme for ecosystem based management of the deep sea

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Cold-water corals (CWC) are important as they can provide structural habitat that may be used as a refuge for other species which leads to increased localised diversity, thus are of great ecological significance. CWC are known to be vulnerable to fishing activity, and as such are protected under a number of initiatives. Cold-water coral reefs, coral gardens, and communities which are composed of epifauna that provide a structural habitat (e.g. xenophyophores and sea pens) for other associated species, are listed as Vulnerable Marine Ecosystems (VMEs) under the Food and Agricultural Organization (FAO). The Oslo-Paris Convention (OSPAR) lists a number of deep-sea habitats as 'threatened or declining', including: *Lophelia pertusa* reefs, coral gardens, carbonate mounds, and sea pen and burrowing megafauna communities; while cold-water coral reefs, coral gardens and sponge dominated communities all come under the definition of Annex I listed 'reef' habitat under the Habitat Directive (92/43/EEC).

To protect adequately deep-sea species and habitats and meet obligations for implementing marine protected areas (MPAs) under EC directives, habitat mapping is necessary to understand the spatial distribution of habitats. To ensure a coherent network of MPAs across Europe, standardised terms are needed. Habitat classification systems are a prerequisite to mapping and understanding the marine environment. A range of marine habitat classification schemes that are applicable to the deep sea exist, and include those that are hierarchical, nested, and are focussed on biological components, such as EUNIS (European Nature Information System), and those that are top-down schemes and are more geologically based (Greene et al. 1999). While the higher levels of EUNIS are useful for habitat mapping, it is lacking at the biotope level and currently fails to provide as much detail for deep-water habitats (>200m) as it does for shallow-water habitats.

The FP7 project CoralFISH began in 2008 with a consortium of 16 partners from 10 countries with the objective of assessing the interaction between cold water corals (CWC), fish and fisheries, in order to develop monitoring and predictive modelling tools for ecosystem based management in the deep waters of Europe and beyond.

Within the project CoralFISH, a hierarchical cold-water coral (CWC) biota classification scheme has been developed using habitat mapping data (from imagery) from across Europe to capture the range of CWC habitats. This hierarchical scheme allows data to be recorded from a broader coral class down to biotope level, independent of the resolution of the imagery footage being interpreted; and as such can be used at an appropriate level for management. Using the CWC biota classification scheme, the distribution of CWC habitats in the Bay of Biscay will be presented.

Foraminiferal assemblages in active volcanic area of Azores Islands

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The present study shows the preliminary micropaleontological results carried out on grab and box corer samples collected during a marine geological survey in the Terceira offshore (Azores Archipelago, Portugal) occurred in September 2011, in the framework of the *Eurofleet* program. This multidisciplinary project aims to reconstruct high-resolution morpho-bathymetry offshore Terceira Island and to define the evolution history of the Terceira volcanic edifice. A main WNW-ESE oriented fissural zone, characterized by the alignment of scoria cones and eruptive fractures, crosses the island extending down to the sea, along the Serreta Ridge. An intermediate-depth submarine eruption occurred in 1998-2001 producing a consistent amount of volcanic materials (lava balloons, highly vesciculated basaltic scoria, lapilli, etc.) scattered around the vent.
In this study benthic and planktic foraminiferal assemblages were studied in order to obtain an ecological characterization of sea-floor and water masses in natural stressed environments like volcanic area of the Azores Islands, after the last volcanic eruption. The samples collected in a bathymetrical interval ranging between 260 and 410 m water depth, are constituted of blackish, sand-sized glass shards, likely originating by volcanic explosive events, in which highly vesicular to scoriaceous clasts prevail on fluidal striated fragments. All samples were stained with Rose Bengal to distinguish living and dead assemblages. Diversity index (α-Fisher index), Faunal density and Foraminiferal Abnormality Index (FAI) were calculated to define the structure of the assemblage and the degree of environmental stress. The preliminary results show that in the most part of the samples, the living taxa number ranges from 18 to 43 while the α-Fisher index shows constant values around 15-16. The living benthic assemblage (Rose Bengal stained specimens) is dominated by deep infaunal species like *Angulogerina angulosa*, and *Bolivina* spp. *Angulogerina angulosa* is considered in some cases epifaunal and in other ones infaunal species. In this study, the record of living specimens of *A. angulosa* along the whole box-corer, almost until 10 cm depth, suggests a certain capability of this taxon to migrate into the bottom sediments. Probably this species is rather mobile and able to shift its microhabitat from infaunal to epifaunal, somehow reflecting stress forcing. Subordinately, epifaunal (*Lenticulina* spp., *Eherenbergina bradyi*, *Stomatorbina concentrica, Quinqueloculina seminulum*) and agglutinated (*Aplophragmoides canariensis*, *Ammoglobigerina globigeriniformis*, *Spiroplectinella wrightii*, *Textularia* spp., *Eggerelloides scabrus*) species are recorded too. Moreover, small sized specimens of *Anomalinoides* spp. and *Miliolinella subrotunda* seem to prefer a way of life attached on volcanic shards. Also some agglutinated foraminifers (mainly *Aplophragmoides canariensis*) were found clinged to glass fragments. Their test are constituted by exclusively glass grains reflecting the compositions of the bottom. Significant frequencies of specimens, showing signs of decalcification of the tests, were found too. Similar test alterations, due to hydrothermal fluids, were recorded in foraminiferal specimens coming from other volcanic bottoms (Aeolian Arc, Tyrrhenian Sea).The dominance of living and dead *A. angulosa* specimens allows to consider this species as opportunistic pioneer taxon able to colonize stressed environments. In fact, the highest values of FAI (>2), recorded in the most samples, indicate a persisting environmental stress due to the occurrence of repeated volcanic events in the past years. Moreover *A. angulosa* and *Bolivina* spp. are the species showing more abundant deformed specimens. The test abnormalities consist mainly of irregular development of chambers and aberrant tests (e.g., double apertures).
The total planktic foraminiferal association reflects a clear seasonality. In fact, the living planktic assemblage is characterized by temperate-warm taxa like *Globorotalia inflata*, *Globorotalia truncatulinoides* (left), *Globorotalia hirsuta*, *Globigerinoides* spp. while cold affinity taxa as *Globigerina bulloides* and *Turborotalita quinqueloba* are frequent mainly in the dead assemblage. Plankton seems to be not affected by the Azores Front-Current System, that is centred at 34° N, south of Azores Islands.

Benthic foraminifera from Terracina basin: preliminary data of environmental characterization

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Benthic foraminiferal assemblages coming from 27 samples, collected in the southern sector of Terracina Gulf in front of Gaeta city (Southern Latium), during an oceanographic cruise occurred in February 2002, were studied. The samples were collected by means of box corer in a depth interval ranging from -19 m to -69 m. In order to define an ecological characterization of the present day bottom sediments, only the top cores, 2 cm thick, were analyzed. The total (living and dead) assemblage was considered suitable for the environmental characterization because it demonstrates a reduced seasonal variability together with low spatial variability (Scott and Medioli, 1980). Diversity by mean of α-Fisher index was calculated.
The Terracina basin is located within the Eastern Tyrrhenian offshore of Latium and represents the seaward extension of the Piana Pontina, bounded to NE and SE by the Ausoni and Aurunci carbonate massifs. It is separated from Gaeta basin by a wide belt of structural highs located immediately offshore the Gaeta coastline. On the whole the two basins cover an offshore area of about 750 km^2 in which the shelf break is at a water depth of about -200 m. The continental slope is characterized by the occurrence of two important slope basins in the Pontine Archipelago (Palmarola and the Ventotene basins). The Terracina basin is characterized by roughly N-S oriented, half-graben structures which becomes larger seaward and laterally merges into the Gaeta basin. Quaternary sediments are displaced by normal faults, which affect also the Meso-Cenozoic tectonic units (Aiello et al., 2000).
The studied samples are mainly constituted of clayey silt and silty clay; the sandy fraction is low occurring in millimetric levels. The preliminary micropaleontological study pointed out the presence of transitional infralittoral assemblages that gradually turn into circalittoral assemblages. Among the 91 species recognized, those which have a percentage of presence greater than 3% are 27. On the whole, the most abundant species are *Ammonia beccarii, A. parkinsoniana, Bulimina elongata, B. marginata, Bolivina catanensis, Cassidulina carinata, Elphidium advenum, Haynesina depressula, Hyalinea baltica, Nonionella turgida, Rectuvigerina phlegeri* and *Valvulineria bradyana*. Three assemblages were highlighted: infralittoral assemblage, infra/circalittoral transitional assemblage and circalittoral assemblage.
The infralittoral assemblage, collected at – 19 m, is composed mostly by *A. beccarii, A. parkinsoniana, B. elongata, B. catanensis* and *E. advenum*.
The second association, found between – 29 m and – 49 m water depth, is represented by typical transitional species, from lower infalittoral to circalittoral zone, for the high frequencies of *B. elongata, B. marginata, E. advenum, H. depressula, N. turgida, R. phlegeri* and *V. bradyana*.
The third assemblage, recorded in the deeper sediment (-59 m and -69 m), is characterized by the presence of circalittoral foraminifers like *Bulimina* spp., *Bolivina* spp., *C. carinata, Globocassidulina subglobosa*, *H. balthica*, *N. turgida, P. raphanus* and *V. bradyana*.
In almost every samples, the significant frequencies of *Bulimina* spp. and *Bolivina* spp., suggest reduced oxygen environment (Barmawidjaia et al., 1992). Furthermore *N. turgida, V. bradyana*, taxa which can tolerate high organic matter content, indicate probably eutrophic bottom conditions (Van der Zwaan and Jorissen, 1991).
Moreover the low values of α-Fisher index, which don't reach the value of 9, together with the low percentage of epiphytic species confirm stressed bottom conditions. The preliminary results displayed that the low oxygen content and organic matter, well related to fine grain size sediments, control strongly the present day benthic foraminiferal distribution.

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Marine benthic cartography of two interesting marine areas in the S - E Sicily: s.i.c. ITA090027 and ITA090028

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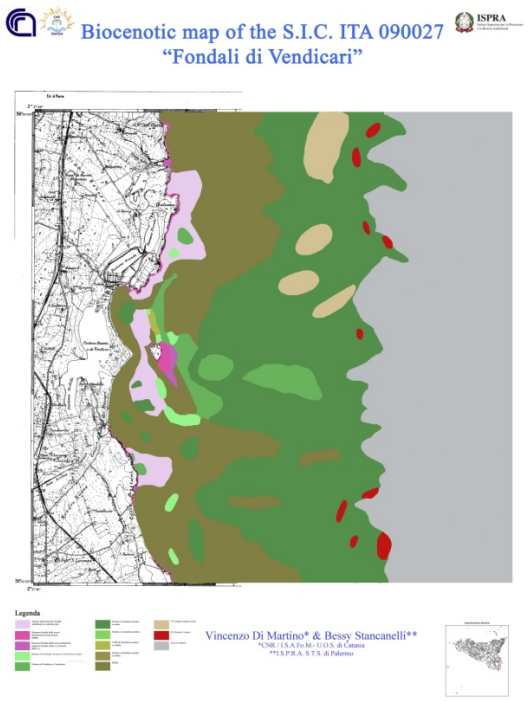
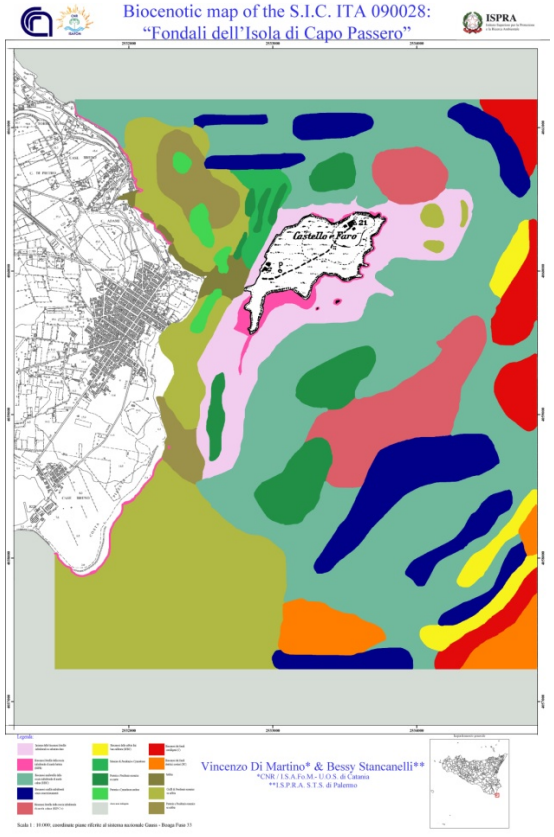
Key words: benthos communities, biocenotic map, South Eastern Sicily, Mediterranean Sea, endangered species

In the present paper a bionomic study and cartography of the benthos of the s.i.c. ITA 090027 “Fondali di Vendicari” and the s.i.c. ITA 090028 “fondali dell’isola di Capo Passero” and surrounding areas are presented.
The goals of this particular survey can be summarized as follows: 1) to chart the benthic communities (and the area of each one); 2) to evaluate the benthic diversity of the areas; 3) to produce visual documentation of the distributions of the benthic organisms; 4) to identify human-induced pressures on the benthic environment; 5) to make recommendations for future management based on the visual assessment; and 6) to set up a new methodology for making large biocenosis maps that would help to manage marine protected and non-protected areas.
The fauna and flora of the meso- and macrobenthos were studied by a triple sampling procedure: standard, visual and photographic samples were simultaneously taken along underwater transects. These, together with the floristic and faunistic study of each algal and invertebrate group, served as the basis for the bionomic survey of the Vendicari and Capo Passero Island sea bottoms. In a first approach, the supra- and mediolittoral communities were studied. Further work focused on the infralittoral stages and their communities along representative transects. The survey was conducted from surface (+0,50 m) to 40 metres of depth that is the limit of the study site.
During this study was found, also, 41 benthic species and many biocoenoses of high naturalistic value protect of many international law agreements.
The study led to a comprehensive review of the main biotope systems of this coastal area, as well as their environmental condition, and this will be an essential element for their future management.





The MAREMAP* Acoustic Data Interpretation Workshop: Results and Implications

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Worldwide, the oceans and marginal seas are under increasing pressure from human activities and there is an increasing need for accurate seabed and habitat maps to underpin environmental and socio-economic impact assessments, and to assist in the development of effective management measures that will contribute to our responsible stewardship of the marine environment and the sustainable use of its resources. Rather than motivated by exploration science, specific policy requirements now drive the development and application of habitat mapping. In Europe, national legislation (e.g. the Marine and Coastal Access Act in the UK) and several European Directives (e.g. the Marine Strategy Framework Directive) require an improved understanding and characterisation of seabed habitats, and thus improved methods to support the mapping and monitoring of seabed habitats.

The advent of swath acoustic techniques has revolutionised seabed mapping science, as we are now able to map the seabed at high spatial resolution and accuracy. Despite this, we are still some way from producing effective mapping techniques that accurately characterise seabed habitats, which are complex and highly variable. This is due to at least two reasons: Firstly, very few nations have thus far implemented large-scale seabed mapping programmes (e.g. 'Integrated Mapping for the Sustainable Development of Ireland's Marine Resource' and 'Marine Area Database for Norwegian waters') due to the high costs involved. Secondly, the development of robust, validated, repeatable, and objective methods of swath acoustic data interpretation is lagging behind the ability to acquire high-quality swath acoustic data.

It is against this background that we coordinated a "MAREMAP Acoustic Data Interpretation Workshop" in Edinburgh on 23rd and 24th October 2012. The workshop was centred on a common data set exercise: Multibeam echosounder and physical seabed sampling data were made available prior to the workshop. Participants were asked to interpret the data sets in terms of seabed sediments, by applying their preferred methodology. The methods presented included manual interpretation, object-based image analysis, geostatistics and machine learning. The similarity of the produced maps was compared against each other, and the results were discussed and compared during the workshop. The accuracy of the maps was assessed against a validation data set of sampling data. Clear advantages and disadvantages associated with the respective methods emerged. This presentation summarises the main outcomes of the common data set exercise.

* Marine Environmental Mapping Programme; www.maremap.ac.uk

The new wave of bathymetry data – uses and limitations for marine benthic habitat mapping and geomorphology.

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Bathymetry data used for benthic habitat mapping and marine geomorphology come from a variety of sources, offering information on seabed terrain at a variety of data resolutions. Multibeam surveys have largely become the preferred means for acquiring bathymetry data, where funds permit. However, as mapping continues, people are increasingly making use of compiled datasets either by combining several neighbouring multibeam surveys or by including other sources of bathymetry data. The compilation process may be local, national or even regional (e.g. EMODNET Hydrography Portal) and global (e.g. GEBCO) and typically the broader the area the more diverse sources of bathymetry have gone into creating the compiled bathymetry product.

These compiled datasets are a fantastic resource, providing ready-gridded bathymetry data, either at a single, or multiple resolutions. This meets a demand for bathymetry information which can be used for many applications, including benthic habitat mapping. However, compiled data resources, by their very nature, mean that the data user is increasingly distant from the original data source. Even if quality data are supplied with the data, the user no longer has the same contact with the data acquisition and processing pipeline as they did with discrete area surveys. This can make it all too easy to ignore issues of data quality and/or uncertainty which are inherent to the use of gridded bathymetry data.

Focussing on application of such data to geomorphology and benthic habitat mapping we examine those issues that remain particularly important to consider when using bathymetry data from several sources, and compiled datasets. Using slope as an example we focus on the implications of data resolution, quality and data analysis scale in deriving terrain variables which are quantitative measures of geomorphic properties relevant to habitat mapping. We also present a practical method for computation of a confidence index for ready-gridded bathymetry data which is based on a Monte-Carlo simulation.

General Bathymetric Chart of the Oceans (GEBCO) (http://www.gebco.net/)

European Marine Observation and Data Network (EMODnet) Hydrography Portal (http://www.emodnet-hydrography.eu/)

QUATERNARY EVOLUTION AND GEODIVERSITY AT THE EASTERN BRAZIL SHELF

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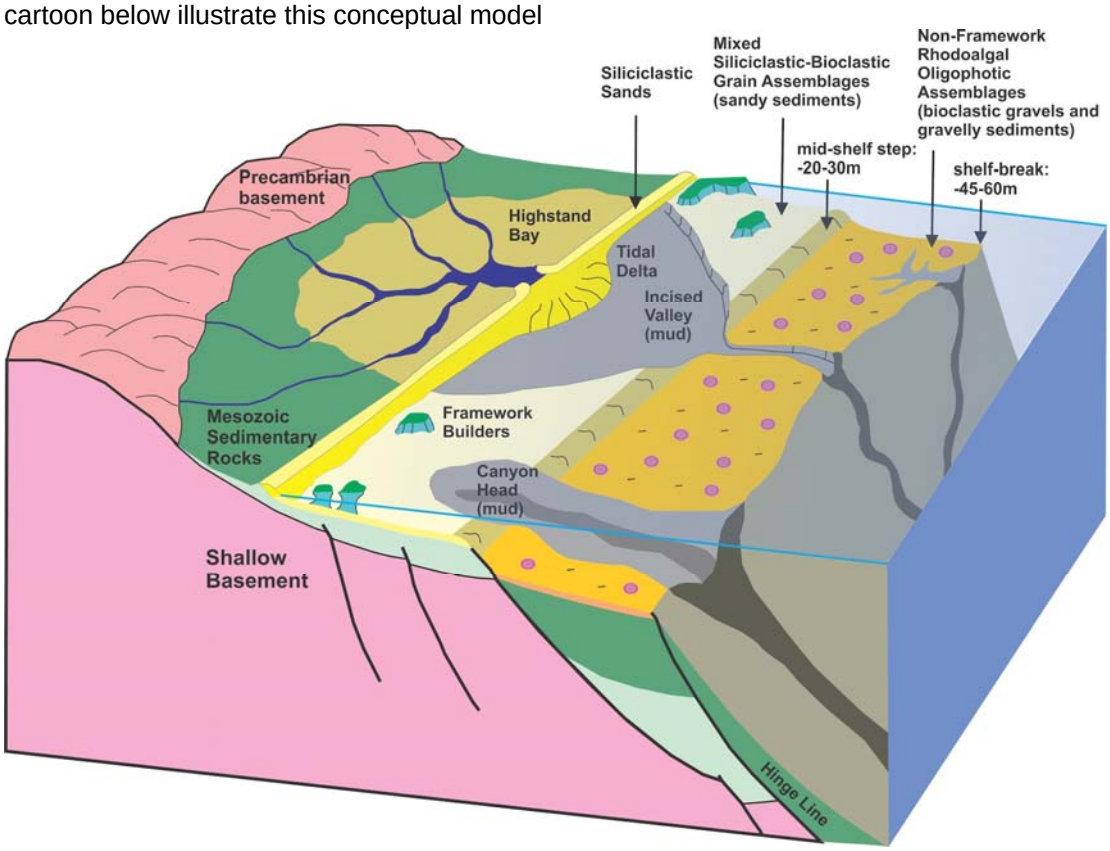
The continental shelf off eastern Brazil, extending from 10 to 16^{o}S, is unusually narrow (~ 20km) and shallow. Shelf break is located at the 45-50 m isobaths. During the Quaternary, mean position of sea level was around -65m implying that during most of the time the shelf was entirely exposed to subaerial conditions. Submarine geomorphology is thus strongly controlled by this extended sub-aerial exposure and reduced subsidence. Prolonged sub-aerial exposure has resulted in widespread incision and embedding of smaller drainage basins on the shelf. Flooding of the shelf began around 10,000 yrs ago and was completed 3,000 years later. Therefore almost instantaneously, oligophotic conditions were created in the outer shelf, where non-framework carbonate sedimentation began. Along the coastal zone, as soon as eustatic sea-level stabilized, smaller estuaries and bays were rapidly infilled and siliciclastic sands accumulated along the shoreline reaching a major expression in the vicinities of tidal deltas and larger river mouths. Carbonate framework builders began developing on the shallow euphotic areas (<20m) fringing the coastline, using the hard substrates available (abrasion terraces carved into the Mesozoic sedimentary rocks). The low lying areas on the shelf surface, such as ancient incised valleys and canyon heads trapped the fine-grained sediments dispersed shelf-wise as a result of their decelerating effect on the shelf flows. This conceptual model of the major controls on shelf geodiversity is presently been used to access the biodiversity in this region. As an example artisanal fisheries, targeting high-value commercial species associated with hard bottoms, is controlled by the distribution of hard bottoms on the outer shelf and shelf break and incised valley walls. The cartoon below illustrate this conceptual model



Tracking coastal anthropogenic modification using live-dead mollusk assemblages (Israeli Mediterranean)

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Shelled mollusks (bivalves, gastropods) are sensitive indicators of seafloor health conditions. Mismatches between the local living mollusk community and the dead molluscan assemblage have been shown to be associated with recent, rapid, anthropogenic changes. This study is aimed at testing for match or mismatch in the coastal community structure of modern (sediment-top) death assemblages vs. live-collected mollusk assemblages, from clean control (PL29) and polluted sites (PL3), near the Shafdan sewage sludge outfall offshore of Palmahim, Israel.

Seasonal variability in both the polluted and clean stations was captured by box-core sampling in January (winter), May (spring), July (summer) and November (fall) of 2012. Dead and live mollusks were taken from the upper 1.5 cm of the sediments using a 2 mm sieve. A vessel-operated dredge was dragged over a distance of 30 m to acquire a larger volume of sediment containing live mollusks. Community structure variables (species richness, evenness, feeding style and live habit), environmental parameters and BENTIX index are under analysis to define the differences between the live and dead assemblages, within and between sampling stations.

To date, winter (January, 2012) and fall (November, 2012) live and dead assemblages from PL3 and PL29 have been analyzed. *Corbula gibba* is the dominant bivalve in all assemblages. Death assemblages of both stations show high agreement in taxonomic composition and relative abundance. However, live-dead comparisons within each station, and live-live comparisons between stations showed a significant difference in species relative abundances. *Nucula nitidosa* and *Nuculana pella* are more abundant in the polluted station PL3 than in the clean station PL29 only during winter sampling. These species are deposit-feeding bivalves known to thrive in organic-rich sediments.

The ultimate database will include also benthic foraminifera and ostracodes from the same samples. Differing sensitivity of these three calcareous-shelled groups to anthropogenic impact can be used to evaluate environmental change in comparable areas around the Mediterranean.

Using alternative bathymetry data to complement multibeam echo-sounder data in sediment and biotope mapping

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The Norwegian seabed mapping programme MAREANO (www.mareano.no) has been in operation since 2005 and generates a wide range of products, including sediment and benthic biotope maps. So far production of these maps has relied heavily on full-coverage multibeam data (bathymetry and backscatter), which have revealed the seabed in unprecedented detail, and which have formed the basis for geological interpretations and the identification of seabed terrain of ecological relevance. The acquisition of multibeam data however represents a significant proportion of the total annual MAREANO budget, and efforts to reduce this cost, including use of alternative bathymetry data, will help to maximize the cost-effectiveness of the programme in the future.

One potential alternative source of bathymetry data is accumulated single-beam bathymetry compiled by the Norwegian navigation system manufacturer Olex AS (www.olex.no). In order to evaluate this dataset for sediment and biotope mapping, we performed a study simulating a situation of sediment interpretation and biotope modelling having to be done without access to full-coverage multibeam data. The study area comprised 15 000 km^2 on the continental shelf offshore North Norway, where Olex data coverage is very good. Within this area, we artificially limited multibeam coverage to four 10 km wide cross-shelf transects, and combined the multibeam data with Olex bathymetry data gridded to a resolution of 50 m. The combined Olex/multibeam dataset was used as a basis for interpreting sediment distribution and modelling the distribution of benthic biotopes, following standard MAREANO procedures. This approach allowed direct comparison of the simulated results with published MAREANO maps from the same area (based on full-coverage multibeam data).

Despite the quality and resolution of Olex bathymetry being considerably lower than those of the multibeam bathymetry, our study showed that sediment and biotope maps of acceptable standard can be produced at a regional scale (1:250 000 or coarser) using alternative bathymetry data sources combined with limited coverage multibeam data. Both simulated and published maps displayed the same general trends in sediment and biotope distribution, and testing of modelled biotope distributions based on the two datasets showed little difference in model performance. These positive results have since been followed up by the actual use of Olex and other alternative bathymetry data in MAREANO cruise planning, with multibeam surveying restricted to prioritised areas (e.g. where coral reefs are known to occur). Video and sample data from the cruises are presently being used in the production of sediment maps covering areas both with and without multibeam bathymetry, and future biotope modelling will be based on these maps and on the bathymetry datasets combining multibeam and other data.

Despite the encouraging results of our simulated study, there remain numerous limitations to be considered when using Olex or other alternative bathymetry for MAREANO purposes. Among the most important are (1) that the quality of alternative data may not allow for detection of smaller topographic features, e.g. coral reefs and pockmarks, and (2) that the lack of full-coverage backscatter data in cruise planning may result in sampling stations not being optimally placed, thus adversely affecting the biotope maps that rely on this information. Recent experience however shows that valuable knowledge of sediments and topographic features can be gained through acquiring additional multibeam data between stations during sampling cruises. This opportunistic data acquisition has proven a great help when interpreting surficial geology in areas of low-resolution bathymetry.

Mapping of macroalgae species and communities distribution in South-Eastern Baltic Sea (Russian EEZ) for conservation purposes

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The development of different offshore facilities (ports, harbor infrastructure, oil platforms and pipelines, extracting of mineral resources) belong to important direction of economic strategy for Kaliningrad region of Russia. Existing and implemented mapping programmes include a comprehensive geological surveys, but didn't take into account biological aspects of underwater habitats. Distribution of habitats with dominance of floral communities were completely unknown at Russian EEZ in South-Eastern Baltic Sea.

Area of domination of perennial macroalgae species such as red *Furcellaria lumbricalis* and *Coccotylus truncatus,* brown *Fucus vesiculosus,* are ecologically valuable as areas of high macroinvertebrate diversity, forage and spawning habitat for commercial fish species.

In given study first results of delineation and mapping of sensitive habitats with dense underwater vegetation along the northern coast of Sambian Peninsula are presented. Data collected in 2008-2012 by SCUBA diving and underwater video. Sampling points was marked by JPS. Maps for every sampled species and areas of distribution of annual and perennial macroalgae and interpolation of data were made by ArcGIS tools. Sampling sites were chosen on base of substrates distribution, areas with unsuitable substrates and below 15 m (out of euphotic zone) were excluded from consideration and biomass and occurrence of species were taken as zero.

Area with algal communities are distributed very locally and were found near the Taran Cape, Gvardeisky Cap and Sokolniki. Several algal association were defined: Cladophora glomerata+Ulva prolifera or Ulva intestinalis+U. prolifera (0- 1m); Cladophora glomerata – Ceramium tenuicorne (1-3m); Furcellaria lumbricalis – Polysiphonia nigrescens (2-9 m) and Coccotylus truncates (8-12 m). Below 12 m depth macroalgae was not found.

The most valuable habitat with the highest biomass and dense coverage of perennial macroalgae is located around the Cap Taran and associated with bedrocks and tillstones, pebble and gravel beds up to depth of 12 m. These habitat, unique for the Russian EEZ, is rather vulnerable because on sharp slope, wave exposure and low water transparency, redoubled by coastal sewages. Some conservation measures, including creation of marine protected area, are necessary.

A B C D

Figure 1. A - Community of Furcellaria lumbricales (6 m); B – F.lumbricalis and Cocctylus truncates (11 m); C, D – fish caviar at F.lumbricalis and C.truncatus

Habitat mappings application in assessing benthic impacts from fishing in New Zealand

Rich Ford, Jenny Black

Ministry for Primary Industries, New Zealand

Assessing the impact of fisheries is a legislated component of New Zealand's fisheries management. Fishing gear that contacts the seafloor is known to impact upon seafloor biota, particularly for structural biota (e.g. sponges, corals). Impacts will however differ depending on many factors including fishing gear contact frequency and habitat type. Assessing the impacts of fishing over the scale of New Zealand's Exclusive Economic Zone (>4 million km^2) requires a complex approach that includes habitat mapping components. Firstly we need to divide the seafloor into biologically realistic units. In the absence of detailed habitat mapping the Benthic-Optimised Marine Environment Classification (BOMEC) was used to predict 15 benthic classes based upon both environmental (e.g. temperature, depth) and benthic invertebrate population distribution information. Trawl footprints were then generated for deepwater trawl fisheries from 1989/90 to 2010/11. The overlap of this trawl footprint with the BOMEC benthic classes was calculated. Analyses have shown levels of overlap between trawling over the entire 20 years and the 15 BOMEC classes to vary between ~0 and 73%. Acceptable levels of benthic impact upon these BOMEC classes are a societal/political decision, but should be informed by science about the intensity of trawling and the vulnerability, connectivity and recoverability of the benthos. This presentation will outline relevant findings, ongoing research and areas for improvement in this research, including how improvements to habitat mapping can advance our understanding of benthic impacts.

An integrated approach to map the rocky outcrop habitats (tegnùe) offshore Chioggia, Northern Adriatic Sea.

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Peculiar hard substrata punctuate the northwestern Adriatic shelf at depths of 15 to 40 m as patchy rocky reefs that serve as habitat to a variety of organisms. These 'reefs' occur as discrete clusters from offshore Grado south to the Po river delta with best developed fields just located off Chioggia where they are locally known as "tegnùe". Compositionally, they are basically carbonate-cemented sands with a strong biogenic overprint that contributes to the final construction of the 'reef'. Beside this basic motif, the 'tegnue' display a significant typological variability. The origin of these rocky outcrops is not fully understood yet and many genetic interpretations have been proposed thus far, contemplating among other cementation due to beach-rock like processes (e.g., Stefanon, 1969) or the action of ascending fluids enriched in hydrocarbons (e.g., Gabbianelli *et al*., 1997, Casellato and Stefanon, 2008). An on-going multidisciplinary approach, combining biological, geological and geochemical data, supported by a detailed bathymetric mapping and robust geophysical evidence, will hopefully shed light on the genetic processes backing the distribution, early genesis and evolution of such relevant habitats. For instance, multibeam swath bathymetric data (MB) document that the rocky outcrops off Chioggia at ca. 20 m chosen for this project are organized in a dendritic pattern. Very High Resolution Seismic (VHRS) show that cemented layers are part of the Holocene deposits. As a working hypothesis, we suggest that tegnue may originate by concretioning processes at the expenses of sandy/gravelly sediment related to former marsh environments, eventually submerged by the sea level rise between 6,000 and 2,000 years ago (Giovanardi *et al*., 2003). Whatever their final genesis, once exposed such rocky substrata are then quickly colonized by living organisms, which contribute to the growth and expansion of the reef. Calcareous algae play a prominent role in the reef consolidation and growth, especially through the action of Peyssonneliaceae and Corallinaceae (Bressan and Babbini, 2003). Benthic invertebrates like bryozoans, mollusks, serpulids and corals (*Cladocora caespitosa*) also contribute to the final building of the tegnue. Based upon layer thickness calibrated by some dating, it has been estimated an annual growth rate in the range of 0,25-0,75 mm/year (Gabbianelli *et al*., 1997). A variety of organisms exploit the reef ecospace thus formed, mainly cnidarians (*Cereus pedunculatus*, *Cerianthus membranaceus*), sponges (*Dictyonella incisa*, *Geodia cydonium*), polychaetes (Errantia like nereids or eunicids, and Sedentaria as *Sabella spallanzanii*), bivalves (pectnids and *Hiatella*), bryozoans, and tunicates (*Polycitor adriaticus*, *Aplidium conicum*, *Aplidium tabarquensis*). A diverse and quantitatively abundant fish fauna takes advantage for food and shelter of these environments. This includes demersal species like annular seabream, conger eel, small serranids, croakers and drums, sparids, wrasses, blennids and scorpionfishes. The unique habitat provided by the tegnùe is attractive also to pelagic (anchovy) or nektonic (saddled seabream, bogue, hake) species (Cenci and Mazzoldi, 2006), some of which relevant to fishery management.

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Supervised and unsupervised classification of sediment types on marine shallow waters using multibeam echosounder data and *in situ* sampling

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Multibeam echosounder systems (MBES) are effective mapping tools due to their simultaneous bathymetry and backscatter strength data acquisition. Moreover, the acoustic response of the seafloor could be potentially used to infer some of the physical characteristics of the sediment and benthic habitats. Unfortunately, the methods used are not yet scientifically well tested or accepted. This investigation evaluates the ability to perform an automatic classification of sediment types by using both supervised (Maximum Likelihood) and unsupervised (Iso data) digital image classification algorithms, with MBES data and *in situ* sediment samples.

As demonstration case-study, an area located within the Basque coast (SE Bay of Biscay), was used. It covers 0.32 km^2, ranging from 40 m up to 85 m water depth, and was selected because previous studies highlighted the morphological diversity of the seafloor. The morphological aspects were derived from a digital elevation model produced from SeaBat 7125 MBES data, while the backscatter strength was recorded with an EM3002D MBES. The aspects considered for the automatic classification were depth, rugosity, slope, backscatter mean level and variance. A total of 63 grab samples were collected for sediment analysis. Additional macroinvertebrates and demersal fish information was derived from 9 grab samples and 3 beam-trawls, respectively. Video images of the seafloor were recorded on 14 locations.

Based on the grab samples, 4 sediment types were identified according to their grain size: very fine sand, fine sand, medium sand, and coarse and very coarse sand. The grab samples were randomly divided into two datasets: 50 samples were used as reference for the classification process (*i.e.* 80%), while 13 were used for validation of the classification (*i.e.* 20%). First result of the unsupervised classification showed a very low precision (15.4%) and reliability (Kappa = 0.16). The resulting classified sediment map was biased by the bathymetry and it was not in accordance with the sediment distribution and morphological aspects of the seafloor. After the removal of depth distribution from the classification process, the subsequent results showed that supervised classification obtained higher precision than the unsupervised classification (76.9% and 39.7%, respectively) and higher reliability (0.7 and 0.2, respectively).

According to these results, the unsupervised classification was only useful as a first estimate of the spatial distribution of seafloor types and should only be used in studies where *in situ* samples are not available. In contrast, supervised classification demonstrated its ability to discriminate more sediment type facies than the unsupervised classification and was especially effective in areas where the seabed displayed heterogeneous features and multiple sediment types. The resulting classified map corresponded well with the benthic assemblages obtained by clustering of the macrobenthos data. In contrast, there was no statistically significant correlation between fish assemblages and sediment characteristics. The results of this investigation confirm the potential of MBES and automatic classification algorithms for the production of classified maps of sedimentary characteristics and habitat distribution, with a sufficient reliability for management applications.

Side-scan Sonar and Surface Sediment Investigation of a Mixed Carbonate-Siliciclastic Shelf: Açu Incised Valley area, NE Brazil

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A side-scan sonar survey revealed noteworthy features of the northeastern Brazilian continental shelf. The high-resolution data cover an area of 500 km^2 over the ancient Açu River, in a very shallow (60 m) and narrow (43 km) shelf, which comprises the submerged portion of the Potiguar Basin (fig. 1). The sea-floor imagery was integrated with 571 sea-floor sediment samples and provided details of the sedimentary boundaries of the mixed shelf sediment distribution (siliciclastic-carbonate). The sediment grains size increases from muddy siliciclastic sediments on nearshore to biogenic gravel on outer shelf. The shelf sediments and morphologies are distinctively associated. Carbonate-rich sediment is predominant, except on the eastern margin of the Açu Incised Valley (AIV), nearshore and estuarine mouths. The incised valley-fill, predominantly muddy sediments, represents the latest deposition during transgression and now these deposits are reworked. Bedform configurations indicate bottom-flows associated with tidal currents. An especial attention is given to the outer shelf, where a large field of newfound patch reefs occurs in between 20 and 40 m depth. SCUBA dive inspections revealed the existence of coralline algae colonies over the fossil reefs. These reefs are probably linked to the limestones of the Guamaré Formation, one of the Potiguar Basin units, and are carbonate sediment source to the adjacent shelf. The shelf sedimentary evolution is strongly associated with the interplay of shelf hydrodynamics and morphodynamics, which control sediment dispersal and deposition, and sea-level fluctuation during the last transgression.

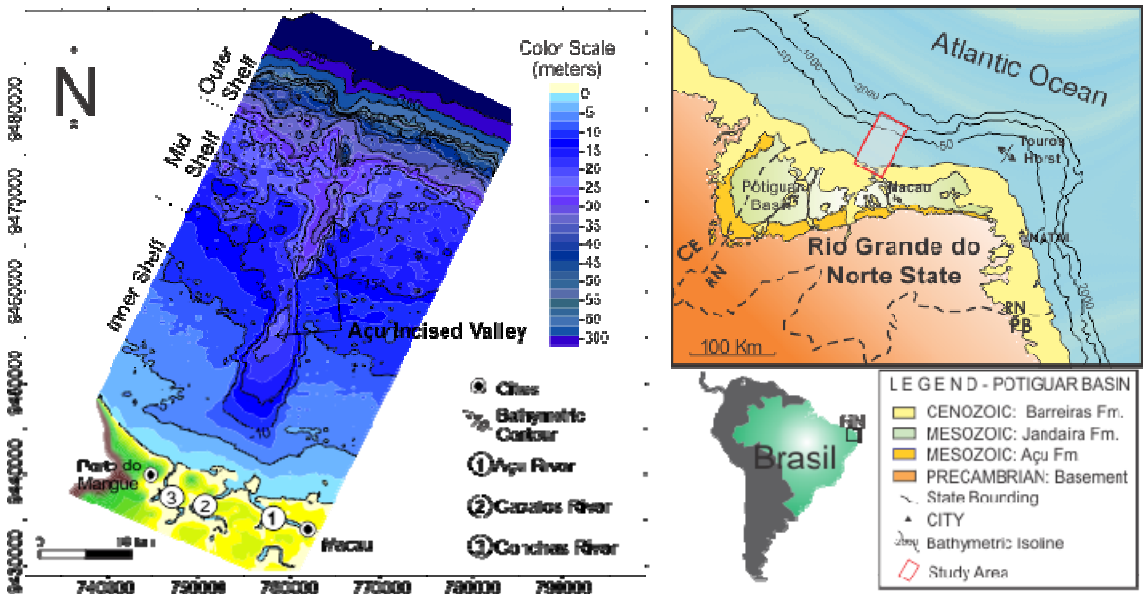

Figure 1 - Bathymetric map of the study area evidencing the Açu Incised Valley in the north-eastern Brazilian Continental Shelf. Main coastal rivers, shelf divisions and the Potiguar Basin are indicated.

Key-words: continental shelf, hydroacoustic, bedforms, patch reefs.

Marine Environmental Mapping Programme – The UK approach to delivery of common geoscientific objectives in marine mapping

MAREMAP Partners

The Marine Environmental Mapping Programme (MAREMAP) was launched in 2010 with the aim of development and integration of common geoscientific objectives in marine mapping. The initiative is led by the British Geological Survey (BGS), National Oceanography Centre Southampton (NOCS) and the Scottish Association for Marine Science (SAMS) with Associate Partners from the Centre for Fisheries and Aquaculture Science (Cefas), The Channel Coastal Observatory (CCO), The Maritime and Coastguard Agency (MCA), Marine Scotland Science, The University of Plymouth and the University of Southampton.

The scope of work covered by the Programme is diverse and focuses on seven themes; coastal and shelf geological and habitat models, deep water geological and habitat models, submarine hazards, sediment mobility and 4D monitoring/modelling, technology and techniques, heritage and archaeology and data and products. MAREMAP also provides a platform for improvement in collaborative working, transfer of knowledge and experience between organisations, and steps towards development of common methodologies.

This poster presents a range of MAREMAP case studies from the first years of the Programme.

http://www.maremap.ac.uk/index.html

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Developing tools and methodologies to promote ecosystem based management of deep-sea resources - some key outputs from the EU FP7 'CoralFISH' project

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CoralFISH, by studying the interaction between cold-water coral habitat, fish and fisheries, is developing methodologies and tools to support the implementation of an ecosystem-based management approach in the deep-sea. One of the key outputs will be the development of standardised mapping approaches to support classification and quantification of benthic habitats, particularly cold-water corals.

CoralFISH partners have generated new maps of coral habitat settings in six different eco-regions in the oceans and seas of Europe, stretching from Norway to the Azores through to the Ionian Sea. To quantify the extent of coral habitat in each region and to facilitate regional comparisons, an area of approximately 10 km2 has been chosen as representative of the densest coral cover in each region. Semi-automated geomorphological classification has been applied to each area and ground-truthed using geo-referenced video survey. First-order approximations of both 2d and 3d coral cover are presented for each region and used as a basis to assess quantitative regional variations in the importance of corals as a habitat constructor.

Spatially corrected gas flux estimates using seafloor backscatter: Example from a seep area in the Black Sea

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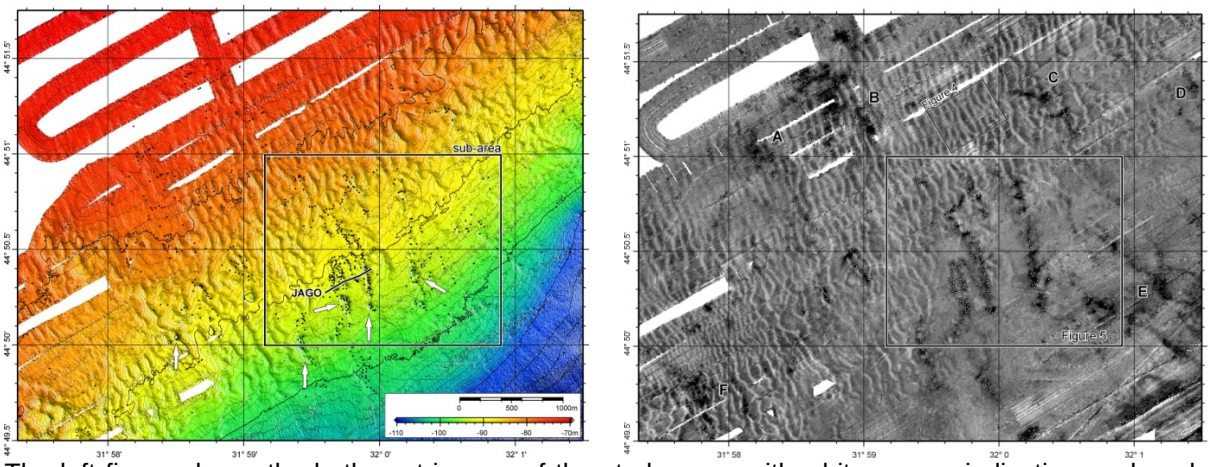
At marine seep sites, free gas (bubbles) as well as dissolved geochemical species are released, which this is a globally occurring phenomenon. General processes are reasonably well understood but still only little is known about the spatial and temporal variability of the methane release and its possible impact on atmospheric methane concentrations when occurring in shallow water (<100m). Initial bubble sizes and the initiation of bubble plumes are as critical for final fluxes into the atmosphere as the extrapolation over larger areas. Visual observations, direct sampling and hydroacoustic methods (passive and active) can be used for determining fluxes from single spot or local measurements; extrapolating to larger areas is more challenging when also considering the transient behaviour of gas fluxes.
In a seep area on the shelf west of Crimea Peninsula in the Black Sea, we used multibeam backscatter response to extrapolate the total number of seeps in a 22km^2 area between 70 and 115m water depth. Here, a clear linear correlation exists between the number of seep vents per m^2 and the backscatter intensity. Despite pockmarks and larger sediment waves at the seafloor the enhanced backscattering around the seep areas is caused by carbonate precipitation in the sediment due to methane oxidation and not by morphological influences, seafloor roughness or grain size changes.



The left figure shows the bathymetric map of the study area, with white arrows indicating pockmarks and small black dots indicating gas release sites (vents). The right figure shows the backscattering of the multibeam with irregularly shaped discreet high backscatter patches (black) that match very nicely with the occurrence of bubble release (tiny white dots).

Using submersible dives for bubble size spectrum observations and direct flux measurements, we were able to determine the free gas flux from the seafloor into the water column by extrapolating gas fluxes using our backscatter/vent correlation. We further applied a bubble dissolution model using the measured bubble size spectrum and accounting for temperature and salinity changes in the water column to calculate methane fluxes directly into the atmosphere as well as into the mixed layer in the top 15m of the water column. The flux of dissolved gas into this mixed layer that resulted is very similar to independently measured sea-air methane fluxes of the same area. This confirms that in this particular case and study area we were able to quantitatively track free gas fluxes from the seafloor into the atmosphere based on backscatter analyses, a good example of how geophysical mapping techniques can improve geochemical flux extrapolations.

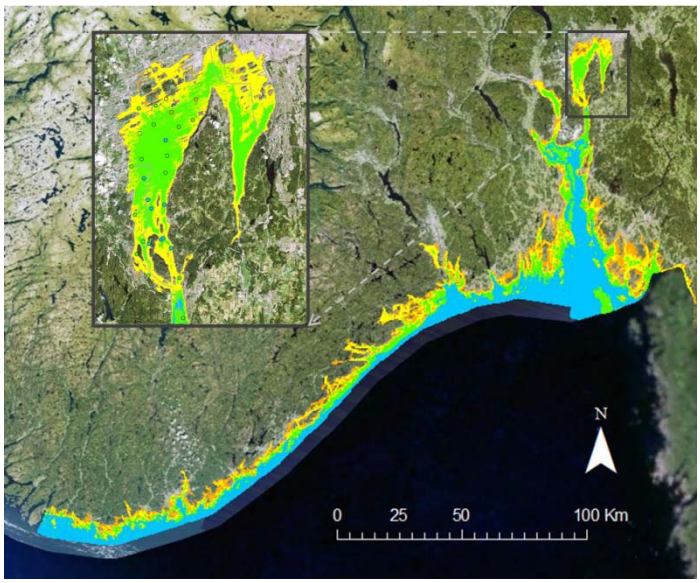
Spatial predictive modeling of reference conditions for soft sediment benthic macroinvertebrate indices in Norwegian coastal waters

Gundersen, H., Bekkby, T., Norling, K., Rygg, B. and Walday, M.

Soft sediments cover most of the ocean seabed and often contain benthic communities with high biological diversity. Macrofauna composition and diversity in soft sediments are commonly used as ‘‘health indicators’’ in various pollution monitoring programmes worldwide, and this fauna component has also been selected as one of the main quality elements in the EU Water Directive.
Knowledge of national, regional and local scale natural state is needed primarily since sampling and modelling clearly show that several areas deviate from the set reference conditions. In addition, Norway and the majority of EU member states use a single value of reference conditions for all regions and water types within a country. We believe that there is a need for differentiation of this value.

The presentation shows how we have integrated GIS models on geophysical variables (such as depth, slope, wave exposure, terrain structures) and different infauna indices developed based on data collected for more than 30 years. The model selection technique Akaike Information Criterion (AIC) was used to select the best statistical model, which further was used to develop a spatial predictive model of reference conditions for soft sediment benthic macroinvertebrate indices in Norwegian coastal waters.

The method and results from this study is considered as a great improvement compared to earlier classifications where the same reference value was used for all regions, counties and municipalities in Norway.



Predicted reference condition map of the Skagerrak coastal waters produced by the selected model for Indicator Species Index (*ISI)*. Color codes are in accordance with colors used for the five classes of ecological status (blue=high, green=good, yellow=moderate, orange=poor, red=bad).

Macrofauna and sediment changes in a construction area

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In an interdisciplinary approach, benthic habitat dynamics were studied by analysing patterns of macrofauna communities (benthic organisms retained in a 1 mm mesh) integrated with sediment and acoustic (multibeam and side-scan sonar) data.

The study site was located in the vicinity of the JadeWeserPort, the deepwater harbour in the Inner Jade channel in the Southern North Sea, Germany. The construction works involved changes in the composition and spatial distribution of sediments and macrofauna communities due to dredging and dumping activities, enhanced by modified hydrodynamic conditions. Since the land reclamation, sand extraction and redirection of the fairway took place in the western part of the channel, a comparison between directly and indirectly disturbed areas was feasible.

During a survey in May 2010 different levels of physical disturbance caused by the ongoing dredging works were documented using hydroacoustic measurements. Sediment and macrofauna samples were analysed for ground truthing. The outcomes were compared with sedimentological and macrofauna data, which had been collected in 2002, before the port construction.

The results indicated complex sediment and macrofauna changes in the study site. With the exception of the old fairway, a mainly coarsening trend was observed in the sediments of the study site. An increase of opportunistic and stress tolerant species was determined, predominantly without strict sediment preferences. In 2010 more macrofauna communities were distinguishable than in 2002. Thus, the heterogeneity of habitats in the study site increased.

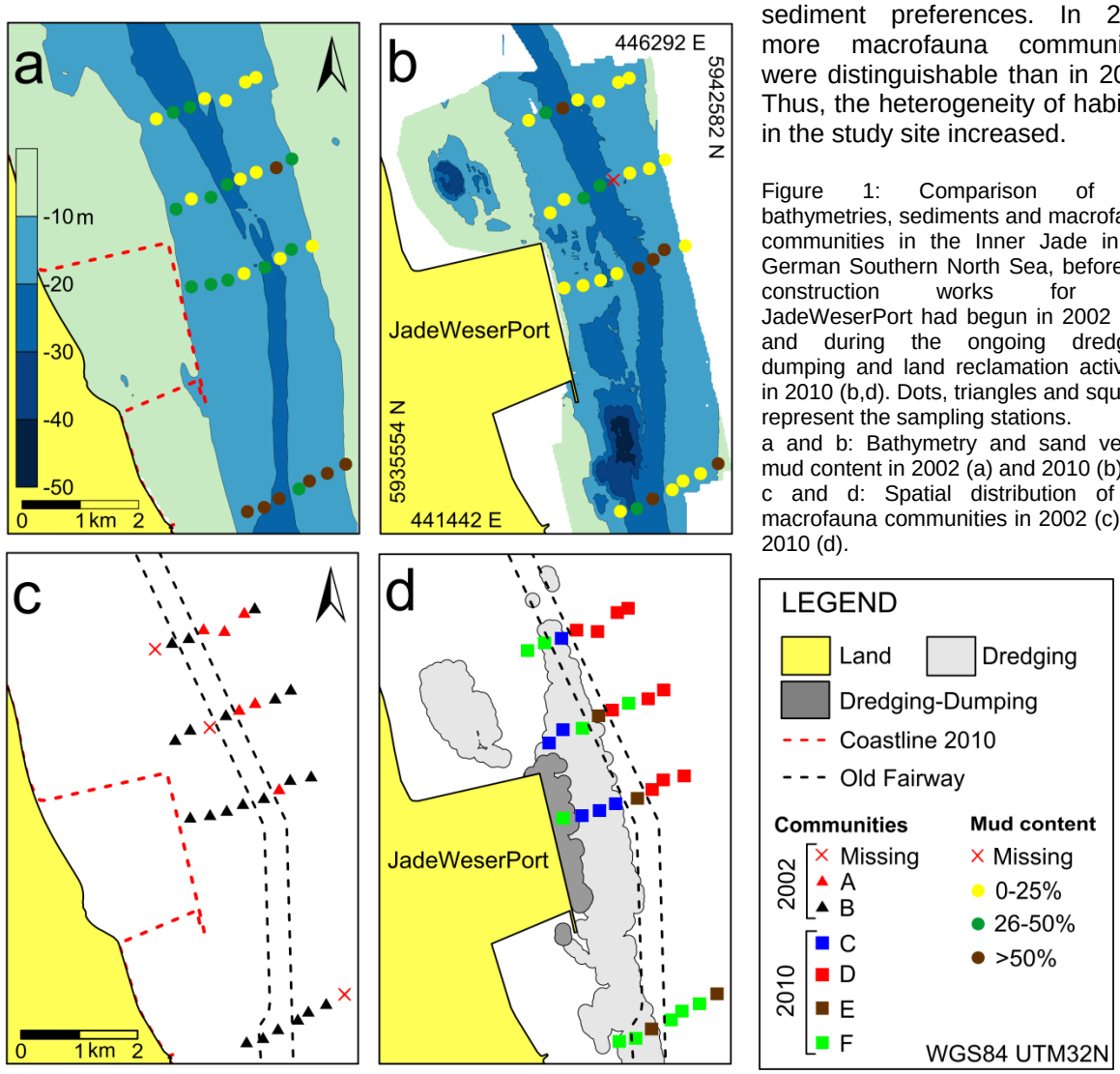

Figure 1: Comparison of the bathymetries, sediments and macrofauna communities in the Inner Jade in the German Southern North Sea, before the construction works for the JadeWeserPort had begun in 2002 (a,c) and during the ongoing dredging, dumping and land reclamation activities in 2010 (b,d). Dots, triangles and squares represent the sampling stations.
a and b: Bathymetry and sand versus mud content in 2002 (a) and 2010 (b).
c and d: Spatial distribution of the macrofauna communities in 2002 (c) and 2010 (d).

Evaluation of Satellite Derived Bathymetry Surveys conducted worldwide

Heege T., Hartmann K., Critchley D.

EOMAP, Germany

Satellite based mapping of bathymetry is capable to map large or remote coastal areas worldwide. Few different approaches are applied for satellite sensors, using stereoscopic image pairs, radar and SAR imagery interpreting the impact of water depth on surface waves or water level, and multispectral images analyzing the spectral response of reflected light on water depth. The latter is nowadays most effective for optical shallow waters up to depth of about 30m.

This multispectral technology requires sophisticated algorithms that take into account sensor properties, multiple environmental impacts from atmosphere, sea surface, in-water and seafloor properties. The approach presented here is therefore based on a physics based retrieval algorithm, that account for these impacts and is applicable for multi- and hyperspectral satellite and airborne sensors. Especially the satellite based bathymetry results in significant cost and time savings with a very fast delivery time. Still, for example turbidity and organic absorbers and their variations in the water column have a dominant impact on the depth limit and product quality, as well as the recording geometry or the choice how to parameterize the spectral sea floor properties.

To evaluate the feasibility of an area of interest or of specific satellite imagery, several aspects must therefore be evaluated, such as the natural turbidity in the target area, expected sunglitter, spectral, radiometric and geometric properties of applicable satellite sensors.

Various EOMAP Bathymetry surveys in the Mediterranean Sea, the Atlantik, Caribbean Sea, the Indian Ocean, and the Middle East are presented, validated and discussed in the context of the users requirements for hydrographical, routing and offshore applications.

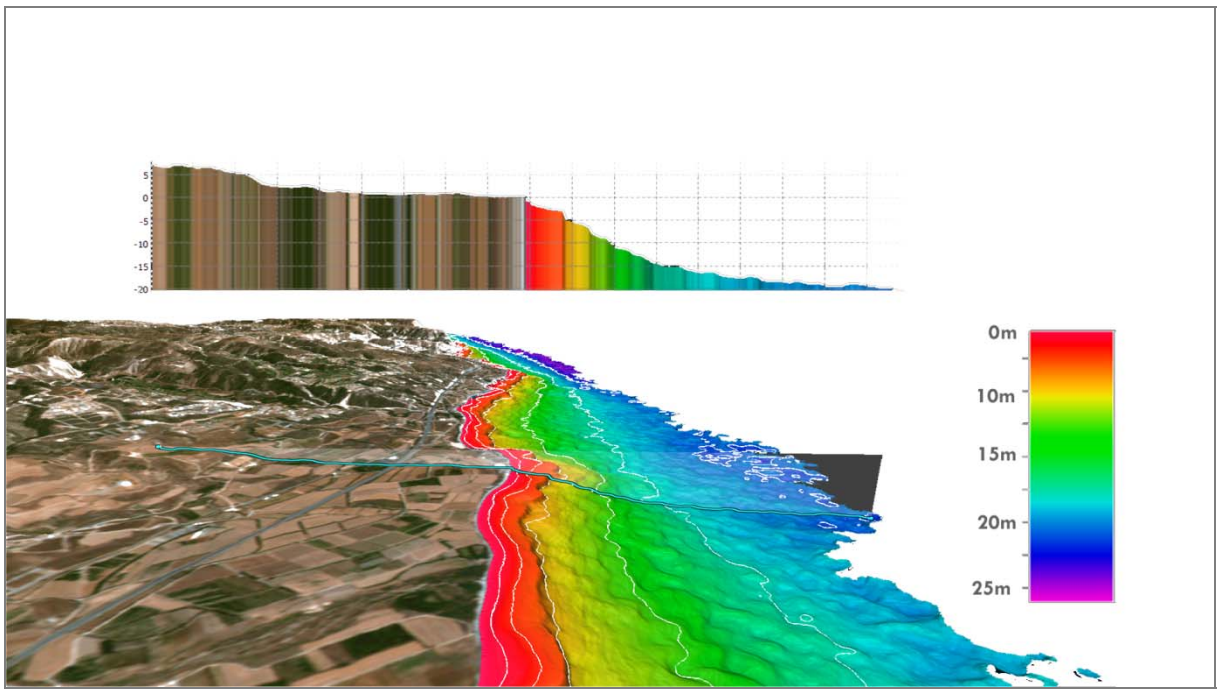

Figure: Satellite derived bathymetry of the South Cyprus derived out of RapidEye.

Impact of the tube worm *Lanice conchilega* on the interpretation of side scan sonar backscatter data

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A Marine Strategy Framework Directives has been developed recently in Europe and similar Strategies are developing in other countries (e.g. Australia, USA) with the aim to achieve a good environmental status of the marine habitats. Therefore habitat mapping applying hydro-acoustic methods has become an important issue in terms of investigation and monitoring. Besides data from ongoing seafloor surveys, legacy data are used to complement datasets for identifying habitats. However, large hydro-acoustic data volumes render a traditional, visual interpretation increasingly difficult. Automatic seafloor classification, on the other hand, is still a developing field and especially fraught with difficulties in situations where the seafloor is dominated by benthic organisms. This is due to the poorly understood acoustic signature of benthic organisms during different stages of their lifecycle.

Repeated side scan sonar surveys were carried out between 2010 and 2012 offshore Sylt Island (North Sea) to assess the distribution and temporal stability of different sedimentological seafloor facies. During these surveys we noticed that areas were substantially covered by the tube worm *Lanice conchilega*, identified by visual observations (under-water video, grab samples) and texture analysis using the well-established parameters entropy and homogeneity. We found a relationship between texture and tube density that might be used for quantitative habitat mapping in the future. However, the spatial distribution as well as the acoustic appearance of areas covered by *Lanice conchilega* changed drastically between the individual surveys. These changes are attributed to a) the seasonal lifecycle of *Lanice conchilega* and its impact on acoustic seafloor properties and b) short- and long-term climate conditions. Short-term conditions include the influence of strong hydrodynamic forcing during and directly prior a survey and observed long-term climate conditions causing a mass mortality during particularly cold winters, here the winter 2009/2010. Our findings indicate that repeated surveys with resolutions better than 50 cm and the consideration of long-term metocean data (e.g. wind speed, waves and temperature) are necessary for the evaluation of habitat maps based on acoustic backscatter data. Legacy backscatter interpretations should be critically reconsidered, where a lack of such meta information exists.

Application of hydro-acoustic techniques for broad scale seafloor classification and monitoring in the context of the Marine Strategy Framework Directive

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Worldwide, marine ecosystems are under pressure from human activities. To counter marine environmental degradation, the Marine Strategy Framework Directive (MSFD) was enacted in 2008 by the European Parliament and Council. The European Commission demands reports from federal and state authorities, with detailed information on the inventory and status of marine habitats. Apart from the biological and oceanographic conditions, the information on the substrate plays an important role for the evaluation of habitat status and stability.

Multi-method approaches are strongly needed to match those requirements for broad scale habitat investigations. We employ single-beam echo sounders (SBES) coupled with Acoustic Ground Discrimination Systems (AGDS) for real-time sediment classification and long-term monitoring observations. Here, the interpretation is based on the information on surface roughness and hardness. If full coverage information is needed, we carry out high-resolution studies with swath systems in selected areas. Bathymetric data is collected with multi-beam echo sounders to support interpretations based on seabed morphology. High-resolution Side Scan Sonar (SSS) surveys provide backscatter data suitable for the creation of sedimentological facies maps. Finally, we obtain information on sediment thickness and the geological-build up from shallow water seismic profiling (SBP). Both, the analysis of SSS and SBP data mainly focus on the characterization of the habitat substratum. All gathered hydro-acoustic data are calibrated and validated by ground truthing with grab samples, sediment cores and underwater video observations.

Examples of seabed classification from the North and Baltic Sea, derived from data collected with a permanently mounted AGDS (ECHO*plus*, Sea Ltd.), are presented. Supervised and unsupervised classification approaches were tested and compared with detailed full coverage habitat maps. Based on the results we discuss the advantages and disadvantages arising from SBES and swath techniques in terms of habitat characterization. In this context we like to focus on the requirements given by the Marine Strategy Framework Directive.

Relating remotely sensed optical variability to marine benthic biodiversity

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Biodiversity is important in maintaining ecosystem viability, and the availability of adequate biodiversity data is a prerequisite for the sustainable management of natural resources. As such, there is a clear need to map biodiversity at high spatial resolutions across large areas. Airborne and spaceborne optical remote sensing is a potential tool to provide such biodiversity data. The spectral variation hypothesis (SVH) predicts a positive correlation between spectral variability (SV) of a remotely sensed image and biodiversity. The SVH has only been tested on a few terrestrial plant communities. Our study is the first attempt to apply the SVH in the marine environment using hyperspectral imagery recorded by Compact Airborne Spectrographic Imager (CASI). All coverage-based diversity measures of benthic macrophytes and invertebrates showed low but statistically significant positive correlations with SV whereas the relationship between biomass-based diversity measures and SV were weak or lacking. The observed relationships did not vary with spatial scale. SV had the highest independent effect among predictor variables in the statistical models of coverage-derived total benthic species richness and Shannon index. Thus, the relevance of SVH in marine benthic habitats was proved and this forms a prerequisite for the future use of SV in benthic biodiversity assessments.

Use of predictive habitat modelling to assess the distribution and extent of the current protection of 'listed' deep-sea habitats

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Global declines in biodiversity have resulted in the establishment of marine protected area (MPA) networks. Currently area closures for the protection of 'listed' deep-sea habitats are based on maps of recorded presence of species considered indicative of that habitat. Recently it has been shown that predictive habitat modelling, rather than species modelling, may provide more reliable estimates of habitat extent. With political bodies setting percentage protection targets, habitat predictive distribution maps may then be used to assess current protection measures. This study uses combined predictive modelling methods (GAMs and Maximum Entropy) to produce distribution maps of three listed habitats in the NE Atlantic: *Lophelia pertusa* (Linnaeus, 1758) reef, *Pheronema carpenteri* (Thomson, 1869) aggregations, and *Syringammina fragilissima* (Brady, 1883) aggregations. Models use presence and absence data with terrain parameters derived from the GEBCO 30 arc-second grid as predictor variables, and are validated using repeated 70% /30% data splits, using AUC and threshold dependent assessment methods. Within the current MPA network in the NE Atlantic, 23% (*Lophelia pertusa* reef), 2% (*Pheronema carpenteri* aggregations) and 6% (*Syringammina fragilissima* aggregations) of the area predicted as suitable for each listed habitat are currently contained with protected areas. New results from a repeat study based on a 200m multibeam grid and derived terrain parameters are also presented.

Multidisciplinary approach to shallow water habitat mapping for fisheries management

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LiDAR for shallow water mapping provides the means for scientists and managers to fill in the “coastal white stripe”, allowing for seamless mosaics from terrestrial to marine environments. The resolution afforded by these systems has allowed collection of high-resolution bathymetry and intensity data in often difficult to survey areas. Multiple uses of these costly datasets are desirable as extending applications beyond the initial scope of survey maximizes the value of mapping programs. In this study we demonstrate how observation datasets can be combined with LiDAR-derived seafloor structure using geostatistical approaches to improve stock management of a commercially important mollusc, the black lip abalone *Haliotis rubra (Leach).* Fishery dependent data were used to develop a species distribution model identifying the extents of potential suitable fishery grounds. Approximately 200,000 effort records from the fishery were analysed to determine spatial patterns in the distribution of fishing activity. Fishing effort tended to be clustered, with spatial patterns varying temporally. LiDAR-derived habitat models were also used to determine spatial connectivity of reef patches and test hypotheses regarding the dispersal characteristics of abalone. Population genetic analysis involving the assessment of allele frequencies at 15 polymorphic microsatellite loci across 16 locations. The results indicate

extensive gene flow across reef patches and evidence of a single genetic stock spanning more than 1000km of coastline. We demonstrate multidisciplinary approaches integrating LiDAR-derived surrogates with genetics, video observations and fisheries data to improve the current spatial management of the abalone fishery.

First evidence of active cold seep offshore Zannone Island: a possible new shallow-water habitat in the Tyrrhenian Sea (Italy)

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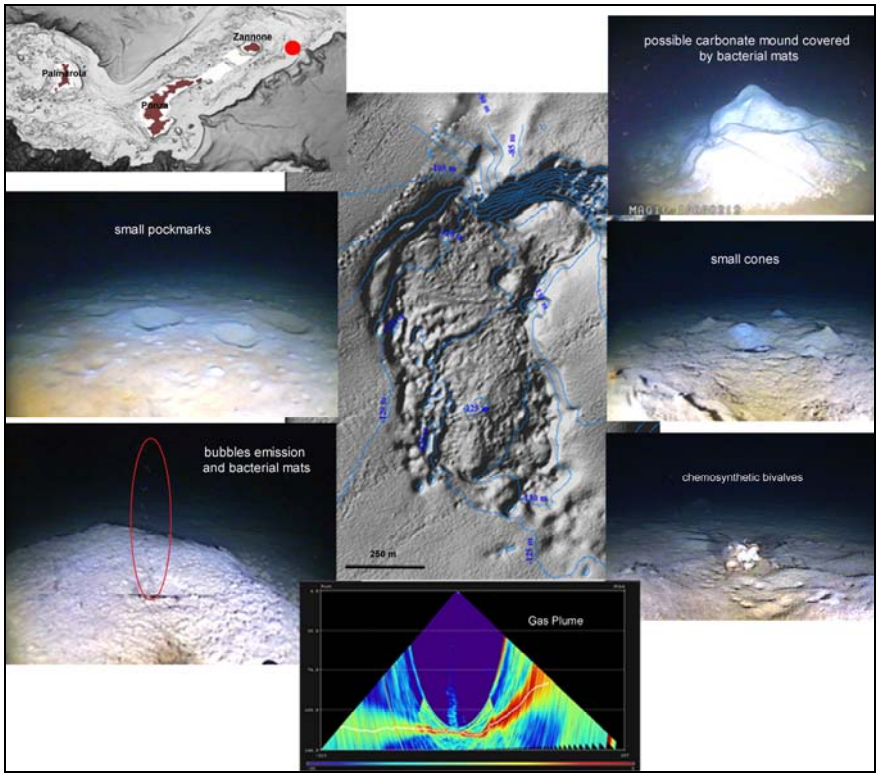
Several seafloor depressions have been found in the eastern and northern sector of Zannone Island (Western Pontine Archipelago, Tyrrhenian Sea, Italy) by means of very high resolution multibeam bathymetry and side scan sonar data. They are located a few kilometers far from the coast at depth between 110 and 140 m. Remotely Operated Vehicle video were used for ground-truth and multibeam sonar water-column backscatter data allowed us to detect gas emission. R.O.V. data and grab sampling revealed in detail geologic and biologic features related to active fluid emissions. We present the result from the larger depression to the east of the island. It has a surface of 0.5 km^2 and ranges in depth between -105 and -130 meters. It is 900 m long, 500 m wide, and 15 m deep respect to the surrounding seafloor. The depression affects lowstand deposits formed until some 20.kys ago.
By integrating different data sets has been possible to define, within the main depression, the occurrence of several pockmarks (up to 70 m wide) and small cones, the presence of widespread bacterial mats, and signs of chemosynthetic bivalves and possibly authigenic carbonates. First analysis reveal the higher concentration of dissolved gases (CO_2, CH_4, C_4H_6) in the water column samples taken inside the main depression than the samples taken outside . We also found evidence of widespread prokaryotic mats, containing very high viral abundances, and apparently chemosynthetic bivalves. Preliminary biological analyses on sediments highlighted a high prokaryotic biodiversity and DNA metagenomic analyses shows the importance of several putative metabolic pathways (e.g. for the sulfur cycle), providing new insights on the biological and ecological properties of these particular benthic habitats. The analysis of the biochemical composition of the sediment organic matter reveals the presence of a large fraction of bioavailable organic matter (proteins, lipids and carbohydrates), apparently related with the presence of a relevant chemosynthetic activity. More detailed studies encompassing geochemical, microbial, and geological samplings will be realized in the framework of the RITMARE national project in order to understand characters and genesis of the fluid. All these features confirm the presence of an active cold seep that provides the first evidence of shallow fluid emissions in the Tyrrhenian Sea.



Multiscale Analysis of Abiotic Parameters For Automated Deep Sea Habitat Mapping

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Automated habitat mapping is a useful tool in making ecosystem-based, marine spatial management a reality. It has been implemented in shallow waters but is less common in the deep sea. With numerous developments in technology, a broad spectrum of data is increasingly available and can be incorporated into marine habitat mapping. The aim of automated habitat mapping methods is to be statistically robust, objective, repeatable and applicable at a variety of scales.

Following on from previous research, a technique to automate deep-sea habitat mapping has been established. The procedure consists of the three main steps: (1) reduction of data dimensionality, (2) determination of optimal number of clusters and (3) data clustering. However, questions remain about scale and scaling methods to integrate data of different resolution into the automated classification. Additional to that, another important step is to ensure that information from these datasets is optimized even after potential rescaling.

Cell-based multiscale analysis was used to combine datasets with different resolution, applying different window sizes to generate the input parameters. Results from initial trials show that when multiscale parameters were added into the automated habitat mapping process, the step facilitated the delineation of different terrain features at different scales. Additionally, multiscale analysis helped the detection of meaningful classes in the habitat maps and reduced noise with increasing window size.

Black Bream nesting habitat in the English Channel, U.K.

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The construction of nests for spawning on the sea bed by black bream off the coast of southern England has produced a distinctive pitted landscape which is particularly well imaged on sidescan sonar records. The sidescan sonar records have enabled the location, extent and form of nests to be mapped. Sub-bottom shallow seismic records and regional geological studies have provided the context and evidence for the construction of nests in particular localities. The geophysical evidence and interpretation has been ground truthed by diving, video and still photography.

In spring each year black bream migrate to shallow coastal waters within the study area. Once inshore the black bream form spawning congregations. Larger male black bream seek characteristic sea bed surfaces which enables them to build or excavate individual 'nests' as depressions on the sea bed in the hope of attracting a mate. Male black breams use their tail during nest building to remove unconsolidated and relatively fine mobile sediment on the sea bed surface layer to expose bedrock or compacted gravel to form the floor of these nests.

Sea bed substrates and features which have been correlated with black bream nests include thin sand and gravel, and gravel on bedrock, some have been on sea bed adjacent to reefs and wrecks. The bedrock they have been noted on includes Cretaceous Chalk and Tertiary Bracklesham Group sediments.

Individual bream nests are typically between 1–2 m^2 in area and 5–30 cm in depth. Collectively they form distinctive groups of pitted features numbered in tens and hundreds on the sea bed. Where bedrock is exposed as very low linear scarps, groups of nests are seen on the shallow dip slopes behind these scarps.

Once a female bream has selected a suitable nest she will lay her eggs in a thin layer within the nest; bream eggs are sticky and become strongly attached to the substrate. After the female has laid her eggs the male fish will fertilise them, the male fish will then guard the eggs until they hatch to protect them from predators such as crustacean and to ensure siltation of the nest does not occur. However, this philopatry does make the adults susceptible to fisheries exploitation. Unmolested juvenile bream will remain in the vicinity of the nest sites until they are 7–8 cm in length; they then disperse but remain in the inshore areas for 2–3 years, when may attain approximately 20 cm in length.

Neretva River delta - clastic delta in a karst environment (Adriatic Sea, Croatia)

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Neretva River is the largest river in the eastern part of the Adriatic basin (average flow 414 m^3s^{-1}) and is the only river in Croatia which formed delta on the river mouth. The Neretva delta extends on the area of 170 km². Its catchment area is built of different magmatic, metamorphic, carbonate and clastic sedimentary rocks. Large quantities of suspended material and bed load have been delivered to the coastal karst area and the sea by Neretva in the past. Today, sediment delivery to the sea is largely reduced due to the sediment trapping in reservoirs behind large dams which were built across Neretva in the last century. Formerly, during the last glacial maximum (30.000 to 18 000 years BP) the sea-level was 120-130 meters lower than today and paleoNeretva was carving riverbed in carbonate basement, and was carrying suspended load to the former mouth between the Korčula and Vis islands.

Sub-bottom profiling and sediment core analysis in the recent prodelta area in the sheltered Neretva Channel indicates slackened sedimentation of fine-grained siliciclastic sediments, and sharp contact with Pre-Holocene basement.

Use of Multibeam Sonar Backscatter Data for Surface Substrate Mapping in Complex Marine Area, a Case Study in the Northern Baltic Sea

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The seabed surface substrates are one of the primary parameters in habitat mapping. Nevertheless in the Finnish marine areas the knowledge of the uppermost sediments is often lacking as the geological mapping is traditionally made with 0.5 m vertical resolution. We have tested the backscatter classification software, QTC Multiview, in a complex shallow seafloor area in order to produce data on surface substrates efficiently.

We conducted multibeam surveys in four case study areas in the Eastern Gulf of Finland during May 2012. The areas vary in size and cover together about 52 km^2. The case study areas were segmented with QTC to acoustically resembling classes. We performed stratified sampling on the basis of the acoustic classes and groundtruthed the surface material of each class. The grain size distribution was analysed with sieve and sedigraph. Finally the grain sizes were compared with acoustic classes. Here we will show our results and discuss the usability of of the semi-automated classification of acoustic data in shallow, complex marine area.

The study is a part of ENPI CBC funded Finnish-Russian co-operation project, the TOPCONS. Project aims to develop innovative spatial tools for the regional planning of the sea areas in the Gulf of Finland, the Baltic Sea. These marine spatial planning tools will improve management and sustainable use of marine resources, to ensure the wellbeing of the Baltic Sea. The TOPCONS is implemented in close relationship to the Finnish Inventory Programme for the Underwater Marine Environment (VELMU).

SEABED MULTI-BEAM BACKSCATTER MAPPING OF THE AUSTRALIAN CONTINENTAL MARGIN.

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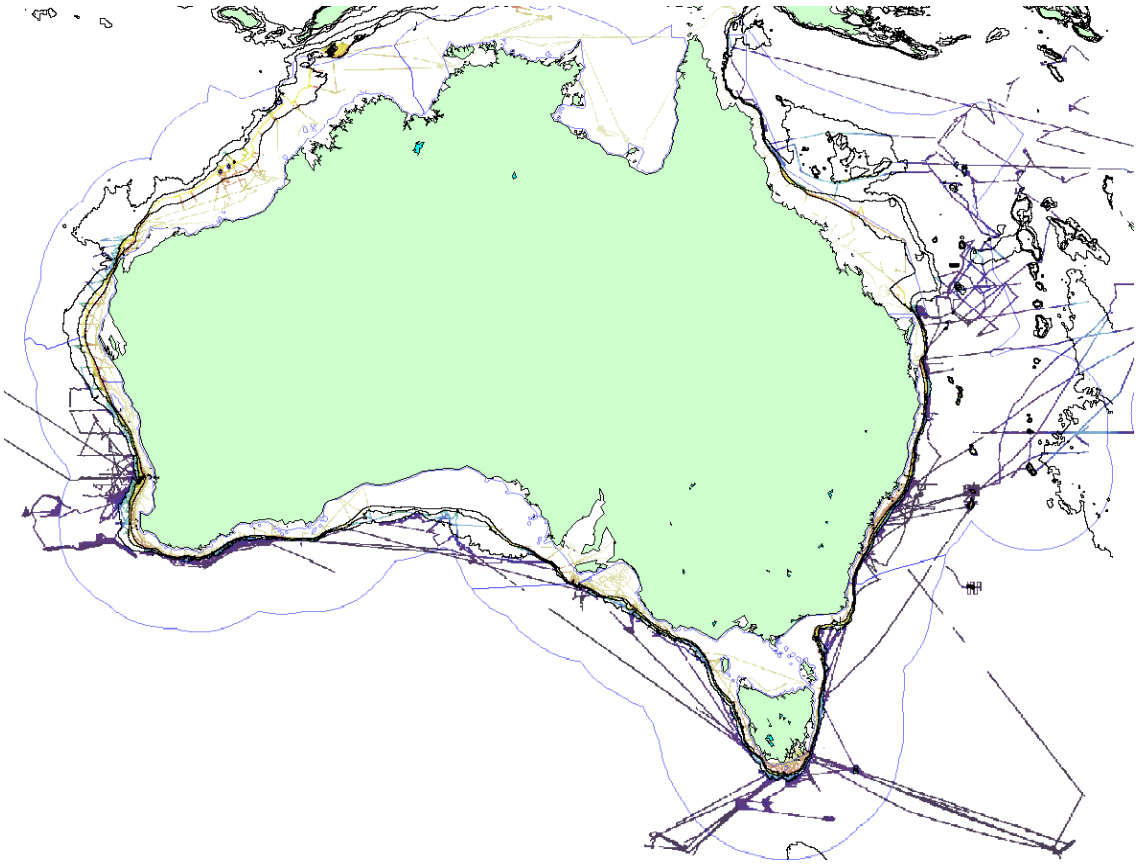
A multi-beam sonar (MBS) has been used to map Australia's continental margin seabed from the marine national facility vessel Southern Surveyor on opportunistic transit and research voyages since 2004 with 6.98 M km^2 mapped. The MBS data are used to infer key ecological features based on bathymetry (e.g. seamounts, canyons, terraces, banks and deep reef's) and backscatter data for ecological hard (consolidated, e.g. rock for attachment of fauna) and soft (unconsolidated, e.g. mud for burrowing fauna) substrate. Seabed consolidation inference is consistent with a seabed scattering model.

To consistently infer ecological significant hard and soft substrate from the backscatter data requires minimisation of errors. Corrections due to changing absorption (~2 dB) with temperature and depth, and estimates of area insonified due to seabed slope (<8 dB) are described. Area insonified corrections were required for both across and along-ship slopes. Highest corrections were needed for along-ship slopes in canyon regions and large incidence angles (>60^o).

A data collection and processing framework is described that works towards a national backscatter mapping program for environmental seabed mapping. Data collected and processed at level 2 of a 5 level hierarchy is available for viewing at http://www.marine.csiro.au/geoserver.



Information on seabed geology and biology – a solid base for marine spatial planning: The Baltic Sea Case

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It is known worldwide that the oceans are suffering. To ensure the sustainable use of marine resources, effective tools are needed. Marine Spatial Planning (MSP), with the ecosystem approach, is a powerful tool for analyzing, coordinating and allocating the distribution of human activities in marine areas. That enables us to achieve sustainable development by balancing economic, environmental and social objectives (HELCOM 2010).

At the Gulf of Finland, the Regional Council of Kymenlaakso is drafting the regional plan for the trade- and sea area of the region. MSP and the sustainable management of sea areas in general are seen as important current challenges in regional planning. TOPCONS project has had a close co-operation with the Council already in the early phase of regional planning process. Scientists have provided information on seabed geology and biology, human pressures, harmful substances in sediments and seafloor hypoxia among others.
TOPCONS project has interacted with planners in order to evaluate, what kind of geological and biological data is of practical relevance for spatial planning, what is available and what is missing. Co-operation is essential to make scientific data on our sea areas more easily available and understandable to spatial planners and improve the interplay between science and planning officials.

The study is a part of ENPI CBC funded Finnish-Russian co-operation project, the TOPCONS. Project aims to develop innovative spatial tools for the regional planning of the sea areas in the Gulf of Finland, the Baltic Sea.

Completion of and lessons from the 6000 km^2 California Seafloor Mapping Project: Why it was done, how it was done, what we learned, and how the data are being used.

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The use of ecosystem based management (EBM) for managing marine and coastal ecosystems has become widely adopted throughout the United States, especially in California where a large network of marine protected areas (MPAs) has been implemented. Because California's MPA network is required by law to capture representative amounts of regional seafloor bottom types within specific depth zones, information was needed on the extent and variety of marine substrates. This need drove the initiation of the California Seafloor Mapping Program (CSMP) in 2005, which is the first comprehensive mapping of a state's entire territorial sea in our nation's history. The ultimate goal of the CSMP is the creation of onshore and offshore habitat and geology maps using a combination of technologies including multibeam, LiDAR, sub-bottom profilers, and interferometric sonars. While the CSMP was launched to meet a diverse set of critical marine management needs, including identifying hazards to navigation, assessing earthquake and tsunami risks, modeling coastal erosion and sea level rise, making wiser development decisions, exploring the potential for offshore energy, as well as a basemap for applied and basic research, the driving force behind the CSMP has been California's Marine Life Protection Act and its mandate to create the nation's first network of MPAs. Prior to the CSMP, California's submerged continental shelf was generally regarded as a relatively flat, featureless surface cut by numerous deep submarine canyons. Now, with the remarkable seafloor detail unveiled by the CSMP, California's continental shelf is revealed as a highly complex mosaic of diverse physical features. This new knowledge is providing the foundation for improved understanding and management of the rich diversity of marine habitats, species and ecosystems found along California's coast. For example, a closer look at the shallow continental shelf reveals much detail that is important to marine communities, species and individual organisms than was thought prior to the collection of the CSMP data. The substrate can be divided into a range of rock types and sediment veneers that provide a great range of shapes and textures, each important for specific kinds of marine life. These findings from the CSMP are now being used to associate different ecologically and economically important species with the variations in habitat types to predict their distributions across the network of MPAs. In addition, a new ecologically relevant habitat was identified; rippled scour depressions (RSDs). These distinct sediment features account for nearly as much of the state waters seabed as rocky habitat and support different species assemblages compared to the surrounding finer-grain soft sediment. These findings from the CSMP data can now be used to re-evaluate MPA network designs, assess changes in population status over time, and predict marine population response to a variety of environmental influences including climate change, ocean warming, and changing human activities.

Virtual Fieldwork on the Seafloor: Close Range Photogrammetry from ROV Imagery

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As well as providing well-localized samples, Remotely Operated Vehicles (ROVs) produce huge quantities of visual data whose potential for geological data mining has seldom if ever been fully realized. We present a new workflow to derive essential results of field geology such as quantitative stratigraphy and tectonic surveying from ROV-based photo and video material.

We demonstrate the procedure on the Charles Darwin Seamounts, a field of small hot spot volcanoes recently identified at a depth of ca. 3500m southwest of the island of Santo Antão in the Cape Verdes. The Charles Darwin Seamounts feature a wide spectrum of volcanic edifices with forms suggestive of scoria cones, lava domes, tuff rings and maar-type depressions, all of comparable dimensions. These forms, coupled with the highly fragmented volcaniclastic samples recovered by dredging, motivated surveying parts of some edifices down to centimeter scale. ROV-based surveys yielded volcaniclastic samples of key structures linked by extensive coverage of stereoscopic photographs and high-resolution video. Based upon the latter, we present our workflow to derive three-dimensional models of outcrops from a single-camera video sequence, allowing quantitative measurements of fault orientation, bedding structure, grain size distribution and photo mosaicking within a geo-referenced framework. With this information we can identify episodes of repetitive eruptive activity at individual volcanic centers and see changes in eruptive style over time, which, despite their proximity to each other, is highly variable (Fig. 1).

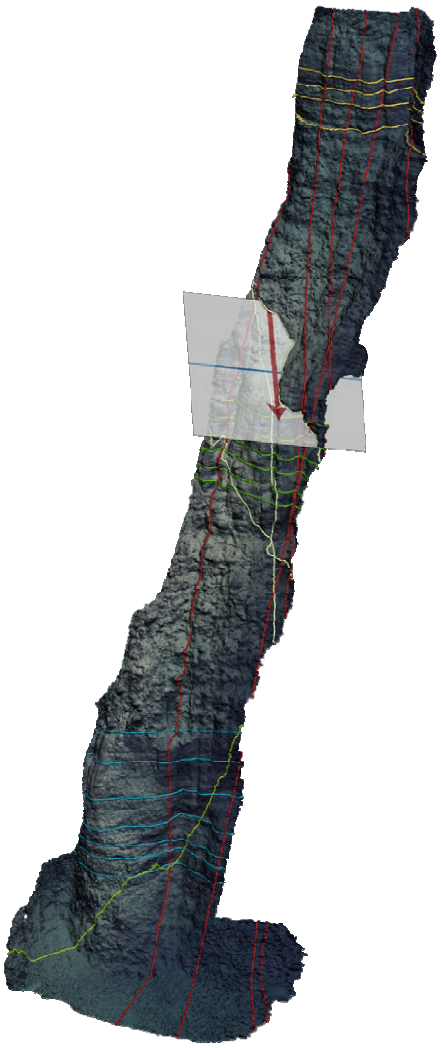

Figure 1: Georeferenced 3D model of the 28m high inner crater wall of a deep-sea volcano at 3200m depth. The spatial resolution is 15cm, the textural resolution varies from 8mm to 2cm. The sequence was created from a 2min long full HD video clip and georeferenced using the ROV navigation data. Colored linear features illustrate measured bedding planes and joints. The plane in the center of the image illustrates our virtual geological compass to measure strike (blue) and dip (red) for the features. Three upward fining sequences can be distinguished that are partly separated by erosional unconformities.

TOPCONS - Transboundary tools for spatial planning and conservation of the Gulf of Finland, the Baltic Sea

Ari O. Laine[1*], Miina Karjalainen[2], Anu Kaskela[3], Kirsi Kostamo[4], Aarno Kotilainen[3], Varpu Mitikka[5], Marina Orlova[6], Minna Ronkainen[4], Daria Ryabchuk[7], Riikka Venesjärvi[8] and TOPCONS partners

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The Baltic Sea is an European inland sea with a catchment area inhabited by almost 90 million people. Anthropogenic uses have lead to severe environmental problems like eutrophication, loss of coastal habitats and accumulation of harmful substances. To be able to implement sustainable ecosystem based management there is need for effective tools.

TOPCONS is a Finnish-Russian co-operation project that will develop innovative spatial tools for the regional planning of the sea areas. These will help the society when striving for the sustainable consolidation of human activities and the marine nature values. The objective of the project is to create methodology and tools to aid in mapping the locations of the most diverse and sensitive marine landscapes.

The project utilizes existing knowledge and collects new data on the geology, biology and human pressures in the Eastern Gulf of Finland (EGoF). The datasets will be combined in the GIS-environment. One of the central research questions is, if the biologically diverse marine areas could be predicted with statistical methods based on the geological and physical conditions. In addition TOPCONS will study the distribution of the coastal fish reproduction areas in relation to the marine landscapes. The impact of human pressures, especially on sensitive areas is of interest as well. One of the aims is to produce harmonized and comparable, multidisciplinary and transboundary data for the joint use of both Finnish and Russian researchers and managers from the t EGoF.

TOPCONS produces knowledge that can be directly utilized for the planning of sustainable use and the conservation of the marine habitats. During this project, the first version of the spatial planning tool, to be tested by the potential end-users, e.g. decision-makers, designers and researchers, will be created.

UK Marine Conservation Zone - Data and Evidence Collection Programme

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The United Kingdom's Marine and Coastal Access Act (2009) requires the establishment of a network of conservation sites in the English marine area. The Act requires that the network must conserve or improve the UK marine environment and protect a range of representative features. In the Secretary of State's waters the network will comprise European Marine Sites, Sites of Special Scientific Interest, sites designated under the Ramsar Convention and Marine Conservation Zones (MCZs). The identification of potential MCZs in English inshore waters and English, Welsh and Northern Irish offshore waters, was led by four regional MCZ projects: Balanced Seas, Finding Sanctuary, Irish Sea Conservation Zones and Net Gain. These Projects brought together a wide range of stakeholders - conservationists, fishermen and other sea users – and used guidance provided by JNCC and NE to develop proposals for where recommended Marine Conservation Zones (rMCZ's) should be, and they submitted their findings to Government in Sept 2011.

As a consequence of that exercise, further data and evidence is now being collected to increase the quality and amount of evidence available for some recommended sites.

Defra commissioned £4M of additional survey work to be conducted during 2011/12 to support the acquisition of this additional data and evidence. Further significant survey work has also been commissioned in 2012/13. Cefas acted as the coordinator of this survey program on behalf of Defra, and worked in close partnership with JNCC, NE, EA and Defra to ensure that the data and evidence collected under this program met the needs of Government and its advisors. Site survey priorities were agreed between Defra, JNCC and NE based on the information in the regional MCZ project site reports. As result of this process, by the end of 2012/13, new survey information will have been collected from almost 70 rMCZ's in English territorial waters and UK offshore waters. This will have been achieved through the combined use of UK's fleet of public sector vessels as well as the commissioning of commercial contractors, resulting in over 400 operational sea days over the two years of work. This new survey data will comprise a combination of multibeam bathymetry and backscatter, sidescan sonar, grabs and video/stills imagery. Survey work will continue during 2013/14 and will be used to increase the evidence base for sites being considered for designation in future tranches and to increase the evidence base to inform management decisions for sites designated in the first tranche.

The data collected to date is currently being processed and Quality Assured; Cefas have already used some of the data to provide updated seabed habitat maps for a number of rMCZ's. The data will also be provided to JNCC and NE to enable them to advise the Government on rMCZ sites that might be proposed for designation as part of current and future consultation exercises.

High-resolution predictive mapping of Cold Water Coral species in the Cap de Creus Canyon (northwest Mediterranean)

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High impact deep-sea bottom trawling activities are seriously compromising the conservation of Cold Water Coral (CWC) ecosystems. It has been recently discovered that submarine canyons can act as hosting areas for benthic communities dominated by CWCs. Favorable environmental conditions along the canyons coupled with the rough seafloor morphology can foster their development. The importance of a reliable mapping of CWC communities in submarine canyons is increasingly being necessary to establish suitable conservation and management strategies. The aim of this study is to statistically predict the distribution of three CWC species (*Madrepora oculata*, *Lophelia pertusa* and *Dendrophyllia cornigera*) in the Cap de Creus Canyon (NW Mediterranean), based on high-resolution swath-bathymetry data (pixel resolution: 5m) and video observations from the submersible JAGO (IFM-GEOMAR). Species distribution models have been constructed with a Maximum Entropy approach (MaxEnt model) using the layers derived from multibeam bathymetry such as slope, geomorphologic category, rugosity, aspect (orientation of the pixel respect to the North) and backscatter and the presence data of CWC from video imagery. For the three species the predictive model performance is outstanding, with the area under the curve (AUC) from the sensitivity-specificity approach of 0.98 for *M. oculata* and *D. cornigera* and of 0.99 for *L. pertusa*. The most relevant variables responsible for the CWC distribution are the slope and aspect for *M. oculata* and *L. pertusa,* and rugosity and aspect for *D. cornigera.* According to the models, CWC species are most likely to be found on the medium to steep rough walls of the southern flank of the Cap de Creus Canyon and almost exclusively along the regions facing the north and the northwest, from where strong organic sediment-rich currents flow. Results are coherent with previous observations and quantitative studies performed in the area. Insights coming out from the application of geo-spatial statistical models could represent the basis for the development of a scientifically-based approach in the planning and management of Marine Protected Areas.

ROV-documentation of drastic population decline in the poriferan *Geodia barretti* in the Skagerrak in response to temperature extremes

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Geodia barretti has been a dominating poriferan species at depths below 60 m in fjord environments of the NE Skagerrak .

Starting winter and spring of 2006/7, multiple observations were made during ROV-missions of large numbers of dead or dying colonies of *Geodia*. High mortality in *Geodia* was again observed in winters of 2008/9 and 2009/10 respectively.

Decline in *Geodia*-populations was quantified at a fixed bottom transect through a trawl-damaged part of a cold-water coral reef (Tisler reef) in the Hvaler area. A bottom transect (weighted bottom line) was established in this area at depths around 120m in 2005, and has been monitored regularly by video and still photography until present. Temperature, salinity and current were recorded continuously at the same depth over the period 2006/11. The transect contained dense populations of *Geodia* in 2005. About 43 % of the population died in the winter of 2006/7. An additional 75 % of the remaining population died in the winters of 2008/9 and 2009/10, resulting in a total mortality rate of approximately 86 % over the observed period. High mortality rates in *Geodia* were preceeded by periods of high temperatures (approximately 2 - 3°C above normal, as indicated by available historical records) recorded in the late autumn of respective years. ROV-observations indicated that mortality rates in *Geodia* were highest at depths above 90m and low at depths below 140m.

Our observations could be one of the first indications of major ecological effects in deep-water habitats in the Skagerrak as a result of global warming.

The influence of benthic macrofauna on hydroacoustic methods.

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To determine how the results of different acoustic sea floor classification devices relate to the distribution of benthic macrofauna communities and sediment properties in the German Bight, we studied an area of approximately 6 km² northwest of the island Helgoland within the WIMO project ("Scientific monitoring concepts for the German Bight"). The area was surveyed by sidescan sonar, single-beam echosounder and multi-beam echosounder simultaneously. Samples along four transects of 39 stations were retrieved using a 0.1 m² Van Veen grab sampler for ground-truthing the acoustic data. Grain-size analyses and benthic macrofauna analysis were carried out in the laboratory. At each of the stations three subsamples were taken: two grabs for macrobenthos studies and one grab for sedimentological analyses. The sediment composition ranges from mud (southern and western part) to coarse sand, gravel and cobbles. We found a typically *Nucula nitidosa- Abra alba* community on the fine to muddy sand area in the northern part (white square). The *Nucula nitidosa- Amphiura filiformis* community is a transitional community (black square). It shows typical species of the *Nucula nitidosa- Abra alba* and the southern *Amphiura filiformis- Kurtiella bidentata* community but in lower abundances. Furthermore, a high abundance of the snail *Hyala vitrea* is typical for this community. In the northern and eastern part rock outcrops were identified by hydroacoustic methods. Here, a quantitatively sampling by the 0.1 m^2 Van-Veen grab was difficult, but we found a typical hard substrate community (black dot). Within the more homogeneous muddy sediments in the southern parts, we identified an additional sea floor class , although no changes of sediment composition or sea floor structures were recorded. Large amounts of the brittle star *Amphiura filiformis* and their commensal bivalve *Kurtielle bidentata* characterized the southern area (white triangle). The disk of the brittle star is buried in the sediment at about 3-4 cm depth. *Amphiura filiformis* catch organic material out of the water column with the long arms reaching out of the sediment. For an averaged abundance of *Amphiura filiformis,* we assumed for one active feeding arm per individual a minimum of 1711 arms/m^2 and in the case of four active feeding arms 6844 arms/m^2. It is possible, that the occurrence of the brittle star in high abundances (1000-2400 individuals per 1 m²) increase the roughness on the seafloor, because of the outreaching arms. This increased roughness of the seafloor causes an increased backscattering of the acoustic waves.

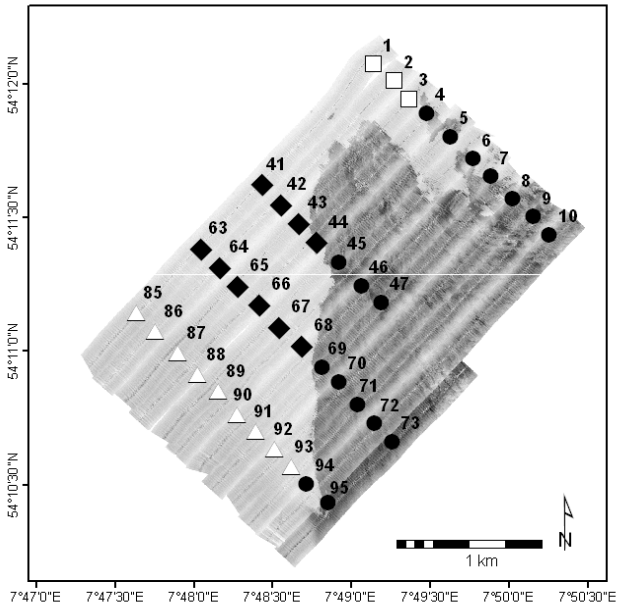

Fig. 1. The distribution of the found communities in the study area on top of the acoustic diversity map (Sidescan Sonar). *Nucula nitidosa- Abra alba* community (white square), a *Nucula nitidosa- Amphiura filiformis* (black square), a hard substrate community (black dot) and a *Amphiura filiformis- Kurtiella bidentata* community (white triangle).

Deep-sea benthic habitat mapping in the Italian seas in the framework of the RITMARE Project: a 5-year perspective for the definition of best procedures for habitat mapping in complex areas

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Deep-sea benthic habitats are still poorly investigated. Only 5-10% of deep seafloors have been mapped with a detail similar to the subaerial environment and most of the research is related to shallow-water areas (< 50-100 m w.d., e.g. *Posidonia oceanica* and coralligenous in the Mediterranean Sea). As a consequence deep-sea habitats are poorly known and the distribution of significant communities (e.g. deep-water corals, sponge grounds, communities related to seamounts, canyons, cold seeps, etc.) is largely unknown, as well as their functioning and vulnerability to the anthropogenic stressors. This is particularly true for semi-enclosed basins such as the Mediterranean Sea which, despite its small size (0.7% of global marine surface), is recognized as a biodiversity hot-spot hosting more than 7% of the world's marine macro-flora and macro-fauna biodiversity. In addition, the Mediterranean Sea is subject to increasing anthropogenic pressures, both in coastal and deep-sea areas, therefore marine biodiversity and deep-water habitats are dangerously threatened.

Because of these substantial gaps in knowledge, habitat mapping studies carried out by using integrated strategies and approaches are needed. This will be attempted by the task of habitat mapping activities in the Italian seas (SP4.WP2.A1 - Development of integrated methods for habitat mapping to assess biotic and abiotic resources) which is developed in the framework of a five-year national project funded by the Italian Ministry of University and Research and coordinated by the National Research Council (RITMARE flagship project – 2012-2016, managed by F. Trincardi). Main objectives of the habitat mapping action are: 1) to produce maps showing the distribution of habitats at different scales and in different morpho-bathymetric settings; 2) to define best strategies and procedures for benthic habitat mapping activities (survey methods, classification, data integration etc.) in complex areas such as the Italian seas. Specific objectives are: 1) the assessment of biodiversity and health status of most relevant observed habitats; 2) to provide background data for ecosystem goods and services studies and human impact assessments. These objectives will be achieved by investigating specific areas that have been selected for the possible occurrence of relevant habitat types and that also represent particular morpho-bathymetric settings. Broad-scale maps (1:500.000 spatial scale) will be produced for the southern Tyrrhenian Sea and the Adriatic Sea. Intermediate and fine-scale maps (1:50.000-1:5.000) will be defined for the Bari Canyon, the Gioia Canyon, specific sectors of the Sicily Channel, of the Marsili Seamount and of the Pontine offshore. Habitat maps will be defined using different methods for the broad-scale mapping and the intermediate-fine scale ones. Broad-scale maps will be produced by integrating different physical factors, such as depth zones, morphology, substrate and oceanographic data. Intermediate and fine-scale maps will result on the integration of morphoacoustic-bathymetric data with biological-substrate ground-truth data. As a whole, the activities will be carried out by using a strictly interdisciplinary approach, based on biological, geological and oceanographic information, in order to fully describe both biotic and abiotic components of benthic habitats.

Mapping of deep-sea benthic habitats will represent a fundamental tool for a proper marine spatial planning and eco-sustainable exploitation of the marine environment and resources, with particular reference to the recent European Marine Strategy Directive.

Predicting seafloor sediment properties from acoustic backscatter: a comparative evaluation of three methods

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The relationship between acoustic backscatter and sediment grain size is examined using three different quantitative methods, covering a range of image- and angular response-based approaches. Multi-beam time-series backscatter (300 kHz) imagery and modelled angular response curves acquired in 2008 off the coast of East Anglia (UK) are compared with mean sediment grain size from a series of 130 Hamon and 16 Clamshell grab samples. Previous analysis for a heterogeneous seafloor (Collier and Brown, 2005) demonstrated significant potential for predicting sediment grain size from image-based analysis (1st order statistics) of side-scan sonar backscatter imagery (r^2=0.531; p<0.001). Here, we explore these relationships using MBES data in a relatively shallow water environment where the seafloor sediment is more homogeneous and coarser.

The relationship between acoustic backscatter and mean grain size is explored using correlation and regression for each method. Predictive methods examined include: 1) image-based, using mean backscatter intensity from 32-bit backscatter imagery; 2) angular response-based, using predicted mean grain size estimated from angular response analysis (*ARA*) functionality of *Fledermaus Geocoder Toolbox (FMGT);* and 3) 1st principal component and classification outputs from *Quester Tangent Corporation's QTC-Multiview* software. Differences in mean grain size are also examined using ANOVA, based on the variability within groups arranged by binning predictive variables (mean backscatter and *ARA*) and the results of the classification process (*QTC*).

Results for the Hamon grab data (n=130) indicate significant correlations between mean grain size and; mean backscatter intensity (r^2=0.284; p<0.001), angular response predicted mean grain size (r^2=0.231; p<0.001) and 1st principal component of *QTC* analysis (r^2=0.152; p<0.001). Results for the Clamshell grab data (n=16) for two of the methods have stronger positive correlations by comparison; mean backscatter intensity (r^2=0.619; p<0.001) and angular response predicted mean grain size (r^2=0.692; p<0.001). The correlation for the 1st principal component of *QTC* analysis was insignificant (p=0.764).

Results of the ANOVA for the Hamon grab data show that mean of mean grain size observed within individual acoustic groups are significantly different for: mean backscatter binned in 1.5 dB increments (F [10, 119] =6.965; p<0.001); angular response predicted grain size binned in 0.5 Φ increments (F [10, 119] =4.471; p<0.001), and *QTC* class (F [10, 119] =2.525; p=0.009). Similarly, the results of ANOVA for the Clamshell grab show a significant difference between in groups for mean backscatter (F [7, 8] =11.929; p=0.001), angular response predicted grain size violated assumptions of equality of variance within grouping variables and *QTC* class was not significant (p=0.536).

In terms of a direct comparison between the results of the Hamon and Clamshell grab data, there is a stronger positive correlation with the Clamshell data, although this is achieved with a limited number of samples. The results show considerable promise in that between 63 and 69% of the variance in the mean grain size of the Clamshell grab samples can be explained by either mean backscatter or predicted grain size from the angular range analysis respectively. The results of the binned and class predictor data provide a useful indication of the reliability of these methods for the purpose of acoustic facies mapping. This shows a convincing degree of distinction between the classified outputs in terms of observed particle size data with a degree of replication at the facies level. The results of our study support the position that there is a significant predictive relationship between bulk sediment characteristics and multibeam backscatter imagery, both at the level of 1st order statistics and using angular response-based analyses.

References

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Kenmare River EUNIS Habitat Map and Reef Profile

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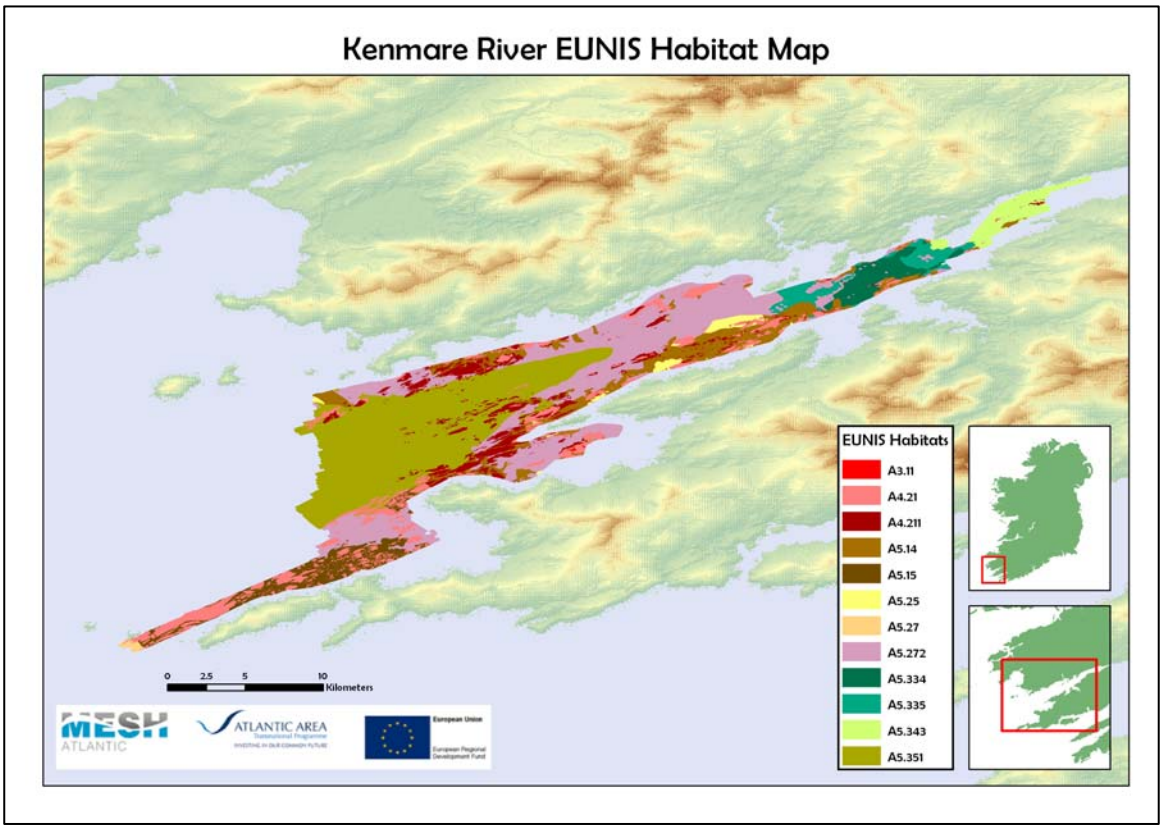
As part of the INTERREG IVB MeshAtlantic project, an acoustic survey of Kenmare River on the southwest coast of Ireland was carried out in August 2011 with the purpose of generating a high level EUNIS habitat map for this Natura 2000 site. The multibeam echosounder (MBES) shaded relief imagery and backscatter data acquired were post processed and classified into rock outcrops and acoustic groups respectively. Video transects of reefs and sediment samples were used to groundtruth the highlighted features. The classified substrate data were combined with data on kinetic energy and bathymetry to generate a low level EUNIS habitat map.

Biological samples taken were analysed using PRIMER software, and assigned a EUNIS class. Substrate type, bathymetry and kinetic energy layers were used in a Maximum Likelihood Classification (MLC) process. The EUNIS samples were overlain on the raster data and used by the MLC tool to generate a unique profile for each habitat based on the 3 input layers.

These data were used to refine the physical habitat map into a higher level EUNIS habitat map, generating 12 EUNIS habitats, 6 of which are classed to EUNIS level 5. A reef profile was also created.

FIGURE 1: A panel from the poster showing the EUNIS habitat map



Geomorphological features of coastal dunes in the Marine Protected Area "Torre Cerrano" (central Adriatic coast, Abruzzo, Italy)

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The main geomorphological features of dunes and beaches were investigated along the central Adriatic coast of Italy (Abruzzo). Out of nine main foredune areas typified by established dunes and incipient dunes present in the Abruzzo area, in this work the detail features of the coastal dunes which characterize the Marine Protected Area "Torre Cerrano", were investigated through (i) detailed geomorphological surveying, (ii) analysis of historical maps and photographs (aerial and land), (iii) accelerator mass spectrometry (AMS) ^{14}C dating.
The dunes are located along a low coast segment backed by a narrow coastal plain and by a sharp coastal slope. The morphology is typical of foredunes, with elongated fields of dunes slightly oblique to the NNW-SSW coastline, developed on a >20 m wide beach. The area is characterised by incipient dunes (D1), with sporadic grassy vegetation and located toward the beach, and established dunes (D2), stabilised by dense, mainly shrubby vegetation, and partly covered by extensive pinewood, developed behind the dunes (Fig. 1). The orientation is mostly NW-SE on a NNW-SSE coast; the total dunes' length is ~2,500 m (height up to 2.5 m, width up to 70 m for a total area of >125,000 m^2) for established dunes with incipient dunes on at least a 900 m beach reach (height up to 1.5 m, width up to 10 m for a total area of >6,000 m^2); the orientation is mostly NW-SE parallel to the coast. These values, however, are varying and growing rapidly year by year, also due to the protection actions implemented within the Marine Protected Area "Torre Cerrano". The sand of the established dunes is characterised by plentiful shells and fragments of pulmonary gastropods Helix sp. Radiometric AMS ^{14}C dating, obtained from the core of an established dune at a height of about 1 m asl and about 25 m from the coastline, provided an uncalibrated age of 730±40 years BP.
Analyses of historical maps and photographs (aerial and land) led to the reconstruction of coastal dune morphology from the beginning of the 1800s to the turn of the 20th century, showing a strong surface reduction in recent times, while radiometric datings show that the Cerrano dune filed has had a long centennial geomorphological history.
The overall study enabled the reconstruction of the geomorphological arrangements of the dune area of the Marine Protected Area "Torre Cerrano", allowing to define the dunes as semi-natural foredunes, with mainly direct and locally indirect management control.
The reconstruction of dune evolution identifies oldest recognizable period of aeolian deposition in the late-Middle Ages. The first significant human-induced processes began in the 1900s and over the last 50 years human activity has played an important role in the coastal morphogenesis, with direct and indirect effects on coastal dunes reduction and removal, heavily affecting the whole coastal system.

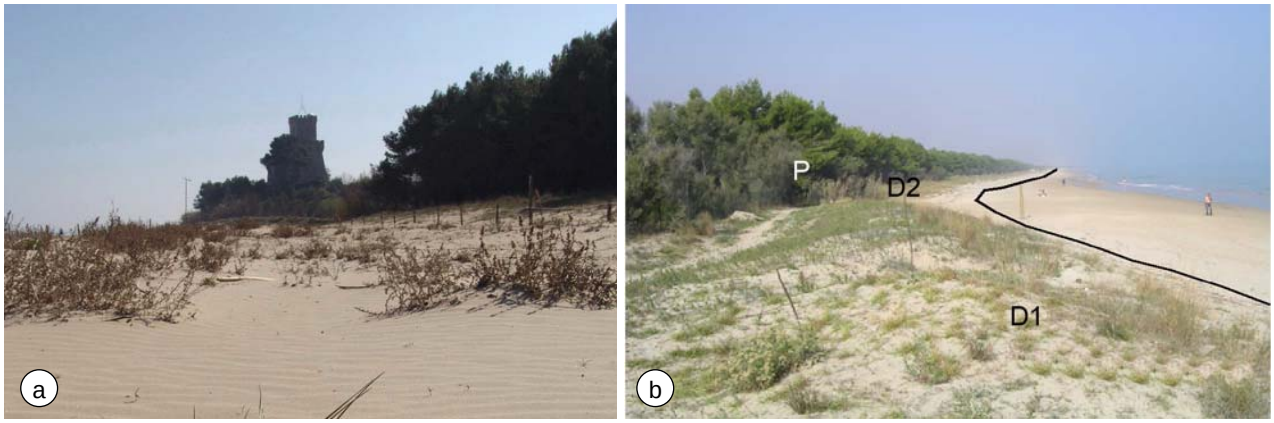

Fig. 1 - a) Torre Cerrano, foredunes area. b) Torre Cerrano, incipient dunes with grassy vegetation (D1) and established dunes (D2), with extensive pinewood behind (P).

Predicting "sea finger" (*Alcyonium acaule, Octocorallia*) suitable habitat in shallow water off south coast of Portugal

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Octocorals are vulnerable and sensitive species that are considered to be threatened and/or declining in the North-East Atlantic by WWF, OCEANA and OSPAR. Sea fingers are present on "coral gardens" communities categorised as a priority habitat in OSPAR Regions. *Alcyonium acaule* associated with several gorgonians species (*Leptogorgia lusitanica, L. sarmentosa Eunicella verrucosa, E. gazella, Eunicella labiata* and occasionally *Paramuricea clavata*) is characteristic of coastal water habitats from south coast of Portugal. Identification and mapping of the occurrence and distribution of niche and suitability habitat of this species provide a base for future management. Niche-based spatial predictions provide continuous habitat distribution maps from presence/absence data or presence only data. Ecological niche model from "sea finger" was used and generated using the MaxEnt software v3.3.2. The occurrence data for the predictive modelling were compiled from RENSUB project carried out in the central Algarve between 0 and 30 meters depth. Raster-based covariable such as sediment type and derived products from bathymetric (Slope, Aspect, Bathymetric Position Index and Curvature) and bioclimatic data (Chlorophyll, Fraction of light and SST) were used in the modelling process. The AUC (0.975) value obtained indicate excellent performance of the model with sediment type (39%), slope (27.6%) and depth (13.1%) as the covariables with higher contribution to the model. The True Skill Statistic (TSS) value (0.785) also indicates a very good accuracy and performance of the model. The model accuracy suggests that could be used on predicting the species niche and habitat for the entire Algarve coast.

Deepwater seabed characterisation, Rockall Trough, west of Ireland

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In response to the EU Green Paper on Future Maritime Policy, the European Commission initiated the European Marine Observation and Data Network (EMODnet) with the aim of compiling fragmented marine data and making the data interoperable, contiguous and publicly accessible across European basins and seas. As part of this preparatory phase of EMODnet-Geology a requirement to compile and harmonise all available seabed sediment information at a scale of 1:1 million for European basins and seas was identified. Seabed classifications have been derived for certain sectors of the Irish offshore whilst areas of the deepest water depths have been relatively unclassified. One such area is the Rockall Trough, a large deep water basin lying west of Ireland and the British Isles, approximately 1000 km long and 250 km wide. The Rockall Trough multibeam swath acoustic datasets have associated inherent deepwater data processing and interpretation challenges, however the application of new data processing algorithms has significantly helped to improve interpretations of the acoustic datasets. As part of the Irish data contribution to EMODnet-Geology which was completed last year, a preliminary sediment distribution map was produced for the first time for the Rockall Trough. Here we present a recently revised version based on an integrated approach using image based classification, backscatter angular analysis, shallow seismics and sediment samples, which has led to improvements in spatial resolution and sediment characterisation.

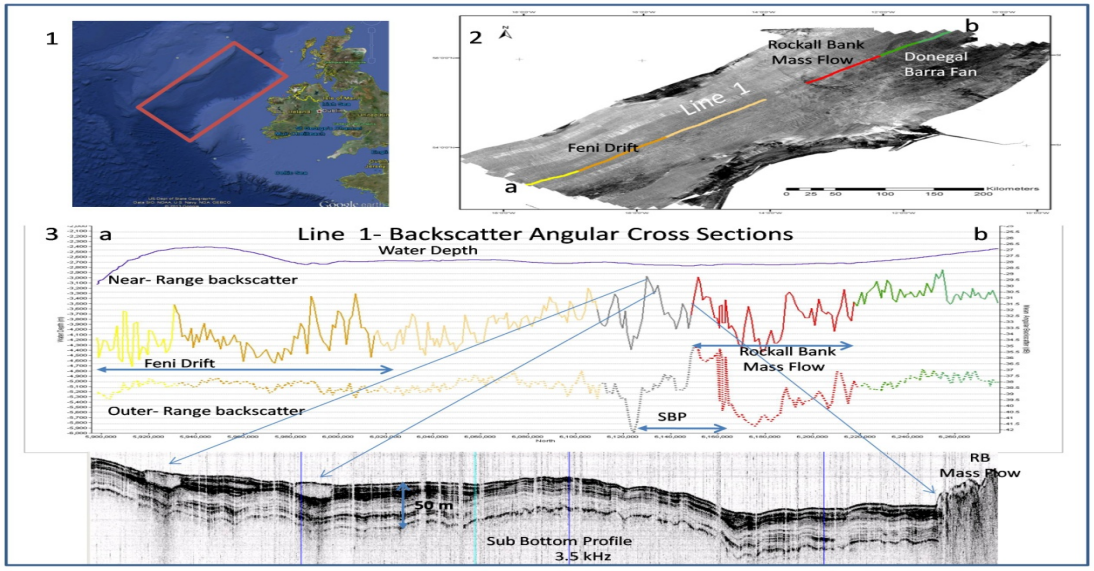

Figure. Panel 1. Index map of the study area. Panel 2. Backscatter mosaic showing position of line 1. Panel 3. Line 1 backscatter cross sections , including near-range and outer-range angular plots. Color intervals in the backscatter plots reflecting sub bottom echo facies. Bottom: shallow seismic record correlated showing change around the Rockall Bank Mass Flow region.

MAPPING NORTHERN CONTINENTAL SHELF OF RIO GRANDE DO NORTE STATE AND ASSOCIATED FORAMINIFERA HABITATS (AREIA BRANCA, NE BRAZIL, TROPICAL ATLANTIC).

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This study aims to evaluate the foraminiferal assemblages on the northern continental shelf adjacent to the city of Areia Branca (NE Brazil), see Figure 1. We intend to show data on seafloor geology and its habitat for marine microorganisms. Data set consist of satellite images, single beam bathymetry, and bottom sediments samples analyzed to grain size, mineralogy and microforaminifera (both living and dead specimens). Our results show that depth and sediment type are influencing the foraminifera species where inner continental shelf (up to 15m deep) present *Quinqueloculina lamarckiana*, *Q. patagonica, Bolivina striatula* and *Lagena striata* and mid continental shelf (15 to 25m deep) presents *Cornyuspyra involvens, Textularia earlandi*, *Pyrgo nasuta* and *Cibicides mckannai*. *Ammonia tepida*, *Elphidium poeyanum* and *Pseudononion atlanticum* are found in both inner and mid continental shelf. Presence of planctonic foraminifera indicates the proximity of outer shelf (25 -40m deep). Samples with the highest content of mud, organic matter and silt are habitat for *Cornuspira involvens, Cibicides mackannai, Quinqueloculina patagonica, Bolivina striatula, Elphidium poeyanum, Buliminella elegantissima* and *Fissurina laevigata* whereas *Quinqueloculina lamarckiana, Quinqueloculina patagonica, Textularia earlandi, Fissurina laevigata, Triloculina baldai, Pseudononion atlanticum, Cibicides variabilis, Cornuspira involvens, Ammonia tepida,* and *Pyrgo nasuta* inhabit sediments with medium mud and medium sand whereas.

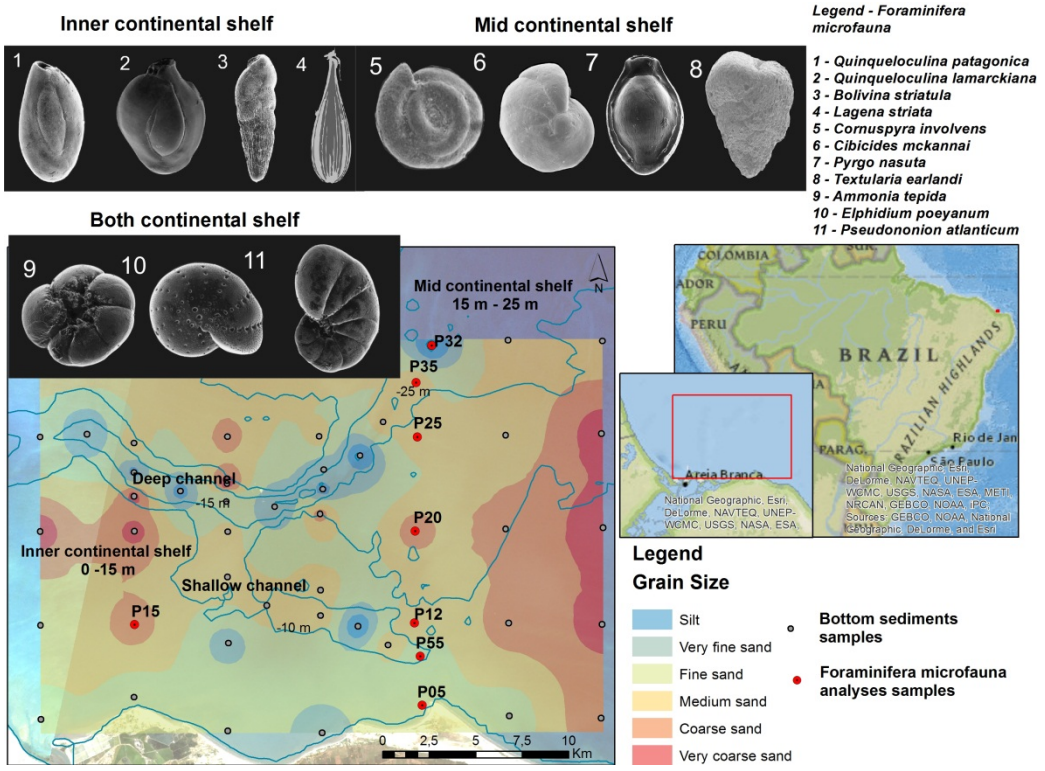

Figure 01. Microforaminifera assemblages associated with depth and sediment type on the northern continental shelf adjacent to the city of Areia Branca (NE Brazil).

(CAPES - Ciências do Mar 207-10; PRH22-ANP/MCT; CNPq; INCT AmbTropic/WG 2.1).

Using hydroacoustic methods to detect and map fibrous sediments

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A development and evaluation of using hydroacoustic methods to detect and map the horizontal and vertical distribution of polluted fibrous sediments is presented.

Many regions in Sweden experienced an industry between the late 19th and 20th Century that produced or contributed to the production of different kind of wooden products, such as pulp and particle boards. The process of manufacturing involved several steps where different types of chemicals, e,g., mercury and chlorinated compounds, were required. The factories were in most cases located in the direct vicinity to watercourses, and the wastewater was often discharged untreated into the streams. Beside the toxic substances, large amounts of fibrous material from the raw wood cultivation were discharged with the wastewater, and thus transported and accumulated in calm environments downstream. In some locations, these fibre accumulations contain immense amounts of contaminants and are considered as environmental risks since the uplift of land results in an increased exposure from waves and currents and thus an increased risk of resuspension of sediments containing contaminants. Furthermore, the fibrous accumulations generate large quantities of sediment gas and an anoxic seabed environment due to the degradation of the fibres.

Twenty-two areas along the coast of the Bothnian Sea in the county of Västernorrland, north eastern Sweden, have been tested and investigated with regards on hydroacoustic methods (sub-bottom profiler, seismics, multibeam, swathsonar and side scanning sonar) as well as ground truthing to fibrous sediments. The results show that accumulations of pure cellulose are possible to distinguish using a single or a combination of batymetrical and backscatter data from multibeam and swathsonar as well as penetrating data from sub-bottom profilers and seismics. The seabed here is often characterized by a rough surface and a large variation in acoustic reflectivity seen in bathymetrical and backscatter data, respectively. The presence of large quantities of methane gas causes heavy shallow absorptions, diffusions and attenuations of sound signals, particularly, in the frequency of sub-bottom profilers, as well as reversed soundwave reflections.

Pure cellulose deposits are usually found in the vicinity of the factory wastewater outlet. The content of fibrous material then decrease in the sediment with increasing distance from the source. Wooden chip and splinters diluted in postglacial clay gyttja are found in large areas around some industries and prove that factory discharge has been transported and spread by currents. This also indicates that conventional marine geological mapping using hydroacoustics and ground-truthing, which give knowledge of surface geology and sediment dynamics, facilitates and streamlines the mapping of polluted fibrous sediments.

High-resolution survey for Coralligenous habitat mapping applied to environmental assessment and management of a Marine Protected Area (Tavolara - Punta Coda Cavallo / NE Sardinia - Italy)

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[1] Area Marina Protetta "Tavolara – Punta Coda Cavallo" – Ministero dell'Ambiente
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[3] Andromede Oceanologie – Carnon (France)

Geomorphological and biological multidisciplinary habitat mapping investigations has been a result of the seabed survey of the Marine Protected Area (hereinafter AMP) of Tavolara carried out during the second half of 2011: very high resolution datasets came out from the use of both multibeam (Kongsberg-GeoSwath Plus 250 kHz) and side scan sonar (Klein 3900 – 445/900) equipment, together with videos and images made with ROV, towed camera and by divers up to -75 meters deep using closed circuit rebreathers. Now we can say that the geomorphological context of the AMP's seabed is extremely complex, including the limestone and dolomite submerged karstic landscape surrounding the Isle of Tavolara, rich in rockfalls, paleo wave cutting platform, isolated witness peaks (Pope's shoal), and the granite underwater scenery of Molara Island with residual Inselberg and Tor reliefs; conglomeratic sandstone beach-rocks are also presents at different deeps, the most important one was found at -55 meters deep. ROV survey and direct diving investigation has allowed the recognition and determination of coverage parameters for the main species which characterize the different hard surfaces' biocenosis: Coralligenous (C), Coralligenous deep (Cp), beach-rocks, granites and semi-dark caves (GSO), *Corallium rubrum*'s facies. *Paramuricea clavata*'s populations with algal concretions increase the formation placed at foot of the Pope's shoal presenting steps of bio-concretions up to 1 meter highness. Inselbergs' coralligenous has a lesser thickness, with a lower biodiversity than the deeper beach-rocks coralligenous which appears to be a biodiversity hotspot.
All the datasets produced have been analyzed in a GIS environment in order to facilitate the optimization of the multidisciplinary and multiscale interpretative different series; moreover, a 3D/4D GIS dedicated application has been developed to support the analysis of complex morpho-ecological processes, considering space (3D) and time (4D). The adoption of integrated geomorphologic and bionomics methodologies in order to define the presence and state of preservation of coralligenous is trusted to be a very important step to build the finest knowledge needed to implement successful management policies for the protection of the whole AMP's biodiversity.

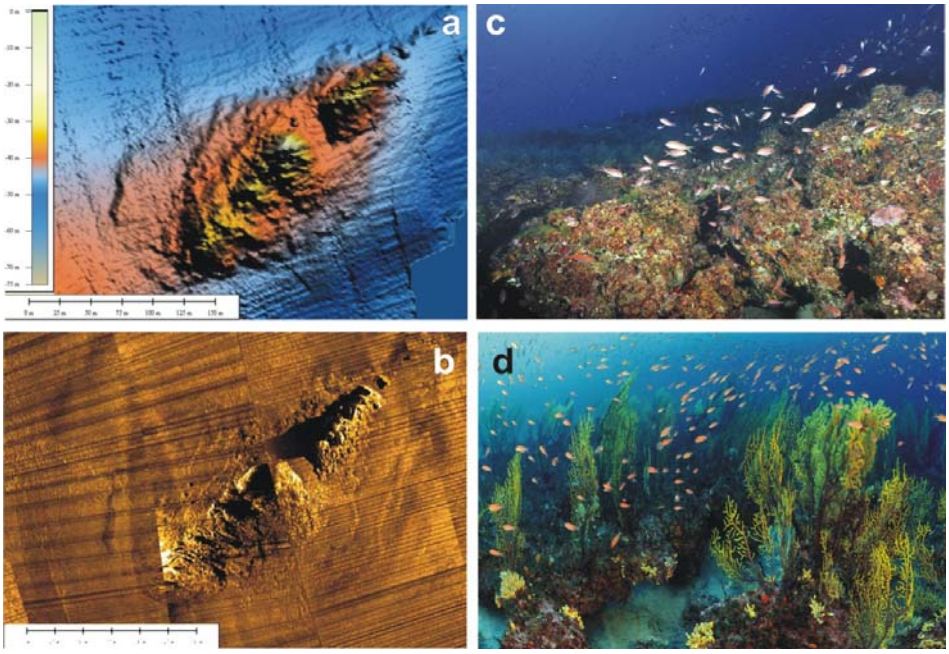

Figure 1: **a**) Shaded relief of the Pope's shoal from multibeam dataset; **b**) side scan sonar backscatter image of the same region; **c**) bio-concretion steps with *P. squamaria* and *L. pruvoti*; **d**) populations of *P. clavata* with algal concretions.

Shallow water multibeam data collected with a mid-water system. How well does it work?

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In 2012 we conducted a bathymetric survey in the Hauraki Gulf, immediately north of Auckland, New Zealand's largest city. The water depth in the survey area ranges from 25m to 150m, but for operational reasons we used our mid- to deep-water multibeam echosounder on RV *Tangaroa*, rather than a shallow water system. The Kongsberg EM302 used has a nominal frequency of 30 KHz. It has a 1°x2° beam opening, double-ping capability, and multiple soundings per beam (432 soundings on 288 beams), and is capable of soundings in water depths ranging from 10m to 7000m, but primarily designed for depth greater than 70m, and is widely used in off-shore deep-water surveys.

The survey lasted 17 days, with used swath coverage being between 3-4 times water depths (75m to 400m) in width, which is in the expected range for any water depth with this kind of system. The data was processed using both, CARIS HIPS for bathymetry and IFREMER's SonarScope for the backscatter, and we also post-processed the navigation and attitude data using Applanix POSPac software. The resulting bathymetry and backscatter data are of excellent quality and demonstrate the potential for a mid-water system in shallow water. Quality Assessment included standard hydrographic measures such as ping density, standard deviation, TPU, etc.

The data were collected as part of New Zealand's OS2020 program which aims to provide baseline data, including bathymetry and backscatter, to help developing a better understanding of New Zealand's marine realm, the fifth largest in the world. As part of this programme we developed a preliminary habitat classification map based on the supervised backscatter segmentation produced by SonarScope. The bathymetry data will also be included in an updated version of NIWA's published chart of the Hauraki Gulf, a data set widely used by interest groups for the marine planning in this area with its high population density and the resulting challenges.

Remote grain size analysis through backscatter data – implications from the southern Baltic Sea

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Mapping seafloor is potentially time consuming and expensive, and a lot of effort has been made by many to improve data acquisition techniques and shorten the time of marine survey. New tools derived to widen the use and benefit of Multi Beam Echo Sounders (MBES), includes backscatter mosaics and further analysis of backscatter response signals. In our study, the aim was to use the FM Geocoder tool along with backscatter mosaics from two different MBES, to evaluate its potential use as a grain-size determinator.

Acoustic backscatter mosaics were combined with Fledermaus Geocoder Toolbox (FMGT) V 7.3.0a software to derive Angular Range Analysis (ARA) and statistical parameters determination on datasets from a 3002D Multi beam echo sounder to investigate the mapping qualities of seafloor characteristics. The results were compared and verified with towed Side Scan Sonar mosaics, sediment sampling with grain size distribution analysis and drop camera imagery.

The field site used in this study, is situated in the southernmost part of the Baltic Sea within close proximity to the seashore on the northern shores of the Island Rugen, Germany. The geological setting consists of recent marine deposits, mainly fine silty sands, overlying older shoreline deposits. At the time of investigation, the site was used as a marine sediment extraction site for construction material. Older deposits have been exposed due to excavation and display a range of grain sizes, ranging from sand to the occasional medium sized boulders, cobbles and pebbles.

Results show that the mosaics can be used to map the majority of the grain sizes within the field area. Statistical outputs, indicate areas with strong variation in grain size. However, despite a relatively high density survey, comparative backscatter analysis could not outweigh important geological information achieved by the towed Side Scan Sonar with regards to detail, I e rough seafloor and areas with very coarse material.

Benthic Habitat Mapping at Hudson Canyon head by integrated analysis of acoustic and groundtruth data: insights for the definition of approaches and methodologies

Pierdomenico M.[1], Martorelli E.[2], Guida V.[3], Macelloni L.[4] & Chiocci F.L.[1-2]

1) Sapienza University of Rome, Italy; 2) CNR IGAG, Italy; 3) NOAA NMFS, Northeast Fisheries Science Center, USA; 4) University of Mississippi, USA

In the last decades habitat mapping has become an important tool for the management of the marine environment, since managing human impact and exploitation on ecosystems requires the identification and mapping of natural regions over a range of different scales. Nowadays, various strategies and methods are used to produce benthic habitat maps, involving the integration of different datasets. Apart from large-scale and very small-scale studies (the former usually combine only environmental physical data layers and the latter are often accomplished only by ROV dives), habitat mapping is mainly performed through the analysis of geophysical data coupled with seafloor sampling and ROV videos. Integrated analysis of data is a crucial step in the process of habitat mapping, as the classification of habitats and their distribution are highly dependent on the approach used in this phase. Among the wide range of methods currently adopted, two main approaches can be distinguished: 1) the top-down approach, by far the most widely used, is mainly developed from the seafloor map production within the field of marine geology, with biological information subsequently incorporated from groundtruth data. Conversely, the bottom-up approach first examines benthic assemblages and then establishes statistical relationships with environmental data layers to delineate habitats. Although the latter is a more sophisticated and objective mapping approach, it requires much more efforts in terms of data acquisition and analysis, and at present is still poorly adopted. We present a case study of benthic habitat mapping of the upper reach of the Hudson Canyon (~160 km off New York, US) by integrated analysis of acoustic and groundtruth data. Acoustic mapping, performed using AUV-mounted multibeam sonar, provided ultra-high resolution bathymetric and backscatter imagery (3m and 1m respectively) between 80 and 700 m water depth, for identification of geomorphological features and for the characterization of seafloor sediments. Identification of benthic and demersal communities was accomplished by visual groundtruthing with underwater vehicle video and still cameras. CTD-rosette sampler provided water column salinity-temperature profiles and water samples for dissolved methane analysis. The distribution of habitats was primarily inferred from geophysical data characteristics. Comparison of backscatter imagery with ground truth data enabled validation of acoustic classification of the seafloor, allowing to define morpho-acoustic classes corresponding to as many habitats and to extend the results over larger areas. When observed habitats did not match the preliminary geophysical classification of the seafloor, data interpretation was refined considering information from morphological and ROV data; this last information was used as the most significant parameter to define habitat types in a consistent way with the observed pattern in macrofaunal assemblages. Analysis of data revealed a complex of topographic structures that provide a wide range of physical habitats in a relatively small area. Habitats encompasses mosaic of sandy and muddy substrates, gravel beds, pockmark fields, rock and semilithified clay outcrops that host rich and varied faunal assemblages including deepwater coral and sponge communities, supporting the interest for the area as biodiversity hotspot that may contribute to sustain the regional fishery. The strategy used in this study cannot be considered a strictly top-down or bottom-up approach, however it enhances the subjective critical interpretation of the data to delineate habitats, solving some of limitations that can arise from these methods. We suggest that a top-down approach is effective in delineating pattern in environmental conditions that are likely to host different communities, also allowing to optimize the groundtruth planning; however a bottom-up approach should then be used to distinguish ecological meaningful boundaries in the geophysical data layers. Moreover, interpretation of results and additional information such as oceanographic components, can clarify misleading interpretation of geophysical data.

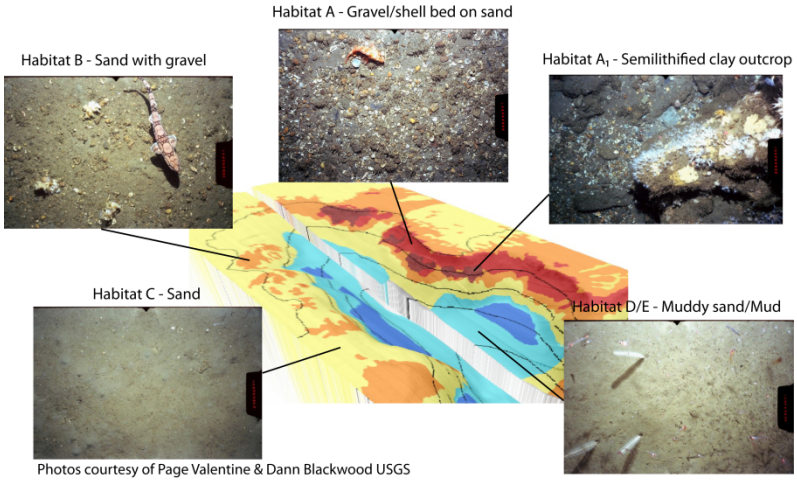

Fig.1 Habitat distribution at the upper reach of Hudson Canyon.

MORPHOLOGY OF THE SUBMERGED REEFS OF BARREIRINHAS (NE BRAZIL) AND ASSOCIATED BENTHIC BIODIVERSITY

Guilherme Cherem Schwarz Pierri[1]; Guido Grimaldi[2]; Helenice Vital[3]; Tatiana Silva Leite[4]

Federal University of Rio Grande do Norte [1,2,3,4], Postgraduate Programme in Geodynamic and Geophysics [1,3]. Postgraduate Programme in Ecology [2,4] Department of Geology/CNPq Researcher [3] Department of Oceanography and Limnology [4].

Some efforts are current apply by the Brazilian government to promote the marine sciences, looking for the knowledge of their marine natural resources, as well to ensuring the rights to use its territorial sea. This work is part of a research conducted in the Federal University of Rio Grande do Norte by the Laboratory of Marine Geology and Geophysics and Environmental Monitoring (GGEMMA) and Laboratory of Benthos and Cephalopoda (LABECE). The main aim, of this research is mapping the reefs of the continental shelf of Rio Grande do Norte State (RN), Northeast Brazil. Seabed morphology and backscatter texture were mapped in a tropical marine area known as submerged reefs of Barreirinhas, located south from Natal, the capital of RN. High resolution hydroacoustic techniques (mono and multibeam echo sounders, side-scan sonar), associated with sediment sampling and ecological methods were used to evaluate the benthic biodiversity and in a smaller scale the analysis of structural complexity of the reef. A better understanding of how the biological community is structured and how the abiotic and biotic characteristics of the system are interrelated is the main result expected. The results show that the reefs distant about 4 nautical miles from the coast are submerged to a depth of 13 to 16 meters, with a length up to of 1000 m and 150 m wide. The reef is elongated parallel to the current coastline and presents a complex visual topography with a live benthic coverage predominantly dominated by seaweeds (macroalgae) and sponges (porifera), and in lower proportion by corals. There is an important record of lobsters sea turtles and molluscs encountered in the area. The combination of seabed physical attributes assists in identifying suitable habitats to develop certain benthic communities. The study group will continue working to understand the oceanographic processes and other biotic and abiotic factors that regulate the biodiversity associated with seafloor features of Barreirinhas reef and furthermore some close reef areas, with similar or diverse characteristics.

(CAPES - Ciências do Mar 207-10; PRH22-ANP/MCT; PLAT N-NE_Rede05/FINEP/CTPETRO, CNPq; INCT AmbTropic/WG 2.1).

Seabed mapping in a mixed carbonate-siliciclastic Eastern Adriatic shelf using a quantitative split-beam echo sounder

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Acoustic methods are widely used for numerous and various seabed investigations. Data collection using acoustic methods are non-invasive and less time-consuming comparing to traditional seafloor data collection. Topography and seabed material influences bottom habitats, fish distribution and behaviour. For this reason, acquiring both, fish and seafloor acoustic data simultaneously is very efficient, because the same instrument is used.

This investigation aimed to test the usefulness of acoustic signals from gently sloping part of the eastern Adriatic seafloor (off the western Istrian coast within 20-50 m depth) with heterogeneous grain size and mineral composition. Differences in sediment structure (mineral composition, grain size, orientation and structural arrangement of particles, organic matter and pore fluid content) produce sediments of various physical properties. These properties (bulk density and porosity), in turn, control acoustic behaviour of sediment.

The acoustic data were collected at the frequency of 38 kHz within PELMON Project during regular annual (2009) acoustic survey on small pelagic fish. Investigated area is part of the eastern Adriatic shelf, covered by mixture of carbonate and siliclastic, recent and subrecent (relict), as well as mixture of biogenic and terrigenous sedimentary material. The bottom survey locations are influenced by modern and palaeo-Po River sediment supply, in which generally, two sedimentary regions could be distinguished. Fine-grained (muddy) sediments, belonging to the modern Po muddy prodelta cover W-NW part. In the E-SE part relict coarse-grained (sandy) sediments dominate, reflecting terrestrial and coastal sedimentation on the alluvial plain during Pleistocene and minimal recent particle supply from the Istrian karstic coastal zone. In this zone *in situ* biogenic carbonate production occurs. The area between these two sedimentation zones is transitional area, veneered by mixtures of fine-grained and coarse-grained sediments in various proportions.

Acoustic data were collected on the board of R/V *Bios Dva* using SIMRAD EK60 split-beam scientific echosounder with calibrated hull-mounted SIMRAD ES38B transducer. Echoview® post-processing software was used for data calibration, integration and extraction. Elementary distance sampling unit (ESDU) of 0.25 NM has been used to average acoustics data collected within cells bordered by sounder-detected sea bottom line and corresponding sea bottom -0.5 m linear offset line. Mean volume backscattering coefficient (S_V mean) was calculated for each cell. The seabed sediment data were ground-truthed by 38 grab samples, additionally used for seabed echoes classification.

Obtained acoustic data have revealed differences correlated with sediment mean grain size to a significant extent. Mud-dominated western part have revealed weaker backscattering strength (-17 to -26 dB). Sand-dominated eastern part had greater S_V values (-8 to -11 dB). A higher backscattering coefficient in sandy area is related to an increased mean diameter, which is, in turn, related to higher bulk density (and lower porosity) of the sand compared to mud. A higher sediment density results in greater backscattering strength. In the transitional zone (muddy sand and sandy mud) between these two areas a transitional backscattering coefficient (-9 to -16 dB) was obtained, related to a bimodal distribution of sediment grain size.

Spatial distribution of S_V values has displayed a strong similarity with existing seabed sediment textural maps. This allows us to use acoustic data collected by scientific echosounder at 38 kHz as suitable for seabed characterization in geology, ecology and fishery studies despite of highly mixed nature of sediment.

GEOLOGICAL HABITAT MAPPING FOR COASTAL GEOHAZARD MANAGEMENT COUPLING TERRESTRIAL AND MARINE DATASETS IN THE NW AREA OF MALTA

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Coastal hazard management is an increasingly topical issue involving scientists and stakeholders trying to define the best procedures to face risks and increase community resilience, either reducing natural hazards or diminishing vulnerability. Coastal environments are particularly sensitive and susceptible to relevant damages in case of both sudden events (e.g., tsunamis, landslides, storm surges) and long-term processes (e.g., sea-level changes). One of the fundamental issue to give an assessment of the coastal geohazards is to provide a combined and continuous map of terrestrial and marine environment.

The aim of this research is to analyze geomorphological ad geological features, coupling terrestrial and marine datasets, to give a complete map of the coastal areas located NW of Malta.

We will outline the geomorphology of the NW coast of the Island of Malta (Sicily Channel) since the Last Glacial Maximum, to better understand the kinematics of active processes along the shoreline, such as landslides, through the correlation between emerged and submerged features.

The University of Modena and Reggio Emilia (UNIMORE) is working, since 2006, on the coastal landslides located along the NW coast of the Island of Malta (Sicily Channel). The researches carried out showed how these landslides are likely to extend well below the sea level; moreover, the Maltese archipelago has been subject to significant changes in sea level since the Last Glacial Maximum, when the sea level was some 120-130 metres lower than present. Therefore coupling subaerial and submarine datasets is likely to provide useful information for hazard assessment in these areas. For this reason, marine datasets were recently acquired thanks to a collaboration between UNIMORE, CNR-ISMAR of Bologna and CNR-IRPI of Padova. High resolution bathymetric and backscatter data offshore the NW coast of the Island of Malta have been processed in order to perform geomorphological and geological analyses of the seafloor.

The methods used imply: 1) processing bathymetric and backscatter data using CARIS HIPS and SIPS 7.1; 2) perform morphometric and backscatter analysis; 3) produce a joined geomorphological map of marine and terrestrial environment; 4) analyze coastal processes and outline the geomorphological evolution of shorelines through time.

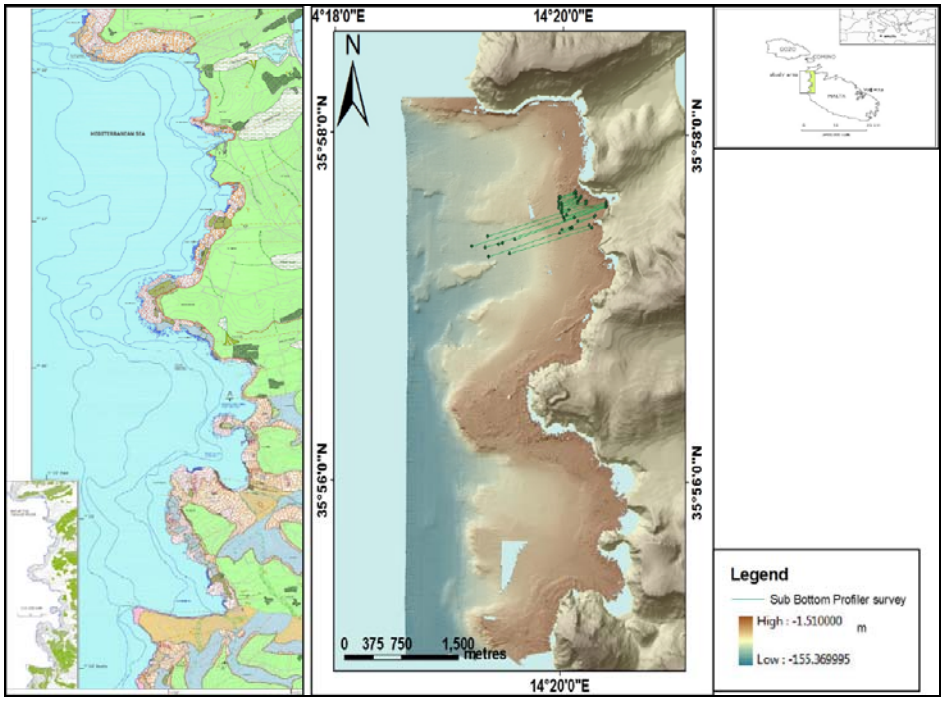

Figure 1. On the right top, the geographical setting of the Maltese archipelago. Overview of the terrestrial (on the left; Devoto et al., 2012) and marine (on the right) datasets along and offshore the NW coast of the Island of Malta and legend of the bathymetric data (on the right bottom).

Devoto S., Biolchi S., Bruschi V.M., Furlani S., Mantovani M., Piacentini D., Pasuto A. e Soldati M. (2012). *Geomorphological map of the NW Coast of the Island of Malta (Mediterranean Sea)*. Journal of Maps, 8(1), 33-40.

CATAMI (Collaborative and Annotation Tools for the Analysis of Marine Imagery and video) – Unlocking the potential of marine imagery

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** Presenter not author*

Underwater raw imagery is used to create quantitative information about the marine habitat and analysis of this information currently requires substantial effort by human experts. Manual processing of the high volume of marine imagery being collected is unsustainable. At the same time, taxonomic expertise remains limited. In addition, there is a lack of standardised approaches to the methodology, annotation, classification and analysis of this imagery. To help solve these issues, the CATAMI project in Australia are developing online tools that allow organisations to collaborate with each other by uploading, sub-setting, annotating, classifying and downloading imagery. We anticipate that this project will support researchers to improve science outcomes and lead to cost-savings for both researchers and organisations.

We have also released a CATAMI classification scheme, which has been adopted by a range of organisations and will assist in aggregating data from across Australia (http://catami-australia.blogspot.com.au/2013/02/release-of-catami-classification-scheme.html). We have an active user base with participation from major Federal (Australian Institute of Marine Science, CSIRO, Geoscience Australia, Australian Antarctic Division, NERP) and State Government (WA Department of Environment and Conservation, NSW Department of Primary Industries) research agencies, as well as major universities (University of Western Australia, University of Tasmania, University of Sydney). For further information please review our blog and YouTube channel:

- http://catami-australia.blogspot.com.au/
- https://www.youtube.com/user/CATAMIAustralia

For code and documentation visit:

- http://catami.github.com/

This project includes development funded by the Australian National Data Service (ANDS, http://ands.org.au) and the National eResearch Collaboration Tools and Resources (NeCTAR, http://nectar.org.au). ANDS is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy Program and the Education Investment Fund (EIF) Super Science Initiative. NeCTAR is an Australian Government project conducted as part of the Super Science initiative and financed by the Education Investment Fund. The University of Melbourne has been appointed the lead agent by the Commonwealth of Australia, Department of Industry, Innovation, Science, Research and Tertiary Education.

Underwater photogrammetry: an integrative method for mapping marine seagrasses on seafloor

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Seagrasses are of vital importance in coastal marine ecosystems. They play an important functional role by ensuring two important mechanisms: sediments can be stabilized and removed from water column and nutrients are filtrated from runoff sources. Seagrass beds can also be considered ecological indicators of marine ecosystem quality. Acoustic methods (Side Scan Sonar and Multibeam Sonar) are commonly used for mapping seagrass meadows, allowing defining extent and typology with a certain precision. However, these methods have some limitations due to the correct interpretation of acoustic signals that sometimes cannot be guaranteed. It is worth noting that the photographic and video techniques are also used in a variety of marine applications: in particular, video and photo image techniques are directly applicable to monitor seagrass beds. The aim of this work is to present a simple and integrative procedure for seafloor habitat mapping: Underwater Photogrammetric Methodology (UPM). The UPM needs of a vertical georeferenced video recording survey, carried out at a constant speed and a constant distance from the bottom. This paper compares different commercial and free image auto stitching software in order to show the processing of videos and photo frames. Finally, the paper takes into account different parameters related to photomosaics developed (e.g. cover percentage, continuity, proximity), to synthesize the information available.
The results obtained show that the proposed technique is cost saving, practical and efficient; in fact, the software photomosaic applied for the development of this technique, can be also used to improve the interpretation of the acoustic signals for echosounders methods.

The Quaternary development as a trigger for the distribution of habitats in the North Sea and the Baltic Seas

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Maps of habitat distribution in marine environments, derived from hydroacoustic datasets, are essential to assess the ecological value of the seabed. In this context, the geological evolution of a sea floor is of outstanding importance, as it serves as a boundary condition controlling the spatial distribution and partly the stability of geo-habitats. However, a different geological and morphological evolution of a marine environment determines different distribution patterns of sediments as well as variations of morphodynamic and hydrodynamic conditions. Surveys, employing hydroacoustic systems (multibeam echosounder (only coastal waters), side-scan sonar, sediment classification systems) supplemented by groundtruthing, were carried out to investigate the sea floor. We collected comprehensive datasets on sediment distribution patterns and sedimentary texture in the North- and Baltic Sea, which are strongly linked to habitat structures and the distribution of benthic communities.*

A comparison of the tide-dominated North Sea with the non-tidal Baltic Sea provides a good example to elucidate the importance of different geological histories for resulting habitat distributions. Of particular interest for the present habitat distribution in both areas and especially for their comparison is the development since the middle and late Pleistocene. In this time period the North and Baltic Seas underwent substantial differences in ice sheet coverage, as the Saalian Ice sheet covered the area of today's Baltic Sea and the whole German Bight, whereas the ice sheet of the Weichselian glaciations did not reach the area of the southwestern and southern North Sea. Hence, morainic material of Weichselian age is limited to the Baltic Sea. During the Weichselian, periglacial conditions prevailed in the North Sea area. The recent overlying Holocene sedimentary sequence consists of large scale areas of fine- to medium-grained marine sands formed during the end of the last glacial period and reworked Pleistocene material also containing coarser sand fractions. Late Tertiary Kaolonitic sand was appears locally close to the surface (Sylt Outer Reef) and was reworked during the course of the following transgressional phases. Partly the North Sea area is characterised by sandy material of melt water deposits originating from the Weichselian ice sheet located eastwards. The rivers Ems, Weser, Eider and Elbe formed a glacial spillway draining into the North Sea basin. This ancient spillway, forming a geomorphological depression, is filled with fine-grained Holocene sediments to date.

Generally, the rather shallow southern North Sea shows no distinctive morphological variation. Reworking processes of glacial deposits have progressed far more than in the Baltic Sea and as an important difference a fine-grained belt of mud flats developed in the peripheral regions as a consequence of the Holocene transgression. Additionally, there is a lack of significant abrasion platforms in the North Sea as they can be found in parts of the southern Baltic Sea (e.g. Kiel Bay, Mecklenburg Bay and Danish waters). In contrast to the sedimentological and morphological conditions in the North Sea area, the Baltic Sea is characterised by numerous sills and basins originating from the last glacial period with a comparatively large relief. The basins function as sinks for fine-grained sediments (silt and clay), whilst sandy material is deposited in shallower areas, which leads to a very patchy and heterogeneous distribution pattern. There are major morphological differences which provide very dissimilar framework conditions for the differentiation of geo-habitats. The Baltic Sea developed a wide range of sub-habitats interlocked at the small-scale, whereas the North Sea exhibits larger scale habitat distribution patterns.

*Data result from the projects: a) Full coverage sediment mapping in the North- and Baltic Sea by applying different hydroacoustic systems. Cooperation with the Federal Maritime and Hydrographic Agency (BSH). b) Compilation of marine Habitats in the Baltic Sea. Cooperation with State Agency for Agriculture, Environment and Rural Areas Schleswig-Holstein (LLUR)

Internal and external validation of predictive habitat maps: Why we need independent data even if it is deep, and tricky to obtain

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In the deep-sea, data collection is prohibitively expensive and as such data remain sparse. Faunal data is particularly time consuming to collect, and as a result regularly suffers from small spatial coverage. A bottom-up approach is often employed whereby relationships between the observed fauna and environmental variables acquired via acoustics mapping techniques are used to produce full coverage biotope maps. Many statistical techniques are being developed, but as data is limited, opportunities for an external validation process with independent data are rare. In this study, predictive habitat modelling approaches (Redundancy analysis, MaxEnt and Random Forest) were applied to a highly heterogeneous section of Rockall Bank (100-350 m in depth), Northeast Atlantic. The predictive maps were based on 8 km of remotely operated vehicle (ROV) imagery transects, 37 km^2 of sidescan backscatter maps and 380 km^2 of ship-based multi beam bathymetry collected during the 2011 JC-060 cruise. In 2012, a section was revisited and two additional ROV imagery transects (1 km) were collected. Three very different maps were obtained with each approach weighting more strongly environmental variables varying over specific spatial scales. Internal validation processes showed similar fair performances, with error rates of ~30%. However, the external validation process (contingency tables, kappa statistics and area under the curve (AUC)) all clearly demonstrated that the approaches considered were unable to adequately capture the spatial variation observed. Possible explanations for these discrepancies may include (1) different vehicle systems causing differences in observed fauna and leading to relative positioning errors or (2) the very fine scale variation in sediment composition, found to greatly affect variation explained, was not adequately captured by the environmental variables considered. Research into other potential explanations is still on-going, but the present results suggest that independent data collection for external validation is critical to ensure the usefulness of the products created. Our research highlights the fact that, although it is repeatedly mentioned as a crucial step in model assessment, external validation is still infrequently carried out in the deep-sea.

Constrains and limitations of multibeam echosounders Backscatter Strength measurements for monitoring the seabed. Surveyor and geologist point of view

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An obligation for regular monitoring programs, to evaluate and follow the environmental status and impact of human activities on the marine environment, will be established in a near future in the European Union ("Marine Strategy Framework Directive" - Directive 2008/56/EC, Official Journal of the EU, 25.6.2008). Coastal waters, including the seabed and subsoil, are an integral part of the marine environment and will be covered by this Directive.

Due to their ability to provide simultaneously the bathymetry and the acoustic image of the seabed - reflecting the nature of the sediment - high frequency multibeam echosounder systems are certainly the most effective tools to monitor the seabed habitats in very shallow waters. The quality of a time-series data set depends on the internal variance of the measurement system. In a monitored area, variations of the bathymetry and modifications of the nature of the seabed are revealed by comparing successive digital terrain models and seabed images - "mosaics" derived from the validated soundings and the BS (backscatter strength) values. The detection of significant changes (in m or in dB) can be effective only under two conditions: a stable and reliable measurement system and a thorough knowledge of the confidence level of each measurement. The control of the parameters affecting the quality and the reproducibility of the bathymetrical measurements are well known and the IHO standards provide a clear framework for assessing the quality level of the soundings. Currently, despite the ever-increasing use of BS data from multibeam systems, there is no a formal quality level scale (as IHO standards) for the BS and consenquently, no level of reliability of the dB values can be defined for the final mosaics.

In order to use the BS for monitoring changes in the nature of the seabed, external potential sources of variation must be first clarified by the surveyor – geologist. On board: antenna state, absorption coefficient, navigation orientation… In office: post processing software.

The aim of our "surveyor-geologist" contribution is to present some quantifications of these main external sources of variation of BS that we have been identified during 10 years of measurements with the Kongsberg EM1002 and later with the EM3002D and EM2040 multibeam echosounders on the very shallow sand extraction areas on the tidal sandbanks of the Belgian continental shelf. According to our data, with a good control on external parameters and a standard post processing procedure, 0.3 dB can be considered as an indicative value of the std associated with the average of the BS measurements of the same area within a short period (one tide cycle). However, high ΔdB values from one post-processing software to another restricts dramatically the quantitative acoustic characterization of the seabed and the comparison and exchange of processed BS data between geoscientists.

To allow a rigorous use of multibeam echosounder BS data, several improvements should be developed as soon as possible by the scientific community together with hardware and software companies:

- define quality standards for BS measurements and tools to evaluate on board the quality level of the BS measurement?
- define a standardisation in the post-processing software to allow exchange of processed BS data in dB level between geoscientists?

Predictive modelling of aquatic vegetation in Baltic Sea

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Protection of endangered species and habitats through a network of marine protected areas (MPA's) is a common goal for the UN Convention on Biological Diversity and EU directives, such as Habitats Directive and Marine Strategy Framework Directive. To achieve this goal a large amount of data on marine species and habitats is needed and modeling approach is best way to get the general knowledge.

The Finnish Inventory Programme for the Underwater Marine Environment (VELMU) collects data on marine geology and biology. This data is used e.g. in modelling distributions of key species, communities and bottom habitats that require protection under the Habitats Directive. Under the VELMU framework, the EU Life+ project FINMARINET has in 2010-2013 investigated also the sufficiency of the current Natura 2000 network. FINMARINET focuses on six geologically and biologically different areas along the Finnish coastline ranging from the low-saline Bay of Bothnia through the fragmented Archipelago Sea to the Gulf of Finland. The results obtained are the first to cover large coastal areas and a large number of species in Finland.

We present results on inventories and modelling of aquatic plants and macroalgae in different FINMARINET areas. Presence-only predictive modeling software Maxent was used to model species and communities distribution. The most important variables influencing distributions were depth, exposure, salinity, temperature and total phosphorus and nitrogen. Models were validated using 5-fold cross validation, and the accuracy of the model was evaluated using AUC-value and true skill statistic (TSS). Pros and cons of such a modelling approach, and the potential use of the results in development of the Finnish MPA network, are discussed.

SPATIAL VARIATION OF MARINE LANDSCAPES ABIOTIC COMPONENTS IN THE EASTERN GULF OF FINLAND (BALTIC SEA)

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In the frame of TOPCONs project (Transboundary tool for spatial planning and conservation of the Gulf of Finland) of ENPI Program and RFBR project “Structure and response of subaqual landscapes of the Baltic Sea to natural and anthropogenic influences” (11-05-01093) an interdisciplinary research of submarine landscapes within the three key-areas of the eastern Gulf of Finland was undertaken. Multibeam and backscatter survey, repeated side-scan sonar profiling, submarine video observations and sediment sampling were used for geological study of the sea bottom. The key-areas are characterized by high geodiversity of sea bottom, different salinity gradient and variable bottom hydrodynamics.

Gulf bottom of the key-area located in the Vyborg Bay (north-western part of Russian Gulf of Finland waters) is characterized by the very high geodiversity (from very shallow moraine ridges, covered by boulders to relatively deep troughs filled by silty-clayey mud). A special attention was focused here on the processes of the Fe-Mn concretion regeneration after submarine extraction in 2006-2008.

Along the northern coast of the Gulf there were established constant (static) and dynamic elements of the relief in macro-, meso- and microscale, including submarine terraces, erosion runnels and channels, sand waves, ripples and megaripples at the different bottom depth up to 9 m. There have been hypothesized the role of multiply spatial ecotones specified by geological processes in the formation of biotic components of underwater landscapes.

Within the steep submarine coastal slope of Kurgalsky Peninsula series of landslides were found using multibeam and low frequency acoustic data. The submarine ridge surface is covered here by large boulders with special benthic community, while in the deep (20-25 m) depression near the slope base, silty-clayey mud is accumulated. Recent development of the sedimentation basin is characterized by alternation of oxic and anoxic conditions.

The other interesting features of the marine landscapes of the eastern Gulf of Finland are several areas of pockmarks occurrence. Pockmarks diameter is up to 15-20 m, relative depth – 1-2 m. Widespreading of these structures can be an indicator of periodic active gas and (or) fluids seepage from sediments to near-bottom waters. One type of gas craters are located around the Gogland Island in the sedimentation basins filled by marine Holocene mud. Genesis of this type of pockmarks most probably cause by active recent transformation of organic matter of mud by microbiological processes and formation of big amount of gas (methane and hydrogen sulphide). The other type of pockmarks is observed at the bottom covered by lacustrine-glacial clays (Vyborg and Koporsky bays). Side-scan sonar profiling undertaken by VSEGEI in 2012 allowed to find 72 pockmarks of different size and “age” (relict, not active, active) within relatively small area. Morphology of pockmarks indicates pulsating character of the fluid emission. In Koporsky Bay pockmark field is situated within the area of tectonic fracture zone and underground water discharge. Significant difference in geological structure within areas of pockmarks occurrence allows to suppose polygenic nature of pockmarks in the eastern Gulf of Finland.

The role of habitat mapping in deep-sea ecosystem-based management: an Ionian Sea (Mediterranean) case study

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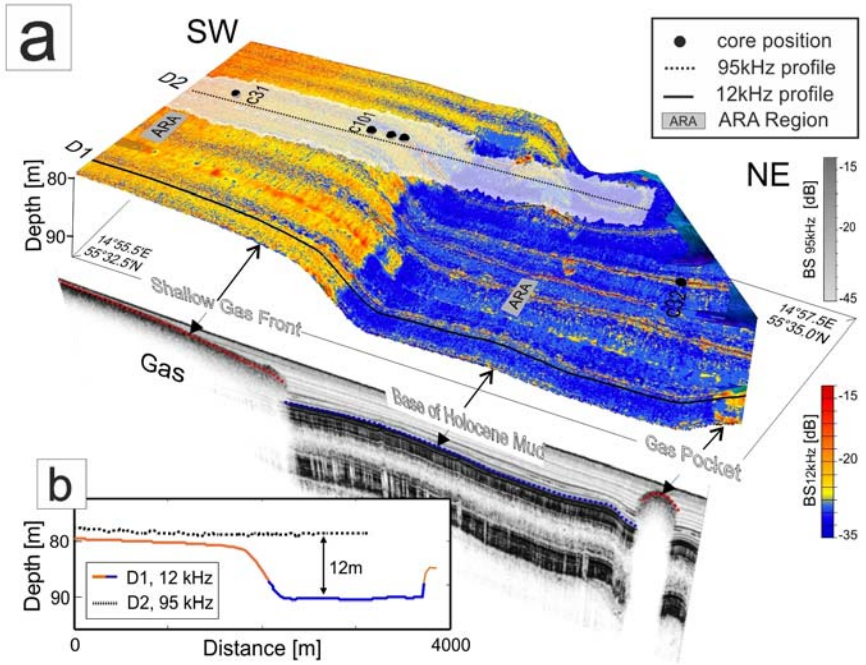
The growing need for better spatial management of our marine environment has strongly increased awareness regarding the importance of deep oceans as natural resources. The management and conservation of such offshore resources requires a synthesis of spatial data for the distribution and intensity of human activities, as well as the overlap of their impacts on marine ecosystems.

Our work made use of a set of data obtained from ship-based research surveys collected within the northern Ionian Sea, in a Cold-Water Coral (CWC) province that was found to be a remarkable biodiversity hotspot for the entire Mediterranean Sea. Seafloor mapping, video inspections, and previous results from sediment samples were integrated in order to investigate the relationships between acoustic facies and benthic habitats on a variety of spatial scales. In particular, the collected data was analyzed and interpreted using proper GIS-based tools in order to: 1) Map and model the distribution of deep-sea benthic habitats on the northern Ionian Margin, with an emphasis on the recognition of Vulnerable Marine Ecosystems (VME, i.e.: CWC habitats); 2) Map and classify anthropogenic threats that were identifiable in the examined data and investigate their relationship to the mapped distribution of VMEs and seafloor geomorphology. Our results sought to contribute to the development of proper methodologies for assessing the distribution of deep-sea benthic habitats and the potential impact of human pressures on these areas within the Mediterranean Sea.

A low frequency multibeam assessment: subbottom mapping of shallow gas by enhanced penetration and angular response anomaly

Schneider v. Deimling, Wilhelm Weinrebe, GEOMAR, Germany



*(**a**) Backscatter chart of EM120 (12 kHz, colored) and 95 kHz (grey, transparent) both draped onto their respective bathymetric grids. Strong variations in backscatter and bathymetry occur in the 12 kHz data with high backscattering strength values (BS) to the left (red, gas) and low ones (blue, no gas) to the right part of the figure. This corresponds to the underlying subbottom findings visible in the vertical curtain image. The 95 kHz data (grey surface) plots on top of the 12 kHz surface and shows neither amplitude nor bathymetric changes across- or alongtrack (**b**) Depth profiles D1 and D2 gathered from 12 kHz and 95 kHz bathymetric grids. Depth differences of up to 12 m occur between both data.*
(submitted to Marine & Petroleum Geology, 2012)

Kongsberg and ELAC multibeam systems (EM120, EM1002, SB3050) of low to medium frequencies between 12-50 kHz and various subbottom profilers were used to analyze the seafloor of the Baltic Sea between twenty and one hundred meter water depth. The working areas are characterized by soft mud allowing for significant acoustic penetration even at 50 kHz. Locally, shallow gas was found transforming the low-reflectivity mud acoustically into a strong volume scatterer. Single beam subbottom profiles across these shallow gas areas show distinct blanking effects between one and five meters below the seafloor. We demonstrate that low frequency multibeam systems are ideally suited to map those shallow gas areas over the entire swath of 140°. First the depth of the working areas was successfully determined with the shallow to mid-water 95kHz multibeam system. No backscatter anomaly was found while crossing the transition zone between mud and gas-bearing mud. In contrast a 12kHz survey over the same location reveals several meters deeper soundings. The resulting bathymetric data mimics the subbottom morphology of a till structure rather than the seafloor. The reason is strong penetration into the mud up to ten meters. Obviously low frequency multibeam echosounders are prone to subbottom mapping of strong reflectors within very soft sediments, which is a common geological setting in the marine environment. High scattering gas bubbles embedded in the mud could be mapped by backscatter anomalies. Angular backscattering strength analysis suggests distinct differences between gassy and non-gassy areas and demonstrates the sensitivity of the low frequency multibeam sounder on free gas even on the very outer beams of the swath. Even small gas pockets of only a few meters extension can be resolved. The data were groundtruthed by subbottom profiling and geochemical sampling both indicating free gas.
We conclude that the MBES together with subbottom profiling can be used as an efficient tool for spatial subbottom mapping of high scatterers hosted in soft sediment environments.

A machine-learning system for the automated detection of megafauna and its applicability to unseen footage

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The need for extensive analysis of the growing amount of oceanic image data, calls for computational approaches to assist and guide the field experts (biologists, geologists) in their work. One such automated approach is the machine-learning based system *iSIS* (intelligent Screening of Image Series). *iSIS* aims at detecting arbitrary types of megafauna, as well as their traces, in benthic images. It was trained on a set of 70 images, taken at the deep-sea observatory HAUSGARTEN.
Initial steps in the development of *iSIS* showed the principal necessity to homogenize the images of a transect, regarding illumination and color distribution. Thus, a pre-processing was installed that removed the illumination cone out of every image as well as equalized the histograms of each image to create comparability across the whole transect.
From those pre-processed images, a high dimensional set of MPEG7 and Gabor features were extracted. The feature vectors were then used to train Support Vector Machines for each type of megafauna individually. Recently we reported final detection results by means of precision and recall of 0.67 and 0.87 respectively.
Here we present first results from an application of *iSIS* to data from different years and/or stations. We discuss the chances and limitations and the computational methods involved. The results show the general applicability of a trained *iSIS* system to new image data, which has not been considered in the system design and parameterization. The applicability is conditioned by relatively stable camera distance and illumination properties (see Figure 1).
We were able to computationally remove some differences within the unseen footage, based on the pre-processing, developed for the training of the machine-learning algorithms. Nevertheless *iSIS* was still significantly dependent on the color properties. In some transect data, we had to neglect up to 80% of he images because of a too strong variation in camera-object distance.
As the distance of the camera to the seafloor affected the color and illumination significantly, it is crucial for automated detection tasks to keep this distance as constant as possible. This is essential within a single transect but also between transects to allow for generalization.
We now face an even bigger challenge, as the image capturing device was significantly redesigned, giving us better pixel resolution but completely different illumination and color characteristics compared to the previous transects. In an upcoming study, we will thus create a training set for those images and use it to train new Support Vector Machines. Thus an automated, multi-year, multi-station assessment of the benthic megafauna at HAUSGARTEN will be targeted.

Figure 1: Examples of four different types of megafauna or traces that were detected in previously unseen footage. From top to bottom: the sea cucumber Kolga hyalina, a white anemone, the sea lily Bathycrinus carpenter and burrow entrances.

Comparing supervised classification methods for prediction of substrate type using multibeam acoustic and legacy grain-size data

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For effective planning and management of marine ecosystems and resources detailed seabed substrate maps are increasingly in demand. It has become common to use remotely sensed multi-beam data in the form of bathymetry and acoustic backscatter to inform the mapping of seabed substrates. Making the best use of existing data is important because of the significant costs involved in undertaking multi-beam and ground truth surveys.

This study compares the performances of a range of supervised classification techniques for predicting substrate type from multi-beam acoustic data. The study site is an area of the North Sea, which lies off the north east coast of England, the site ranges from 55-100m in depth. A total of 258 ground truth samples obtained from a legacy dataset of the British Geological Survey (BGS Legacy Particle Size Analysis uncontrolled data export (2011), British Geological Survey, www.bgs.ac.uk) are classified into four substrate classes. The exact vintage of the samples is unknown; however all samples were collected prior to the introduction of GPS and substantial positional errors are to be expected. The multi-beam bathymetry and backscatter data were collected as part of the Civil Hydrography Programme. The bathymetry and mean backscatter gridded to a 10 m resolution provided the primary input features. A range of secondary features were derived from the backscatter and bathymetry grids making a total of 15 input features.

Six supervised classification techniques are tested, including; Classification Trees, Support Vector Machines, *k*-Nearest Neighbour, Neural Networks, Random Forests and Bayesian Decision Rules. Each classifier is trained multiple times using different subsets of input features. The predictive performances of the models are validated using a separate test set of ground truth data set aside prior to the analysis. The statistical significance of the model performances are compared against a baseline represented by a very simple model (Nearest Neighbour predictions on bathymetry and backscatter) to assess the benefits gained by using more sophisticated algorithms and incorporating more input features.

The best performing models achieved accuracies of around 80% on the test set, which when considering the limitations of the data is a satisfactory result. Tree based methods and Bayesian decision rules were the best performing techniques. The models that used all 15 input features didn't generally perform well; this highlights the need for some means of feature selection. It is also worthwhile considering computation cost involved as there was a large variation between methods in the time taken during the training phase.

Mini-mounds of the Explorer and Dangaard Canyons – were they once thriving cold-water coral reef?

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The Celtic Margin is a west-northwest—east-southeast trending passive margin characterised by a relatively steep continental slope incised by canyons. During the course of the Mapping European Seabed Habitats survey (MESH Cruise 01-07-01) 1106 km^2 of multibeam echosounder data, 320 line km of 2D seismic and 44 photographic 'ground-truthing' sites were acquired to characterise the morphology, evolution, sea-bed sediments and biological assemblages of the Explorer and Dangaard canyons and the flank of a third canyon located in Irish territorial waters.

The data revealed the presence of two previously undocumented provinces of 'mini-mounds' identified from multibeam bathymetry data and located on the two canyon interfluves. The mini-mounds were located in water depths of between 250 m and 410 m with more than 100 mounds present on each interfluve. The mini-mounds appear as mottled areas of strong reflectance on maps of backscatter intensity with maps of Bathymetric Positioning Index being the most effective at identifying individual mounds and chains of mounds. These mounds range in height from 2-4 m and in width from 50-150 m making them comparable in size with the Darwin Mounds (northeast Rockall Trough) and Moira Mounds (Porcupine Seabight). Biological analysis revealed that these mounds host the reef rubble habitat 'Ophiuroids and *Munida sarsi* associated with coral rubble' suggested here not to be associated with a live reef area but rather was once an area that hosted live *Lophelia pertusa* colonies that have been damaged, most probably by fishing activity. Seismic data show that these mounds are surficial features with no sub-surface expression suggesting that these mounds are, in geological terms, relatively young and possibly Holocene in age.

From the acoustic data it could be suggested that the mini-mounds from the SW Approaches may be carbonate in origin, and thus could be classified as carbonate mounds under OSPAR.

The use of statistical methods for identification and classification of habitats from hydrographic data of different instruments.

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The need for interpretation of hydrographic data with verification from sampling and video or photo is important for relevant habitat mapping. Interpretation with high adequacy is essential to enable effective management of the marine environment. The acoustic data received from multibeam and side scan sonar is used for interpolatation of the information gained from the biological sampling to map the biological community and classify the seabed into biotopes and habitats. Backscatter together with side scan sonar and bathymetry is the main geophysical information sources for both identifying areas of interest for further biological sampling 'ground truthing' and interpretation of the habitat extension. A lot of information is stored in the acoustic data which can be used to increase the accuracy of the interpretation. The most common way of using backscatter data is to identify substrates with different hardness by displaying the mean signal strength. Relationships between several factors can have an impact on the interpretation results. Description of the characteristics of biological communities is undertaken during the analysis of the biological sampling and video photo identification together with historically known characteristics for the specific biotope. Depending on the instruments used, factors such as depth, slope, instrument frequencies and opening angles may have an impact on the hydrographic data information gained for the seabed characteristics. From the experience of habitat classification there has been a need for extracting more information from the hydrographic data and understanding how the different factors impact on the data. FMGT was used to investigate if information from signal strengths can be used not only to identify areas of different hardness but also if the biotope characteristic seabed can be identified with regards to the specific signal. Several acoustic instruments are used in different habitats to evaluate the signal information.

Modeling a MED-Ridge brine lake: a multivariate approach on Urania Anoxic basin

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In the deep-sea environments, the improvement of the employed technologies has allowed, in the last 50 years, a progressive capability of exploration and study, revealing the existence of peculiar structures.
From 1980', the Eastern Mediterranean Sea has revealed the presence of particular depressions, characterized by oxygen absence, a variable concentration of H_2S and CH_4, and filled with hypersaline brine, representing "extreme" environment and habitat.
Up to now, the research activities on these anoxic basins have been mainly focussed on the collection and study of the geochemical, the biological and the sedimentological information, coupled only recently with a geophysical high resolution bathymetry and the seismic investigation. In the ambit of the EU Moccha Project (Multidisciplinary study of continental/ocean climate dynamics using high-resolution records from the eastern Mediterranean), from 2008 to 2011 about 15000km^2 of seafloor bathy-morphological data have been surveyed on both sides of the Mediterranean Ridge, interesting some of the named anoxic basins. The comparison between the recent geophysics and some previous acquired data, collected with different methods (BIODEEP and Moccha Project: CTD profiles, video inspections, sediments sampling, etc), allow us to observe a sensitive disparity between the depth information, as the position of the brine-sea water interface, the vertical extension of the brines detected by geochemical evidences, the real bottom of the considered basin etc. These differences are directly connected to the kind of employed techniques, but a complete spatial, geochemical a physical analysis, and then multidisciplinary study of that systems, requests a cross validation of the data obtained with different sources.
The intent of this work is to realize a comparison between various Digital terrain Model, obtained by the elaboration of Morpho-bathymetric data collected in correspondence of the Urania Anoxic Basin. The models have been realized applying different Sound Velocity Profiles, modified from the raw CTD cast, considering the physical parameters of the selected basin (Salinity, Conductivity, Temperature etc). The comprehension of how the geophysics responses to the application of geochemical parameters will return a new method for an optimized study of the considered features. This multivariable and multidisciplinary approach will allow to extend the physical, chemical, and also biological information, obtained by punctual samplings and casts, into the three dimensions, returning a complete and less approximated representation of the anoxic basins, and favouring new frontiers on "habitat mapping" in deep-sea and extreme environments.

MAREANO - an integrated national seabed mapping programme providing knowledge for ocean management

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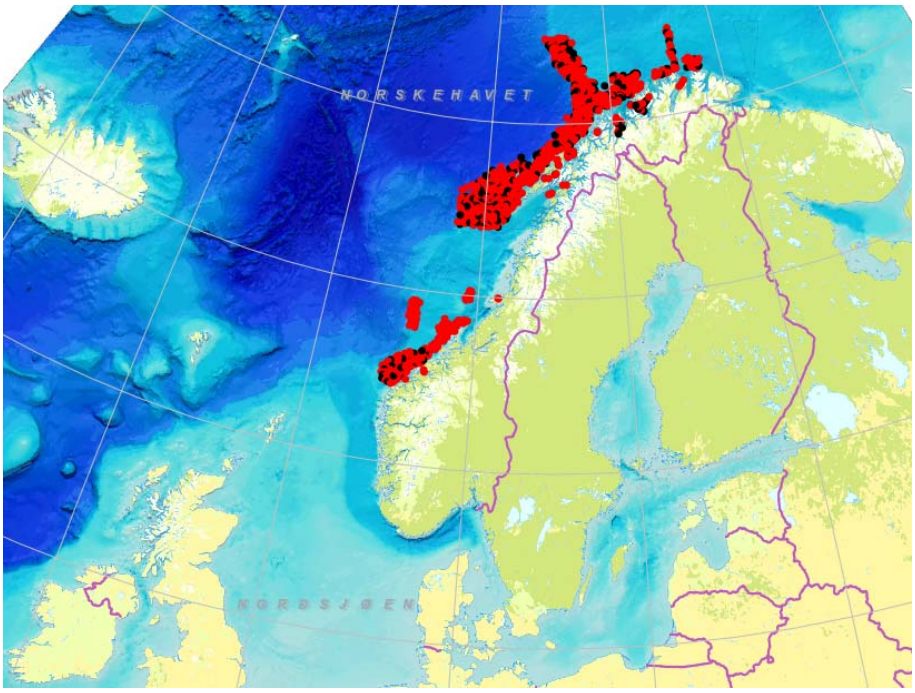
The oceans are a major source of wealth, yet marine resources are not endless and require sustainable management. Ecosystem based management of the oceans requires a sound knowledge on the geographic distribution of benthic habitats and their ecosystem function, not just their biology. Good data on bathymetry, geology (including geomorphology) and oceanography are vital components of this knowledge base, providing fundamental information for the characterisation and spatial delineation of benthic habitats. Documentation and understanding of these abiotic drivers of habitat distribution is essential for effective ecosystem based management.

The MAREANO programme in Norway started in 2005, and is funded by the Norwegian government (12.6 Mill. EURO in 2013). It has so far documented 107 000 km^2 of seabed by mapping bathymetry, sediment composition, habitats and biotopes, biodiversity, as well as pollution in the seabed in Norwegian coastal and offshore regions. MAREANO's work is conducted by the Institute of Marine Research (marine biology), the Geological Survey of Norway (marine geology) and the Norwegian Hydrographic Service (hydrography). Results from the programme feed directly into the documents and reports that form decision support for the government.

The area studied 2005 – 2012 encompasses continental shelf, slope and deep water zones and includes many extreme habitats including shelf-edge canyons and submarine slides. Some of the world's largest cold water coral complexes occur in this area. Geological features include a narrow, glacially shaped continental shelf, a continental slope with extensive erosion by canyons and submarine slides, and a continental rise with large submarine fans. Cold seeps and gas flares occur locally, and contribute to a high geodiversity forming the basis for a rich biodiversity. Ship-borne multibeam data including backscatter and water column data is a major data source. Recently AUV's with Synthetic Aperture Sonar (SAS) have been tested as a possible new mapping method, and have shown some very interesting results.



Overview map with stations acquired by the MAREANO program in 2005-2012 (107 000 km^2)

Mapping of Marine Biodiversity in the Baltic Sea:
Experiences from a first year of comprehensive inventories in the Finnish sea areas

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The use of marine space is increasing at a rapid pace. Therefore several international conventions and EU policy papers and directives, such as the Marine Strategy framework Directive (MSFD), emphasize the importance of an ecosystem based approach to planning and management. To succeed, such planning requires extensive data on marine life. Scarcity of such data hampers informed Marine and Coastal Spatial Planning (MSP) and the sustainable use of marine resources and ecosystem services.

The Finnish Inventory Programme for Marine Underwater Environment (VELMU) was set up in 2004 and expanded gradually to all main sea areas surrounding Finland by 2009. Initially, activities were largely funded through various short-term projects, and the coverage of the inventories lagged behind the rapidly increasing information needs.

In 2011, a new era of the Finnish inventories of marine environment started, when the Finnish parliament allocated a major state grant for the inventories. This made it possible to develop a nation-wide integrated inventory plan. The plan was specifically designed to be cost-effective and to produce data suitable for species and habitat modeling. It took into account environmental variation, such as water salinity and turbidity, exposure to wind driven wave action and topographical variation, and encompassed more than 17.000 randomly selected observation sites (Fig. 1).

The inventories following this plan started in 2012 and will continue until 2015. New organizational structures were established, infrastructure was purchased and field methods were developed and integrated. All major institutes and organizations were involved in the biological inventories, using methods such as drop-video, ROV, photography, scuba diving and benthic sampling. Various remote sensing methods, such as satellite observation, aerial photography and LIDAR (Light Detection and Ranging), were tested and will be further developed to complement the traditional inventory methods.

Here we present our goals and challenges, describe the rationale behind the new inventory plan and share some first experiences - difficulties and success stories - in implementing the programme. We also report how the knowhow gained will be used in developing the national monitoring programme according to the EU MSFD, due by July 2014.

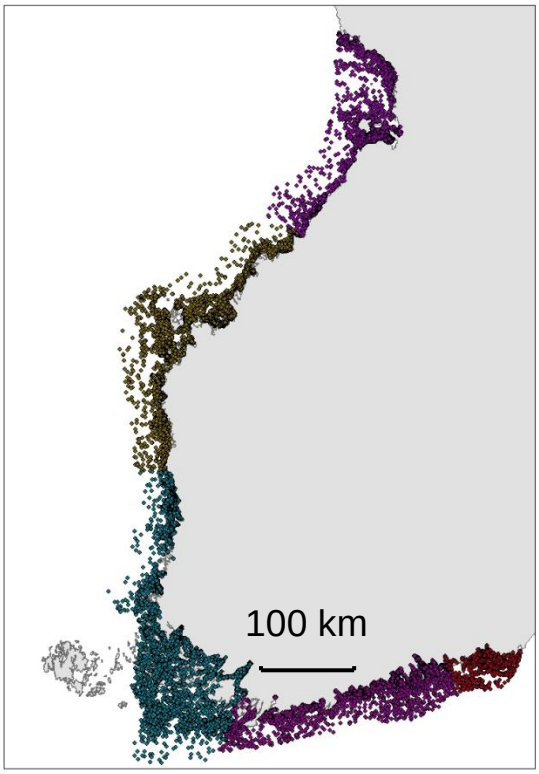

Fig. 1. The new Finnish inventory plan, including ca. 17.400 sites. The observations are made with the “drop video” method, ROV scuba diving and with benthic sampling.

GEODIVERSITY AND BIODIVERSITY OF SUBSTRATES IN THE CONTINENTAL SHELF, WORKING GROUP 2.1 – INCT AMBTROPIC, BRAZIL

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The continental shelf off the north-northeast of Brazil was exposed subaerially most of the time, considering that the shelf break in this region is extremely shallow (45-60m). Only during brief intervals of time, as nowadays, this platform was completely flooded. Currently most of the continental shelf is covered by sediments whose distribution is controlled by the physiography inherited from a long period of exposure, by river inputs, and by the in situ accumulation of hard parts of marine organisms and the forcing of marine agents (waves and currents). The shelf sedimentary cover exerts a direct influence on density, biomass, distribution and diversity of their benthic communities. Despite the current scenario of growing anthropogenic pressures in this environment, a major obstacle to understanding these impacts is the absence of benthic habitat maps and associated communities, particularly in the north-northeast of Brazil. Maps of benthic habitats and associated communities are a powerful tool that will allow scientists and managers to understand the distribution of living and non-living resources in the sea floor and will make easier to monitor the effects of climate change and the extent and effect of pollution from nutrients and contaminants, the delimitation of conservation units, and evaluation of ocean engineering projects and exploitation of marine aggregates for beach nourishment. These global approaches are undoubtedly useful to perform an initial assessment of the problem, but are difficult to implement in specific aspects mainly because of the lack of a minimum database, as is the case in north-northeastern Brazil. To minimize this gap, the main objective of the Science and Technology National Institute in Tropical Marine Environments (INCT AmbTropic), through its Working Group 2.1, is to investigate the spatial heterogeneity of shelf substrates in north-northeast of Brazil, the controls of this heterogeneity, and the communities of organisms associated with them. Specific objectives include: (i) What are the main geological /oceanographic controls on the distribution of the different types of substrates and the ecology of the marine landscape? (ii) What are the communities of marine organisms associated with or directly controlled by this mosaic of substrates? (iii) How this mosaic of substrates controls the spatial heterogeneity of biodiversity on the platform? (iv) What are the main sources of marine aggregates that could eventually be used in the process of adaptation of the shoreline to rising sea levels with special emphasis on large urban areas. To answer the questions above mentioned, eight priority areas were selected for case studies, covering the entire spatial shelf heterogeneity that can be found at the northeast, northern Brazilian coast, from Espirito Santos to Amapa State Data integration will be done in GIS (ArcMap / ArcMarine) where the different parameters set will be integrated to generate the final maps showing distribution of the different parameters mapped. Through this mapping, it will be defined geological and biological units to be expressed in terms of environmental units. This database will also be integrated with (i) the shoreline erosion and progradation data and (ii) Environmental Sensitivity Atlas to Oil Spill. This integration will allow the elaboration of a conceptual model and answer the questions presented above as well as point to future research topics. The generation of a database for marine substrate classification will also give support for monitoring programs, providing a basis for establishing standards of environmental responses to climate variations. The central unifying theme of the INCT Tropical Marine Environments (AmbTropic**)** is the spatial-temporal heterogeneity of tropical marine environments and how this may determine the response patterns of these environments and their resilience to climate changes that will affect the North-Northeast of Brazil in this century. This is of high strategic importance for that region. Scientists distributed in 7 institutions of education and research share this vision and integrates de Working Group 2.1 GEODIVERSITY AND BIODIVERSITY OF SUBSTRATES IN THE CONTINENTAL SHELF.

INCT AmbTropic (CNPq/FAPESB/CAPES), http://www.inctambtropic.org

The visualization of geographical dataset on mobile devices using Augmented Reality application based: a case of study from Liguria Region

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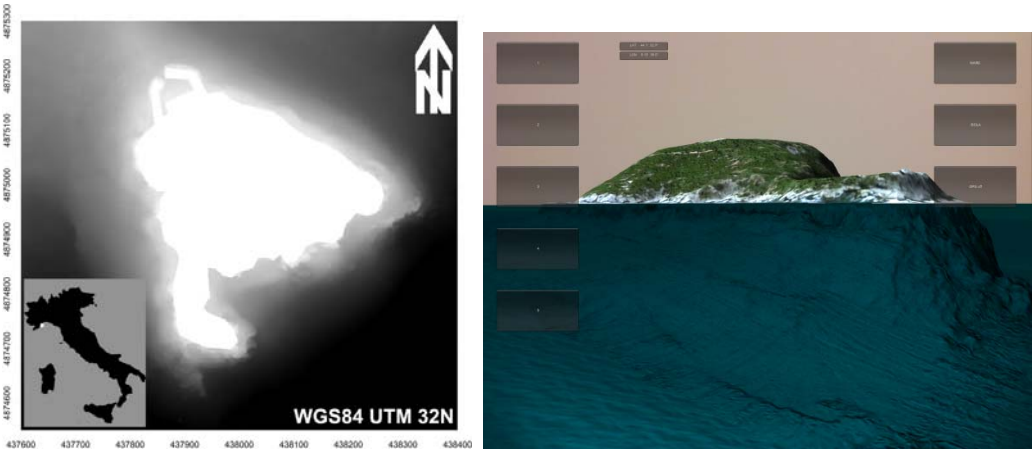
Underwater seascapes are often of difficult perception also for insiders if not familiar with diving activities, compromising social awareness towards conservation strategies. With the growing performances of mobile devices and their diffusion, augmented reality (AR) could become a key tool for the visualization of many GeoSpatial datasets. Existing research is limited to recreational applications and on augments paper-based of city maps and only few works focus on the potentiality of AR in real settings. Data from field studies may impact heavily on development and design of environmental managing. In this study we assess the capacity of the AR using bathymetric data and benthic habitat information to develop a 3D reconstruction display of the geomorphological data from Gallinara Island (Ligurian Sea, Italy). We used cartographic information and real time 3d rendering techniques, combined with GPS and sensors like gyroscope, accelerometer, compass, and image processing to create AR geographical data visualization. Results provide a new way of visualizing marine geophysical dataset that can be run on low cost mobile devices. Furthermore, the method proposed could be applied as a standard protocol for future AR applications. Our future research goal focuses on adapting existing methodological approaches such as 3D benthic stereo image reconstructions and designing new algorithms to improve outdoor AR on modern mobile devices.

Keywords:
3D, marine ecosystems, bionomic map, seabed morphology, augmented reality, mobile devices



Figures: on the left side, the raster map based on the multi-beam bathymetric grid files (1x1 meter) of the Gallinara Island at the Ligurian Sea. The Z values are represented in grey scale. The emerged part of the island is masked in white. Data provided by the Liguria Region. On the right side a screenshot of the App. The figure shows the Gallinara island seabed morphology in 3D representation using the augmented reality approach. The emerged part is realized using a DEM provided by INGV Institute (Istituto Nazionale di Geofisica e Vulcanologia).

http://www.geohab2013.it