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MESH ATLANTIC

MAPPING ATLANTIC AREA SEABED HABITATS FOR **BETTER MARINE MANAGEMENT**

15-17 SEPTEMBER 2013

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ATLANTIC AREA Transnational Programme

EUROPEAN COMMUNITY
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'Investing in our common future'

Mapping Atlantic Area Seabed Habitats
for Better Marine Management

University of Aveiro, Portugal
15-17 September 2013

Cover Photo by **Victor Quintino**

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INDEX

The main objective of MeshAtlantic was to provide harmonised seabed habitat mapping over the coastal and shelf zones of the Atlantic Area in order to help informed spatial planning and management.

MeshAtlantic successfully delivered the products it had committed to. Primarily these were habitat maps, historic and new alike, either local or global. This is the key achievement of MeshAtlantic, as shown by its WebGIS, a platform to visualise, consult and download mapping products for the Atlantic Area.

The final conference of MeshAtlantic, themed "Mapping Atlantic Area Seabed Habitats for Better Marine Management", brings together many of the results obtained in the project and is enriched by presentations from other studies. Craig Brown (McGregor GeoScience Limited, Canada), Alan Stevenson (British Geological Survey, UK), Lene Buhl-Mortensen (Institute of Marine Research, Norway), Vladimir Kostylev (Geological Survey of Canada - Atlantic, Canada) and Roger Coggan (formerly CEFAS, UK), give invited talks.

The Journal of Sea Research has agreed to produce a Special Issue from presentations given at the Conference. Manuscripts are welcome and will go through the standard international pier reviewing system used by the journal.

The organizers welcome you all at the University of Aveiro and wish you an enjoyable and fruitful Conference.

The Organizing Committee

Aveiro, 16 September, 2013

Organizing Committee:

Victor Quintino

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Jacques Populus

Scientific Committee:

Alan Stevenson, British Geological Survey, UK

Ana Maria Rodrigues, CESAM & University of Aveiro, Portugal

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Victor Quintino, CESAM & University of Aveiro, Portugal

Victor Henriques, IPMA, Portugal

Vladimir Kostylev, Geological Survey of Canada - Atlantic, Canada

SEPTEMBER 15

15:00 Registration

18:00 Icebreaker

SEPTEMBER 16

09:00 Opening Session

09:30 Marine Habitat Mapping: Historical perspectives and present status
Craig Brown (Keynote Speaker)

10:10 A broad scale seabed habitat map for the Atlantic Area
Jacques Populus, Mickaël Vasquez

10:30 The MeshAtlantic interactive mapping portal (webGIS)
Hellen Ellwood

10:50 MeshAtlantic – Outputs and Benefits at a National Level
Fergal McGrath

11:10 Coffee break

11:40 Broad-scale habitat mapping: the issue of computing ecologically-relevant thresholds
Mickaël Vasquez

12:00 A multi-model ensemble approach to seabed mapping
Markus Diesing, David Stephens

12:20 Airborne laser as a tool for mapping of underwater vegetation and habitat types
Sofia A. Wikström, Karl Florén, Michael H. Tulldahl

12:40 Benthic communities in the English Channel: from the use of the Rallier du Baty dredge to Remotely Operated Vehicle (ROV) and from the characterization of general patterns to the description of habitat mosaics
Jean-Claude Dauvin

13:10 Lunch break

14:20 Integrating marine information from Europe's seas – the European Marine Observation and Data Network (EMODnet)
Alan Stevenson (Keynote Speaker)

15:00 Outputs from the workshop: Using EUNIS habitat classification for benthic mapping in European Seas
Ibon Galparsoro

15:20 Marine habitat mapping of the Milford Haven Waterway, Wales, UK: comparison of facies mapping and EUNIS classification for monitoring sediment habitats in an industrialized estuary
Drew Carey, Joseph Germano, David Little, Blaise Bullimore, Melanie Hayn

15:40 Habitat mapping and biotope classification – the basis for biotope assessment in the Baltic Sea
Kerstin Schiele, Alexander Darr, Michael Zettler

16:00 Mapping and registration of seabed biotopes in the German Exclusive Economic Zones (EEZ) of the Baltic Sea and the North Sea
Dieter Boedeker, Roland Pesch, Winfried Schröder, Claudia Propp, Manfred Zeiler, Dario Fiorentino, Bastian Schuchardt, Kolja Beisiegel, Mayya Gogina, Michael Zettler

16:20 Coffee break

16:50 Biologically relevant predictions of benthic assemblages using Telemac3D results
Alex Callaway, John Bacon, Claire Beraud

17:10 Unique offshore site for benthic biodiversity: the Plateau of Rochebonne, French Atlantic coast
Anne-Laure Barillé, Annaïk Cocaud, Sandrine Derrein-Courtel, Mathieu Oriot, Nicholas Truhaud, René Derrein

17:30 Marine habitat characterization and mapping in Portuguese coastal areas
Victor Henriques, Miriam Guerra, Beatriz Mendes, Maria José Gaudêncio, Paulo Fonseca

17:50 18:30 Poster Session

20:30 Conference dinner

SEPTEMBER 17

09:00 Habitat mapping as a tool for conservation and sustainable use of marine resources
Lene Buhl-Mortensen (Keynote Speaker), Pål Buhl-Mortensen, Margaret Dolan, Geno Gonzales Mirelis

09:40 Habitat mapping as a tool for management and planning of Natura 2000 marine sites in Brittany
Michel Ledard, Benjamin Guichard

10:00 Assessing the SW Europe MPA network representativeness using the new MeshAtlantic broadscale seafloor map
Fernando Tempera, Patrícia Amorim, Mickael Vasquez, Ricardo Serrão Santos, Jacques Populus

10:20 Mapping the extent and complexity of seabed habitats within Marine Protected Areas: choices of techniques employed
Oliver Crawford-Avis

10:40 Using a combination of survey-derived and broad-scale predicted habitat maps to assess Marine Protected Area networks in United Kingdom waters
Alice Ramsay, Helen Ellwood

11:10 Coffee break

11:30 The use of habitat maps in marine planning and conservation
Roger Coggan (Invited Speaker)

11:50 Multi-approach mapping to help spatial planning and management of the kelp species *Laminaria digitata* and *L. hyporborea* : Case study of the Molène archipelago coastal area
Touria Bajjouk, Sebastien Rochette, Axel Ehrhold, Martial Laurans, Philippe Le Niliot

12:10 Mapping marine biodiversity as a tool for marine spatial planning: the coast of Algarve case study
Jorge M.S. Gonçalves, Jose Luis Sanz Alonso, Pedro Monteiro, Margarida Castro, Frederico Oliveira, Margarida Cristo, Dulce M. Chacón, Carlos Afonso, Luis Bentes, Ricardo Aguilar, Karim Erzini

12:30 13:00 Poster Session

13:00 Lunch break

14:20 Seabed mapping for Ocean Management – Canadian perspective
Vladimir Kostylev (Keynote Speaker)

15:00 Inventory and comparative evaluation of seabed mapping, classification and modelling activities in the Northwest Atlantic, USA to support regional ocean planning
Drew Carey, Emily Shumchenia, Marisa Guarinello, Jennifer Greene, Andrew Lipsky, Larry Mayer, Matthew Nixon, John Weber

15:20 Mapping marine litter and lost fishing gear in the Gorringe Bank
Rui Pedro Vieira, Isabel Palma, Marina R. Cunha

15:40 INFOMAR and MESH Atlantic – Value from Seabed Mapping
Fergal McGrath

16:00 Mapping of different benthic habitat components in the Basque Continental Shelf (NE Bay of Biscay) and its application within the MSFD
J. Germán Rodríguez, Ibon Galparsoro, Iratxe Menchaca, Iñaki Quincoces, Joxe Mikel Garmendia, Ángel Borja

16:20 Coffee break

16:50 Deep-sea biotope cataloguing and mapping in the Azores (NE Atlantic)
Fernando Tempera, José Nuno Pereira, Chris Yesson, Andreia Braga Henriques, Filipe Porteiro, Valentina Matos, Miguel Souto, Brigitte Guillaumont, Ricardo Serrão Santos

17:10 The influence of data resolution on estimates of extent and distribution of deep-sea habitats
Lauren Ross, Rebecca Toss, Heather Stewart

17:30 The impact of model selection on predicted distribution and extent of deep-sea benthic assemblages
Nils Piechaud, Anna Downie, Heather Stewart, Kerry Howell

17:50 Development of a deep-sea section for the Marine Habitat Classification of Britain and Ireland
Megan Parry

18:10
18:30 Closing Session

POSTERS

Establishing energy thresholds in the EUNIS classification - Portuguese Case Studies
Luis Bentes, Pedro Monteiro, Jorge M.S. Gonçalves

Mapping the benthic communities of the Wyville-Thomson Ridge using Maxent predictive modelling
Andreia Carvalho, Kerry Howell, Heather Stewart

Biotope identification in deep rocky reefs offshore Portimão and Sagres
Jorge M.S. Gonçalves, Joana Boavida, Frederico Oliveira, Carlos M.L. Afonso, Dulce M. Chacón, Pedro Monteiro, Luis Bentes, Ricardo Aguilar, José Luis Sanz Alonso

Biotope identification in S. Vicente and Portimão submarine canyons
Jorge M.S. Gonçalves, Pedro Monteiro, Frederico Oliveira, Carlos Afonso, Luis Bentes, Ricardo Aguilar

Transboundary Planning in the European Atlantic (TPEA)
Jorge M.S. Gonçalves

Quantifying deep-sea habitats: a cold-water coral example from the FP7 CoralFISH project
Anthony Grehan, Laurent de Chambure, Alessandra Savini, Jean-Francois Bourillet, Anna Rengstorf, Tina Kutti, Jan Helge, Steinunn Olafsdottir, Fernando Tempera

Using EUNIS to classify Southern European seabed habitats: the marine protected area Luiz Saldanha Marine Park (Arrábida Natural Park, SW Portugal) case study
Miriam Tuaty Guerra, Maria José Gaudêncio, Beatriz Mendes, Victor Henriques

Single-beam acoustic variability associated with varying echo integration spatial survey step and sediment types
Renato Mamede, Ana Maria Rodrigues, Victor Quintino, Rosa Freitas

Predicting the spatial distribution of superficial sediments using single-beam acoustics: the Portuguese continental shelf (Nazaré-Ovar)
Renato Mamede, Ana Maria Rodrigues, Rosa Freitas , Victor Quintino

A broad scale seabed substrate map of the Portuguese coast
Roberto Martins, M.R. Azevedo, A.J.F. Silva, R. Mamede, F. Ricardo, L. Magalhães, P. Monteiro, L. Bentes, J.M.S. Gonçalves, V. Quintino, A.M. Rodrigues, R. Freitas

Mapping the South Coast of Portugal: Portimão and Sagres study sites
D. Mata, J. L. Sanz, J.M.S. Gonçalves, L. Bentes, P. Monteiro, L.M. Agudo

MeshAtlantic interaction with stakeholders
Beatriz Mendes, Victor Henriques, Jacques Populus, Ibon Galparsoro, José Luis Alonso, Fergal McGrath, Jorge M.S. Gonçalves

Application and effectiveness of EUNIS habitat classification in the European south coast: *Anemonia sulcata* and *Paracentrotus lividus* in association with *Dictyota dichotoma* as a new provisional biotope for the classification
Pedro Monteiro, Luis Bentes, Frederico Oliveira, Carlos M.L. Afonso, Jorge M.S. Gonçalves

Submerged sea caves of Sagres (South of Portugal-Algarve): an overview of their biological communities and threats
Pedro Monteiro, João Rodrigues, Luis Bentes, Mafalda M.O. Rangel, Frederico Oliveira, Carlos M.L. Afonso, Jorge M.S. Gonçalves

Kenmare River EUNIS Habitat Map and Reef Profile
Eimear O'Keeffe, Fergal McGrath

EUNIS Habitat Mapping – Applications at European and National Levels
Eimear O'Keeffe, Fergal McGrath

The Portuguese Coastal Shelf seabed habitats: relationships between multivariate benthic species analysis and EUNIS classification
Victor Quintino, Roberto Martins, Ana Maria Rodrigues, Michael Elliott

Habitat mapping of the Avilés Canyon System and the near continental shelf (Cantabrian Sea)
Francisco Sánchez, Ana García-Alegre

Craig Brown

McGregor GeoScience Limited, Canada

Craig Brown has 18 years experience in cross-disciplinary science, with specialism in benthic ecology and seafloor habitat mapping. Dr. Brown earned his PhD from the University of Portsmouth in the UK in the field of marine fouling ecology in 1998, and has since held positions in Government science (UK and Canada), academia and the private sector, and has over 40 peer-reviewed publications in main-stream scientific literature.

Dr. Brown's post-doctoral work has focused on the application of seafloor acoustics (multibeam sonar, sidescan sonar, single beam acoustics) for studying, mapping and monitoring benthic ecosystems, and over this time he has gained experience working across the fields of marine ecology, geology, geophysics and oceanography. His recent R&D work has focused on extracting quantitative data from acoustic backscatter from multibeam sonar systems for use in species, community and habitat distribution modeling.

In recent years Dr. Brown has also focused on the development and application of benthic monitoring techniques utilizing a range of methods (acoustic, video, photographic and in situ sampling approaches). In 2011 he joined McGregor GeoScience Ltd. in Bedford Nova Scotia as their Chief Scientist, where he leads the company's environmental survey and R&D activities.

He is also currently an Adjunct Professor at Memorial University, Newfoundland, where he is supervising a number of postgraduate students working on benthic habitat mapping projects.

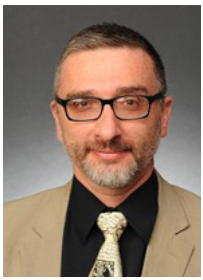
Lene Buhl-Mortensen

Institute of Marine Research, Norway

Dr. Lene Buhl-Mortensen is a senior scientist in the Benthic habitat and community research group at Institute of Marine research in Bergen, Norway. She has seven years of experience from mapping marine environment and biotopes off Norway involving identification of important areas for nature management and presenting those to decision makers.

Interests: Benthic habitat and fauna biodiversity, community structure.

Experience: 25 years experience of marine benthic fauna studies with particular interest in the relation between habitat quality and diversity. Author and co-author of more than 40 peer-reviewed publications dealing with topics ranging from taxonomy and fauna responses to management. Leading numerous research cruises as chief scientist. 2001-2003 visiting scientist on a project onCoral Ecosystems in Atlantic Canada at Bedford Institute of Oceanography. 2003-2005 leader of a Norwegian project investigating the response of benthos to hypoxia in fjord-basins, 2007-2010 coordinating the MAREANO-mapping program (www.mareano.no).



Vladimir Kostylev

Geological Survey of Canada - Atlantic, Canada

I received my Ph.D. in Marine Zoology from Gothenburg University (Sweden) in 1996, studying the effects of habitat complexity and spatial heterogeneity on marine benthic fauna. I was fortunate to carry my research in a variety of geographical areas and habitats - from polar to tropical, and from intertidal to deep-water.

I was actively involved in seabed habitat mapping at Bedford Institute of Oceanography since 1998, carrying research on the relationship between distribution of benthic communities and physical properties of seafloor habitats (geological and oceanographic conditions) in Canadian waters. Working closely with marine geologists, I apply recent advances in underwater remote-sensing technology and ecological theory to benthic habitat classification and mapping.

Currently I am a Section Head, Coastal and Shelf Studies at Geological Survey of Canada (Atlantic), Natural Resources Canada, developing a Targeted Integrated Mapping Strategy for Canada's offshore in order to maximize return on investment in Ocean mapping by targeting Government of Canada strategic priorities and finding synergy between departments through better integration.

Alan Stevenson

British Geological Survey, UK

Alan Stevenson is Head of the Marine Geology team at the British Geological Survey (BGS) in Edinburgh. As the BGS Co-ordinator of the UK Marine Environmental Mapping Programme (MAREMAP), he manages the sea-bed mapping outputs (including habitat mapping) of the UK Natural Environment Research Council's main geoscience centres (BGS, the National Oceanography Centre and Scottish Association for Marine Science) and associate partners from public science organisations and universities.

Alan is Co-ordinator of the geological component of the EC's European Marine Observation and Data Network (EMODnet), consisting of a network of 37 geoscience organisations from 30 countries, which finished its preparatory phase in 2012 and will start full operations in 2013. He holds a number of committee roles, as Vice-Chair of the Association of European Geological Surveys Marine Geology Expert Group, Secretary of the Marine Studies Group of the Geological Society of London and the UK Government's Sea-bed Mapping Working Group.

Alan has been involved in the GeoHab (Geology of Marine Habitats) Conferences since 2001 and is a member of the Scientific Organising Committee for GeoHab 2013 in Rome. Alan is involved in the European Consortium for Ocean Research Drilling (ECORD) as part of the outreach team and a member of the programme's strategy committee.

ORAL PRESENTATIONS

Marine Habitat Mapping: Historical Perspectives and Present Status

Craig J. Brown
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Human impacts on the seafloor environment have reached unprecedented levels. To facilitate ocean management and mitigate these impacts there is a need to improve our understanding of seabed habitats. Recent developments in acoustic survey techniques have revolutionised the way we are able to image, map and understand benthic ecosystems, and over the past two decade we have witnessed the nascence of the field of benthic habitat mapping. It is now cost effective to image large areas of the seafloor using these techniques, and the information from such surveys provides base line data from which thematic maps of the seabed environment, including maps of benthic habitats, can be derived when interpreted in conjunction with in-situ ground-truthing data.

This presentation reviews the development of various strategies and methods used to produce benthic habitat maps over this time frame. The applications of three acoustic survey techniques are examined in detail: single-beam acoustic ground discrimination systems, sidescan sonar systems, and multibeam echo sounders. As acoustic survey tools have become ever more complex, new methods have been tested to segment, classify and combine these data with biological ground truth sample data. Although the specific methods used to derive habitat maps vary considerably from study to study, a number of common, over-arching strategies are identified and presented. Whilst there is still no widely accepted agreement on the best way to produce benthic habitat maps, all of these strategies provide valuable map resources to support management objectives. There is still considerable work to be done before we can answer many of the outstanding technological, methodological, ecological and theoretical questions that have been raised here. However, progress in the field of benthic habitat mapping founded on high-resolution environmental data sets will undoubtedly help us to examine patterns in community and species distributions, which is a vital first step in unravelling complexities and thus providing improved spatial information for management of marine systems.

A broad scale seabed habitat map for the Atlantic Area

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MeshAtlantic's commitment to produce a broad-scale map for the Atlantic Area resulted from an incentive from DG/MARE to complete preliminary achievements of the Emodnet EUSeaMap project in the northern regions of Europe (Celtic, North Sea and Baltic marine basins).

The partnership embarked on collating and preparing the suitable data layers as per the EUSeaMap methodology described in Cameron (2011). Bathymetry data and seabed substrate maps were collated by each partner and stitched together into seamless layers for the whole Atlantic Area. For bathymetry, a 250m resolution gridded depth terrain model was created by merging all source data files and interpolating them. Likewise a polygon substrate map was produced by stitching the various substrate maps from all four countries – actually available in a range of different scales – and translating them to the simplified Folk classification scheme used by EUNIS. The process was quality-controlled by assessing the confidence of each contributing file according to the EUSeaMap protocol. For substrate it was an adaptation of the method primarily designed for habitats. For bathymetry, in the absence of particular guidelines, MeshAtlantic applied a simple combination of three quality criteria.

A lot of resources were devoted to collating oceanographic data such as light penetration in water and energy at the seabed necessary to determine EUNIS depth zones and energy cut-offs. The assessment of these thresholds is reported in another presentation in this conference (Vasquez, 2013). Significant efforts were also made to address the deep sea, however substrate maps are drastically lacking for these areas and we could only produce proxies to EUNIS classes.

When all contributing layers were ready, the model was run in ArcGIS. The broad-scale map is represented using the colour scheme designed for EUSeaMap at EUNIS levels 3 to 4 by taking into account a palette currently in use in the marine geology community. The broad-scale map sheets were designed to fully cover the Atlantic Area - including the Azores - in such a way that basins or national entities could be respected while working at a roughly constant scale for all the sheets.

The map is available in the MeshAtlantic webGIS, limited to its Atlantic Area extent and also similarly in the EUSeaMap portal where it covers the whole north-east Atlantic region from the Baltic Sea to southern Spain.

The MeshAtlantic interactive mapping portal (webGIS)

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Habitat mapping results of the MESH Atlantic project are disseminated to the public via an online interactive mapping portal, or webGIS. The webGIS was built on the original portal created in 2007 as part of the MESH project , extending the coverage to include up to 50 new habitat maps in the Atlantic Arc.

Visitors to the webGIS are able to view, query and download the habitat maps created and collated by the MESH and MESH Atlantic partners. One of the notable new features of the webGIS is the interoperability with the websites of other projects. All habitat mapping metadata is stored in a pre-existing online catalogue hosted by the International Council for the Exploration of the Seas and dynamically linked to the map viewer. The webGIS also links dynamically to the products of other relevant European project - EUSeaMap's broad-scale habitat map and MAIA's Marine Protected Areas layer for the Atlantic Arc. Further to this is the ability for users to add layers to the map view from any external webGIS that offer a 'Web Map Service'.

Although the MESH Atlantic project is coming to an end, the second phase of the European-funded EMODnet Physical Habitats project, EUSeaMap (first phase: 2009 to 2012), is about to begin and will run for three years. The project aims to expand the coverage of the original EUSeaMap from the Baltic Sea, Greater North Sea, Celtic Seas and Western Mediterranean to all EU waters. The project will integrate the MESH Atlantic broad-scale predicted map with new coverage, and improve the map quality where EUSeaMap outputs are already available. This new phase includes the additional objective of continuing the work of MESH and MESH Atlantic to publish survey-derived habitat maps in European waters (as on the MESH Atlantic webGIS) and therefore ensuring the longevity of this increasingly important service.

MeshAtlantic – Outputs and Benefits at a National Level

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The INTERREG IVB MeshAtlantic Project is supported by INFOMAR, Irelands national seabed mapping programme. MeshAtlantic aims to provide a harmonised seabed habitat map of the coastal and shelf areas of the Northeast Atlantic in order to aid the development of sustainable management plans at both regional and European levels.

Involvement in MeshAtlantic has facilitated leveraging of extra resources in order to discharge a programme of data collation which otherwise could not have been carried out.

The outputs of the project in Ireland include acquisition of new data in Kenmare Bay, a EUNIS habitat map for Kenmare Bay, direct support of monitoring work in the WFD, a collated habitat map for a significant part of Irelands seabed, and collation of existing habitat maps and source data. The outputs of the project in an Irish context have been integrated into the national MSFD plan.

More importantly, perhaps, it has acted as a focal point for collation and standardization of these data sets at a national level. It has also resulted in improved interaction between the agencies responsible for seabed mapping and stakeholders. The collation of these data for Ireland has also resulted in close collaboration with other EU funded projects (e.g. EMODNET).

Broad-scale habitat mapping: the issue of computing ecologically-relevant thresholds

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The EUNIS classification system uses biological zones, substrate and energy (exposure to waves and current) to characterize seabed habitat types. For example in the Circalittoral biological zone, on a rocky substrate, and where there is high energy the habitat is named "High energy Circalittoral rock".

Therefore the methodology developed for broad-scale habitat mapping is simple: it consists in making a map of the substrate, another map of the biological zones, a third on the levels of energy and, ultimately, combining these three maps via GIS techniques. The challenge here is to build those three base maps, i.e. to find a way to approach each category identified in these layers.

As an example, for the energy EUNIS identifies three levels: high, moderate and low. In order to be able to make a map of this we first need to figure out which environmental variable is the best proxy for the energy, then to prepare a climatological and spatial layer of that variable, and at least to calibrate the cut-off values that will allow to classify the layer into the three categories of energy considered by EUNIS. The last step, calibrating cut-off values (or thresholds), is crucial, and there are a few hidden obstacles on the way to get it done.

One example of those obstacles is the huge lack of sample data. Due to the hierarchical nature of EUNIS, the methods used to define the cut-off values must be based on statistical analyses of biological points. Any other method of statistical analysis, not biology-driven, would obviously lead to significant disagreements between EUNIS classes given by broad-scale maps and those given by point sampling. Thus broad-scale mapping can't be done without sample data. Unfortunately, even though there are many sample datasets around Europe, they are rarely easily made available. Thus one of the lessons learned is that in any project of broad-scale mapping a specific effort has to be devoted to the collation of occurrences of habitats or communities.

This paper examines how the thresholds issue was tackled within the MeshAtlantic project. The lessons learned and the potential solutions to some problems will also be presented.

A multi-model ensemble approach to seabed mapping

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The advent of multibeam echosounder (MBES) technology has revolutionised our ability to map and represent the seabed of oceans and marginal seas in recent years. We are now able to map the seabed at unprecedented spatial resolution and accuracy. At the same time, the data volumes are dramatically increasing. In the United Kingdom (UK), the increase in seabed coverage with MBES data is mainly driven by the Civil Hydrography Programme. It has been estimated that seabed coverage has increased in recent years to 200,000 km^2 or approximately 26% of the UK Continental Shelf.

Those large data volumes are not effectively analysed by eye using expert interpretation. We therefore compared the performance of six supervised machine learning techniques (k-Nearest Neighbours, Decision Tree, Random Forest, Support Vector Machines, Artificial Neural Networks and Naïve Bayes) in their ability to map seabed substrate classes. We selected 'Bayman's Hole to Dunbar' off the north-east coast of England as a test site covering a seabed area of 5272 km^2. Input features were MBES bathymetry, backscatter and several derivatives thereof. Sample data were derived from a legacy dataset of seabed samples from the British Geological Survey (BGS Legacy Particle Size Analysis uncontrolled data export (2011), British Geological Survey, www.bgs.ac.uk). Sample data were split into training and test sets in a random stratified way, to allow an assessment of model performance. Overall map accuracy, kappa statistic and balanced error rate were calculated. The influence of the choice of input features on prediction performance was also tested.

The three best performing models achieved overall map accuracies of 80 – 81%, kappa statistics of 0.45 – 0.50 and balanced error rates of 0.37 – 0.41. The outputs of these models were combined to an ensemble map using a simple voting procedure to determine substrate class. A major advantage of this approach is that it also yields the agreement between model predictions which could be used as a measure of class allocation uncertainty. We found that in 70.3% of seabed area, all three models agreed, in 27% of area at least two models agreed and in only 2.7% of area there was no agreement between models.

Airborne laser as a tool for mapping of underwater vegetation and habitat types

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Airborne laser scanning is today mainly used for bathymetric mapping, but could potentially also be a tool for mapping of benthic habitats. We have analyzed data from one of the operational systems for bathymetric mapping (Hawk Eye II) from the Baltic Sea to evaluate if the laser signal can also be used to retrieve information on benthic biotopes and habitats. The laser data was both used alone and in combination with high resolution satellite data (WorldView-2 imagery). Field data from UV-video was used to calibrate classification models and validate the produced maps.

A combination of depth recording and wave-form variables from the returning laser pulse allowed classification of the sea floor into broad habitat types (rock/sediment and presence/absence of vegetation), with up to 88% classification accuracy. When including satellite data it was possible to map several biotopes and habitats according to HUB (Helcom Underwater Biotopes/habitats), the new EUNIS-compatible habitat classification system for the Baltic Sea. The habitat classification together with the bathymetric data was also shown to be useful for mapping of the Annex I habitats Sublittoral sandbanks (1110) and Reefs (1170). The results show that airborne laser, alone or in combination with satellite imagery, is a promising method for mapping of broad habitat types in shallow areas.

Benthic communities in the English Channel: from the use of the Rallier du Baty dredge to Remotely Operated Vehicle (ROV) and from the characterization of general patterns to the description of habitat mosaics

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The English Channel (EC) is a shallow epicontinental sea, extending ~ 77,000 km², characterised by a series of strong offshore-inshore and capes/bays gradients with progressive changes in temperature, bathymetry and shear stress which ones are recorded both in sediment and benthic communities. Benthic historical works at the EC scale, as a megatidal sea model, had been made in the 1960's-1970's by two teams, respectively Holme team coming from the Plymouth laboratory (UK) and Cabioch team coming from Roscoff Biological Station (France). During this period, benthic sampling was mainly qualitative, i.e. using a dredge such as the 'Rallier du Baty' dredge for the French team. It was focused on the knowledge of the main distributions of benthic communities and species. The whole EC scale surveys permitted to identify general feature. Two main patterns had been identified: 1) the role of the hydrodynamic on the spatial distribution of sediment, benthic species and communities; 2) the presence of a west-east climatic gradient of fauna impoverishment. Then benthic studies in the 1980's-1990's were focused on the long-term survey in a limited number of sites, for example in the Bay of Seine and the Bay of Morlaix along the French coast to identify seasonal and pluriannual changes on fauna, and estimate the charge capacities and production of such benthic communities. The implementations in the 2000's of the European Water Framework Directive and the Marine Strategy Framework Directive to define the Ecological Quality Status of marine environments have increased the need to get better knowledge of the benthic communities' structures and functioning. Benthic species and habitats have been recognized as good indicators of human pressure on marine ecosystems. Face to the increase of marine human activities, those of invasive species and the need to preserve sensitive marine habitats, benthic works have been focused to develop a 'toolbox' to help decision-making and planning for both sound governance and sustainable management of the Channel sea's marine resources and human activities. Multidisciplinary approaches were used to differentiate habitats more precisely. Both indirect (side scan sonar, ROV) and direct (grab sampling with benthos identification and grain-size analyses) approaches were used and combined to permit benthic habitats description using a lot of descriptors. These approaches were mainly arranged to a local scale which permitted to describe a lot of habitat mosaic mainly in the coarse sand, gravels and pebbles areas which covered 80 % of the EC surface. They also permit to enrich the EUNIS habitat classification for the infralittoral and circalittoral zones.

Integrating marine information from Europe's seas – the European Marine Observation and Data Network (EMODnet)

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The main environmental challenges for Europe's marine sector have been established in a number of European Commission (EC) policy and strategy documents, but which most recently have been outlined in the Marine Strategy Framework Directive (MSFD) of June 2008, which aims to achieve Good Environmental Status (GES) in Europe's seas by 2020. GES involves protecting the marine environment, preventing its deterioration and restoring it where practical, while using marine resources sustainably.

Recognising that knowledge is the engine for sustainable growth, the EC published '*Marine Knowledge 2020: marine data and observation for smart and sustainable growth*' in September 2010. In this document, the Commission outlined the case for a more coordinated approach to marine data collection and assembly and described an action plan to achieve this aim. Central to this approach was the European Marine Observation and Data Network (EMODnet), which was established through the EC's maritime policy preparation actions to test the concept of assembling existing bathymetry, geology, phsyics, chemistry, biology and habitat mapping information for selected areas of the European regional seas.

Within EMODnet, the geological parameters identified by the EC to support the MSFD are the sea-floor substrate, bedrock lithology and stratigraphy, coastal behaviour, geological events (earthquakes, submarine landslides) and mineral resources. To deliver this information, a group of 14 geological survey organizations took part in the preparatory phase of EMODnet from 2009-2012, and an expanded group of 36 organisations from 30 countries will provide geological information for the entire European regional seas in the full EMODnet Programme which started in 2013.

The deliverables identified by the EMODnet Programme will significantly improve the framework of marine information available at a pan-European level. Developing harmonised map outputs of the seabed and sub-seabed geology of Europe's seas and coasts will be a major step towards delivering information that has been defined as a priority by a range of advisers to the EC.

However, regardless of the importance of EMODnet in achieving integration of geological, bathymetric, chemical, oceanographic, and habitat information, the long-term aim should be to build European information from a national level such that every-day activities can be fed through to European-level outputs. The broad scale at which information at a pan-European level can be integrated will always disguise the underlying, more-detailed information and interpretations that are regularly updated and maintained at national level. The most important deliverables will therefore be those that can be aligned at a national level to help solve problems at both local and international scale; web-delivery methods such as Web Map Services (WMS) can be used to access the best available information from source so that users of marine geoscience outputs can be confident that they are obtaining access to the most reliable and up-to-date information.

Outputs from the workshop: Using EUNIS habitat classification for benthic mapping in European Seas

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This contribution presents an overview of the main discussion and conclusions of a workshop entitled ''Using EUNIS habitat classification for benthic mapping in European seas'' held in San Sebastian (Spain) on 23rd–24th April 2012, organised by the MeshAtlantic project. The event was focused upon the interchange of scientific knowledge gained in different marine habitat (mapping) programmes around European regions including the Baltic, Atlantic, Mediterranean and North Sea, using the EUNIS habitat classification, together with the experience of scientists using other habitat classification schemes in Norway and the USA.

The aims of the meeting were to: (i) bring together scientists with experience in the use of the EUNIS marine classification and representatives from the European Environment Agency (EEA); (ii) agree on enhancements to EUNIS that ensure an improved representation of the European marine habitats; and (iii) establish practices that make marine habitat maps produced by scientists more consistent with the needs of managers and decision-makers.

It was scientifically agreed that there are a number of issues unique to the development and implementation of broad-scale classification schemes such as EUNIS.

It was also commonly agreed that the structure and underlying assumptions of the current EUNIS classification system requires improvements to make it applicable to all regions, more ecologically-meaningful and to make it useful when producing map outputs. The suggested critical improvements could be summarised as (i) inclusion of new habitat classes observed in the field, (ii) revision of the existing habitats to enhance the ecological significance of the scheme and its comprehensiveness, (iii) development of EUNIS below level 4, and (iv) development into less well-represented biogeographic areas such as the deep-sea, the Black Sea and the southwestern European seas (with a particular focus on the Atlantic Area. Thus, several opportunities were identified for modifying the system in order to make it more fit-for purpose for habitat categorization, and consequently, for marine mapping, implementation of European directives (e.g. Habitats Directive, MSFD, INSPIRE, etc.), management purposes and MSP.

Marine habitat mapping of the Milford Haven Waterway, Wales, UK: comparison of facies mapping and EUNIS classification for monitoring sediment habitats in an industrialized estuary

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A detailed map and dataset of sedimentary habitats of the Milford Haven Waterway was compiled for the Milford Haven Waterway Environmental Surveillance Group (MHWESG) from seafloor images collected in May, 2012 using sediment-profile and plan-view imaging (SPI/PV or SPI) survey. This is the most comprehensive assessment of sediment distribution and benthic habitat composition available for the Milford Haven Waterway with 559 stations covering over 40 km² of subtidal habitats. The SPI survey obtained images of cross-sections of the sediment-water interface and plan-view images of the seafloor surface. The results included grain-size information, biological characteristics, and evidence of sediment transport conditions and effects of biological activity.

In the context of the Milford Haven Waterway, an interpretative framework was developed that classified each station within a 'facies' that included information on the location within the estuary and inferred sedimentary and biological processes. This framework groups the stations into classes with similar sediment transport conditions used to describe landscape-scale habitats and can be used to direct future monitoring activities within the Milford Haven Waterway.

Collection of images from a high density of stations provided a synoptic view of the sediment mosaic and was used assess the condition of sediment infaunal communities of the waterway system. In order to map the sediment mosaic, facies descriptions were used to integrate the SPI and PV information. Intertidal sediment 'facies' maps have been compiled in the past for Milford Haven Waterway; this approach was expanded to map the subtidal portions of the Waterway. Because sediment facies can be projected over larger areas than individual samples (due to assumptions based on physiography, or landforms) they represent a model of the distribution of sediments in an estuary. This model can be tested over time and space through comparison with additional samples or older sample results. This approach provides a means to evaluate stability or change in the physical and biological conditions of the estuarine system.

Initial comparison with past results for intertidal facies mapping and grain size analysis from grab samples showed remarkable stability over time for the Milford Haven Waterway. The results of the SPI mapping effort were cross-walked to the EUNIS classification to provide a comparison of locally-derived habitat mapping with European-standard habitat mapping. Cross-walk was conducted by assigning each facies (or group of facies) to a EUNIS habitat (Levels 4 and 5) and compiling maps comparing facies distribution with EUNIS habitat distribution. The approach was comparable at Level 4 EUNIS Habitat (e.g. Sublittoral sand in variable salinity) and for some Level 5 EUNIS Habitats. The facies approach provides critical information on landscape-scale habitats including relative location and inferred sediment transport processes. The seafloor imaging approach cannot consistently identify key species contained within the EUNIS Level 5 Habitats. For local planning and monitoring efforts, a combination of EUNIS classification and facies description provides the greatest flexibility for management of dynamic soft-bottom habitats in coastal estuaries. This approach is practical if a robust cross-walk methodology is developed to utilize both classification approaches.

Habitat mapping and biotope classification – the basis for biotope assessment in the Baltic Sea

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Habitat maps and a classification system are basic requirements to assess the status of marine biotopes. They are not only relevant tools for conservation efforts e.g. under the Habitat Directive but also for the general management of marine areas and their assessment under the European Marine Strategy Framework Directive (MSFD). In order to meet the demands of the MSFD each Member state must be able to identify its biotopes within a classification system. Predominant and special habitats are to be assessed in descriptors 1 (biodiversity) and 6 (seafloor integrity) of the MSFD.

We present the current work from the south-western Baltic Sea where data gained in mapping and monitoring activities are used to verify a biotope classification system. The aim is to identify and locate habitats and their associated benthic communities and to ensure an ecological meaningful classification of habitats. Therefore, the proposed HELCOM underwater biotopes/ habitats classification system (HUB) was tested against the field data. The focus was on soft-bottom communities and on predominant habitats in offshore waters.

The HUB is a Baltic Sea wide typology that has been designed to be compatible with the European Nature Information System (EUNIS). It consists of levels 1-6: 1) region, 2) vertical zones), 3) substrate, 4) community structure, 5) characteristic community, 6) dominating taxon.

More than 500 sampling stations were analysed in regard to the highest possible level of the classification system. Macrozoobenthic community composition and their linkage to environmental parameters such as salinity, sediment characteristics, light availability and oxygen were investigated.

Based on the analyses of biotic and abiotic data, 13 biotopes (level 5 and level 6 of the classification) were identified. Seven biotopes occur on sandy sediments, three are found on muddy sediments and on mixed substrates, respectively. Most biotopes are dominated by infaunal bivalve or polychaete communities. Several others are dominated by epifauna, and one biotope is dominated by vegetation. For some biotopes varying states of health were recognized in benthic fauna. We discuss implications for an appropriate assessment and for further evaluation concerning the status of biotopes. Mapping is not only a necessary first step before any evaluation of habitats can begin; comprehensive and complete habitat maps are needed for a subsequent quantifying assessment of biotopes/ habitats such as the estimation of habitat loss.

The application of the HELCOM classification system for the south-western Baltic Sea is feasible, in regard to the implementation of the MSFD as well as the Baltic Sea Action Plan. This finding is an important step towards a coherent marine management within the Baltic Sea and for all European Seas applying EUNIS or EUNIS compatible classification systems. The methods used in this study may also be helpful to validate biotope classifications in other marine areas.

Mapping and registration of seabed biotopes in the German Exclusive Economic Zones (EEZ) of the Baltic Sea and the North Sea

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This presentation focuses on a large-scale project aiming at the identification, registration and mapping of seabed biotopes in the German EEZ. Such maps are needed in order to meet the requirements arising from different provisions of the European Union and national laws such as the Habitats Directive[1], the Marine Strategy Framework Directive[2] and the Federal German Nature Conservation Act. Both, EU-Directives and national law, obligate Germany to protect certain seabed biotopes. Further, for the German Federal Agency for Nature Conservation (BfN), the contracting authority of the project, biotope maps are important tools in the course of environmental impact assessments in the EEZ.

The project started in 2012 and has so far concentrated on seabed biotopes within the Natura 2000[3] sites in the EEZ. By the end of 2014, the project has to create a guidance document for marine biotopemapping under consideration of existing biotope classification systems such as the European Nature Information System (EUNIS) and the classification used for the German red list of biotopes. The remaining German EEZ area outside of Natura 2000 sites is planned to be mapped in a stepwise approach from 2015 on.

Besides existing data, the collection of new data on benthic species and sediments as well as on other relevant parameters is necessary. Therefore, the project is subdivided into two subprojects: *Subproject A* thereby focuses on biological investigations, data management and biotope modelling and is carried out by the University of Vechta (coordination, data administration, biotope modelling), the Leibniz Institute for Baltic Sea Research, Warnemünde (benthic sampling Baltic Sea) and the company BioConsult (benthic sampling North Sea). *Subproject B* aims at sediment mapping by use of side scan sonar, under water video and grab samplers and is performed by the Federal Maritime and Hydrographic Agency of Germany, Hamburg, in cooperation with the Alfred Wegener Institute / Helmholtz Centre for Polar and Marine Research Sylt, the Leibniz Insitute for Baltic Sea Research Warnemünde, the Institute of Geosciences at Christian-Albrechts-University of Kiel and Senckenberg am Meer Wilhelmshaven.

Since the beginning of the project geological and biological surveys were performed in the Natura 2000 sites *SylterAußenriff* and *Borkum-Riffgrund* (North Sea) as well as Fehmarnbelt and Kadetrinne (Baltic Sea). Older existing and newly collected data are combined in a geo-referenced GIS register. Some Baltic seabed biotopes could already be classified by applying levels 5 and 6 of the new EUNIS based HELCOM underwater biotope (HUB) classification for the Baltic Sea. For the North Sea, where so far less information on benthic biology is available, a concept for the creation of a biotope-typology by abiotic parameters has been developed and will be tested in the near future. The concept depends on statistical modelling techniques and was applied on data from environmental impact studies.

[1] DIRECTIVE 92/43/EEC of 21 May 1992
[2] DIRECTIVE 2008/56/EC of 17 June 2008
[3] According to DIRECTIVE 92/43/EEC of 21 May 1992 and Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds

Biologically relevant predictions of benthic assemblages using Telemac3D results

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Recent benthic habitat mapping has been strongly influenced by geophysical methodologies and geological interpretations resulting in maps that represent acoustic facies and associated physical conditions rather than distributions of biota. The propagation of using physical surrogates for habitats was supported by observations of strong species-sediment relationships. However, benthic species are not necessarily associated with a particular sediment type and exist across a range of physical parameters which cannot be elucidated by geophysical methods alone.

Unfortunately, beyond multibeam echosounder (MBES) data, which provide continuous information across large areas of seabed at metric resolution, few data are available at a resolution high enough to provide accurate predictions of faunal distributions. Where water column information has been used in habitat map production it is often at kilometric resolution and difficult to reconcile with patterns observed in ground-truth data.

As part of the UK's marine conservation zone programme Cefas has been required to create 'broad-scale habitat' maps for recommended sites that required verification of the substrata classes listed in the site assessment recommendations. These 'broad-scale habitats' are mostly substrata based, the exception being a biogenic reef class, and fit within the EUNIS/MNCR framework, e.g. A5.2 Subtidal Sand. Here we present the results of an investigation into the use of very high resolution TELEMAC 3D (15 m^2) hydrodynamic model results to complement acoustic data sets in benthic substrata and habitat mapping. We also investigate whether such model results can be used to create adequate 'broad-scale habitat' maps in the absence of hi-res acoustic data.

The study concentrated on one of the recommended marine conservation zones (rMCZ). The North St Georges Channel rMCZ, located in the Mid-Irish Sea, is north-west of Anglesey. It covers approximately 1,300 km^2 and contains a series of interesting geological and geomorphological features such as methane-derived authigenic carbonate, drumlins and trochoidal sand waves. Taking advantage of the flexible mesh within TELEMAC 3D, the model covers the Malin Shelf, Irish and Celtic Seas and Western Approaches; with a resolution down to 15m over the rMCZ we are able to generate hydrodynamic forcing over the study area at a scale fine enough to be biologically relevant. These results are then used alongside MBES ground-truth data to create maps using object based image analysis and machine learning techniques.

Direct comparison between the model-derived habitat maps and the original broad-scale habitat map, shows that hydrodynamic and bed evolution data can successfully be used as a proxy in the absence of acoustic data or to further compliment and extend datasets acquired from field operations.

The technique has significant application in all areas where the sensitivity or response of the ecosystem to changed hydrodynamic or geomorphological regime is required, either from natural or anthropogenic forcing.

Unique offshore site for benthic biodiversity: the Plateau of Rochebonne, French Atlantic coast

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The Plateau of Rochebonne is located 70 km offshore, west of Ré island on the French Atlantic coast. It is characterised by three granitic tabular structures emerging from a micashist bedrock at -50m depth and almost reaching the surface (-4m below the mean water level). These three rock walls about 2-3 km long, oriented perpendicularly to the main swell create a strong hydrodynamism with violent currents and big waves, which explain why this unique environment had been investigated only in 1965 and 1967 (Castric-Fey, 1973). Deep vertical rifts occurred in the tabular structures creating many anfractuosities (Callame, 1965) allowing a high diversity of biotopes. This site is known to be frequented by numerous dolphins (*Globicephalas melas, Delphinus delphis, Tursiops truncates*), the porpoise (*Phocoena phocoena*) and the basking shark (*Cetorhinus maximus*) and plentiful of fishes. La Congrée, which is the westernmost reef is an important reproduction zone for European seabass (Dicentrarchus labrax).

In 2010, a study was realized for the CARTHAM French mapping program. The northern of the reefs constituted by schist bedrock has been investigated with sonar surveys (Créocéan). For the reef exploration, a campaign of 15 dives between -4 and -50 m were organized from July to September by Bio-Littoral in collaboration with the French National Museum of Natural History. It was an explorative mission intended to prospect marine habitats of interest with no aim of exhaustive inventory, but the site revealed a huge potential of biodiversity with 55 macroalgal species (with the rare *Desmarestia dresnayi*), 125 benthic invertebrates, and high diversity of sponges (34 species were indentified). The euphotic zone was dominated by kelp forest with the annual species *Saccorhiza polyschides* on the top of the tabular stuctures, where winter hydrodynamism prevents algal implantation. Below the shore-break zone, dense forest of *Laminaria hyperborea* reach depth of -28m. One of the site originality rely on the continuum between deeper habitats (down to -80m) and the surface, explaining the presence of deep-dwelling species rarely observed at such shallow depth, like the habitat "*Phakellia ventilabrum* and axinellid sponges on deep wave-exposed circalittoral rock". Large area of dense hydroid turfs of *Gymnangium montagui* have been observed in zone of lower hydrodynamism. Dense populations (> 100 ind/m^2) of brachiopods (*Megerlia truncata* and *Terebratulina retusa*) were observed for the first time in Europe, covering large surfaces (> 10 m^2); a specific habitat has been asked to be created in EUNIS typology. This study confirmed the biological interest of the Plateau of Rochebonne, but revealed the difficulty to map such vertical structures in spite of the complementarity of investigative tools (sonar/ROV/scuba-diving). Eventually, this study raised the question of management of this area, since ecological functioning is largely unknown. The hypothesis that cyclonic currents are generating up-welling from the deeper southern mudflats, which are langoustine reproductive zones, remains to be tested.

Marine habitat characterization and mapping in Portuguese coastal areas

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The degree of existing knowledge on the spatial distribution of seabed attributes and species communities is regarded as of fundamental importance for the management and monitoring of the marine environment. As such, maps have increasingly become an essential tool for representing information on the geographic distribution of marine habitats.

In this study we present the results of habitat mapping for two coastal sites in the Portuguese continental coast. The first, located in the West coast, covers the marine protected area of the Arrábida Natural Park (Luiz Saldanha Marine Park) with an extent of 89 km2 and depths down to about 100 m. The second, in the Southwest coast, comprises an area of 36 km2, located South of Sines and extending to about 50 m depth.

Soft sediment sampling for grain size and benthic macrofauna characterization was performed with a 0.1 m^2 Smith-McIntyre grab. Acoustics seabed remote sensing survey for seabed physical characterization was carried out using single beam AGDS (50 kHz) and sidescan sonar (450 kHz). Video footage obtained from a monochromatic video camera and sediment particle size characterisation were used to validate and complement the data obtained by the acoustic methods.

The information on the distribution of sediment type, depth, seabed light intensity, seabed energy, wave base ratio and benthic communities was spatially integrated along with data thresholds established within the MeshAtlantic project through map algebra. As a result, predictive benthic habitat maps were obtained for both study areas by classifying seabed habitats according to EUNIS units.

These maps provide easy and comprehensive information on habitat spatial distribution in both sites and highlight differences and similarities in physical and biological aspects.

Habitat mapping as a tool for conservation and sustainable use of marine resources

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One of the main goals of marine spatial management is to promote a sustainable use of marine resources while not putting marine biodiversity and habitats at risk. Objectives for marine biodiversity and habitats are stated by the Biodiversity Convention, Habitat Directive and the Marine Strategic Framework Directive and involves that no species or habitats should be lost, and sea floor integrity should not be compromised.

These goals and objectives clearly requires knowledge of what species and communities are present, the characteristics of natural and healthy biotopes/habitats, and effects of different human activities to be able to make plans for human activities and need for protection.

Mapping health status of benthic habitats/biotopes has traditionally been based on soft bottom collection of infauna using grabs (~ 0.1 m^2). This documents only a limited part of the sea floor biodiversity. Depending on depth, hydrography, and local landscape complexity the substratum can be homogenous but seasonally variable in fauna composition, have varied topography and sediment but stable fauna composition over time, or a wide range of combinations in variability. This clearly demands for a broad approach to mapping for management of species and habitats.

As a first step visual inspection can show what the general features are in areas that has been mapped with multibeam echosounder. A coarse classification of seabed habitats/biotopes based on the composition of megafauna and substrates can be carried out from video analysis of benthic megafauna. The scale of variability is crucial for density of observations and samples needed, and the substratum decides what bottom sampling gear can be used to describe the species diversity more complete than just the megafauna visible with video camera. Contrasting water bodies can explain fauna changes with depth that are not supported by visible habitat changes. Identifiable habitat/biotope classes reflect different environmental settings in marine landscapes (e.g. banks and troughs on the shelf). These are often the major features comprising habitats with different substrates that can be subdivided into biotopes with specific fauna composition, functionality and production.

The presented approach to mapping can identify biologically valuable areas, assess human impact and health status for marine bottom habitats/biotopes in a broad set of marine landscapes.

Habitat mapping as a tool for management and planning of Natura 2000 marine sites in Brittany

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The sea in Brittany hosts a remarkable marine natural heritage, with a very diverse fauna and flora, sometimes very original. Well-known along the sea-shore, this diversity is also typical of Breton seabeds. Maintaining biodiversity is also a need for many activities depending on the quality of marine environment. Brittany consequently has a great responsability towards France and Europe to preserve this rich and exceptional heritage. To address these preservation challenges France has various tools, among which six categories of Marine Protected Areas according to the Law of the 30th of April 2006 :

1/ National parks with a marine part
2/ Natural reserves with a marine part
3/ Biotope decree with a marine part
4/ Marine nature parks
5/ Natura 2000 sites with a marine part
6/ Marine parts of the public land belonging to the French coastal conservatory

Each category concerns a different scale of territory. Biotope decrees usually aim at very precise preservation challenges on small areas, whereas marine nature parks cover vast surface areas where a rich biodiversity is under the pressure of many human uses or activities. As for OSPAR convention relating to the protection of marine environment in north-east Atlantic, Natura 2000 sites respond to France international commitments, within the scope of setting up a coherent network at the European scale. After the designation of several sites from 2007 to 2009, the network of Natura 2000 marine sites is now in place in Brittany, with 35 Sites of Community Importance (Directive 92/43/EEC) and 22 Special Protection Areas (Directive 79/409/EEC).

The perimeters of these sites were defined mobilising the scientific knowledge available on marine environment from different organizations among which IFREMER, Universities, the National Center for Scientific Research and the National Museum of Natural History, the latter being the referent for the French Ministry of Ecology, Sustainable Development and Energy.The main challenges for coastal biodiversity were targeted : Zostera beds, maerl banks, kelp forests, boulder fields, Sabellaria alveolata reefs, Lanice conchilega seabeds... This will allow France to address the objectives of the European directive on habitats (92/43/EEC) with regards to knowledge acquisition and appropriate management, in order to reach the good conservation state of habitats and species in Natura 2000 sites. Many tools can be used to elaborate the objectives documents, that define management and planning for each Natura 2000 site in France. Among these, habitat mapping is essential and widely used for knowledge acquisition, communication, management and evaluation in marine Natura 2000 sites.

From 2009 to 2012, the CARTHAM project for marine habitat mapping was conducted by the French MPAs Agency, and allowed precise mapping of 10 SCIs in Brittany. This work will complete the habitat maps produced by the REBENT programme since 2000, focusing on Natura 2000 sites since 2009.

Assessing the SW Europe MPA network representativeness using the new MeshAtlantic broadscale seafloor map

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As pressures from industrial and leisure activities build up on coastal and offshore environments, mapping marine habitats distribution and extent has become instrumental for adequate marine spatial planning and management.

With the increasing availability of global scale data on key variables regulating marine biological distributions, desktop methods have been developing over the last decade which already permit the production of predictive habitat distribution maps at sub-kilometric resolutions.

The MeshAtlantic project has recently compiled GIS layers on fundamental physical parameters of the SW Europe seas, including (i) bathymetry, (ii) substrate nature, (iii) light penetration and (iv) hydrodynamic exposure to near-seabed currents and wave action.

Based on analyses of biological occurrences, significant thresholds were fine-tuned for each of the abiotic layers and later used in multi-criteria raster algebra. The final result was a harmonised broadscale seabed habitat map with a 250 meter resolution covering a seabed area exceeding 2 million km2 and extending latitudinally from Ireland to Gibraltar and longitudinally from the Bay of Biscay out to the archipelago of the Azores. By relying on a set of standard criteria and the EUNIS habitat classification, this map represents a basic thematic layer for regional marine habitat assessments. Using such baseline information along with the spatial compilation of Marine Protected Area designations in SW Europe produced project MAIA, an assessment is made in this communication of the region's MPA network representativeness in terms of broad-scale habitat extents.

A series of quantitative indicators are presented that provide a gauge of marine habitat protection in SW Europe. These numbers should help establish the conservation needs of each habitat in the region and per country, vis a vis total predicted habitat extents.

This new geographical and quantitative information is put forward for planners, managers and scientists to discuss and define their needs, future priorities and investments. Overall it contributes to more informed and comprehensive Marine Planning and Management.

Mapping the extent and complexity of seabed habitats within Marine Protected Areas: choices of techniques employed

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There are inherent challenges to overcome when mapping the extent of habitats. Defining the purpose and end uses of the outputs, deciding on the most appropriate habitat classification scheme to use, the classification level, scale and degree of precision to best represent the information are a few of the critical questions faced at the beginning of the mapping process. The choice of technique and the data utilised has a significant bearing on habitat mapping products and their complexity.

A recent study for the JNCC tested these questions, and applied three habitat mapping strategies in the analysis of the data available to assist our understanding of the extent and spatial complexity of the features present within a subset of Marine Protected Area proposals. Data available to the study consisted of bathymetric and backscatter datasets from multibeam sonar, sediment type data, grab samples and photographic imagery data. The study required the selection of the most appropriate mapping categories from the full range of habitats identified and biotopes assigned to the survey sample data.

The first approach employed a rule-based/top down process in which broadscale physical parameters were intersected to produce a categorised habitat map. A bottom-up/ survey data driven approach was the second habitat mapping technique applied. The sample data were used to interpret the acoustic datasets incorporating object-based image analysis (OBIA). Habitat maps were derived from a supervised classification using the data-rich features identified from the acoustic images. The third approach was a variation of the second and categorised the objects identified through the OBIA process according to mapping categories. The result was a habitat map based on the most likely seabed category at any location.

It is critical that such maps are used with clear understanding of how they were generated and the reasons for the differences between the outputs. The JNCC study explored how such understanding can be supported through the generation of layers which illustrate the levels of certainty of classification and the probability of each habitat's occurrence.

Each approach may paint a slightly different picture in terms of feature presence and extent within the study area. The different approaches have their merits in utilising all available data and presenting the user with different interpretations of information with which to better understand the likely feature composition in the area. This presentation will examine the implications of this study on practical considerations of how and when the different mapping outputs might be best utilised by the JNCC in the development of marine nature conservation advice.

Using a combination of survey-derived and broad-scale predicted habitat maps to assess Marine Protected Area networks in United Kingdom waters

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The UK has signed up to international agreements such as the Convention on Biological Diversity and the OSPAR Convention, that aim to establish an 'ecologically coherent network of Marine Protected Areas (MPAs)'. The Joint Nature Conservation Committee (JNCC), a public body that advises the UK Government and devolved administrations (in Northern Ireland, Scotland and Wales) on UK-wide and international nature conservation, is working with other UK agencies to develop a network of MPAs in UK waters. JNCC developed a mapping product that combines survey-derived habitat maps and a national-scale habitat map derived from habitat prediction models, to create a single UK-wide habitat map. The present paper describes how this single map was used to identify potential MPAs and support emerging assessments of whether the MPA network is 'ecologically coherent' at a UK level.

Key principles for determining whether a MPA network is ecologically coherent are 'representation', 'replication' and 'adequacy'. The tests are whether the marine habitat features thought to occur within a national territory are represented in the MPAs within a network; whether the network protects a sufficient number of replicates of each feature; and, whether a sufficient proportion of the total area of each habitat has been protected. To assess these principles, it is crucial to use a map of habitat distribution across the seabed of the national territory. Furthermore, such a map should be derived from the best available data so that any MPA network analysis accurately reflects the current state of the network.

JNCC produced a single mapped layer of EUNIS Level 3 physical habitats for UK waters, which used a decision process to select the best available mapped data at any given spatial location. The UK level habitat map is generated from the composite EUNIS layer (created by combining habitat maps determined from survey data, as seen on the MESH Atlantic interactive mapping portal (Reference 1)) and the UKSeaMap 2010 layer (a full-coverage predicted map based on physical parameters (Reference 2)). Maps of seabed habitats from survey data are not available for all areas and therefore predictive habitat mapping was used to 'fill-in' the areas in-between the survey-derived maps.

The decision-making process adopted for prioritising/selecting the best available mapped habitat data is described in this paper. The complexities of using a map with multiple origins, including how to accommodate a map which has constituent parts that vary in quality, and the considerations that need to be taken into account when undertaking MPA network analyses on such a map will be discussed. This single mapped layer is being used for carrying out an analysis of the UK's MPA network. The paper will present our progress with mapping in relation to the MPA network assessment and the challenges encountered will have wider relevance to MPA practitioners in other countries attempting network analysis.

The use of habitat maps in marine planning and conservation

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There are two types of habitat map available for use in marine spatial planning, those based on modelled data (model maps) and those based on survey data (survey maps). This presentation compares and contrasts some of the features of these different types of map, and considers how these influence both spatial accuracy and classification accuracy. There can be significant disagreement between model maps and survey maps when they are overlapped, and it is important that planners understand why the maps disagree. It is reasoned that modelled maps are more suited for use in advisory policy (where there are several options for locating an activity) and survey maps are more suited to prescriptive, spatially explicit policy (deciding what activity can take place where). The need for planners to understand the habitat classification system is also highlighted, as this determines the feature richness of the maps that they commission.

Multi-approach mapping to help spatial planning and management of the kelp species *Laminaria digitata* and *L. hyporborea*: Case study of the Molène archipelago coastal area

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The Molène archipelago in Brittany hosts one of the largest kelp forests in Europe. Thousands of tons of kelp are collected each year for the needs of the chemical and food industries. Harvesting mainly concerns the two species *Laminaria digitata* (56,000 T) and *Laminaria hyperborea* (over 13,000 T) representing approximately 95% of the landings. Estimating the size and the distribution of the stock remains a need to provide appropriate management measures.

Various studies have highlighted the difficulty to accurately estimate the distribution of kelp along Brittany's coast. So far, rough estimates were based on cross-tabulating rock extent, average biomass and kelp cover rate from expert's say. In order to enable more accurate spatial biomass estimates, we combined different sources of direct and indirect observations with a simple statistical approach.

Firstly, surveys and appropriate processing provided a detailed seabed topography map and accurate delineation of hard substrate. This delineation was based on airborne Lidar and optical imaging acquisitions and was completed in deeper areas by acoustic data. Statistical models of presence/absence and biomass were then developed for each species by relating in situ observations from underwater video and sampling to the many biotic and abiotic factors that may govern kelp species distribution. Our statistical approach also provided spatial indicators of the uncertainty associated with each prediction to help management decision. A risk analysis was performed for presence/absence distribution and the extreme limits (minimum and maximum) of biomass estimates were mapped knowing the confidence interval of each prediction.

The present study, by simplifying the interpretation of model uncertainties, provides immediate support for managers. As revealed by in situ data analysis, further work is needed, particularly on spatially-explicit population dynamics. Identifying productive areas and apprehending the temporal dynamics of the kelp stock may be of major importance for long-term management.

Mapping marine biodiversity as a tool for marine spatial planning: the coast of Algarve case study

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Within the framework of the MeshAtlantic project, an analysis of historical habitat maps and the execution of new surveys in order to map and evaluate the presence of marine biodiversity hotspots, threatened species and priority habitats were carried out. The aim of this data collation was to produce habitat and biotope maps usable in the process of marine spatial planning and integrated coastal management.

Several historical habitat maps were assembled following the EUNIS giving space to the introduction of new habitats of the southern Atlantic coast of Europe in this classification. The biodiversity maps produced also included areas with priority habitats such as seagrass meadows and maerl beds.

New surveys using multibeam and side scan sonar for the characterization of bathymetry, topography and sediment type were conducted, while underwater visual census (scuba diving and ROV), Van Veen dredge and beam trawl were performed for the biodiversity mapping and ground truthing of rocky and soft bottoms, respectively. Some of the habitats sampled were associated with special features such as Sagres MPA, Portimão and São Vicente submarine canyons, which by its turn presented unique habitats.

EUNIS thresholds for biological zonation and energy were refined and European catalogue of seabed signatures was complemented. The spatial distribution of threatened species was modelled following habitat suitability patterns and validated by the data acquired.

All this information have been combined with sediment maps with the intention of consolidate MPAs in place, propose new priority habitats to OSPAR and suggest marine sites to be integrated in the NATURA 2000 network in Portugal mainland.

Seabed mapping for Ocean Management – Canadian perspective

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Accurate and detailed mapping of the seafloor (geology, habitat and bathymetry) is key to economic development and effective management of our marine environment. Canadian Ocean sector activities generated an estimated $17.7 billion in direct GDP (2006), creating over 171,000 direct jobs. While 99% of Canadian landmass is mapped in high resolution, less than 10% of Canada's submerged lands are known to a similar detail. Countries like Ireland and Australia have successfully mapped most of their offshore territory which provide multiple economic benefits in navigation safety, environmental conservation, attraction of investment, reduced risk to exploration, fishery, tourism, and streamlined ocean governance. The US recently completed a valuation study that demonstrated a 35:1 return on investment of seafloor and coastal mapping considering direct (job creation, investment, trade) and indirect economic benefits (through ensuring sustainable marine ecosystems). Ireland reported 6:1 ROI on multibeam mapping of the EEZ. It is reasonable to assume that the new maps of Canadian maritime transportation highways, bottom habitats and seabed hazards and resources could yield an order of magnitude return on investment in integrated ocean mapping. Fishing, transportation, mining, oil and gas industry have direct benefits from multi-discipline, interpreted seabed maps through increased profitability and through loss reduction (increased efficiency in operations and management, hazard risk reduction, lower insurance costs, lesser fuel expenses, decreased environmental impacts and mitigation costs etc.). Maps also yield indirect social and environmental benefits by helping government regulators identify prospective resources and barriers to development and in assisting resolution of seabed use conflicts through efficient access to information for decision-making. There could be enormous benefits from coordination of seafloor mapping activities and from adopting strategic approach to 1) Implementing standardized operational acquisition and delivery of information on seafloor bathymetry, geology, habitat and biodiversity; 2) On-demand provision of seafloor maps and derived knowledge to address urgent issues (e.g. managing the impacts of marine pollution incidents on marine resources, habitats and users) as well as for ongoing resource, environmental and social planning needs (e.g. streamlined environmental assessments, design of MPA networks and characterization of EBSAs); 3) Systematic, long term, country-wide collection of baseline mapping information on the seafloor to facilitate strategic economic development projects. Such strategy is essential for ocean economy of countries with large volumes of marine trade/tourism/fishery, long coastlines and large shelf areas.

Inventory and comparative evaluation of seabed mapping, classification and modelling activities in the Northwest Atlantic, USA to support regional ocean planning

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All seabed mapping efforts confront conflicts between local, regional, national and international approaches and policy needs. As the United States begins to implement a National Ocean Policy that explicitly addresses Marine Spatial Planning, these conflicts and their resolution may inform European debates over mapping and marine management. The Northeast Regional Ocean Council (NROC) is a United States state-federal partnership that seeks to find and implement solutions to New England's most pressing regional coastal and ocean issues such as climate change/adaptation, energy siting, and fisheries management. NROC member states include Connecticut, Rhode Island, Massachusetts, New Hampshire, Maine, and Vermont. Among member states and federal agency partners, there are several independent marine habitat classification and modeling efforts currently underway. Although occurring in neighboring waters, management and policy drivers differfor each of these efforts . However, common elements (particularly science and data needs) are likely synergistic and would benefit from a collaborative, coordinated effort in the future.

Recognizing this, in 2012 NROC convened a regional Habitat Working Group comprising representatives from state and federal organizations in order to contribute to a regional inventory and comparative evaluation of seabed characterization, classification and modeling activities. Overall, NROC's goal was to advance our understanding and management of ocean habitats in New England.

As facilitators of this comparison and evaluation, we solicited detailed information regarding the biological, geological and physical mapping data that had been collected in New England over approximately the past decade. For the first phase of the comparison, we organized projects based on whether they were "data generators" (e.g., mapping projects) "data consumers" (e.g., modeling projects) or "classifiers" (e.g., scheme building projects). We then documented responsible entities, purpose, scope, budget, scale, classification scheme, audience, and data types for each of the major regional and state mapping initiatives. We developed a simple visual schematic that scientists, managers and the public could easily interpret in order to compare mapping projects based on these categories.

In the second phase, we identified metrics based on the project inventory with which to conduct a detailed project comparison. We polled members of the Habitat Working Group to determine which metrics would be most important for assembling a detailed methodological evaluation. Members identified "Species or habitat targeted for mapping" and "Mapping strategy: abiotic surrogates, top-down, or bottom-up" as the two most important metrics. We considered the top ten metrics in the detailed project comparison, again employing simple visual schematics in order to report results to a wide range of stakeholders.

As a result of our inventory and comparison, we have achieved a regional consensus (among members collecting seabed data) to use the U.S. Coastal and Marine Ecological Classification Standard (CMECS) for regional seabed habitat maps. We were informed by regional efforts to "cross-walk" local classification systems to CMECS that lowered barriers to implementation. In addition, we have highlighted the potential steps necessary to "edge-match" adjacent and/or spatially nested projects. Our results represent best-practices and include lessons-learned throughout New England that are useful for implementation of European standards for seabed mapping.

Mapping marine litter and lost fishing gear in the Gorringe Bank

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Studies concerning marine litter input into the ocean received a great attention over the last years by the scientific community mainly due the ecological and economic impacts in the ecosystems, from coastal waters to the deep ocean seafloor.

The distribution, type and abundance of marine litter in the two seamounts of the Gorringe Bank was analysed from photo and video imagery obtained during ROV-based surveys under the framework of the E/V Nautilus Exploration Program, cruise NA017.

The Gorringe Bank is located in the Azores-Gibraltar transform plate boundary, 150 nautical miles WSW of Portugal; it is formed by the Gettysburg and Ormonde seamounts which rise from depths over 5000 m to a few tens of meters below surface.

The high frequency of lost or discarded fishing gear, such as cables, longlines and nets, observed in the Gorringe Bank suggests that fishing activities may impact the benthic habitats. The deep sea fishery, mainly in terms of drifting vertical long-line fishery, extends to 2000 m depth but the extent to which trawling is done is unknown.

Other types of litter were less frequent and included mostly metal (e.g. ship artifacts, tins, cans), glass (e.g. bottles) and to a much lesser extent, soft plastic. Litter composition suggested an origin mostly from maritime activities and its abundance appeared to be lower than in continental margin areas.

The large areas with rocky outcrops support vulnerable habitats such as coral gardens and sponge aggregations at bathyal depths and coralligenous algae and kelp beds at the summit. The highly diverse and productive benthic assemblages provide food and habitat for commercially important fish species turtles and cetaceans. Because of these characteristics the Gorringe Bank was used by WWF as a showcase example and subsequently nominated by Portugal for the OSPAR system of Marine Protected Areas. Information on distribution and type of litter and lost fishing gears is important for the management plans which have to be developed and enforced and should be used to increase societal and scientific awareness regarding marine debris.

INFOMAR and MESH Atlantic – Value From Seabed Mapping

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The MeshAtlantic Project is supported by INFOMAR, Irelands national seabed mapping programme. It was managed under INFOMARS Value Added Work Programme. This element of INFOMAR seeks to add value to the national seabed mapping programme and, as such, is evolving in importance given the current financial environment. In supporting projects such as MeshAtlantic, and integrating the outputs, INFOMAR seeks to address national directives in co-operation with the responsible bodies, while also evolving its product suite. The seabed mapping element of MeshAtlantic will also be incorporated directly into INFOMAR.

Mapping of different benthic habitat components in the Basque continental shelf (NE Bay of Biscay) and its application within the MSFD

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To properly apply European directives (mainly Habitat and Marine Strategy) Member States and the European Commission require information about the marine environment, of which seabed habitats are an integral part. Within this context, in 2005, a seafloor mapping programme, funded by the Basque government, commenced with the aim of seafloor characterisation and benthic habitat mapping of the Basque continental shelf. After this, in 2010 the MeshAtlantic project was launched, including a case study for the Basque continental shelf. The objectives of this case study were (i) to characterize those habitats with little information (i.e. rocky habitats), (ii) to improve the EUNIS habitat classification, suggesting adaptations to fit with the characteristics of this region, (iii) to propose new habitats of ecological importance to be included in the EUNIS classification, and (iv) to contribute to a broad-scale habitat map for the Atlantic area.

Seafloor mapping was based on multibeam echosounder (MBES) (operating up to 200 m water depth). A total of 2,523 grab samples, were collated for ground-truthing and sediment characterisation. Biological benthic data included 461 grabs from soft-bottom, 50 samples from rocky seafloor taken by divers, 83 underwater image recordings at circalittoral zone (survey date 2010 and 2011 and 9 km of ROV track records (survey date 2012). The approach used in this investigation is based on a mixed top-down and bottom-up approach. High resolution information recorded with remote sensing techniques was used for the preliminary physiographic or seascapes classification. Then, sedimentological and wave energy on the seafloor was integrated, which resulted in the level 3 (rock substratum) and level 4 (sedimentary substratum) of EUNIS abiotic habitat map. The assessment of rocky seafloor habitat characterisation was carried out by the interpretation of underwater images and video analysis by an expert benthologist. Information on physical characteristics and species lists were extracted and linked to geographical location of the images.

On the other hand, the assessment of soft-bottom benthos was based upon a statical analysis within PRIMER. It was carried out to relate the sedimentological and oceanographic conditions to species distribution. The aforementioned information was then used for habitat classification and mapping by environmental information layer combination in a GIS environment. The habitat classification was based on EUNIS, but it was adapted to the specific characteristics of the Basque continental shelf habitats. Apart from this, the Habitats of Community Interest according to Natura2000 were identified and habitats of interest in the Basque area were finally identified and mapped.

A total of 39 habitat classes were identified: 4 of them were classified as littoral, 29 as infralittoral (from which 11 were of rocky substratum and 12 sedimentary substratum), 2 were coastal habitats, 3 artificial habitats and 1 habitat class was used for estuaries (complex habitats).

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 region in the last 60 years. A total of 50 different megafauna-dominated benthic facies are inventoried in an 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. A thousand biological records extracted from the COLETA database are used to model the mesoscale distribution of 28 coral genera on the Azores Plateau (220,000 km2). Explanatory variables are drawn from an original selection of 40 geomorphological, oceanographic, biological, physical and chemical parameters up- and down-scaled to a common resolution of 300m from publicly available datasets and climatological atlases.

The results are used to assess the representativeness of the Azores MPA network and the overlap between fishing activities and coral habitats hotspots. Furthermore, this work contributes towards the mapping of some of the most important deep-sea biotopes of conservation importance and to inform the development of the deep-sea section of the EUNIS habitat classification system.

The influence of data resolution on estimates of extent and distribution of deep-sea habitats

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Estimates of extent and distribution of habitats is an essential prerequisite for conservation and management of marine ecosystems. Predictive species distribution modelling techniques provide a robust, repeatable method of biotope map production, however the influence of data resolution on the application of these distribution modelling methods to conservation target assessment has so far received inadequate attention.

We use maximum entropy (MaxEnt) modelling together with high resolution multi-beam bathymetry and contemporary data on habitat distribution to produce maps for three listed habitats (Vulnerable Marine Ecosystems) in the NE Atlantic deep sea (UK and Irish extended continental shelf limits). The percentage representation of each habitat within an existing MPA network is quantified and compared to that calculated from distribution maps built from coarse resolution models (750m) (Ross & Howell, 2013), revealing how model resolution influences the assessment of existing area closures for the protection of listed habitats in the marine environment.

The impact of model selection on predicted distribution and extent of deep-sea benthic assemblages

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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. All three modelling techniques performed well giving PCC, sensitivity and specificity values >0.8 for all 3 VMEs except LpReef for which sensitivity values for both RF models were low (0.49 and 0.61). Although all three models performed similarly well, the final maps presented up to 30-35% variation in predicted extent of a VME as well as clear differences in distributions. The implications of this variation in output are discussed in terms of the future use of predictively modelled maps in marine environmental management.

Development of a deep-sea section for the Marine Habitat Classification of Britain and Ireland

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Technological advances, coupled with legislative drivers, have led to a dramatic increase in offshore surveys over the last decade. As the current Marine Habitat Classification for Britain and Ireland only covers waters of up to 200m depth, it has become a priority to develop a deep-sea component to allow data from deeper waters to be assigned consistent biotopes and maintain cohesion within the scientific community. The structure of the deep-sea classification needs to be biologically relevant and suitable for both top-down mapping and bottom-up use.

The deep-sea classification structure has been developed following assessment of the advantages and disadvantages of approaches taken for the existing EUNIS classification and other systems used within Europe, as well as those proposed within the deep sea scientific community. Various options for incorporating biogeography, biological zonation, substratum and biological community into the classification were considered.

The proposed structure introduces one new environmental factor at each level of the hierarchy to better facilitate its use for mapping. The proposed hierarchy structure incorporates the following factors: level 1 environment (marine); level 2 biogeographic region; level 3 biological zone; level 4 substratum; level 5 broad community; and, level 6 species composition. Definitions for biogeographic region and biological zone categories will be developed based on expert review and investigation of broad scale patterns in deep sea communities identified from UK survey data.

Once an overall structure is agreed, the next step is to populate the lowest levels with recognised deep sea biological assemblages, in the appropriate places. A widely recognised problem with the current classification is that, due to inherent sampling bias in the methodologies used to collect datasets used for development, most biotopes describe either the epifaunal OR the infaunal component of the biological community and not both. Taking this into account, separate pieces of work are underway to define infaunal deep-sea assemblages and epifaunal deep-sea assemblages; these will be included separately in the classification. The proposed structure will be reviewed by classification users and the scientific community before official release.

The uptake of a deep-sea classification will contribute to the sampling design for the UK's marine biodiversity monitoring programme, implementation of proposed MPAs, assessments of habitat distribution and extent, and marine planning in deeper waters.

POSTERS

Establishing energy thresholds in the EUNIS classification - Portuguese Case Studies

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The wave energy and currents near the seabed influences the type of the associated biological communities, being thus important to the EUNIS habitat classification. Establishing energy thresholds from wave and currents using kinetic energy is essential to define energy classes. However, due to regional specificity it is not possible to use thresholds from one region in another one. The thresholds should be calculated for every country or at least for areas sharing the same energy model and species.

Kelp samples (*Saccorhiza polyschides, Laminaria hyperborea* and *Laminaria ochroleuca*) derived from historical data and wave and currents models calculated from 90 percentile of kinetic energy, both for Portugal mainland, were used to define classes of energy limits. Each sample location for each species was associated to a value of wave and currents energy.

Based on a rank approach for each kelp species and type of energy, the optimal range of energy was calculated between different lower and upper limits based on different percentile approaches, namely between the lowest value and the 75 percentile and between the 12,5 percentile and the 87.5 percentile.

Results point out that *Saccorhiza polyschides* should be use to establish energy thresholds since its wide distribution along the Portuguese mainland coast contributes to its use as an energy indicator of the moderate class energy (0.003 – 0.043 N.m-2).

Mapping the benthic communities of the Wyville-Thomson Ridge using Maxent predictive modelling

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The Wyville-Thomson Ridge (WTR) in the NE Atlantic represents an important biogeographic boundary for deep-sea species. As a result the area has recently been proposed as a Marine Protected Area for the conservation of biodiversity. However, few data are available on the range and distribution of benthic assemblages (biotopes) at the site. Habitat maps to inform the management process would be desirable. This project uses biological data collected from photographic sea bed survey in 2006 to describe the benthic assemblages of the WTR. Two hundred and six images from fourteen transects were quantitatively analysed. Hierarchical cluster analysis was used to investigate benthic community structure using PRIMER V.6. SIMPER analysis was used to identify main characterising species for each identified cluster. Eleven benthic assemblages were recognized and a description of their main species as well as the environmental conditions under which they were found was made. Maximum Entropy modelling (Maxent) was then used to predictively model the distribution of each biotope. Predictor variables were derived from high resolution multibeam data acquired as part of the survey. The predictive habitat maps highlight the difference in community structure north and south of the ridge driven by the complex hydrography of the region. The results are discussed in terms of potential future management of the site.

MeshAtlantic interaction with stakeholders

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The competition for space in the oceans has been increasing in recent years and spatial information is now regarded as an important issue for the implementation of marine and maritime policies. To address the need for seabed information in the Atlantic area, the MeshAtlantic project aimed at providing shared knowledge, namely as harmonised maps of seabed habitats, covering Portugal (including the Azores), Spain, France and Ireland areas. The maps are designed to support the European Commission and Member States in the development of environmental protection, spatial planning and management actions, at both global and regional levels (e.g. Habitats Directive, and Marine Strategy Framework Directive - MSFD).

In this project, the feedback of stakeholders was deemed valuable to better understand their current needs, and develop the products that best fit their requirements. To communicate with stakeholders and the community at large, MeshAtlantic set up a multi-faceted communication plan. In this regard, stakeholders were invited to take part in national workshops and to fill out a questionnaire.

More than 280 people attended the national workshops, and 224 responses were gathered throughout the partnerships. The questionnaire consisted of 21 questions about the intervention area, map scales and depth ranges, habitat mapping along with stakeholders' profiles.

The results of the questionnaire analysis demonstrate that habitat maps are frequently used and add high value to end-users activities. Stakeholders are increasingly interested in marine habitat maps in a wide range of scales, including deep-sea and seabed sediment structure and associated biological communities. The analysis also showed that some stakeholders hold datasets that could add valuable information for marine habitat maps.

Biotope identification in deep rocky reefs offshore Portimão and Sagres

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The circalittoral rocky bottom between 30 and 90 meters depth off the coast of Portimão and Sagres, Southern Portugal, were surveyed for the first time using a sidescan sonar (Klein 3000), a multibeam (Reson 8125) and two remotely operated vehicles (ROV - Seabotix LBV200 and Falcon Seaeye 400), making these sites the best surveyed circalittoral habitats in Portugal mainland. One habitat mapping campaign was carried out in the spring of 2011 and two ground truthing campaigns were performed in the spring of 2012 and 2013. MB and SSS covered an area of 28.68 km2 (30-62m depth) in Portimão and of 24.16 km2 (7-72m depth) in Sagres, respectively. Twenty-seven dives using ROVs were conducted across the survey area (30-90m depth).

These expeditions made possible the identification of several particular habitats such as the ascidian aggregations (e.g. *Stolonica socialis*, 30-40m), two gorgonian gardens types (*Eunicella* spp.+ *Leptogorgia* spp. 30-50m depth and these species plus *Paramuricea clavata* + *Ellisella paraplexauroides* at 50-70m depth) and several coral gardens characterized by patches of *Dendrophyllia* spp. (40-60m depth), *Savalia savaglia* (60m depth) and *Corallium rubrum* (70-90m). A characteristic in common to most of these habitats is the presence of high densities of zoanthids belonging to the species Parazoanthus axinellae, various unidentified massive and incrusting sponges, cup and stalked sponges of the species Phakellia ventilabrum and Axinella spp. and the presence of Astrospartus mediterraneus, an ophiuroid, epibiont of scleractinian and octocorals. Some of the explored high relief ledges with vertical walls showed a high percentage cover of incrusting biota mainly oysters, bryozoans and sponges and sheltered crustaceans such as the spiny lobster *Palinurus elephas*.

This was the first time such an extensive habitat of red coral (*C. rubrum*) and golden coral (*S. savaglia*) was documented in the Atlantic Ocean. The coral gardens are considered priority habitats by OSPAR and given the high levels of marine biodiversity observed it probably justifies the inclusion of these areas in the Natura 2000 Network or even in a new MPA.

Biotope identification in S. Vicente and Portimão submarine canyons

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Within the scope of the MeshAtlantic project the University of Algarve (UALG/CCMAR) participated in the "OCEANA Ranger Expedition 2011: Heading Toward Seamounts" with the aim of identifying the main biotopes associated with the two major submarine canyons in the south coast of Portugal: Portimão and São Vicente (Sagres). The campaign was conducted with the help of an underwater robot ROV (Falcon Seaeye 400), descending to 600 metres depth. Two surveys were carried out during the summer (June-August 2011): offshore Portimão, 2 ROV transects were performed in the canyon (60-450m depth); offshore Sagres, 4 ROV transects covered 2 deep rocky reefs and the S. Vicente canyon (50-550m depth).

This expedition allowed the presentation of several new priority habitats to the OSPAR such as the mixed gorgonian gardens (Eunicella labiata, E. verrucosa, Leptogorgia samentosa and Paramuricea clavata) on rocky circalittoral bottom (59- 120 m depth). In deep rocky reefs near Sagres, another potential priority habitats were found such as black coral forests forests (Antipathes subpinnata) and caves and overhangs with extensive oyster beds (Neopycnodonte cf. cochlear) and red coral gardens (Corallium rubrum) (70-110m depth). In the deeper waters of São Vicente canyon the sponge fields dominated with Artemisina transiens aggregations on circalittoral rocky bottom (35-125 m depth) and Asconema setubalense on bathyal rocky bottoms (325-475 m depth). On the other hand, the Portimão submarine canyon presented a batial soft bottom dominated by the sea pen Kophobelemnon stelliferum (450m depth). The expedition allowed the identification of over 100 different marine species on both canyons, and the recognition of essential fish habitats for at least three important commercial species: hake (Merluccius merluccius), monkfish (Lophius piscatorius) and Norwegian lobster (Nephrops norvegicus).

These new findings reflect the high levels of marine biodiversity and richness found and, probably justify the inclusion of these areas in the Natura 2000 Network.

Transboundary Planning in the European Atlantic (TPEA)

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Europe's seas offer unparalleled opportunities for sustainable use, both for traditional and emerging maritime sectors. Blue growth is contingent on ecosystem health, and activities need to be carefully planned in relation to each other and the surrounding environment.

Maritime Spatial Planning (MSP) is recognised as a key mechanism for achieving these goals. However, MSP requires careful coordination across marine and coastal jurisdictions, to take account of the interests and dynamics of neighbouring areas.

Transboundary Planning in the European Atlantic (TPEA), co-funded by DG Mare, is developing a commonly-agreed approach to cross-border MSP in the European Atlantic region. The TPEA project is a response to the European Commission's call for a project on Maritime Spatial Planning in the Atlantic, including Celtic Sea and Bay of Biscay, and follows on from similar projects recently completed for the Baltic, Bothnian and North Seas.

TPEA involves ten governmental and research partners from Ireland, Portugal, Spain and the UK, and expert advisors from the whole region are also actively involved. The project is carrying out cross-border planning exercises in two pilot sites, one in the north of the region (within the waters of Northern Ireland and the Republic of Ireland) and another in the south Atlantic (within the waters of Spain and Portugal situated around Guadiana).

The project will examine critical elements of the planning process in the context of legal and policy frameworks, participatory approaches and technical considerations. More specifically the TPEA aims to 1) develop recommendations for a cross-border MSP process for application within project region sea areas that are characterised by multiple demands and potentials, based on an overall study of the conditions (legal, administrative, technical and social), and in the development of pilot studies in transboundary areas; 2) formulate recommendations for overcoming barriers and progressing cross-border MSP and 3) investigate the relationship between MSP and ICZM and recommend means for their closer integration.

Quantifying deep-sea habitats: a cold-water coral example from the 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 km^2 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.

Using EUNIS to classify Southern European seabed habitats: the marine protected area Luiz Saldanha Marine Park (Arrábida Natural Park, SW Portugal) case study

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Habitat classification systems facilitate comparisons at different geographic scales and help providing information in an accessible manner, namely in reports and maps. For this reason, they constitute valuable tools for a wide range of purposes, such as environmental assessment, monitoring and management, and strategic planning of human activities. The use of the European Nature Information System (EUNIS), a hierarchical classification that provides a common reference set of habitats, is currently recommended by several EU policies, as a means of ensuring a common technical terminology among Member States for mapping and reporting on marine habitats.

In this study we present the classification of hard and soft sediment marine habitats according to EUNIS in the Luiz Saldanha Marine Park, based on historical data. In the first case formerly identified communities were reclassified according to EUNIS units and codes. In the second case, several sampling programmes provided the necessary information for the habitats classification. The methodological approach involved sampling with a 0.1 m2 Smith-McIntyre grab, classification of sediment types following the scheme agreed within the MeshAtlantic project and identification and characterization of macrofauna spatial distribution and species assemblages using the analytical techniques available in the software PRIMER v6.

A total of eleven level 5 habitats without EUNIS correspondence was identified and proposed for inclusion in the system. New proposed units are: A3.14_PT7-[*Lithophyllum incrustans*] on infralittoral rock, A3.15_PT8-[*Corallina elongata*] on infralittoral rock, A3.15_PT9-[*Gelidium corneum*], [Asparagopsis armata] and [Mytilus galloprovincialis] on infralittoral rock, A3.21_PT10-[Condracanthus acicularis] on infralittoral rock, A3.31_PT11-[*Saccorhiza polyschides*] on infralittoral rock, A5.23_PT13-Infralittoral sand with peracarid crustaceans and bivalves, A5.23_PT15-Circalittoral sand with polychaetes [*Aponuphis bilineata*] and bivalves [*Tellina donacina*], A5.26_PT16-Circalittoral muddy sand with peracarid and decapod crustaceans, polychaetes, ophiurids and bivalves, A5.27_PT17-[*Nephtys hombergii*] and [*Laevicardium crassum*] in deep circalittoral muddy sand, A5.27_PT18-Deep circalittoral muddy sand with [*Chloeia viridis*], [*Panthalis oerstedi*] and [*Owenia fusiformis*], A5.37_PT19-Deep circalittoral sandy mud with [*Maldane glebifex*]. Amendments to unit A5-231-Infralittoral mobile clean sand with sparse fauna, and replacement of unit A5.246-[*Ervilia castanea*] beds in infralittoral sand, with unit A5.23_PT14-[*Ervilia castanea*] beds in infralittoral sand (after renaming level A5.23 to Infralittoral sand), are also proposed.

These habitats were included in the habitat map produced for the marine park and made available in the MeshAtlantic WebGIS.

The present results highlight the need to revise the EUNIS classification of marine habitats so as to accommodate new units and update existing ones. Therefore they can be regarded as a contribution to enhance and complete the EUNIS description of southern European marine habitat types.

Single-beam acoustic variability associated with varying echo integration spatial survey step and sediment types

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The present study is part of a wide predictive modelling work of the benthic habitats in the Portuguese Continental Shelf, between Nazaré and Ovar. The acoustic data was registered by an acoustic ground discrimination system connected to a single-beam echo sounder operating at 50 kHz. The study area covered approximately 5400 Km2 with depth from 10 to 150 meters, and superficial sediments ranging from mud to fine gravel. The study was focused on characterizing the variability of the acoustic backscatter associated with echo integration at various spatial survey steps (250, 500, 750 or 1000 meters) and in several sediment types. The survey included acoustic registers along 27 regularly spaced perpendicular transects to the coast and 121 ground-truth sediment samples. The results revealed that the acoustic signature associated with the intermediate sediment types (medium sand) presented the highest variability. The length of the echo integration survey step showing the lowest inherent acoustic variability was of 250 meters for all types of superficial sediments covered in our study, except in the case of mud and very fine sand that was 750m. These spatial steps were in accordance selected for the echo integration in the whole study area in subsequent modelling work.

Predicting the spatial distribution of superficial sediments using single-beam acoustics: the Portuguese continental shelf (Nazaré-Ovar)

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The present work focus on the stretch of the Portuguese Continental Shelf between Nazaré and Ovar, and aims to predict the superficial sediments distribution through generalized linear models (GLMs) and generalized additive models (GAMs). The surveyed area of the continental shelf ranges from 10 to 150 meters depth and includes diverse superficial sediment types, from fine gravel to mud. In this area, 27 acoustic transects, perpendicular to coast, were obtained and 121 ground-truth sediment samples were collected. Data acquired by an acoustic ground discrimination system connected to a single-beam echo sounder operating at 50 kHz was used to model various sediment characteristics, such as the percentage of mud, sand and the median.

A broad scale seabed substrate map of the Portuguese coast

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The MeshAtlantic project aimed to generate a broad-scale habitat map for the shelf and coastal area of the Atlantic Area (AA) based on most significant datasets for habitat. For this, one of the most challenging steps involved the collection of historical and new data for the creation of the energy, biological zones, seabed substrate and biological layers.

A detailed seabed substrate map of the Portuguese coast, which covers a great extension of the Western Iberian coast, was not known till 2012. To create this easy-to-use map, historical maps from the Portuguese Hydrographic Institute, published and non-published cartographic information and new sedimentary data were collated and harmonized. The new sedimentary data was obtained from nearly 500 sediment samples distributed along the entire western and southern inner, mid and outer Portuguese continental shelf, but mostly concentrated in areas with poor sedimentary data available. The harmonization involved the (re)classification of historical and new data according to a simplified version of the Folk classification system, used by the European Nature Information System (EUNIS) and adapted by the project.

A final seabed substrate map for the Portuguese coast, up to 500 m water depth, is here presented. Overall, the Portuguese coastal and continental shelf is characterized by: (a) rocky outcrops, irregularly distributed along the entire shelf, especially in the west; (b) mud and sandy mud patches, off the major rivers, namely Guadiana (south), Tagus (west) and Douro (northwest) and near the major Portuguese submarine canyon (Nazaré, west coast); (c) muddy sand, all over the deeper western shelf and western part of the southern shelf; (d) sand, near the coast or surrounding rocky outcrops or coarser deposits, (e) coarse sediment deposits, mainly in the northwestern shelf sector, south of the Nazaré and Setúbal canyons, and sparsely in the southern shelf.

Mapping the South Coast of Portugal: Portimão and Sagres study sites

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Under the EU Interreg IV framework, the Atlantic Area project MeshAtlantic has research from 2010 to 2013 the seabed habitats of the continental shelf areas of France, Ireland, Spain and Portugal to obtain a global broad-scale habitat map based on the EUNIS classification. Within this project were carried out several surveys along the Atlantic Area, they include the Sagres and Portimão Survey, comprise in the southest study area of the MeshAtlantic project.

The purpose of the Sagres and Portimão Joint survey by the Spanish Institute of Oceanography (IEO) and the University of Algarve (UALG/CCMAR) is to explore the seabed in the south Atlantic coast of Portugal to establish the existence of relevant habitat types in natural interesting areas, in order to translate them to the EUNIS habitat classification system and to mapping the obtained results.

The objectives planned for the south coast of Portugal surveys were focused firstly on the acquisition of high resolution data with an acoustic survey using different techniques, as side scan sonar and multibeam echo sounder. Subsequently, was carried out a biological campaign using dredging and ROV techniques, and scuba diving, video and beam trawl to extract biological samples. And finally, the results has been processed and interpreted for provide a base layer for the marine biodiversity information to enable effective management of the marine environment and management of protected areas.

After the comprehensive analysis of the results obtained with the use of all these techniques, it has been proposed the possibility of include new classes of habitat in the EUNIS classification system that comprise ecosystems with very different habitats in the study area of the south Atlantic Portugal coast.

The results obtained in this survey have contributed to elaborate the homogeneous broad-scale habitat map, one of the principal aims of the MeshAtlantic project, as part of a relevant habitat mapping modeling for the European Atlantic zones where it did not exist for the Atlantic Area until now.

Application and effectiveness of EUNIS habitat classification in the European south coast: *Anemonia sulcata* and *Paracentrotus lividus* in association with *Dictyota dichotoma* as a new provisional biotope for the classification

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The EUNIS system is a hierarchical habitat classification developed to be used for environmental reporting and for assistance to the NATURA2000 process and coordinated to the related EMERALD Network of the Bern Convention. The classification has been applied to the North-East Atlantic and Mediterranean coasts but still excludes the south coast of Europe. Under the MeshAtlantic project, the University of Algarve (UALG/CCMAR) and partners have committed to identify habitats at a fine scale and to propose new habitat types for the EUNIS classification scheme. This project allowed the identification of six large biotopes and different biological features and facies among soft and rocky bottom from the south of Portugal. The present study has tested the EUNIS application and effectiveness in the Algarve coast and describes in detail the biotope "*Anemonia sulcata* and *Paracentrotus lividus* in association with *Dictyota dichotoma*" as a case study. This habitat is found on infralittoral rocky areas where the effect of wave energy and currents, as well as the fraction of light that reaches the sea bottom is very significant. *Dictyota dichotoma* and *Cystoseira usneoides* are the characteristic algae species but others algae species are also commonly found. This habitat is also characterized by a large abundance of invertebrates such as anemones (*Anemonia sulcata* and Aiptasia spp.), echinoderms (*Paracentrotus lividus, Holothuria arguinensis, Holothuria mammata* and *Ophioderma longicauda*), molluscs (*Gibbula cineraria* and *Clavagella melitensis*) and bryozoa (*Schizobrachiella sanguinea* and *Pentapora foliacea*). Some fish species such as gobies and blennies as well as wrasses species are also very common and serve as indicative species of this habitat. Different assemblages of species are observed when compared to other biotopes and give a reason for being proposed to the EUNIS classification.

Submerged sea caves of Sagres (South of Portugal-Algarve): an overview of their biological communities and threats

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The submerged sea caves of Sagres are located within the "Parque Natural do Sudoeste Alentejano e Costa Vicentina (PNSACV)" Marine Protected Area (MPA). This MPA was declared Site of Community Importance and integrates the national network of protected areas. The conservation status of this MPA alone provides sufficient concern for the need of detailed information on the sea caves biodiversity. An overview of the biological communities and identifying the main natural and artificial threats of the submerged sea caves of Sagres are the primarily aims of this study. Data collection was based on published papers, anecdotal information, video transects, and photo quadrates.

The submerged caves of Sagres could vary from merely a few meters to more complex structures of hundreds of meters. As expected three communities were recognized in the caves: the entrance communities, the semi-dark and the dark cave communities. Overall, about 245 species were documented between the entrance and the inside of these caves, being evident the decline and change on the biological communities. From the data set, evidences point out for cave habitat dependence of 14 species, while the majority also inhabits the cave vicinities. Sponges were represented with 85 species (e.g. *Chondrosia reniformis, Aaptos aaptos, Corticium candelabrum, Crambe crambe, Terpios gelatinosa, Hymedesmia versiculor)*, comprising more than 36% of the invertebrate richness. Other important groups of species were the *Bryozoa* (41; 17%), the *Annelida* (25; 11%) and *Cnidaria* (29; 12%). Several *scleractinian* coral species were identified within the cnidarians (e.g., *Phyllangia mouchezii, Polycyathus muellerae, Astroides calycularis, Balanophyllia regia, Caryophyllia inornata, Dendrophyllia ramea*). Fifteen fish species were also recorded but only one is a typical to darkness habitats (*Apogon imberbis*). Important species in terms of commercial value were also registered, particularly crustacean species (*Homarus gammarus, Maja squinado, Palinurus elephas, Scyllarus arctus*).

The main identified natural threat is related to seasonal storms that could increase coastal erosion. Oil spills from offshore cargo ships could be the worse threat caused by human activity. Another important hazard to be considered is the negative damaging effect caused by recreational scuba diving on this fragile biotope.

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.

EUNIS Habitat Mapping – Applications at European and National Levels

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Member States and the European Commission require information on marine ecosystems and resources in order to fully implement their policies and to apply Directives, in particular, the Habitats Directive and Marine Strategy Framework Directive. Quantitative and descriptive data of the marine environment through habitat mapping provides a fundamental tool for the conservation of marine biotopes and for the sustainable development of maritime economic activities. Integration of marine habitat data at a European level is the first step in the generation of a marine data infrastructure which will facilitate the development of coherent, interoperable datasets that will inform ocean management, monitoring and conservation.

MeshAtlantic has compiled biological and physical data from existing maps and datasets in the Atlantic Area to deliver harmonized, seabed habitat maps using the European Nature Information System (EUNIS) developed by the European Environment Agency for habitat classification. MeshAtlantic datasets are now available to access via an online portal developed as part of the MeshAtlantic project. In addition, detailed EUNIS habitat maps for regional Natura 2000 sites have been produced.

The Portuguese Coastal Shelf seabed habitats: relationships between multivariate benthic species analysis and EUNIS classification

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Recent studies described the structure and species composition of soft bottom benthic communities of the Portuguese Western and Southern Coastal Shelf, as well as their relationship with environmental drivers, in particular the sediments grain-size. Six main communities were identified, characterized and compared to those from coastal areas in the Northern Atlantic and the Mediterranean: (a) Coarse sediments community, mostly located on the western shelf, with *Protodorvillea kefersteini, Pisione remota, Angulus pygmaeus* and several other interstitial species; (b) near shore fine sands with *Magelona johnstoni, Urothoe pulchella* and *Angulus fabula*; (c) *Abra alba* community in north-western deep muddy sands; (d) South-western very deep muddy sands characterized namely by *Galathowenia oculata* and *Lumbrinerides amoureuxi;* (e) *Euchone rubrocincta, Nematonereis unicornis* and other warmer water species in muddy sands of the southern and sheltered shelf; and (f) muds dominated by *Sternaspis scutata, Heteromastus filiformis* and *Psammogammarus caecus*. Sediment grain-size, organic matter, depth and hydrodynamic regime were the variables best related to the macrofauna distribution patterns. A recent workshop held under the auspices of the MeshAtlantic project discussed present concerns and future need on using EUNIS habitat classification for benthic mapping in European seas. Some of the addressed concerns are here analysed at the light of the identified benthic communities which highlighted the transitional characteristics of this south-eastern European Atlantic area, where northern and subtropical faunas coexist.

Habitat mapping of the Avilés Canyon System and the near continental shelf (Cantabrian Sea)

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The complex Avilés Canyon System is located in the western area of the Cantabrian Sea (Bay of Biscay), whose study is currently being carried out by the INDEMARES (LIFE+) project. The aim of this project is to provide the necessary information to establish a network of representative marine protected areas (MPAs) for the purpose of biodiversity conservation on Spanish waters. For the effective design of MPAs, one of the main objectives of this project is identifying and charting the habitats and the biological communities that inhabit them. However, the EUNIS hierarchical habitat classification system is still not well developed for the characteristics of several ecosystems and in general terms presents important discrepancies in their design. In this study we attempt to determine the suitability of this classification system to the particularities of the complex Avilés Canyon's deep-sea ecosystem, identifying the main problems to be solved in improved versions of the EUNIS to reflect regional peculiarities.

Five main physiographic domains have been recognized in the studied area, corresponding to: narrow continental shelf, complex upper and abrupt lower slope, continental rise and complex canyon system incised from shelf to rise. Three major submarine canyons are present: Avilés, El Corbiro and La Gaviera canyons. It's also noticeable in the area the Agudo de Fuera High (rocky outcrop) and El Canto Nuevo marginal shelf. This structural complexity, in combination with a high gradient of environmental variables (from 50 to 4800 m depth) and the existence of strong hydrodynamic activity associated to the topography, produce a high diversity of habitats and biological communities.

The species distribution data were obtained during four multidisciplinary surveys (2009-2012) using otter trawl, beam trawl and box-corer to sample sedimentary areas and photogrammetric towed sled, ROV and rocky dredge to sample in complex and hard substrates. To identify the megafaunal assemblages and their characterizing species, the quantitative data obtained were analysed using cluster and SIMPER analysis. For some relevant and characteristics species (coral reefs and other benthic vulnerable species) on which it is difficult to represent correctly their spatial distribution we used habitat suitability modeling techniques, using their environmental dependency. The results show that the criteria for the classification of the habitats according to EUNIS does not seem to be suitable for the particular habitats found in the area, specially on the deep-sea, where in some cases it was possible to reach the third level of the hierarchy. The use of two different levels of aggregations on the deep-sea habitats, following two different criteria (substrate type or geomorphology -canyons, trenches, etc) imply that the same habitat/community can be classified into different levels. Also, there is a strong fishing pressure and nearly 400 vessels currently operated in the area. Consequently some of the habitats are altered to a greater or lesser extent by fishing activities. Particularly the habitats located in sedimentary grounds, between 100 and 600 m depths, which are extremely disturbed by trawlers, and the communities that inhabit them do not correspond with the existed originally.